# MTECH 2022

**Discipline :** ELECTRONICS & COMMUNICATION ENGINEERING

**Stream:** ECx (Automotive Electronics)

(with Industry collaboration – Tata Elxsi)

## SEMESTER I

| SLOT | COURSE CODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
|---|---|---|---|---|---|---|---|
| | | | CIA | ESE | | | |
| A | 221TEC101 | AUTOMOTIVE CONTROL SYSTEM | 40 | 60 | 3-0-0 | 3 | 3 |
| B | 221TEC102 | MODERN AUTOMOTIVE SYSTEMS | 40 | 60 | 3-0-0 | 3 | 3 |
| C | 221TEC103 | ADVANCED EMBEDDED SYSTEM | 40 | 60 | 3-0-0 | 3 | 3 |
| D | 221EECXXX | PROGRAM ELECTIVE 1 | 40 | 60 | 3-0-0 | 3 | 3 |
| E | 221EECXXX | PROGRAM ELECTIVE 2 | 40 | 60 | 3-0-0 | 3 | 3 |
| S | 221RGE100 | RESEARCH METHODOLOGY AND IPR | 40 | 60 | 2-0-0 | 2 | 2 |
| T | 221LEC101 | AUTOMOTIVE EMBEDDED SYSTEMS LAB | 100 | -- | 0-0-2 | 2 | 1 |
| **Total** | | | **340** | **360** | | **19** | **18** |

Teaching Assistance: 6 hours

## PROGRAM ELECTIVE 1

| PROGRAM ELECTIVE 1 | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **D** | 1 | 221EEC105 | MODERN AUTOMOTIVE SENSORS & ACTUATORS | 3-0-0 | 3 | 3 |
| | 2 | 221EEC106 | ADVANCED SIGNAL PROCESSING | 3-0-0 | 3 | 3 |
| | 3 | 221EEC107 | ADVANCED OBJECT ORIENTED PROGRAMMING | 3-0-0 | 3 | 3 |
| | 4 | 221EEC108 | MACHINE LEARNING | 3-0-0 | 3 | 3 |

## PROGRAM ELECTIVE 2

| PROGRAM ELECTIVE 2 | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **E** | 1 | 221EEC081 | REAL TIME OPERATING SYSTEMS | 3-0-0 | 3 | 3 |
| | 2 | 221EEC082 | ENERGY STORAGE SYSTEMS FOR VEHICLES | 3-0-0 | 3 | 3 |
| | 3 | 221EEC083 | CONNECTED VEHICLES | 3-0-0 | 3 | 3 |
| | 4 | 221EEC084 | SYSTEMS ENGINEERING | 3-0-0 | 3 | 3 |

## SEMESTER II

| SLOT | COURSE CODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
|---|---|---|---|---|---|---|---|
| | | | CIA | ESE | | | |
| A | 222TEC101 | AUTOMOTIVE NETWORKING | 40 | 60 | 3-0-0 | 3 | 3 |
| B | 222TEC102 | ADAS & MACHINE LEARNING | 40 | 60 | 3-0-0 | 3 | 3 |
| C | 222EECXXX | PROGRAM ELECTIVE 3 | 40 | 60 | 3-0-0 | 3 | 3 |
| D | 222EECXXX | PROGRAM ELECTIVE 4 | 40 | 60 | 3-0-0 | 3 | 3 |
| E | 222EECXXX | INDUSTRY/ INTERDISCIPLINARY ELECTIVE | 40 | 60 | 3-0-0 | 3 | 3 |
| S | 222PEC100 | MINI PROJECT | 100 | -- | 0-0-4 | 4 | 2 |
| T | 222LEC103 | ADAS LAB | 100 | -- | 0-0-2 | 2 | 1 |
| **Total** | | | **400** | **300** | | **21** | **18** |

Teaching Assistance: 6 hours

## PROGRAM ELECTIVE 3

| PROGRAM ELECTIVE 3 | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **C** | 1 | 222EEC089 | AUTOMOTIVE MICROCONTROLLERS | 3-0-0 | 3 | 3 |
| | 2 | 222EEC067 | AUTOMOTIVE POWER ELECTRONICS & DRIVES | 3-0-0 | 3 | 3 |
| | 3 | 222EEC090 | IMAGE PROCESSING & COMPUTER VISION | 3-0-0 | 3 | 3 |
| | 4 | 222EEC091 | AUTONOMOUS VEHICLES | 3-0-0 | 3 | 3 |

## PROGRAM ELECTIVE 4

| PROGRAM ELECTIVE 4 | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **D** | 1 | 222EEC092 | DEEP LEARNING | 3-0-0 | 3 | 3 |
| | 2 | 222EEC093 | VEHICLE SAFETY AND COMFORT SYSTEMS | 3-0-0 | 3 | 3 |
| | 3 | 222EEC094 | DIGITAL TWIN FOR AUTOMOTIVE SYSTEMS | 3-0-0 | 3 | 3 |
| | 4 | 222EEC095 | ROS FOR NEXTGEN VEHICLES | 3-0-0 | 3 | 3 |

## INDUSTRY/ INTERDISCIPLINARY ELECTIVE

| INDUSTRY/ INTERDISCIPLINARY ELECTIVE | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **E** | 1 | 222EEC087 | PERCEPTION SYSTEMS | 3-0-0 | 3 | 3 |
| | 2 | 222EEC088 | AUTOMOTIVE DIAGNOSTICS | 3-0-0 | 3 | 3 |

## SEMESTER III

| SLOT | COURSE CODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
|---|---|---|---|---|---|---|---|
| | | | CIA | ESE | | | |
| **TRACK 1** | | | | | | | |
| A* | 223MECXXX | MOOC | To be completed successfully | | -- | -- | 2 |
| B** | 223AGEXXX | AUDIT COURSE | 40 | 60 | 3-0-0 | 3 | - |
| C** | 223IEC100 | INTERNSHIP | 50 | 50 | -- | -- | 3 |
| D** | 223PEC100 | DISSERTATION PHASE I | 100 | -- | 0-0-17 | 17 | 11 |
| **TRACK 2** | | | | | | | |
| A* | 223MECXXX | MOOC | To be completed successfully | | -- | -- | 2 |
| B | 223AGEXXX | AUDIT COURSE | 40 | 60 | 3-0-0 | 3 | - |
| C | 223IEC100 | INTERNSHIP | 50 | 50 | --- | -- | 3 |
| D | 223PEC001 | RESEARCH PROJECT PHASE I | 100 | -- | 0-0-17 | 17 | 11 |
| **Total** | | | **190** | **110** | | **20** | **16** |

Teaching Assistance: 6 hours

*MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1).

**Students can pursue the Audit course, Internship and Dissertation Phase I at the Collaborating Industry (Tata Elxsi), if they qualify through the selection process.

## AUDIT COURSE

| AUDIT COURSE | | | | | | |
|---|---|---|---|---|---|---|
| **SLOT** | **SL NO** | **COURSE CODE** | **COURSE NAME** | **L-T-P** | **HOURS** | **CREDIT** |
| **B** | 1 | 223AGE013 | ASPICE AND FUNCTIONAL SAFETY | 3-0-0 | 3 | - |
| | 2 | 223AGE014 | AUTOSAR | 3-0-0 | 3 | - |
| | 3 | 223AGE100 | ACADEMIC WRITING | 3-0-0 | 3 | - |
| | 4 | 223AGE001 | ADVANCED ENGINEERING MATERIALS | 3-0-0 | 3 | - |
| | 5 | 223AGE002 | FORENSIC ENGINEERING | 3-0-0 | 3 | - |
| | 6 | 223AGE003 | DATA SCIENCE FOR ENGINEERS | 3-0-0 | 3 | - |
| | 7 | 223AGE004 | DESIGN THINKING | 3-0-0 | 3 | - |
| | 8 | 223AGE005 | FUNCTIONAL PROGRAMMING IN HASKELL | 3-0-0 | 3 | - |
| | 9 | 223AGE006 | FRENCH LANGUAGE (A1 LEVEL) | 3-0-0 | 3 | - |
| | 10 | 223AGE007 | GERMAN LANGUAGE (A1 LEVEL) | 3-0-0 | 3 | - |
| | 11 | 223AGE008 | JAPANESE LANGUAGE (N5 LEVEL) | 3-0-0 | 3 | - |
| | 12 | 223AGE009 | PRINCIPLES OF AUTOMATION | 3-0-0 | 3 | - |
| | 13 | 223AGE010 | REUSE AND RECYCLE TECHNOLOGY | 3-0-0 | 3 | - |
| | 14 | 223AGE011 | SYSTEM MODELING | 3-0-0 | 3 | - |
| | 15 | 223AGE012 | EXPERT SYSTEMS | 3-0-0 | 3 | - |

## SEMESTER IV

| SLOT | COURSE CODE | COURSE NAME | MARKS | | L-T-P | HOURS | CREDIT |
|---|---|---|---|---|---|---|---|
| | | | CIA | ESE | | | |
| **TRACK 1** | | | | | | | |
| A** | 224PEC100 | Dissertation Phase II | 100 | 100 | 0-0-24 | 24 | 16 |
| **TRACK 2** | | | | | | | |
| A | 224PEC001 | Research Project Phase II | 100 | 100 | 0-0-24 | 24 | 16 |
| **Total** | | | **100** | **100** | | **24** | **16** |

Teaching Assistance: 5 hours

**Students can pursue the Dissertation Phase II at the Collaborating Industry (Tata Elxsi), if they qualify through the selection process.

## ASSESSMENT PATTERN

### (i) CORE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

**Continuous Internal Evaluation: 40 marks**

| | |
|---|---|
| Micro project/Course based project: | 20 marks |
| Course based task/Seminar/Quiz: | 10 marks |
| Test paper, 1 no: | 10 marks |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

### (ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).



**Continuous Internal Evaluation: 40 marks**

| | |
|---|---|
| Preparing a review article based on peer reviewed | |
| Original publications (minimum 10 | 15 marks |
| Publications shall be referred): | |
| Course based task/Seminar/Data | 15 marks |
| Collection and interpretation: | |
| Test paper, 1 no.: | 10 marks |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.



**(iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE**

| | |
|---|---|
| **Continuous Internal Evaluation:** | **40 marks** |
| Course based task: | 15 marks |
| Seminar/Quiz: | 15 marks |
| Test paper, 1 no.: | 10 marks |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**(iv) LABORATORY COURSES**

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

**(v) INDUSTRY/ INTERDISCIPLINARY ELECTIVE**

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the University has incorporated Industry/Interdisciplinary electives in the curriculum. Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge- building process between academic institutions and industry. It aids pupils in expanding their knowledge and innovating by allowing them to create something new. While core engineering courses provide students with a strong foundation, evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem- solving techniques. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education and the integration of desirable specialized subjects into the current engineering education system. This will enable students to fulfill the current



industry demands. Students with multidisciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging technology and interdisciplinary approaches such as bigdata, machine learning, and 3-D printing.

**Continuous Internal Evaluation: 40 marks**

Preparing a review article based on peer reviewed

| | |
|---|---|
| Original publications (minimum 10 publications shall be referred): | 15 marks |
| Course based task/Seminar/Data collection and interpretation: | 15 marks |
| Test paper, 1 no: | 10 marks |

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**(vi) MOOC COURSES**

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall



not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

(vii) **MINIPROJECT**

**Total marks: 100, only CIA**

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10.

**TEACHING ASSISTANCESHIP (TA)**

All M Tech students irrespective of their category of admission shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or



tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities (specifically prohibited by University Policy).

**For the tutorial session:**

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancy or if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher if are and make sure that you are not partial to some student/students while grading. Follow basic ethics.

**Handling a laboratory Session:**

(i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the



laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative assessment.



# SEMESTER I

**Discipline: ELECTRONICS AND COMMUNICATION**

**Stream : ECx (Automotive Electronics)**

(with Industry collaboration – Tata Elxsi)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221TEC101 | AUTOMOTIVE CONTROL SYSTEMS | DISCIPLINE CORE 1 | 3 | 0 | 0 | 3 |

**Preamble:** The course is intended to impart comprehensive knowledge in the domain of automotive control systems.

**Course Prerequisites:** Control systems

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Develop mathematical models of Digital Control Systems |
| **CO 2** | Design and analyse digital control systems using classical techniques |
| **CO 3** | Design and analyse SISO and MIMO digital control systems in the state space domain |
| **CO 4** | Apply various techniques for the stability analysis of nonlinear digital control systems |
| **CO 5** | Create and evaluate critically the domain specific applications of automotive control systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | 1 | |
| **CO 2** | 2 | 2 | | 3 | | 2 | |
| **CO 3** | 2 | 2 | | 3 | | 2 | 2 |
| **CO 4** | 2 | | 2 | | 3 | | 2 |
| **CO 5** | 2 | | 2 | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 10 |
| Analyse | 40 |
| Evaluate | 30 |
| Create | 20 |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no: 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University.

There will be two parts; Part A and Part B.

Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

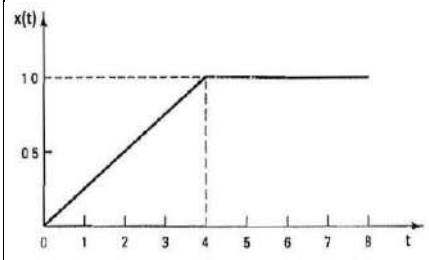
**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIRST SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**
**Course Code: 221TEC101**

**Course Name: Automotive Control Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**
***Answer all questions, each carries 5 marks.***

| | | |
|---|---|---|
| 1 | With a block diagram, discuss the basic elements of a discrete -data control system. Also mention its advantages over the analog control system. | 5 |
| 2 | Find the z-transform of x(t) shown in figure. Assume sampling period T=1s.   | 5 |
| 3 | With help of suitable circuit explain the principle of operation | 5 |

| | | |
|---|---|---|
| | of sample and hold devices. Derive the transfer function of zero order hold circuit. | |
| 4 | Define Stability in terms of Lyapunov. State and Prove Lyapunov's theorem on stability. | 5 |
| 5 | State the properties of state transition matrix in digital control. | 5 |

**PART – B**

***Answer any 5 full questions Each question carries 7 marks***

| | | | |
|---|---|---|---|
| 6 | a | For a unity feedback system, with sampling time T=1sec, open loop transfer function is<br>G(z)= $\frac{k(0.3679z+0.2542)}{(z-0.3679)(z-1)}$<br>Determine the value of K for stability by use of Jury's stability test. Also determine the frequency of oscillations at the output. | 5 |
| 6 | b | Explain folding and aliasing | 2 |
| 7 | a | Find the z-transform of the following function x(k)<br>$x(k) = \sum_{h=0}^{k} (a_k)$<br>Where 'a' is a constant. | 3 |
| 7 | b | Find the inverse z-transform of the following functions:<br>$(i)\ X(z) = \frac{z^{-1}(1-z^{-1})}{(1+z^{-2})^2}$<br>$(ii)\ X(z) = \frac{z-0.4}{z^2+z+2}$ | 4 |
| 8 | a | Draw the Bode plot for the following system with open loop transfer function (sampling period T = 0.2 s)<br>$G(z) = \frac{2(0.01873z = 0.01752)}{z^2 - 1.8187z + 0.8187}$ | 5 |
| 8 | b | Define phase margin and gain margin | 2 |
| 9 | a | Verify that V=x14+x1 2+2x1x2 +2x22 is a suitable Lyapunov's function for the system described by:<br>$\dot{x}_1 = x_2$<br>$\dot{x}_2 = x_2 - x_1^3$ | 4 |
| 9 | b | Describe the different types of singular points and discuss their importance in the stability analyses of nonlinear system. | 3 |

| | | | |
|---|---|---|---|
| 10 | | Determine whether the following systems are completely state controllable<br>i. $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 2 \\ 3 \end{bmatrix} u(k)$<br>ii. $\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u(k)$ | 7 |
| 11 | a | For the following system obtain the state transition matrix.<br>$x(k+1) = Gx(k) + Hu(k)$<br>$y(k) = Cx(k) + Du(k)$<br>$G = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}; \quad H = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \quad C = \begin{bmatrix} 1 & 0 \end{bmatrix}; \quad D = [0]$ | 4 |
| 11 | b | Write the state space representation of a linear time invariant discrete time control system. Explain various matrices in the representation. | 3 |
| 12 | a | Write the function of antilock braking system | 3 |
| 12 | b | What are the four main components of antilock braking system | 4 |

**Syllabus**

**Module 1: Introduction**

Discrete time system representation –Sample & Hold-Mathematical modelling of sampling process – Data reconstruction-Design of the hardware and software architecture – Software requirements- Selection of ADC and DAC- Choice of the sampling period – Prefilter/Antialiasing filters - Effects of quantization errors - Phase delay introduced by the ZOH-Sampling period switching- Dual rate control. Modelling discrete-time systems bypulse transfer function -Revisiting Z-transform -Mapping of s-plane to z-plane - Pulse transfer function - Pulse transfer function of closed loop system - Sampled signal flow graph.

-Stability analysis of discrete time systems -Jury stability test - Stability analysis using bi- linear transformation.

**Module 2: Design of sampled data control systems**

Design of PID controller-Filtering the derivative action- Integrator windup- Bump less transfer between manual and automatic mode - Incremental form-Root locus method - Controller design using root locus - Nyquist stability criteria - Bode plot – Lead compensator design using Bode plot - Lag compensator design using Bode plot - Lag-lead compensator design in frequency domain-Deadbeat response design -Design of digital control systemswith deadbeat response - Practical issues with deadbeat response design - Sampled data control systems with deadbeat response.

**Module 3: Discrete state space model and state feedback design**

Introduction to state variable model for SISO systems- Various canonical forms - Characteristic equation, state transition matrix - Solution to discrete state equation- Controllability, observability and stability of discrete state space models -Controllability and observability - Stability Pole placement by state feedback - Set point tracking controller - Full order observer - Reduced order observer-Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers -Output feedback design - Outputfeedback design: Theory - Output feedback design: Examples. Introduction to Multivariable & Multi-input Multi-output (MIMO) Digital Control Systems.

**Module 4: Nonlinear Digital control systems**

Discretization of nonlinear systems - Extended linearization by input redefinition - - input and state redefinition - output differentiation - Extended linearization using matching conditions – Nonlinear difference equations - Logarithmic transformation- Equilibrium of nonlinear discrete-time systems - Lyapunov stability theory- Lyapunov functions - Stability theorems -Rate of convergence – Lyapunov stability of linear systems - Lyapunov's linearization method- Instability theorems - Estimation of the domain of attraction.

**Module 5: Automotive control system applications**

Stability of analog systems with digital control Hybrid Systems - State plane analysis - Discrete-time nonlinear controller design- Controller design using extended linearization- Controller design based on Lyapunov stability theory - Input-output stability and the small gain theorem, Absolute stability. Anti-Lock Braking System (ABS) control systems-Control cycles of ABS system, Traction Control System (TCS), Adaptive Cruise Control (ACC).

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction** | **9** |
| 1.1 | Discrete time system representation | 1 |
| 1.2 | Sample & Hold-Mathematical modelling of sampling process –Data reconstruction | 2 |
| 1.3 | Design of the hardware and software architecture – Software requirements- Selection of ADC and DAC | 2 |
| 1.4 | Choice of the sampling period –Prefilter/Antialiasing filters - Effects of quantization errors - Phase delay introduced by the ZOH-Sampling period switching | 1 |
| 1.5 | Dual rate control. Modelling discrete-time systems by pulse transfer function | 1 |
| 1.6 | Revisiting Z-transform -Mapping of s-plane to z-plane – Pulse transfer function - Pulse transfer function of closed loop system -Sampled signal flow graph | 1 |

| | | |
|---|---|---|
| 1.7 | Stability analysis of discrete time systems -Jury stability test - Stability analysis using bi-linear transformation. | 1 |
| **2** | **Design of Sampled data control systems** | **8** |
| 2.1 | Design of PID controller-Filtering the derivative action-Integrator windup- Bump less transfer between manual and automatic mode | 1 |
| 2.2 | Incremental form-Root locus method - Controller design using root locus | 2 |
| 2.3 | Nyquist stability criteria | 2 |
| 2.4 | Lead compensator design using Bode plot | 1 |
| 2.5 | Lag compensator design using Bode plot - Lag-lead compensator<br>design in frequency domain-Deadbeat response design | 1 |
| 2.6 | Design of digital control systems with deadbeat response - Practical issues with deadbeat response design - Sampled data control systems with deadbeat response | 1 |
| **3** | **Discrete state space model and state feedback design** | **8** |
| 3.1 | Introduction to state variable model for SISO systems-Various canonical forms - Characteristic equation, state transition matrix | 1 |
| 3.2 | Solution to discrete state equation-Controllability, observability and stability of discrete state space models - | 2 |
| 3.3 | Controllability and observability - Stability Pole placement by state feedback | 1 |
| 3.4 | Set point tracking controller - Full order observer - Reduced order observer-Servo Design- State feedback with Integral Control | 1 |
| 3.5 | Deadbeat Control by state feedback and deadbeat observers - Output feedback design | 2 |
| 3.6 | Introduction to Multivariable & Multi-input Multi-output (MIMO) Digital Control Systems | 1 |
| **4** | **Nonlinear Digital control systems** | **8** |
| 4.1 | Discretization of nonlinear systems - Extended linearization by input redefinition - - input and state redefinition | 1 |
| 4.2 | output differentiation - Extended linearization using matching conditions | 2 |
| 4.3 | Nonlinear difference equations - Logarithmic transformation- Equilibrium of nonlinear discrete-time systems | 1 |
| 4.4 | Lyapunov stability theory- Lyapunov functions - Stability theorems -Rate of convergence | 2 |
| 4.5 | Lyapunov stability of linear systems - Lyapunov's linearization method- Instability theorems - Estimation of the domain of attraction | 2 |
| **5** | **Automotive control system applications** | **7** |



| | | |
|---|---|---|
| 5.1 | Stability of analog systems with digital control Hybrid Systems State plane analysis - Discrete-time nonlinear controller design- Controller design using extended linearization | 2 |
| 5.2 | Controller design based on Lyapunov stability theory - Input- output stability and the small gain theorem, Absolute stability. | 2 |
| 5.3 | Anti-Lock Braking System (ABS) control systems | 1 |
| 5.4 | Traction Control System (TCS) | 1 |
| 5.5 | Adaptive Cruise Control (ACC). | 1 |

**Reference Books**


1. B.C Kuo, 'Digital Control Systems', Oxford University Press, Inc., New York, 2nd Ed, 1995.
2. G.F. Franklin, J.D. Powell, and M.L. Workman, 'Digital control of Dynamic Systems', Addison-Wesley Longman, Inc., Menlo Park, CA, 1998.
3. M. Gopal, 'Digital Control and State Variable Methods', 4th Ed, Tata McGraw Hill Publishing Company, 2017.
4. John F. Walkerly, 'Microcomputer architecture and Programs', Tata McGraw Hill Publishing Company, ,John Wiley and Sons Inc., New York, 1981.
5. K. Ogata, 'Discrete Time Control Systems' , 2 nd Ed, Prentice Hall India Learning Private Limited, 2005.
6. C. H. Houpis and G.B. Lamont, 'Digital Control Systems', McGraw Hill Book Company, 2nd Ed, 1992.
7. C.L. Philips and H.T Nagle, Jr., 'Digital Control System Analysis and Design', Prentice Hall, Inc., Englewood Cliffs, N. J., 1995.
8. M. Sami Fadali Antonio Visioli, 'Digital Control Engineering Analysis and Design', 3rd Ed, Academic Press, 2019.
9. U. Kiencke and L. Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle," Springer-Verlag New York, LLC, 2004.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221TEC102 | MODERN AUTOMOTIVE SYSTEMS | PROGRAM CORE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course is designed to provide an insight into automotive systems and automotive electronics. The course helps to develop the fundamentals of IC engines, Electric Vehicles, Electric drives and Hybrid Electric vehicles. This course also provides an overview of how the sensors and actuators in vehicles interact with ECU for various vehicular control applications.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply the fundamentals of different Internal combustion engines |
| **CO 2** | Describe the components of Electric Vehicles and energy storage systems |
| **CO 3** | Apply the concept of motor drives and power transmission systems in EV design. |
| **CO 4** | Explain the architecture of hybrid electric vehicles and their types |
| **CO 5** | Apply the concept of integrating sensors and actuators with ECU for developing automotive control applications |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | 2 | 3 | 2 | 1 | |
| **CO 2** | 3 | 1 | 1 | 2 | 2 | | |
| **CO 3** | 3 | 1 | 2 | 3 | 2 | 1 | |
| **CO 4** | 3 | 1 | 1 | 2 | 2 | | |
| **CO 5** | 3 | 1 | 2 | 3 | 2 | 1 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |



**Continuous Internal Evaluation Pattern: 40 marks**

| | |
|---|---|
| Micro project/Course based project | : 20 marks |
| Course based task/Seminar/Quiz | : 10 marks |
| Test paper, 1 no. | : 10 marks |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University.

There will be two parts; Part A and Part B.

Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221TEC102**

**Course Name: Modern Automotive Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Define air/fuel ratio in IC engine and explain its impact on engine performance.

2 Explain the operating principle of fuel cells.

3 List the motor requirements for EVs and HEVs.

4 Differentiate between series and parallel HEVs.

5 Draw the generic block diagram of electronic engine control system and explain the different blocks.

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Explain the operation of four stroke spark ignition internal combustion engine.

7 Explain briefly the various energy storage systems in electric vehicles.

8 A step-down chopper fed from a 200-V source operates a dc motor whose armature EMF is 170 V and armature resistance is 0.5 Ω. With the magnitude control ratio of 0.4, find the average output voltage and current of the chopper and determine the quadrant of operation.

9 With the help of block diagram, explain the speed control of BLDC motor.

10 What are the basic functions of a Power train? Illustrate the concept in HEV scenario.

11 Explain the general architecture of series-parallel hybrid electric vehicle.

12 Describe the operating principle of mass air flow rate sensor and give its significance.

**Syllabus**

**Module 1: Fundamentals of IC Engines**

Internal Combustion Reciprocating Engine – four stroke SI IC engine, main components and operating principle and parameters, Working principle of four stroke CI engine and two stroke engines. Definition of Engine performance terms – Effect of air/fuel ratio, spark timing and exhaust gas recirculation (EGR) on performance, Electronic Fuel control system, Electronic Ignition system, Automotive powertrain, Transmission Characteristics.

**Module 2: Electric Vehicles (EV)**

Electric Vehicles – Introduction, Components of EV system, Advantages of EV – in terms of efficiency, pollution, capital and operating cost, Performance of EV.

Energy Storage Systems – requirements, battery parameters, Types of batteries – Lead-Acid batteries, Nickel based batteries, Lithium based batteries, ultra capacitors, ultra highspeed flywheels.

Fuel Cell Vehicles – operating principle of fuel cells, Fuel Cell System Characteristics, Fuel Cell Technologies.



**Module 3: Electrical Drives**

Power Electronics components – DC-DC converters: Basic principle of a DC-DC converter, Types – Buck converters, Boost converters, Buck-Boost converters. DC-AC converters: Basic concept, Types – Single phase and three phase DC-AC inverters.

DC and AC Electric Motors – Motor & Engine ratings, Motor requirements, DC motors, three phase AC motors, Induction motors.

Electric Propulsion Systems (Electric Motor Drives) – DC Motor drives, Principle of operation and performance, Induction Motor Drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives.

EV Drivetrain – Transmission configurations, Transmission components – gears, automobile differential, clutch, brakes; Ideal Gearbox: steady state model, EV motor sizing

**Module 4: Hybrid Electric Vehicles (HEV)**

Classification of HEV: micro hybrid, mild hybrid, full hybrid, plug-in hybrid electric vehicles, fully electric vehicles. General architecture of HEV – Series, Parallel, Series-parallel, Advantages and disadvantages. HEV System Analysis - Power flow of HEV and types, Fuel economy benefits.

Basic Components of HEV – Energy sources: Gasoline engine/ Diesel engine/ Fuel cell; Electric motor, Energy storage system, transmission system in HEV.

Fundamentals of Brake systems of EVs and HEVs, Antilock Brake systems (ABS).

**Module 5: Sensors, Actuators & Vehicular Control**

Motivation for Electronic Engine Control, Concept of an Electronic Engine control system – major controller inputs and outputs. Automotive sensors and actuators – Basic working principle and types, Airflow rate sensor, Throttle Angle Sensor, Temperature Sensors, Engine Coolant Sensor, Exhaust Gas Oxygen (EGO) Lambda Sensors, Piezoelectric Knock Sensor. Engine control actuators – Solenoid Fuel injector, EGR actuator, Electric motor actuators - brushless DC motors, Stepper motors, Ignition system. The concepts of ECU design for automotive applications, Need for ECUs, advances in ECUs for automotive, design complexities of ECUs, V-Model for Automotive ECU's Architecture, analog and digital interfaces. Vehicular Control Applications.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | | |
| 1.1 | Internal Combustion Reciprocating Engine – four stroke SI IC engine, main components and operating principle and parameters | 2 |
| 1.2 | Working principle of four stroke CI engine and two stroke engines | 2 |

| | | |
|---|---|---|
| 1.3 | Definition of Engine performance terms – Effect of air/fuel ratio, spark timing and exhaust gas recirculation (EGR) on performance | 2 |
| 1.4 | Electronic Fuel control system, Electronic Ignition system, Automotive powertrain, Transmission Characteristics | 2 |
| 2 | | |
| 2.1 | Electric Vehicles – Introduction, Components of EV system, Advantages of EV – in terms of efficiency, pollution, capital and operating cost, Performance of EV | 2 |
| 2.2 | Energy Storage Systems – requirements, battery parameters, Types of batteries – Lead-Acid batteries, Nickel based batteries, Lithium based batteries, ultra capacitors, ultra highspeed flywheels | 2 |
| 2.3 | Fuel Cell Vehicles – operating principle of fuel cells, Fuel Cell System Characteristics, Fuel Cell Technologies. | 1 |
| 3 | | |
| 3.1 | Power Electronics components – DC-DC converters: Basic principle of a DC-DC converter, Types – Buck converters, Boost converters, Buck-Boost converters | 2 |
| 3.2 | DC-AC converters: Basic concept, Types – Single phase and three phase DC-AC inverters | 1 |
| 3.3 | DC and AC Electric Machines – Motor & Engine ratings, Motor requirements, DC machines, three phase AC machines, Induction machines | 3 |
| 3.4 | Electric Propulsion Systems (Electric Motor Drives) – DC Motor drives, Principle of operation and performance, Induction Motor Drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives. | 3 |
| 3.5 | EV Drivetrain – Transmission configurations, Transmission components – gears, automobile differential, clutch, brakes; Ideal Gearbox: steady state model, EV motor sizing | 2 |
| 4 | | |
| 4.1 | Classification of HEV: micro hybrid, mild hybrid, full hybrid, plug-in hybrid electric vehicles, fully electric vehicles | 2 |
| 4.2 | General architecture of HEV – Series, Parallel, Series-parallel, Advantages and disadvantages. HEV System Analysis - Power flow of HEV and types, Fuel economy benefits. | 2 |
| 4.3 | Basic Components of HEV – Energy sources: Gasoline engine/ Diesel engine/ Fuel cell; Electric motor, Energy storage system, transmission system in HEV | 2 |



| | | |
|---|---|---|
| 4.4 | Fundamentals of Regenerative Braking – Energy consumption in braking, Brake systems of EVs and HEVs, Antilock Brake systems (ABS) | 2 |
| 5 | | |
| 5.1 | Motivation for Electronic Engine Control, Concept of an Electronic Engine control system – major controller inputs and outputs | 1 |
| 5.2 | Automotive sensors and actuators – Basic working principle and types, Airflow rate sensor, Throttle Angle Sensor, Temperature Sensors, Engine Coolant Sensor, Exhaust Gas Oxygen (EGO) Lambda Sensors, Piezoelectric Knock Sensor | 2 |
| 5.3 | Engine control actuators – Solenoid Fuel injector, EGR actuator, Electric motor actuators - brushless DC motors, Stepper motors, Ignition system | 2 |
| 5.4 | The concepts of ECU design for automotive applications, Need for ECUs, advances in ECUs for automotive, design complexities of ECUs, V-Model for Automotive ECU's Architecture, analog and digital interfaces. Vehicular Control Applications. | 3 |

**Reference Books**


1. Bosch, "Automotive Handbook", 11th Edition, Wiley, 2022.
2. Wei Liu, "Hybrid Electric Vehicle System Modelling and Control", 2017.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. Trzynadlowski, Andrzej M. Introduction to modern power electronics. John Wiley & Sons, 2015.
5. PC Sen, Principles of Electric Machines and Power Electronics, 3rd Edition, Wiley 2013.
6. William B. Ribbens, "Understanding Automotive Electronics, Elsevier Newnes, 6th Edition, 2012.
7. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
8. Bosch, "Automotive Electrics and Automotive Electronics: System and components, Networking and Hybrid drive", Fifth edition, Springer view 2014.
9. NajamuzZaman, "Automotive Electronics Design Fundamental" first edition, Springer 2015.
10. Hillier's, "Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics", Fifth Edition, Nelson Thrones, 2007
11. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221TEC103 | ADVANCED EMBEDDED SYSTEMS | PROGRAM CORE 2 | 3 | 0 | 0 | 3 |

**Preamble:** An embedded system is some combination of computation hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. Industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys as well as mobile devices are all possible locations for an embedded system. This is an attempt to make the students familiar with modern embedded system design methodologies. The course offers an overview of hardware, firmware and operating system requirements for an embedded system.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply the fundamental building blocks of an Embedded system |
| **CO 2** | Develop the architecture and instruction set of ARM Cortex M3 &M4 processors |
| **CO 3** | Identify the basic requirements for the selection of an RTOS Embedded system |
| **CO 4** | Develop firmware in Assembly language for embedded systems |
| **CO 5** | Develop firmware in embedded C for embedded systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | | 3 | 3 | 2 | | |
| **CO 2** | 1 | | 3 | 3 | 3 | | |
| **CO 3** | 1 | | 3 | 3 | | 1 | |
| **CO 4** | 3 | | 3 | 3 | 3 | 1 | 2 |
| **CO 5** | 3 | | 3 | 3 | 3 | 1 | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |



**Continuous Internal Evaluation Pattern: 40 marks**

| | |
|---|---|
| Micro project/Course based project | : 20 marks |
| Course based task/Seminar/Quiz | : 10 marks |
| Test paper, 1 no. | : 10 marks |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University.

There will be two parts; Part A and Part B.

Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221TEC103**

**Course Name: Advanced Embedded Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Compare and contrast embedded systems with general computing systems, highlighting their key differences and application areas.

2 Write a C function to initialize a GPIO pin on an ARM Cortex-M4 processor for output. Explain the steps involved and the significance of each step.

3 Explain the use of the Barrel Shifter in ARM Cortex-M processors. How does it enhance the efficiency of certain instructions?

4 Discuss the advantages and disadvantages of high-level language-based firmware development compared to assembly language-based development.

5 Explain the concept of mutual exclusion in RTOS. How do semaphores help in managing task synchronization?

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 What are the key elements of an embedded system? Discuss the role of sensors and actuators in embedded systems with relevant examples.

7 Explain the process of connecting the ARM Cortex-M processor to memory and peripherals. Discuss the memory access permissions and attributes.

8 Provide a detailed overview of the exceptions and interrupts in ARM Cortex-M processors. How are they managed, and what is the role of the NVIC?

9 Describe the role of structures and unions in Embedded C programming. Provide code examples to illustrate their usage in embedded applications.

10 Explain the significance of the volatile type qualifier in Embedded C. Provide examples to show how it is used to handle hardware registers.

11 Compare and contrast non-preemptive and preemptive scheduling in RTOS. Discuss the advantages and disadvantages of each method.

12 Define device drivers in the context of embedded systems. Discuss the types and responsibilities of device drivers, and the factors influencing their selection.

**Syllabus and Corse Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Embedded Systems** | |
| 1.1 | Embedded Vs general computing systems, Classification of Embedded systems, Application areas of Embedded systems, | 1 |
| 1.2 | Elements of Embedded systems- types of cores and its comparison, | 1 |
| 1.3 | Memory, Sensors and actuators, Types of Communication Interfaces, | 1 |
| 1.4 | Methods of developing Embedded Firmware.<br>Supporting techniques- Reset, Brown-out protection, real time clock, watch dog timers. | 1 |



| | | |
|---|---|---|
| 1.5 | Characteristics and quality attributes of embedded systems | 1 |
| **2** | **Introduction to ARM Cortex-M3 &M4 Processors.** | |
| 2.1 | Advantages of the Cortex-M processors, Architecture, Programmer's model, Operation modes and states, registers, special registers, floating point registers Status and flag registers | 2 |
| 2.2 | Memory system, Memory map, Connecting the processor to memory and peripherals, Data alignment and unaligned data access support. | 2 |
| 2.3 | Bit-band operations, memory access permissions and attributes. | 1 |
| 2.4 | Exceptions and interrupts, Overview of exceptions and interrupts, Exception types. | 1 |
| 2.5 | Overview of interrupt management, Definitions of priority. Vector table and vector table relocation, | 1 |
| 2.6 | Interrupt inputs and pending behaviours, Exception sequence overview, NVIC registers for interrupt control, SCB registers for exception and interrupt control, exception or interrupt masking | 2 |
| **3** | **Instruction set in ARM Cortex-M** | |
| 3.1 | Comparison of the instruction set in ARM Cortex-M processors, | 1 |
| 3.2 | Understanding the assembly language syntax, Use of a suffix in instructions, Unified assembly language (UAL) | 1 |
| 3.3 | Instruction set, M4-specific instructions. | 3 |
| | Barrel shifter, Accessing special instructions and special registers in programming. | 1 |
| **4** | **Firmware design and development** | |
| 4.1 | Firmware design approaches- Assembly language based development, Source file to object file translation, library files usage and creation, linker and locater, object to hex converter, advantages and disadvantages.<br><br>High level language based development – advantages and disadvantages, Mixing assembly and high-level language. | 2 |
| 4.2 | Programing in Embedded C - C vs Embedded C, Using C in Embedded C – review on C programing concepts. | 2 |
| 4.3 | Arrays and pointers, function pointers, arrays of function pointers, structures and unions, structure pointers, structure padding, structure and bit fields. | 2 |



| | | |
|---|---|---|
| 4.4 | Constant declaration in embedded C, Volatile type qualifier in embedded C. | 2 |
| 4.5 | Delay generation and infinite loops in embedded C, Bit manipulation operations. | 1 |
| 4.6 | Coding Interrupt Service Routines, recursive Functions, Re-entrant functions, Dynamic memory allocation. | 2 |
| **5** | **RTOS Based Embedded System Design** | |
| 5.1 | Operating system basics – The Kernel –services provided by kernel. Types of operating systems-GPOS and RTOS. | 2 |
| 5.2 | Basic functions of RTOS, Hard and Soft RTOS. Tasks, process and Threads. Thread Pre-emption, | 2 |
| 5.3 | Multi-processing and Multi-tasking- Types of multi-tasking.<br>Task scheduling – Non pre-emptive, FIFO, LIFO, priority based scheduling. Pre-emptive scheduling. | 2 |
| 5.4 | Task Communication, Shared Memory, Message Passing, Remote Procedure Call and Sockets, | 2 |
| 5.5 | Task Synchronization, mutual exclusion, Semaphore. | 1 |
| 5.6 | Device Drivers-Definition, Types, responsibilities. Factors deciding the selection of RTOS | 1 |

**Text Books**

1. Shibu K V , Introduction to Embedded Systems , 2ed , Mc Graw hill

2. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors,3ed , Elsevier.

**Reference Books**

1. Frank Vahid and Tony Givargis, Embedded Systems Design – A Unified Hardware / Software Introduction, John Wiley, 2002.

2. Iyer - Embedded Real time Systems, 1e, McGraw Hill Education New Delhi, 2003.

3. Lyla B. Das, Embedded Systems: An Integrated Approach, 1/e , Lyla B. Das, Embedded Systems, 2012.

4. Rajkamal, Embedded Systems Architecture, Programming and Design, TMH, 2003.

5. Steve Heath, Embedded Systems Design, Newnes – Elsevier 2ed, 2002.

6. Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier 2ed, 2012.



| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221LEC101 | AUTOMOTIVE EMBEDDED SYSTEMS LAB | LABORATORY 1 | 0 | 0 | 2 | 1 |

**Preamble:** This course aims to provide hands-on experience in developing an Embedded system based on popular microcontroller and Digital signal processor (DSP). Students will gain practical skills to Develop and test Assembly Language/Embedded C programs on ARM CORTEX M3/TMS 320 C 6713 processors with suitable development/ Evaluation board and IDE.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | To develop Assembly language/Embedded C programs on ARM Cortex M3/M4 Microcontrollers for Arithmetic & Logic operations and peripheral interface. |
| **CO 2** | To develop Embedded C programs on TMS 320C 6713 DSP processor for Arithmetic & Logic operations and peripheral interface. |
| **CO 3** | To gain hands on experience in the usage of IDE together with development boards for an Embedded system |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 40 |
| Analyse | 30 |
| Evaluate | 15 |
| Create | 15 |

**Mark distribution**

| Total Marks | CIE | ESE |
|---|---|---|
| 100 | 100 | - |

**Continuous Internal Evaluation Pattern: 100 marks**

The laboratory courses will have only Continuous Internal Evaluation and carry 100 marks. The final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

**Tools:**

Any Evaluation/ development board and suitable IDE for ARM Cortex M3/M4 and TMS 320C 6713



**Syllabus**

| No | Topic |
|---|---|
| 1 | **Familiarization of ARM Cortex Microcontroller** |
| 1.1 | Programming with Arithmetic logic instructions (Assembly & Embedded C) – Basic programming for addition, subtraction, multiply, division, Logical and bitwise AND, OR. |
| 1.2 | GPIO programming ARM microcontroller-interfacing LED, Switches etc |
| 1.3 | Timer programming ARM Microcontroller– using timer for calculating Delay and scheduling –Flashing LED, Pulse generation |
| 1.4 | PWM Generation with ARM Microcontroller |
| 1.5 | Implementation of PI Controller on ARM –DC motor speed control |
| 2 | **Familiarization of TMS 320 C 6713** |
| 2.1 | Programming for Arithmetic operations in C (Linear/Circular Convolution) |
| 2.2 | Interfacing ADC/DAC (CODEC interface)- Signal acquisition and amplification/echo generation. |
| 2.3 | Digital FIR filter implementation |



# SEMESTER I

# PROGRAM ELECTIVE I

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC105 | MODERN AUTOMOTIVE SENSORS & ACTUATORS | PROGRAM ELECTIVE I | 3 | 0 | 0 | 3 |

**Preamble:** This course introduces the students to the design principles and analysis of sensors for measurement of various parameters in an electric vehicle. The first module discusses the static and dynamic characteristics of measurement systems sensors and error and error propagation. The second and third modules focus on Speed sensors, flow sensors and level sensors. The fourth module contains design of Nano and Micro sensor actuator mechanisms in electric vehicles. Fifth module focuses on adaptive filter design and machine learning tools for feature extraction.

**Prerequisites:** Nil

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse measurement systems and aggregation of errors in measurement systems |
| **CO 2** | Explain various transducer systems and operation of speed sensors |
| **CO 3** | Understand operation of various flow and level sensors |
| **CO 4** | Apply the principles of Nano and Micro sensors and different actuator mechanisms |
| **CO 5** | Understand estimation based on multi sensor data fusion, the use machine learning tools for feature extraction, and overview of safety analysis. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | 2 | 2 | | |
| **CO 2** | 1 | | 1 | 1 | 1 | | |
| **CO 3** | 1 | | 1 | 1 | 1 | | |
| **CO 4** | 1 | | 1 | 1 | 1 | | |
| **CO 5** | 2 | 2 | 1 | 2 | 3 | 2 | 1 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC105**

**Course Name: Modern Automotive Sensors & Actuators**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1. If the power in a circuit is calculated from measurements of voltage and current in which the calculated maximum errors are respectively ±1% and ±2%, calculate the maximum likely error in the power value.

2. Describe the principle of optical tachometer



3. Describe the working of dew-point hydrometer

4. Explain the construction of a bulk micromachined capacitive accelerometer

5. Compare linear regression with logistic regression

**PART B**

***Answer any 5 full question, each question carries 7 marks.***

6.a) Comment on the aggregation of Errors from Separate Measurement systems.

6.b) A balloon is equipped with temperature and altitude measuring instruments and is initially anchored to the ground with the instrument output readings in steady state. The altitude measuring instrument is zero order and the temperature transducer is first order with a time constant of 15 s. The temperature on the ground, T0, is 10 0C and the temperature Tx at an altitude of x meters is given by the relation: Tx= T0 – 0.01x

(i) If the balloon is released at time zero, and thereafter rises upwards at a velocity of 5 m/s, draw a table showing the temperature and altitude measurements reported at intervals of 10 s over the first 50 s of travel. Show also in the table the error in each temperature reading. (ii) What temperature does the balloon report at an altitude of 5000 m?

7. Discuss the use of inductive sensors in electric vehicles

8. Describe the principle of ultrasonic flow meter and ultrasonic level sensor

9. Illustrate the working of exhaust gas recirculation valve actuator with diagram

10.a) Write notes on sensor fusion using Kalman filter based estimation

10 b) Distinguish between supervised and unsupervised learning

11. Illustrate Speed measurement using Hall effect sensors and how sensitivity depends on various parameters

12. Illustrate with diagram the working of a piezoresistive accelerometer and derive expression for Gauge factor.

**Syllabus and Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Review of Measurement systems and Errors in measurement** | |
| 1.1 | Elements of a measurement System- sensors and transducers - Static characteristics of instruments: | 2 |

| | | |
|---|---|---|
| | Accuracy, precision, resolution, sensitivity, Linearity-Dynamic characteristics | |
| 1.2 | Design of Zero order and first order systems using mathematical modelling, Time response of first order system using simulation tool | 2 |
| 1.3 | Errors in measurement system-Systematic and random errors - Estimation of Random Error in a Single Measurement-Combined Effect of Systematic and Random Errors- Aggregation of Errors from Separate Measurement systems. | 4 |
| 2 | **Transducer-RLC, Speed sensors** | |
| 2.1 | Resistance Transducer: Resistive Potentiometers, Strain Gauge, Resistance change type Thermometric Sensors, Thermistor. | 2 |
| 2.2 | Inductance Transducer: Inductive Sensors, The Transformer Type Transducer (LVDT), The Hall effect sensor. | 2 |
| 2.3 | Capacitance Transducer: Capacitive displacement transducer for pressure sensor, Differential pressure transducer. | 2 |
| | Speed measurement - Encoders, Resolvers, R/D Converters, Optical tachometer, stroboscopic tachometer | 2 |
| 3 | **Sensors for fluid level, flow, viscosity** | |
| 3.1 | Capacitance Level Measurement, optical level sensors, conductivity level sensor, vibrating sensor, float switch sensor, continuous level measurement sensor, Ultrasonic level sensor, Ultrasonic flow meter, microwave flow meter | 4 |
| 3.2 | Density measurement: Hydrometer, ultrasonic and sonic densitometer. Viscosity measurement: Capillary viscometer, efflux cup viscometer | 2 |
| 3.3 | Humidity measurement: Dew point hydrometer, electrolytic hygrometer - pH meter | 2 |
| 4 | **MEMS/NEMS sensors; Actuators for Electric Vehicles** | |
| 4.1 | Micro electro mechanical system (MEMS)- Nano electro mechanical system (NEMS) based sensors, Piezoresistive Pressure Sensors, Strain Gauge Bonded to Diaphragm, piezoresistive accelerometers, Gauge factor, Micromachined Capacitive Accelerometers. | 4 |
| 4.2 | Actuators for EV-Stepper motor operated and solenoid operated systems, Magnetic Braking Actuator, Solenoid valves for fuel injection, Exhaust gas recirculation valve actuator. | 2 |
| 5 | **Sensor Fusion through estimation; Feature reduction** | |
| 5.1 | Introduction To Kalman Filter. Kalman Filters For Inertial Sensor Fusion. Bayesian Parameter Estimation: | 4 |



| | | |
|---|---|---|
| | Minimum Mean Squared Error (Mmse) Estimation, Maximum A Posteriori Estimation | |
| 5.2 | Sensor data Acquisition-Feature Extraction-Supervised ,Unsupervised learning, Deep learning. Tools for machine learning | 3 |
| | Linear regression assignment, logistic regression, model selection: practical considerations | 1 |
| 5.3 | Safety measures in electric vehicle: Sensor data management, linearity, data processing, error estimation. | 2 |
| | | 40 |

**Text Books**


1. Patranabis.D, “Sensors and Transducers”, 2nd Edition, Prentice Hall of India, 2021.
2. D. Patranabis, “Principles of Industrial Instrumentation”, 4th Edition, Tata McGraw Hill, New Delhi,2017
3. Alan S. Morris and Reza Langari, 2nd ed., Measurement and Instrumentation, Theory and Application, Academic Press, 2015
4. Westbrook, Michael Hereward, and John D. Turner. "Automotive sensors." (1994)
5. Michael Stanley and Jongmin Lee, “Sensor analysis for the Internet of Things”, 1st Edition, Morgan Claypool publishers, 2018


**Reference Books**


1. Anupama Prashar, Pratibha Bansal, “Industrial safety and Environment”, S.K. Kataria &sons, 2009
2. R. K. Jain, “Mechanical and Industrial Measurements”, 12th Edition, Khanna publishers, 2015.
3. Bela G. Liptak, Instrument Engineers' Handbook Process Control and Optimisation, 3rd ed., vol. 2, CRC Press, 2012
4. K. Krishnaswamy, S.Vijayachitra, “Industrial Instrumentation”, 2nd Edition, New age International Private limited, 2011
5. Microsensors, Muller, R.S., Howe, R.T., Senturia, S.D., Smith, R.L., and White, R.M. [Eds.], IEEE Press, New York, NY, 1991
6. Aurélien Géron, “Hands- Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition
7. Automotive Sensors, BOSCH,2002
8. Randy Frank, Understanding Smart Sensors, Artech House Boston. London, 2000
9. Hillier, VA W. Hillier's Fundamentals of Automotive Electronics 2. Oxford University Press-Children, 2014.




| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC106 | ADVANCED SIGNAL PROCESSING | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** The course is intended to impart comprehensive knowledge in the domain of advanced signal processing.

**Prerequisite:** Digital Signal Processing

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Assimilate various forms of sampling alteration devices |
| **CO 2** | Interpret various filter banks and their significance |
| **CO 3** | Implement Hilbert and wavelet transforms in various domains. |
| **CO 4** | Apply digital signal processing (DSP) techniques in various real-world Applications such as radar, image processing, speech processing, and automotive electronics |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | 3 | 3 | | |
| **CO 2** | 3 | | | 3 | 3 | | |
| **CO 3** | 3 | | | 3 | 3 | 2 | |
| **CO 4** | 3 | 2 | | 3 | 3 | 2 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 80% |
| Analyse | 20% |
| Evaluate | -- |
| Create | -- |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M. TECH DEGREE EXAMINATION**

**Stream: M.Tech. in Automotive Electronics**

**Course Code: 221EEC106**

**Course Name: Advanced Signal Processing**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1. Define decimation and interpolation in the context of signal processing.
2. Explain the concept of perfect reconstruction in filter banks.
3. Describe the main properties and applications of wavelet transforms.

4. What is the significance of the discrete Hilbert transform in signal processing?

5. How does multirate signal processing contribute to radar applications?

**PART B**

***Answer any 5 full question, each question carries 7 marks.***

6. Discuss the design considerations for two-channel quadrature mirror filter (QMF) banks. Provide examples to illustrate.

7. Explain the process of constructing Daubechies wavelets. How are they advantageous in signal processing applications?

8. Compare and contrast the short-time Fourier transform (STFT) and the continuous wavelet transform (CWT). When would you prefer to use each?

9. Given an input signal with a sampling rate of 1000 Hz, design a decimation system with a decimation factor of 5. Explain how you would implement this using polyphase techniques.

10. Describe the polyphase technique in multirate signal processing. How does it contribute to efficient implementation of decimators and interpolators?

11. Discuss the application of advanced signal processing techniques in image denoising. Provide examples and explain the underlying principles.

12. Solve the following problem using the continuous wavelet transform (CWT): Given a signal $x(t)=\sin(2\pi t)+\sin(4\pi t)$, analyze its frequency content using the CWT.

**Syllabus**

**Module 1:**

Multirate Signal Processing: Sampling Rate Conversion; Decimation and Interpolation; Time and Frequency Domain Characterization; Filters in Sampling Rate Alteration Systems; Multirate Design of Decimator and Interpolator; Poly-phase Techniques; Poly-phase Down-sampler and Interpolator; Polyphase Filter Design.

**Module 2:**

Filter Banks: Two-channel QMF Banks, Alias free FIR, and IIR QMF Banks; Perfect Reconstruction Two- channel FIR Filter Banks; M-Channel Filter Banks Design; Cosine-Modulated M-Channel Filter Banks Design

**Module 3:**

Discrete Hilbert Transforms: Real and Imaginary Part, Sufficiency of the FT for Causal Sequences, Sufficiency Theorems for Finite length Sequences, Relationship between Magnitude and Phase, HT Relation for Complex Sequences.

**Module 4:**

Wavelet Transforms: Fourier Transform and Its limitations, Short-Time Fourier Transform, Continuous Wavelet Transform, Discretization of the Continuous Wavelet



Transform, Multiresolution Approximations; Wavelet and Scaling Function Coefficients, Harr Wavelets, The Daubechies Wavelets Construction, Fast Wavelet Transform and Image Compression, Denoising using Wavelets.

**Module 5:**

Application of DSP & Multi rate DSP, Application to Radar, application to image processing, design of phase shifters, DSP in speech processing & application of signal processing in automotive electronics.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Multirate Signal Processing** | |
| 1.1 | Sampling Rate Conversion; Decimation and Interpolation | 2 |
| 1.2 | Time and Frequency Domain Characterization | 1 |
| 1.3 | Filters in Sampling Rate Alteration Systems | 1 |
| 1.4 | Multirate Design of Decimator and Interpolator | 1 |
| 1.5 | Poly-phase Techniques | 1 |
| 1.6 | Poly-phase Down-sampler and Interpolator | 1 |
| 1.7 | Polyphase Filter Design. | 1 |
| **2** | **Filter Banks** | |
| 2.1 | Two-channel QMF Banks | 2 |
| 2.2 | Alias free FIR, and IIR QMF Banks | 1 |
| 2.3 | Perfect Reconstruction Two- channel FIR Filter Banks | 2 |
| 2.4 | M-Channel Filter Banks Design | 2 |
| 2.5 | Cosine-Modulated M-Channel Filter Banks Design | 1 |
| **3** | **Discrete Hilbert Transforms** | |
| 3.1 | Real and Imaginary Part, Sufficiency of the FT for Causal Sequences | 2 |
| 3.2 | Sufficiency Theorems for Finite length Sequences | 3 |
| 3.3 | Relationship between Magnitude and Phase | 1 |
| 3.4 | HT Relation for Complex Sequences. | 2 |
| **4** | **Wavelet Transforms** | |
| 4.1 | Fourier Transform and Its limitations, Short-Time Fourier Transform, Continuous Wavelet Transform | 2 |
| 4.2 | Discretization of the Continuous Wavelet Transform, Multiresolution Approximations | 2 |
| 4.3 | Wavelet and Scaling Function Coefficients, Harr Wavelets | 2 |
| 4.4 | The Daubechies Wavelets Construction, Fast Wavelet Transform and Image Compression | 2 |
| 4.5 | Denoising using Wavelets | 1 |
| **5** | **Application of DSP & Multi rate DSP** | |
| 5.1 | Application to Radar, application to image processing | 2 |
| 5.2 | Design of phase shifters | 1 |
| 5.3 | DSP in speech processing & other applications. | 2 |
| 5.4 | Application of signal processing in automotive electronics | 2 |



**Text Books**


1. S. K. Mitra, Digital Signal Processing: A Computer Based Approach, 4/e, TMH, 2013.
2. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4/e, Pearson Education Inc., 2007.
3. M. Vetterli and J. Kovacevic, Wavelets and Subband Coding, CreateSpace Independent Publishing Plat- form, 2013.
4. G. Strang and T. Nguyen, Wavelets and Filter Banks, Wellesley Cambridge Press, 1996.


**Reference Books**


1. A.V. Oppenheim and R. W. Schafer, Discrete – Time Signal Processing, 3/e, Prentice-Hall, 2009.
2. R. E. Crochiere and L. R. Rabiner, Multirate Digital Signal Processing, Prentice-Hall Inc., 1983.
3. C.K.Chui, Wavelets: A tutorial in Theory and Applications, Academic Press.
4. C. S. Burrus, R. A. Gopinath and H. Guo, Introduction to Wavelets and Wavelets Transforms, Prentice Hall Inc., 1997.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC107 | ADVANCED OBJECT-ORIENTED PROGRAMMING | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to develop a strong foundation in programming fundamentals and features of object-oriented programming (OOP). This aims to make students understand and apply fundamental OOP principles and master the core elements of C++ and Python for OOP. The course aims to equip students to apply advanced OOP principles to solve complex real-life engineering problems.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Realize the need and features of OOP |
| **CO 2** | Understand and apply pointers, dynamic memory allocation, and memory management techniques |
| **CO 3** | Design and implement classes and objects with encapsulation, inheritance, and polymorphism |
| **CO 4** | Apply object-oriented concepts in Python |
| **CO 5** | Utilize Python libraries and frameworks for object-oriented programming |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 1 | | 2 | 2 | 2 | |
| **CO 2** | 3 | 1 | | 3 | 2 | 2 | |
| **CO 3** | 3 | 1 | | 3 | 2 | 2 | |
| **CO 4** | 3 | 1 | | 3 | 2 | 2 | |
| **CO 5** | 3 | 1 | | 3 | 2 | 2 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |



**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M Tech DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC107**

**Course Name: Advanced Object-Oriented Programming**

Max. Marks: 60 Duration: 2.5 Hours

**PART A**

***Answer all questions. Each question carries 5 marks*** Marks

| | | |
|---|---|---|
| 1 | Explain the key principles of OOP and provide examples of how they differ from procedural programming | (5) |
| 2 | Illustrate the order of constructor and destructor calls in different inheritance types in C++ with example code. | (5) |
| 3 | Import the NumPy library and use it to create a 2D array filled with random numbers. Then, calculate the mean, standard deviation, and maximum value of all elements in the array. | (5) |
| 4 | Explain the purpose of this pointer in C++ and demonstrate its use within member functions of a class. | (5) |

| | | |
|---|---|---|
| 5 | Compare and contrast pass-by-value and pass-by-reference in C++. Write code examples to illustrate the difference. | (5) |

**PART B**

***Answer any 5 questions. Each question carries 7 marks***

| | | |
|---|---|---|
| 6 | Describe the concept of code reusability in OOP and explain how it is achieved through mechanisms like inheritance and polymorphism. | (7) |
| 7 | Explain the concept of operator overloading in C++ and provide examples of how it can be used for custom behaviours. | (7) |
| 8 | Discuss the differences between lists, tuples, and dictionaries in Python and provide examples of their use cases. | (7) |
| 9 | Describe the concept of Polymorphism. Explain the concepts of function overloading and operator overloading in C++. Give examples of overloading arithmetic operators (+, -) for different data types in a class. Discuss the benefits and limitations of operator overloading. | (7) |
| 10 | Create a Python program that reads data from a text file containing student information (name, marks in different subjects). Store this data in a dictionary, where the key is the student name and the value is a list of their marks. Then, calculate and display the average mark for each student. | (7) |
| 11 | Implement a simple inheritance hierarchy representing shapes (base class) and derived classes for circle and rectangle. Define virtual functions for calculating area and perimeter in the base class. Demonstrate dynamic polymorphism and method overriding in derived classes. | (7) |
| 12 | Explain the basic concepts of processes and threads in Linux. | (7) |

**Syllabus**

**Module 1**

Concepts of Object-Oriented Programming (OOP) – Benefits and applications of OOP, Principles of OOP – Abstraction –Encapsulation – Classes and Objects, Constructors and Destructors – Inheritance – Polymorphism

**Module 2**

Classes and Objects – “this” pointer – Constructors and Destructors – Static Data Members, Static Member Functions and Objects – Inline Functions – Call by reference –Functions with default arguments – Functions with Objects as Arguments – Friend Functions and Friend Classes.

Polymorphism – Function Overloading – Operator Overloading – Dynamic Polymorphism – Virtual Functions – Pure Virtual Functions - Abstract Classes



Inheritance – Multilevel Inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance – Virtual Base Classes, Abstract Classes, Constructors in Derived Classes.

**Module 3**

Python Programming – Introduction – Running code in the interactive shell, Editing, Saving, and Running a script –Using editors – IDLE, Jupyter – Data types and expressions in Python Basic operators– Conditional and control flow statements – Iteration statements in Python – for loop, while loops in python, Loop manipulation using pass, continue, break and else – Functions – Recursive function, lambda function – super function – Files: Create, Open, Read, Write, Append and Close– tell and seek methods

Data structures in Python – Strings and Lists – Tuples Sets and Dictionaries

**Module 4**

Modules and Packages – Numerical Routines. SciPy and NumPy – Basics, Creating arrays, Arithmetic, Slicing, Matrix Operations, Special Functions, Random Numbers, Linear Algebra, Solving Nonlinear Equations, Numerical Integration, Solving ODEs

**Module 5**

Data Visualization: Bar Graph, Histogram, creating a Pie Chart, Creating Line Graph, Plotting: Plotting using PyLab – Exceptions in Python, Exception Handling – Introduction to Linux – Understanding Linux Concepts, Command-line fundamentals: navigation, basic commands, file management, Shell scripting concepts, Bash shell.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **OOP Concepts** | |
| 1.1 | Introduction to Object-Oriented Programming (OOP) | 1 |
| 1.2 | Benefits and applications of OOP | 1 |
| 1.3 | Principles of OOP - Abstraction –Encapsulation – Classes and Objects, Constructors and Destructors | 3 |
| 1.4 | Inheritance | 2 |
| 1.5 | Polymorphism | 1 |
| 2 | **Fundamentals of C++** | |
| 2.1 | Classes and Objects – “this” pointer – Constructors and Destructors | 2 |
| 2.2 | Static Data Members, Static Member Functions and Objects – Inline Functions – Call by reference | 2 |
| 2.3 | Polymorphism – Function Overloading – Operator Overloading – Dynamic Polymorphism – Virtual Functions | 2 |



| | | |
|---|---|---|
| 2.4 | Inheritance – Multilevel Inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance | 2 |
| 3 | **Fundamentals of Python** | |
| 3.1 | Introduction to Python Programming – Ways of running code | 2 |
| 3.2 | Data types and expressions in Python Basic operators– | 2 |
| 3.3 | Conditional and control flow statements | 1 |
| 3.4 | Iteration statements in Python – for loop, while loops in python | 2 |
| 3.5 | Loop manipulation using pass, continue, break and else | 1 |
| 4 | **Functions and Files in Python** | |
| 4.1 | Functions – Recursive function, lambda function – super function | 3 |
| 4.2 | Files: Create, Open, Read, Write, Append and Close– tell and seek methods | 2 |
| 4.3 | Data structures in Python – Strings and Lists – Tuples Sets and Dictionaries | 3 |
| 5 | **Modules and Packages in Python** | |
| 5.1 | Modules and Packages – Numerical Routines. SciPy and NumPy | 3 |
| 5.2 | Data Visualization: Bar Graph, Histogram, creating a Pie Chart, Creating Line Graph, Plotting: Plotting using PyLab – Exceptions in Python | 3 |
| 5.3 | Understanding Linux Concepts, Shell scripting concepts | 2 |

**Reference Books**


1. E. Balagurusamy, Object Oriented Programming with C++ and JAVA, McGraw-Hill, 2015
2. Hardy, Brian, and Bill Phillips, Android Programming: The Big Nerd Ranch Guide. Addison-Wesley Professional, 2013.
3. Yashwant P. Kanetkar, Let us C++, 2/e, BPB Publications, 2003
4. Herbert Schildt, C: The Complete Reference, 4th Edition, Mc Graw Hill Education, 2017
5. Allen Downey, “Think Python”, 1st Edition, Green Tea Press, 2016
6. Introduction to Python Programming, Gowrishankar S, Veena A, CRC Press, 2018
7. Python Programming, Dr Jisu Elsa Jacob, Bharath Viswam, S.K.Kataria, and Sons Publishers
8. John V Guttag. “Introduction to Computation and Programming Using Python”, 2nd Edition, Prentice Hall of India
9. Siever, Ellen, et al. Linux in a Nutshell. " O'Reilly Media, Inc.", 2005.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC108 | MACHINE LEARNING | PROGRAM ELECTIVE 1 | 3 | 0 | 0 | 3 |

**Preamble:** This course introduces machine learning concepts and popular machine learning algorithms. It will cover the standard and most popular supervised learning algorithms including linear regression, logistic regression, decision trees, k-nearest neighbour, an introduction to Bayesian learning and the naive Bayes algorithm, support vector machines and kernels and basic clustering algorithms. Dimensionality reduction methods and some applications to real world problems will also be discussed. It helps the learners to develop application machine learning based solutions for real world applications.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse the Machine Learning concepts, classifications of Machine Learning algorithms and basic parameter estimation methods. |
| **CO 2** | Illustrate the concepts of regression and classification techniques |
| **CO 3** | Describe unsupervised learning concepts and dimensionality reduction techniques. |
| **CO 4** | Explain Support Vector Machine concepts and graphical models. |
| **CO 5** | Choose suitable model parameters for different machine learning techniques and to evaluate a model performance. |
| **CO 6** | Design, implement and analyse machine learning solution for a real-world problem. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 2 | | 3 | 3 | |
| **CO 2** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 3** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 4** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 5** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 6** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 60-80% |
| Analyse | 20-40% |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |



**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed

Original publications (minimum 10 Publications shall be referred) : 15 marks
Course based task/Seminar/Data Collection and interpretation : 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M. TECH DEGREE EXAMINATION**

**Stream: M.tech in Automotive Electronics**

**Course Code: 221EEC108**

**Course Name: MACHINE LEARNING**

**Max. Marks : 60** **Duration: 2.5 Hours**

**PART A**

***Answer All Questions. Each Question Carries 5 Marks.***

1. Explain the principle of the gradient descent algorithm**.**
2. In a two-class logistic regression model, the weight vector **w = [4, 3, 2, 1, 0]**. We apply it to some object that we would like to classify; the vectorised feature



representation of this object is **x = [−2, 0, −3, 0.5, 3]**. What is the probability, according to the model, that this instance belongs to the positive class?

3. Expectation maximization (EM) is designed to find a maximum likelihood setting of the parameters of model when some of the data is missing. Does the algorithm converge? If so, do you obtain a locally or globally optimal set of parameters?

4. What is the basic idea of a Support Vector Machine?

5. What is the trade-off between bias and variance?

## Part B

***Answer any five questions. Each question carries 7 marks.***

6. Suppose $\mathbf{x_1, \ldots, x_n}$ are independent and identically distributed (iid) samples from a distribution with density

$$f_X(x \mid \theta) = \begin{cases} \dfrac{\theta x^{\theta-1}}{3^\theta}, & 0 \le x \le 3 \\ 0, & \text{otherwise} \end{cases}$$

Find the maximum likelihood estimate (MLE) for θ.

7. Derive the gradient descent training rule assuming for the target function $\mathbf{o_d = w_0 + w_1x_1 + \ldots + w_nx_n}$. Define explicitly the squared cost/error function **E**, assuming that a set of training examples **D** is provided, where each training example **d** ε **D** is associated with the target output $\mathbf{t_d}$.

8. Cluster the following eight points representing locations into three clusters: ***A1(2, 10), A2(2, 5), A3(8, 4), A4(5, 8), A5(7, 5), A6(6, 4), A7(1, 2), A8(4, 9).***

   Initial cluster centers are: ***A1(2, 10), A4(5, 8)*** and ***A7(1, 2).***
   The distance function between two points **a =** ***(x1, y1)*** and **b =** ***(x2, y2)*** **is defined as D*(a, b)* = |x2 – x1| + |y2 – y1|**
   Use k-Means Algorithm to find the three cluster centers after the second iteration.

9. Describe Principal Component Analysis. What criterion does the method minimize? What is the objective of the method? Give a way to compute the solution from a matrix X encoding the features.



10. Consider a support vector machine whose input space is 2-D, and the inner products are computed by means of the kernel **K(x, y) = (x.y + 1)² - 1** (**x.y** denotes the ordinary inner product). Show that the mapping to feature space that is implicitly defined by this kernel is the mapping to 5-D given by

$$\boldsymbol{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \rightarrow \phi(\boldsymbol{x}) = \begin{bmatrix} x_1^2 \\ x_2^2 \\ \sqrt{2}\, x_1 x_2 \\ \sqrt{2}\, x_1 \\ \sqrt{2}\, x_2 \end{bmatrix}$$

11. How does random forest classifier work? Why is a random forest better than a decision tree?

12. Consider a two-class classification problem of predicting whether a photograph contains a man or a woman. Suppose we have a test dataset of 10 records with expected outcomes and a set of predictions from our classification algorithm. Compute the confusion matrix, accuracy, precision, recall, sensitivity and specificity on the following data.

| Sl No | Actual | Predicted |
|---|---|---|
| 1 | Man | Woman |
| 2 | Man | Man |
| 3 | Woman | Woman |
| 4 | Man | Man |
| 5 | Man | Woman |
| 6 | Woman | Woman |
| 7 | Woman | Man |
| 8 | Man | Man |
| 9 | Man | Woman |
| 10 | Woman | Woman |

**Syllabus**

**Module-1 (Parameter Estimation and Regression) 8 hours**

Overview of machine learning: supervised, semi-supervised, unsupervised learning, reinforcement learning. Basics of parameter estimation: Maximum Likelihood Estimation (MLE), Maximum a Posteriori Estimation (MAP). Gradient Descent Algorithm, Batch Gradient Descent, Stochastic Gradient Descent. Regression algorithms: least squares linear regression, normal equations and closed form solution, Polynomial regression.



**Module-2 (Regularization techniques and Classification algorithms) 9 hours**

Overfitting, Regularization techniques - LASSO and RIDGE. Classification algorithms: linear and non-linear algorithms, Perceptrons, Logistic regression, Naive Bayes, Decision trees. Neural networks: Concept of Artificial neuron, Feed-Forward Neural Network, Back propagation algorithm.

**Module-3 (Unsupervised learning) 8 hours**

Unsupervised learning: clustering, k-means, Hierarchical clustering, Principal component analysis, Density-based spatial clustering of applications with noise (DBSCAN). Gaussian mixture models: Expectation Maximization (EM) algorithm for Gaussian mixture model.

**Module-4 (Support Vector Machine and Graphical Models) 7 hours**

Support vector machines and kernels: Max margin classification, Nonlinear SVM and the kernel trick, nonlinear decision boundaries, Kernel functions. Basics of graphical models - Bayesian networks, Hidden Markov model - Inference and estimation.

**Module-5 (Evaluation Metrics and Sampling Methods) 8 hours**

Classification Performance Evaluation Metrics: Accuracy, Precision, Precision, Recall, Specificity, False Positive Rate (FPR), F1 Score, Receiver Operator Characteristic (ROC) Curve, AUC. Regression Performance Evaluation Metrics: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), R Squared/Coefficient of Determination. Clustering Performance Evaluation Metrics: Purity, Jaccard index, Normalized Mutual Information, Clustering Accuracy, Silhouette Coefficient, Dunn's Index. Boosting: AdaBoost, gradient boosting machines. Resampling methods: cross-validation, bootstrap. Ensemble methods: bagging, boosting, random forests Practical aspects in machine learning: data pre-processing, overfitting, accuracy estimation, parameter and model selection Bias-Variance trade-off.

**Course Plan**

| No | Topic | No. of Lectures (40) |
|---|---|---|
| 1 | **Module-1 (Parameter Estimation and Regression): 8 hours** | |
| 1.1 | Overview of machine learning: supervised, semi-supervised, unsupervised learning, reinforcement learning. | 1 |
| 1.2 | Basics of parameter estimation: Maximum Likelihood Estimation (MLE) | 1 |
| 1.3 | Basics of parameter estimation: Maximum Likelihood Estimation (MLE) - Examples | 1 |
| 1.4 | Basics of parameter estimation: Maximum a Posteriori Estimation (MAP) | 1 |
| 1.5 | Basics of parameter estimation: Maximum a Posteriori Estimation (MAP) - Example | 1 |



| | | |
|---|---|---|
| 1.6 | Gradient Descent Algorithm, Batch Gradient Descent, Stochastic Gradient Descent | 1 |
| 1.7 | Regression algorithms: least squares linear regression, normal equations and closed form solution | 1 |
| 1.8 | Polynomial regression | 1 |
| 2 | **Module-2 (Regularization techniques and Classification algorithms): 9 hours** | |
| 2.1 | Overfitting, Regularization techniques - LASSO and RIDGE | 1 |
| 2.2 | Classification algorithms: linear and non-linear algorithms | 1 |
| 2.3 | Perceptrons | 1 |
| 2.4 | Logistic regression | 1 |
| 2.5 | Naive Bayes | 1 |
| 2.6 | Decision trees | 1 |
| 2.7 | Neural networks: Concept of Artificial neuron | 1 |
| 2.8 | Feed-Forward Neural Network | 1 |
| 2.9 | Back propagation algorithm | 1 |
| 3 | **Module-3 (Unsupervised learning): 8 hours** | |
| 3.1 | Unsupervised learning: clustering, k-means | 1 |
| 3.2 | Hierarchical clustering | 1 |
| 3.3 | Principal component analysis | 2 |
| 3.4 | Density-based spatial clustering of applications with noise (DBSCAN) | 2 |
| 3.5 | Gaussian mixture models: Expectation Maximization (EM) algorithm for Gaussian mixture model | 2 |
| 4 | **Module-4 (Support Vector Machine and Graphical Models): 7 hours** | |
| 4.1 | Support vector machines and kernels: Max margin classification | 2 |
| 4.2 | Nonlinear SVM and the kernel trick, nonlinear decision boundaries | 1 |
| 4.3 | Kernel functions | 1 |
| 4.4 | Basics of graphical models - Bayesian networks | 1 |
| 4.5 | Hidden Markov model - Inference and estimation | 2 |
| 5 | **Module-5 (Evaluation Metrics and Sampling Methods): 8 hours** | |
| 5.1 | Classification Performance Evaluation Metrics: Accuracy, Precision, Precision, Recall, Specificity, False Positive Rate (FPR), F1 Score, Receiver Operator Characteristic (ROC) Curve, AUC | 1 |
| 5.2 | Regression Performance Evaluation Metrics: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), R Squared/Coefficient of Determination | 1 |
| 5.3 | Clustering Performance Evaluation Metrics: Purity, Jaccard index, Normalized Mutual Information, Clustering Accuracy, Silhouette Coefficient, Dunn's Index | 1 |
| 5.4 | Boosting: AdaBoost, gradient boosting machines. | 1 |



| | | |
|---|---|---|
| 5.5 | Resampling methods: cross-validation, bootstrap. | 1 |
| 5.6 | Ensemble methods: bagging, boosting, random forests | 1 |
| 5.7 | Practical aspects in machine learning: data pre-processing, overfitting, accuracy estimation, parameter and model selection | 1 |
| 5.8 | Bias-Variance trade-off | 1 |

**Reference Books**


1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Second edition Springer 2007.
4. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
5. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

# SEMESTER I

# PROGRAM ELECTIVE II

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC081 | REAL TIME OPERATING SYSTEMS | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to impart comprehensive knowledge about the Real time kernel internals of embedded operating systems. Students will be able to learn the fundamental concepts of RTOS and understand the implementation techniques of a simple RTOS with the help of µC/OS-II.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | To understand the important components and concepts to be implemented **i**n a Real-time system. |
| **CO 2** | To implement different process scheduling algorithms. |
| **CO 3** | To Implement Task Management and Event Control operations in RTOS. |
| **CO 4** | To Implement Deadlock management using semaphores, mutually exclusive locks. |
| **CO 5** | To understand the Memory Management and Queue Management Techniques. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | | 2 | | 2 | 2 | | |
| **CO 2** | | 3 | | | 3 | 2 | |
| **CO 3** | 3 | | 2 | 2 | | 2 | 2 |
| **CO 4** | 3 | | 2 | 2 | | 3 | 2 |
| **CO 5** | 3 | 2 | 2 | | 2 | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 30 |
| Analyse | 30 |
| Evaluate | 30 |
| Create | 10 |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |



**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M Tech DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC081**

**Course Name: REAL TIME OPEARATING SYSTEMS**

Max. Marks: 60 Duration: 2.5 Hours

**PART A**

***Answer all questions. Each question carries 5 marks*** Marks

| | | |
|---|---|---|
| 1 | Explain the differences between Pre-emptive and Non pre-emptive scheduling policies. | (5) |
| 2 | Explain EDF algorithm with an example. | (5) |
| 3 | Discuss the concept of Semaphores and how synchronisation is achieved using semaphores. | (5) |

| | | |
|---|---|---|
| 4 | Explain the operations on Mailbox. | (5) |
| 5 | Explain Memory management as a function of operating system. | (5) |

**PART B**

***Answer any 5 questions. Each question carries 7 marks***

| | | |
|---|---|---|
| 6 | Explain Priority inversion in real time systems. Explain how the operating system manages this issue. | (7) |
| 7 | Explain the different task states in µC/OS-II and their significance in task management. | (7) |
| 8 | How does µC/OS-II handle task synchronization and communication between different tasks within the system? Provide examples. | (7) |
| 9 | Explain the concept of event flag groups in µC/OS-II and their significance in managing multiple event flags. | (7) |
| 10 | Explain the fundamental operations involved in managing message queues in µC/OS-II, such as message queue creation, sending messages, and receiving messages. | (7) |
| 11 | Describe the mechanisms used in RTOS for memory protection, such as memory segmentation, memory protection units (MPUs), and memory access control. | (7) |
| 12 | Explain the concept of using a message queue as a counting semaphore in µC/OS-II. What advantages does this approach offer over traditional semaphores? | (7) |

**Syllabus**

**Module 1**

Introduction to Real-time Concepts — Characteristics and requirements of real-time systems. Advantages of Real-time Kernels, Types of RTOS, Key features of RTOS- Critical Section - Shared resources – Multitasking – Tasks - Context Switches – Kernels – Schedulers – Preemptive/Non-Preemptive kernels – Reentrant Functions – Round Robin Scheduling – Static/Dynamic Priorities – Priority Inversion – Priority Ceiling Deadlock.

**Module 2**

Concept of Real-time Operating Systems – Task Management -TCB- Task Scheduling Algorithms – Rate Monotonic Scheduling – Earliest Deadline First – Deadline Monotonic – Survey of RTOS – FreeRTOS - Interrupts – Latency – Response - Recovery – ISR processing time-Non-maskable Interrupts - Clock Tick, µC/OS-II: Kernel Structure – Task State - Task Scheduling – Idle/Static Tasks- Task Management – Task Stacks – Priorities - functions for Task Management - Time Management – Time management operations.



**Module 3**

Intertask Communication - Synchronization – Event Flags -– Message Mailbox – Message Queues - memory requirements, Semaphore Management – Operations on Semaphores - Mutual Exclusion Semaphores – Mutex Functions. µC/OS-II : Event Control Block – operations in ECB- Event Flag Management – Event Flag Group – manipulating using Event Flags

**Module 4**

Message Mailbox management – Operations on Mailbox – Using Mailbox as a Binary Semaphore – Mailbox for Time delay operation µC/OS-II: Message Queue Management – Operations in Message Queues –Message queue to read Analog inputs – Using Queue as a counting semaphore

**Module 5**

Memory protection and management in RTOS: Memory Management – Memory Control Block – Operations Using Memory Partitions – Waiting for Memory Block from a Partition Porting µC/OS-II to other Processors.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Real-time Concepts** | |
| 1.1 | Characteristics and requirements of real-time systems. Advantages of Real-time Kernels | 1 |
| 1.2 | Types of RTOS, Key features of RTOS | 1 |
| 1.3 | Critical Section - Shared resources | 1 |
| 1.4 | Multitasking – Tasks - Context Switches | 1 |
| 1.5 | Kernels – Schedulers – Preemptive/Non-Preemptive kernels | 1 |
| 1.6 | Reentrant Functions | 1 |
| 1.7 | Round Robin Scheduling ,Static/Dynamic Priorities | 1 |
| 1.8 | Priority Inversion – Priority Ceiling Deadlock. | 1 |
| **2** | **Concept of Real-time Operating Systems** | |
| 2.1 | Task Management -TCB, Task Scheduling Algorithms – Rate Monotonic Scheduling | 1 |
| 2.2 | Earliest Deadline First, Deadline Monotonic | 2 |
| 2.3 | Survey of RTOS – FreeRTOS - Interrupts – Latency – Response - Recovery – ISR processing time-Non-maskable Interrupts - Clock Tick | 2 |
| 2.4 | µC/OS-II: Kernel Structure – Task State - Task Scheduling – Idle/Static Tasks-Task Management – Task Stacks | 2 |
| 2.5 | µC/OS-II: Priorities - functions for Task Management - Time Management – Time management operations. | 2 |
| **3** | **Intertask Communication** | |



| | | |
|---|---|---|
| 3.1 | Synchronisation- Event Flags | 1 |
| 3.2 | Intertask Communication - Message Mailbox – Message Queues | 1 |
| 3.3 | memory requirements- Semaphore Management | 1 |
| 3.4 | Operations on Semaphores | 1 |
| 3.5 | Mutual Exclusion Semaphores – Mutex Functions | 1 |
| 3.6 | µC/OS-II : Event Control Block – operations in ECB | 1 |
| 3.7 | µC/OS-II: Event Flag Management – Event Flag Group – manipulating using Event Flags | 2 |
| **4** | **Message Mailbox management** | |
| 4.1 | Operations on Mailbox | 2 |
| 4.2 | Using Mailbox as a Binary Semaphore – Mailbox for Time delay operation | 2 |
| 4.3 | µC/OS-II: Message Queue Management – Operations in Message Queues | 2 |
| 4.4 | Message queue to read Analog inputs – Using Queue as a counting semaphore | 2 |
| **5** | **Memory protection and management in RTOS** | |
| 5.1 | Memory Management – Memory Control Block | 2 |
| 5.2 | Operations Using Memory Partitions | 2 |
| 5.3 | Waiting for Memory Block from a Partition Porting µC/OS-II to other Processors. | 4 |

**Textbooks**


1. Jean J. Labrosse, “MicroC/OS-II The Real-time Kernel” Second Edition, CMP Books.
2. Jim Cooling, Real-Time Operating Systems: Book 2 - The Practice: Using STM Cube, Free RTOS and the STM32 Discovery Board (2nd Edition Lindentree Associates 2020)
3. David E.Simon, “An Embedded Software Primer”, Addison Wesley; Pap/Cdr edition (5 August 1999) 2nd Edition.


**References**


1. K.C.Wang, “Embedded and Real-Time Operating Systems”, Springer; 1st ed. 2017 edition (6 April 2017)
2. Jean J. Labrosse, “µC/OS-III The Real-Time Kernel”, Micrium (1 September 2009)
3. https://doc.micrium.com/display/osiidoc

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC082 | ENERGY STORAGE SYSTEMS FOR VEHICLES | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** The purpose of this course to equip students with a nuanced understanding of energy storage systems and their pivotal role in shaping the future of sustainable transportation.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Comprehend the fundamentals of Energy Storage Systems |
| **CO 2** | Demonstrate proficiency in the principles, characteristics and technologies of fuel cells as well as their integration into hybrid electric drivetrains |
| **CO 3** | Apply battery technologies and management systems for electric vehicles |
| **CO 4** | Identify the role of energy storage systems in electric vehicle |
| **CO 5** | Identify the impact of smart hybrid supercapacitor in electric vehicles |
| **CO 6** | Apply the basics of Hybrid Energy Storage Systems in Electric vehicles |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | | | 3 | |
| **CO 2** | 3 | 3 | 3 | | | 3 | |
| **CO 3** | 3 | 3 | 3 | | | 3 | |
| **CO 4** | 3 | 3 | 3 | | | 3 | |
| **CO 5** | 3 | 3 | 3 | | | 3 | |
| **CO 6** | 3 | 3 | 3 | | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 20 |
| Apply | 80 |
| Analyse | |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M Tech DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC082**

**Course Name: Energy Storage Systems for Vehicles**

**Max. Marks: 60** **Duration: 2.5 hours**

**PART – A**

***Answer all questions. Each question carries 5 marks***

1. Name the different types of energy storage systems and provide examples of each.

2. Explain the concept of battery management

3. What are the key attributes of battery technologies used in electric vehicles?

4. What are smart supercapacitors?



5. What are hybrid energy storage systems (HESS) and what are the different types?

**PART-B**

***Answer ANY FIVE questions. Each question carries 7 marks***

6. a) What are the basic components of an energy storage system (ESS)?

   b) How do energy storage systems (ESS) contribute to different applications?

7. a) Explain the operating principle of a fuel cell and its characteristics.

   b) Describe the design considerations for a fuel cell hybrid electric drive train.

8. a) Describe the various charging schemes available for electric vehicles.

   b)Briefly explain the factors, challenges, and problems associated with sustainable electric vehicles.

9. a) Explain the structure and working principle of a supercapacitor.

   b) Describe the applications of smart hybrid supercapacitors in electric vehicles and transportation.

10.a) Explain the concept of passive, semi-active, and full-active HESS.

   b) Discuss the aging, thermal, and electric models used for estimating battery performance in electric vehicles.

11. Explain the case study involving an electro motorcycle and its hybrid energy storage system (HESS).

12. Explain the recent advancements in energy storage technologies for electric vehicles?

**Syllabus**

**Module 1**

Introduction-Basic Components of Energy Storage Systems, Types of Energy Storage Systems-Chemical Energy Storage Systems, Mechanical Energy Storage Systems, Electromagnetic Energy Storage Systems, Electrostatic Energy Storage Systems, Electrochemical Energy Storage Systems, Thermal Energy Storage Systems, Terminology used in ESS, Application of ESS, Comparative Analysis of Cost and Technical Parameters of ESS, Analysis of Energy Storage Systems.

**Module 2**

Fuel Cells-Operating principle of Fuel Cell, Fuel cell system characteristics, Fuel cell Technologies, Fuel Supply, Non Hydrogen Fuel cells, Fuel cell Hybrid electric drive train design-Configuration, Power Design of fuel system

Battery technologies for Electric Vehicles-Introduction, Electrochemical energy storage, Challenges in electric and hybrid electric vehicles, eVaro electric sports car,



Battery Chemistry, Battery glossary, Battery charging methods, Battery management system, Battery state of charge estimation

**Module 3**

Introduction, Energy Storage Systems for Electric Vehicle, Types of Electric Vehicles- Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug in Hybrid Electric Vehicle (PHEV), Review of Energy Storage systems for Electric Vehicle Applications- Key Attributes of Battery Technologies, Widely Used Battery Technologies, Alternate Energy Storage Solutions, Electric Vehicle Charging Schemes, Issues and Challenges of ESS in EV Applications, Recent Advancements in the Storage Technologies of EVs, Factors, Challenges and Problems in Sustainable Electric Vehicle.

**Module 4**

Fundamentals of Supercapacitor- Structure and Working Principle, Classification of Supercapacitor, Energy storage mechanisms in Semiconductors

Smart Supercapacitors: Transport Supercapacitors, Supercapacitors in transport, Vehicle applications of Supercapacitor, Electric cars

Potential impact of smart hybrid supercapacitor in electric vehicles: Introduction to smart and hybrid supercapacitors, Working mechanism and characteristics of smart supercapacitors, Applications of smart hybrid supercapacitors

**Module 5**

Hybrid Energy Storage Systems in Electric Vehicle Applications: Review of energy sources- Electrostatic technologies, Electrical double layer capacitors, Electrochemical technologies,

Hybrid energy storage systems (HESS)- passive HESS, semi-active HESS, full-active HESS

Case study: electro motorcycle - Aging, thermal, and electric model for the battery, Motorcycle description, battery current profile with and without HESS, Aging estimation

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| | Module -1 | |
| 1.1 | Introduction-Basic Components of Energy Storage Systems, , Types of Energy Storage Systems-Chemical Energy Storage Systems, Mechanical Energy Storage Systems | 2 |
| 1.2 | Electromagnetic Energy Storage Systems, Electrostatic Energy Storage Systems, Electrochemical Energy Storage Systems, Thermal Energy Storage Systems | 3 |
| 1.3 | Terminology used in ESS, Application of ESS, Comparative Analysis of Cost and Technical Parameters of ESS, Analysis of Energy Storage Systems | 2 |



| | | |
|---|---|---|
| | Module 2 | |
| 2.1 | Fuel Cells-Operating principle of Fuel Cell, Fuel cell system characteristics, Fuel cell Technologies, Fuel Supply, Non Hydrogen Fuel cells, Fuel cell Hybrid electric drive train design-Configuration, Power Design of fuel system | 3 |
| 2.2 | Battery technologies for Electric Vehicles-Introduction, Electrochemical energy storage, Challenges in electric and hybrid electric vehicles, eVaro electric sports car | 3 |
| 2.3 | Battery Chemistry, Battery glossary, Battery charging methods, Battery management system, Battery state of charge estimation | 3 |
| 3 | Module3 | |
| 3.1 | Introduction, Energy Storage Systems for Electric Vehicle, Types of Electric Vehicles-Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug in Hybrid Electric Vehicle (PHEV) | 3 |
| 3.2 | Widely Used Battery Technologies, Alternate Energy Storage Solutions, Electric Vehicle Charging Schemes, Issues and Challenges of ESS in EV Applications | 3 |
| 3.3 | Recent Advancements in the Storage Technologies of EVs, Factors, Challenges and Problems in Sustainable Electric Vehicle | 2 |
| 4 | Module 4 | |
| 4.1 | Fundamentals of Supercapacitor- Stucture and Working Principle, Classification of Supercapacitor, Energy storage mechanisms in Semiconductors | 3 |
| 4.2 | Smart Supercapacitors: Transport Supercapacitors, Supercapacitors in transport, Vehicle applications of Supercapacitor, Electric cars | 2 |
| 4.3 | Potential impact of smart hybrid supercapacitor in electric vehicles: Introduction to smart and hybrid supercapacitors, Working mechanism and characteristics of smart supercapacitors, Applications of smart hybrid supercapacitors | 3 |
| | Module 5 | |
| 5.1 | Hybrid Energy Storage Systems in Electric Vehicle Applications: Review of energy sources- Electrostatic technologies, Electrical double layer capacitors, Electrochemical technologies, | 3 |
| 5.2 | Hybrid energy storage systems (HESS)- passive HESS, semi-active HESS, full-active HESS | 2 |
| 5.3 | Case study: electro motorcycle - Aging, thermal, and electric model for the battery, Motorcycle description, battery current profile with and without HESS, Aging estimation | 3 |



**Reference Books**


1. Sandeep Dhundhara, Yajvender Pal Verma “Energy Storage for Modern Power system Operation” Wiley,2021
2. Mehrdad Ehsani,Yimin Gao,Ali Emadi,”Modern Electric ,Hybrid Electric and Fuel cell Vehicles: Fundamentals,Theory and Design” Second Edition, CRC Press, Taylor and Francis Group, 2017
3. Tariq Muneer and Irene Illescas García, “The automobile, In Electric Vehicles: Prospects and Challenges”, Elsevier, 2017
4. Chaudhery Mustansar Hussain, M. Basheer Ahamed “Smart Supercapacitor Fundamentals, Structures, and applications” Elsevier, 2023
5. Nicolae Tudoroiu, Electric Vehicles - Design, Modelling and Simulation, DOI10.5772/intechopen.111090, IntechOpen, 2023




| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC083 | CONNECTED VEHICLES | Program Elective 2 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to make the students analyse and explore the various aspects of connected vehicles which include the communication standards, applications and future challenges faced in vehicular communication.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse the technologies used for connectivity in vehicles. |
| **CO 2** | Understand the concepts of vehicle to infrastructure communication |
| **CO 3** | Analyse basic principles of Intelligent Transportation Systems. |
| **CO 4** | Understand the concepts of various standards used in vehicular communication |
| **CO 5** | Apply the concept of VANET to vehicular communication. |
| **CO 6** | Evaluate the performance on VANET based vehicular communication. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | | 2 | | | | |
| **CO 2** | | | | 3 | 2 | | |
| **CO 3** | | | 3 | 2 | | | |
| **CO 4** | | | 2 | 3 | | | |
| **CO 5** | 2 | | | | 3 | | |
| **CO 6** | 2 | | | | | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIRST SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC083**

**Course Name: Connected Vehicles**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1. Compare the different technologies used in vehicle to vehicle communication.
2. List the technologies used to implement V2I communication and which among them is the best.
3. Write short note on current ITS communication systems and services.
4. With a diagram explain the DSRC protocol stack.
5. Explain any one application of VANET in V2V communication.



**PART B**

***Answer any 5 full question, each question carries 7 marks.***

6. Explain the basic operation of the GPS positioning system used in V2X communication.
7. Explain the concept of RLVW system using a diagram.
8. Explain the architecture of the ROF system with a diagram.
9. Explain the system architecture of a typical DSRC based V2V on-board system.
10. Analyse the main blocks of a VANET transmitter with a neat labelled diagram.
11. a. With the help of a block diagram explain each functional block of a DSRC system.

    b. Explain the GPS architecture.

12. a. List any four applications of V2I communication.

    b. Explain the concept of CSW warning.

**Syllabus**

**Module 1:** Connectivity fundamentals, ECU(Electronic Control Unit), Navigation-Principles of GPS- trilateration and Triangulation concepts- GPS architecture,V2V communication- Introduction-Technology-V2V On-Board unit(OBU)-Applications.

**Module 2:** Vehicle to Infrastructure(V2I) Communication-overview, V2I applications-Red light violation warning (RLVW), Curve speed warning (CSW), Railroad crossing violation warning (RCVW), Stop Sign Gap Assist (SSGA), Vehicle to Roadside communication- overview, configuration.

**Module 3:** Introduction to vehicular communication- Evolution, vehicular networks, Intelligent Transportation systems (ITS)- Overview, multimedia communication in a car, ITS-data bus, current ITS Communication Systems and services, Visible light communication (VLC)- radio On Fiber (ROF) communication systems -basic configuration.

**Module 4:** Vehicular communication standards- Dedicated Short range Communication (DSRC) protocol stack, DSRC architecture , IEEE 802.11p- Medium Access control and physical layer specifications for wireless access in vehicular environment (WAVE), IEEE1609.0, IEEE1609.2, IEEE1609.3, IEEE1609.4, IEEE1609.12, 6G, Cellular networks and connected autonomous vehicles.

**Module 5**: Introduction to Vehicular ad-hoc network (VANET), Applications of VANET- Vehicle-to- Infrastructure-Intersection violation warning, V2V – Electronic brake warning, On-coming traffic warning, Vehicle stability warning, Lane change warning. Pedestrian-to-vehicle applications -Pedestrian in roadway warning , Data dissemination in VANET. OFDM modulation technique, VANET transmitter, VANET Receiver.



**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Connectivity fundamentals** | |
| 1.1 | Introduction to vehicular connectivity | 1 |
| 1.2 | ECU(Electronic Control Unit) | 1 |
| 1.3 | Navigation- Principles of GPS- trilateration and Triangulation concepts | 2 |
| 1.4 | GPS architecture, | 1 |
| 1.5 | V2V communication- Introduction-Technology | 2 |
| 1.6 | V2V On-Board unit(OBU)-Applications. | 1 |
| **2** | **Vehicle to Infrastructure(V2I) Communication** | |
| 2.1 | Overview | 1 |
| 2.2 | V2I applications- Red light violation warning (RLVW), | 1 |
| 2.3 | Curve speed warning (CSW), | 1 |
| 2.4 | Railroad crossing violation warning (RCVW) | 1 |
| 2.5 | Stop Sign Gap Assist (SSGA), | 1 |
| 2.6 | Vehicle to Roadside communication- overview | 1 |
| 2.7 | configuration | 1 |
| **3** | **Intelligent Transportation systems (ITS)** | |
| 3.1 | Introduction to vehicular communication- Evolution | 1 |
| 3.2 | vehicular networks | 1 |
| 3.3 | Intelligent Transportation systems (ITS)- Overview | 1 |
| 3.4 | multimedia communication in a car | 1 |
| 3.5 | ITS-data bus, current ITS Communication Systems and services, | 2 |
| 3.6 | Visible light communication (VLC)- radio On Fiber (ROF) communication systems | 2 |
| 3.7 | basic configuration | 1 |
| **4** | **Vehicular communication standards** | |
| 4.1 | Dedicated Short range Communication (DSRC) protocol stack | 1 |
| 4.2 | DSRC architecture | 1 |
| 4.3 | IEEE 802.11p- Medium Access control and physical layer specifications for wireless access in vehicular environment (WAVE) | 2 |
| 4.4 | IEEE1609.0, IEEE1609.2, IEEE1609.3, IEEE1609.4, IEEE1609.12, | 1 |
| 4.5 | 6G | 1 |
| 4.6 | Cellular networks and connected autonomous vehicles. | 1 |
| **5** | **Vehicular ad-hoc network (VANET)** | |
| 5.1 | Introduction | 1 |
| 5.2 | Applications of VANET- Vehicle-to- Infrastructure- Intersection violation warning, | 1 |



| | | |
|---|---|---|
| 5.3 | V2V – Electronic brake warning, Data dissemination in VANET. | 1 |
| 5.4 | On-coming traffic warning, Vehicle stability warning, | 1 |
| 5.5 | Lane change warning. | 1 |
| 5.6 | Pedestrian-to-vehicle applications -Pedestrian in roadway warning | 1 |
| 5.7 | Data dissemination in VANET | 1 |
| 5.8 | OFDM modulation technique, VANET transmitter, VANET Receiver. | 2 |

**Reference Books**


1. Intelligent Vehicle Technologies Theory and Appications– L Vlacic, MParent,F Harashima - Butterworth Heinemann, 2015.
2. Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, Vehicular ad hoc Networks: Standards, Solutions, and Research, Springer, 2015.
3. Radovan Miucic, Connected Vehicles Intelligent Transportation Systems, Springer, 2019.
4. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.
5. VANET: Vehicular Applications and Inter-Networking Technologies- Hannes Hartenstein Karlsruhe Institute of Technology (KIT), Germany Kenneth P Laberteaux Toyota Technical Center, USA , A John Wiley and Sons, Ltd, Publication.




| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221EEC084 | SYSTEMS ENGINEERING | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3 |

**Preamble:** The purpose of this course is to expose students to the basic knowledge of designing and managing complex systems by integrating components and ensuring they function effectively together to meet specified requirements.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Understand the foundational principles of systems engineering, encompassing system lifecycle, requirements engineering, modelling, and integration |
| **CO 2** | Apply systems thinking methodologies to analyze complex engineering problems and propose effective solutions |
| **CO 3** | Design resilient system architectures considering factors such as reliability, scalability, and adaptability |
| **CO 4** | Design integration strategies ensuring seamless interoperability within complex engineering systems |
| **CO 5** | Evaluate system performance quantitatively and optimize systems for efficiency, reliability, and maintainability |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO 2** | | 2 | 3 | 3 | 3 | 2 | 2 |
| **CO 3** | 1 | | 3 | 3 | 3 | 2 | 2 |
| **CO 4** | 1 | 1 | 2 | 2 | 2 | 2 | |
| **CO 5** | 1 | 2 | 3 | 3 | 3 | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 20 |
| Analyse | 20 |
| Evaluate | 20 |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publication shall be referred): 15 marks

Course based task/ Seminar/Data collection & interpretation: 15 marks

Test paper, 1 number: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**THIRD SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 221EEC084**

**Course Name: Systems Engineering**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Explain the concept of system boundaries in the context of an autonomous vehicle's electronic systems. How would you define and manage these boundaries to ensure effective system integration and functionality?

2 What are the main types of system requirements, and why is it important to differentiate between them?

3 Describe the role of Model-Based Systems Engineering (MBSE) in system architecture representation.

4 What is the difference between verification and validation in the context of systems testing?

5 Evaluate the ethical considerations involved in the design and deployment of autonomous vehicles, especially focusing on electronic and communication systems. How would you address potential ethical dilemmas in decision-making and ensure compliance with ethical standards?

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Consider a complex transportation system designed to integrate autonomous vehicles, public transport, and pedestrian pathways. Identify potential emergent properties and discuss how systems thinking can help in managing these properties during the design phase. How would you delineate system boundaries to effectively manage interactions among subsystems?

7 You are tasked with developing a vehicle-to-everything (V2X) communication system for an autonomous vehicle. Describe your approach to requirements elicitation and documentation. How would you handle conflicting requirements from different stakeholders, such as manufacturers, regulators, and end-users? Provide a detailed plan for maintaining requirement traceability throughout the project lifecycle.

8 Imagine you are designing the electronic control unit (ECU) architecture for an electric vehicle. What architectural patterns would you consider, and why? Discuss the trade-offs involved in your design choices. Additionally, outline how Model-Based Systems Engineering (MBSE) would assist you in integrating different system components, such as powertrain, battery management, and infotainment systems.

9 You are integrating multiple subsystems in an electric vehicle, including battery management, autonomous driving, and infotainment systems. What integration strategies would you adopt to ensure smooth interoperability among these subsystems? Discuss the potential challenges you might face during integration and how you would address them. Provide a plan for system testing, including both automated and manual testing approaches.

10 With the increasing integration of electronics and communication systems in vehicles, identify and analyze the key challenges and opportunities presented by cyber-physical systems in the automotive industry. How would you address security and privacy concerns in connected vehicles? Discuss a



holistic approach to managing complexity in large-scale automotive systems, using examples from current technologies.

11 Consider a scenario where new regulatory requirements for vehicle communication systems are introduced midway through the development of a connected car. Describe the process you would follow to analyze the impact of this change on the system requirements, architecture, design, and testing phases. How would you ensure that the system remains compliant without significantly disrupting the project timeline and budget?

12 In a team-based project to develop a smart infotainment system for vehicles, you encounter a critical design flaw during the testing phase. Outline the steps you would take to diagnose and rectify the issue. Discuss how systems thinking, effective stakeholder management, and rigorous requirements traceability could help in preventing such issues in future projects. How would you communicate the resolution process to both technical and non-technical stakeholders?

**Syllabus**

**Module 1: Foundations of Systems Engineering**

Introduction to Systems Engineering-Understanding the principles and scope of systems engineering; Key concepts: systems thinking, system boundaries, and emergent properties. Systems Engineering Life Cycle- Overview of the stages in the systems engineering life cycle; Requirements analysis, system architecture, design, implementation, testing, and maintenance. Systems Modeling and Simulation-Introduction to modeling techniques (e.g., SysML, UML);Simulation methods for analyzing and validating system behavior. Systems Thinking Tools-Application of tools such as system dynamics and causal loop diagrams; System decomposition and abstraction techniques. Case Studies-Real-world examples from automotive industry demonstrating the application of systems engineering principles; Analysis of successful and unsuccessful system implementations.

**Module 2: System Requirements Engineering**

Understanding Requirements - Types of requirements: functional, non-functional, and constraints; Requirements elicitation, analysis, and documentation. Stakeholder Management- Identifying and prioritizing stakeholders; Managing conflicting requirements and expectations. Requirement Traceability-Establishing and maintaining traceability between requirements and system components; Impact analysis of requirement changes. Validation and Verification of Requirements-Techniques for validating and verifying system requirements; Importance of clear, complete, and unambiguous requirements. Case Studies and Practical Exercises-Hands-on exercises on requirements gathering, documentation, and traceability; Analysis of real-world projects with emphasis on requirements engineering.

**Module 3: System Architecture and Design**

System Architecture Principles-Principles of designing effective and scalable system architectures; Architectural patterns and trade-offs. Model-Based Systems



Engineering (MBSE)-Utilizing modeling languages for system architecture representation; Integration of models for seamless communication in the design process. Design Optimization and Decision Making-Techniques for optimization in system design; Decision-making methodologies for selecting design alternatives. Interface Management- Strategies for managing interfaces between system components; Standardization and compatibility considerations. Case Studies and Design Projects-Analysis and critique of system architectures in existing products; Team-based design projects applying MBSE principles.

**Module 4: Systems Integration and Testing**

Integration Strategies-Approaches to integrating subsystems into a complete system; Challenges and considerations in integration. System Testing Techniques-Types of testing: unit testing, integration testing, system testing; Test planning, execution, and documentation. Verification and Validation-Ensuring that the system meets specified requirements; Validation of system functionality against user needs. Continuous Integration and Continuous Testing-Principles and practices of continuous integration; Automated testing in continuous integration pipelines. Case Studies and Practical Exercises-Analysis of integration and testing issues in well-known projects; Hands-on testing exercises and simulations.

**Module 5: Advanced Topics and Future Trends in Systems Engineering**

Systems Thinking in Complex Systems-Systems engineering in the context of complex and large-scale systems; Holistic approaches to managing complexity. Systems Engineering for Cyber-Physical Systems-Integration of physical and computational components; Challenges and opportunities in cyber-physical systems. Ethical Considerations in Systems Engineering-Ethical dilemmas in decision-making and design; Case studies on ethical issues in systems engineering. Emerging Trends and Future Challenges-Exploration of cutting-edge technologies impacting systems engineering; Anticipating challenges and opportunities in the future. Project-Collaborative project work applying systems engineering principles to solve a real-world problem; Integration of knowledge acquired throughout the semester.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Foundations of Systems Engineering** | |
| 1.1 | Introduction to Systems Engineering-Understanding the principles and scope of systems engineering; Key concepts: systems thinking, system boundaries, and emergent properties. | 2 |
| 1.2 | Systems Engineering Life Cycle- Overview of the stages in the systems engineering life cycle; Requirements analysis, system architecture, design, implementation, testing, and maintenance. | 2 |



| | | |
|---|---|---|
| 1.3 | Systems Modeling and Simulation-Introduction to modeling techniques (e.g., SysML, UML);Simulation methods for analyzing and validating system behavior. | 2 |
| 1.4 | Systems Thinking Tools-Application of tools such as system dynamics and causal loop diagrams; System decomposition and abstraction techniques. | 2 |
| 2 | **System Requirements Engineering** | |
| 2.1 | Understanding Requirements - Types of requirements: functional, non-functional, and constraints; Requirements elicitation, analysis, and documentation | 1 |
| 2.2 | Stakeholder Management- Identifying and prioritizing stakeholders; Managing conflicting requirements and expectations. Requirement Traceability-Establishing and maintaining traceability between requirements and system components; Impact analysis of requirement changes. | 2 |
| 2.3 | Validation and Verification of Requirements- Techniques for validating and verifying system requirements; Importance of clear, complete, and unambiguous requirements. | 2 |
| 2.4 | Case Studies and Practical Exercises- Hands-on exercises on requirements gathering, documentation, and traceability; Analysis of real-world projects with emphasis on requirements engineering. | 2 |
| 3 | **System Architecture and Design** | |
| 3.1 | System Architecture Principles-Principles of designing effective and scalable system architectures; Architectural patterns and trade-offs. | 2 |
| 3.2 | Model-Based Systems Engineering (MBSE)-Utilizing modeling languages for system architecture representation; Integration of models for seamless communication in the design process. | 2 |
| 3.3 | Design Optimization and Decision Making-Techniques for optimization in system design; Decision-making methodologies for selecting design alternatives. | 2 |
| 3.4 | Interface Management- Strategies for managing interfaces between system components; Standardization and compatibility considerations | 1 |
| 3.5 | Case Studies and Design Projects-Analysis and critique of system architectures in existing products; Team-based design projects applying MBSE principles. | 1 |
| 4 | **Systems Integration and Testing** | |
| 4.1 | Integration Strategies-Approaches to integrating subsystems into a complete system; Challenges and considerations in integration. | 2 |



| | | |
|---|---|---|
| 4.2 | System Testing Techniques-Types of testing: unit testing, integration testing, system testing; Test planning, execution, and documentation.<br>Verification and Validation-Ensuring that the system meets specified requirements; Validation of system functionality against user needs. | 3 |
| 4.3 | Continuous Integration and Continuous Testing-Principles and practices of continuous integration; Automated testing in continuous integration pipelines. | 2 |
| 4.4 | Case Studies and Practical Exercises-Analysis of integration and testing issues in well-known projects; Hands-on testing exercises and simulations. | 1 |
| 5 | **Advanced Topics and Future Trends in Systems Engineering** | |
| 5.1 | Systems Thinking in Complex Systems-Systems engineering in the context of complex and large-scale systems; Holistic approaches to managing complexity. | 2 |
| 5.2 | Systems Engineering for Cyber-Physical Systems-Integration of physical and computational components; Challenges and opportunities in cyber-physical systems. | 2 |
| 5.3 | Ethical Considerations in Systems Engineering-Ethical dilemmas in decision-making and design; Case studies on ethical issues in systems engineering. | 1 |
| 5.4 | Emerging Trends and Future Challenges-Exploration of cutting-edge technologies impacting systems engineering; Anticipating challenges and opportunities in the future. | 2 |
| 5.5 | Project-Collaborative project work applying systems engineering principles to solve a real-world problem; Integration of knowledge acquired throughout the semester. | 2 |

**Reference Books**


1. Systems Engineering Principles and Practice, Alexander Kossiakoff, Steven M Biemer, Samuel J Seymour, David A Flanigan, Wiley-Blackwell, 3rd Edition, July 2020
2. INCOSE Systems Engineering Handbook, V3.2.
3. Blanchard, B. S., and Fabrycky, W. J., Systems Engineering and Analysis, 5th editon, Prentice Hall, 2010.
4. Introduction to Systems Engineering, Sage PAndrew, Wiley-Interscience (2000)
5. SysML Distilled-A Brief Guide to the Systems Modeling Language, Lenny Delligatti Pearson Education. 2013.




| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 221RGE100 | RESEARCH METHODOLOGY & IPR | General Course | 2 | 0 | 0 | 2 |

**Preamble:** This course introduces the strategies and methods related to scientific research. The students are also trained in the oral presentation with visual aids and writing technical thesis/reports/research papers. The salient aspects of publication and patenting along with the crucial role of ethics in research is discussed.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Approach research projects with enthusiasm and creativity. |
| **CO 2** | Conduct literature survey and define research problem |
| **CO 3** | Adopt suitable methodologies for solution of the problem |
| **CO 4** | Deliver well-structured technical presentations and write technical reports. |
| **CO 5** | Publish/Patent research outcome. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| CO 1 | ✓ | ✓ | | | | ✓ | |
| CO 2 | ✓ | ✓ | | | | ✓ | |
| CO 3 | ✓ | ✓ | | | | ✓ | |
| CO 4 | ✓ | ✓ | | | | ✓ | |
| CO 5 | ✓ | ✓ | | | | ✓ | |
| CO 6 | ✓ | ✓ | | | | ✓ | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 70 % |
| Analyse | 30 % |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Course based task: 15 marks

Some sample course based tasks that can be performed by the student given below.

- Conduct a group discussion based on the good practices in research.
- Conduct literature survey on a suitable research topic and prepare a report based on this.

Seminar: 15 marks

Test paper: 10 marks

**End Semester Examination Pattern:**

Total Marks: 60

The examination will be conducted by the respective college with the question provided by the University. The examination will be for 150 minutes and contain two parts; Part A and Part B. Part A will contain 6 short answer questions with 1 question each from modules 1 to 4, and 2 questions from module 5. Each question carries 5 marks. Part B will contain only 1 question based on a research article from the respective discipline and carries 30 marks. The students are to answer the questions based on that research article.



**Model Question paper**

| | | |
|---|---|---|
| **QP Code:** | | **Total Pages:** |
| **Reg No.: _____** | | **Name: _____** |

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIRST SEMESTER M. TECH DEGREE EXAMINATION, Month & Year**

**Course Code: 221RGE100**

**Course Name: RESEARCH METHODOLOGY & IPR**

| | | |
|---|---|---|
| **Max. Marks: 60** | | **Duration: 2.5 Hours** |

**PART A**

| | | ***Answer all questions. Each question carries 5 marks*** | **Marks** |
|---|---|---|---|
| **1** | | Discuss the salient recommendations for great research recommended by Richard Hamming in his famous talk "You and Your Research" | **30** |
| **2** | | What are the characteristics of a good research question? Discuss with an example. | |
| **3** | | Explain the difference between continuum, meso-scale and micro scale approaches for numerical simulation. | |
| **4** | | Discuss any four rules of scientific writing. | |
| **5** | | What are the requirements for patentability? | |
| **6** | | What are the differences between copyright and trademark protection? | |
| | | Read the given research paper and write a report that addresses the following issues **(The paper given can be specific to the discipline concerned**) | |
| **7** | | What is the main research problem addressed? | **3** |
| **8** | | Identify the type of research | **3** |
| **9** | | Discuss the short comings in literature review if any? | **6** |
| **10** | | Discuss appropriateness of the methodology used for the study | **6** |
| **11** | | Discuss the significance of the study and summarize the important results and contributions by the authors | **6** |
| **12** | | Identify limitations of the article if any. | **6** |

**Syllabus and Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction** | |
| 1.1 | Meaning and significance of research, Skills, habits and attitudes for research, Types of research, | 1 |
| 1.2 | Characteristics of good research, Research process | 1 |
| 1.3 | Motivation for research: Motivational talks on research: "You and Your Research"- Richard Hamming | 1 |
| 1.4 | Thinking skills: Levels and styles of thinking, common-sense and scientific thinking, examples, logical thinking, division into sub-problems, verbalization and awareness of scale. | 1 |
| 1.5 | Creativity: Some definitions, illustrations from day to day life, intelligence versus creativity, creative process, requirements for creativity | 1 |
| 2 | **Literature survey and Problem definition** | |
| 2.1 | Information gathering – reading, searching and documentation, types of literature. | 1 |
| 2.2 | Integration of research literature and identification of research gaps | 1 |
| 2.3 | Attributes and sources of research problems, problem formulation, Research question, multiple approaches to a problem | 1 |
| 2.4 | Problem solving strategies – reformulation or rephrasing, techniques of representation, Importance of graphical representation, examples. | 1 |
| 2.5 | Analytical and analogical reasoning, examples, Creative problem solving using Triz, Prescriptions for developing creativity and problem solving. | 1 |
| 3 | **Experimental and modelling skills** | |
| 3.1 | Scientific method, role of hypothesis in experiment, units and dimensions, dependent and independent variables, control in experiment | 1 |
| 3.2 | precision and accuracy, need for precision, definition, detection, estimation and reduction of random errors, statistical treatment of data, definition, detection and elimination of systematic errors, | 1 |
| 3.3 | Design of experiments, experimental logic, documentation | 1 |



| | | |
|---|---|---|
| 3.4 | Types of models, stages in modelling, curve fitting, the role of approximations, problem representation, logical reasoning, mathematical skills. | 1 |
| 3.5 | Continuum/meso/micro scale approaches for numerical simulation, Two case studies illustrating experimental and modelling skills. | 1 |
| 4 | **Effective communication - oral and written** | |
| 4.1 | Examples illustrating the importance of effective communication, stages and dimensions of a communication process. | 1 |
| 4.2 | Oral communication –verbal and non-verbal, casual, formal and informal communication, interactive communication, listening, form, content and delivery, various contexts for speaking- conference, seminar etc. | 1 |
| 4.3 | Guidelines for preparation of good presentation slides. | 1 |
| 4.4 | Written communication – Rules of scientific writing, form, content and language, layout, typography and illustrations, nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX. | 1 |
| 4.5 | Common errors in typing and documentation | 1 |
| 5 | **Publication and Patents** | |
| 5.1 | Relative importance of various forms of publication, Choice of journal and reviewing process, Stages in the realization of a paper. | 1 |
| 5.2 | Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics | 1 |
| 5.3 | Introduction to IPR, Concepts of IPR, Types of IPR | 1 |
| 5.4 | Common rules of IPR practices, Types and Features of IPR Agreement, Trademark | 1 |
| 5.5 | Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures | 2 |

**Reference Books**


1. E. M. Phillips and D. S. Pugh, "How to get a PhD - a handbook for PhD students and their supervisors", Viva books Pvt Ltd.
2. G. L. Squires, "Practical physics", Cambridge University Press
3. Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, Handbook of Science Communication, Overseas Press India Pvt Ltd, New Delhi, 1st edition 2005
4. C. R. Kothari, Research Methodology, New Age International, 2004
5. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.




6. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
7. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
8. William Strunk Jr., Elements of Style, Fingerprint Publishing, 2020
9. Peter Medawar, 'Advice to Young Scientist', Alfred P. Sloan Foundation Series, 1979.
10. E. O. Wilson, Letters to a Young Scientist, Liveright, 2014.
11. R. Hamming, You and Your Research, 1986 Talk at Bell Labs.



# SEMESTER II

**Discipline: ELECTRONICS AND COMMUNICATION**

**Stream : ECx (Automotive Electronics)**

(with Industry collaboration – Tata Elxsi)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222TEC101 | AUTOMOTIVE NETWORKING | DISCIPLINE CORE 2 | 3 | 0 | 0 | 3 |

**Preamble:** The course is intended to impart comprehensive knowledge in the domain of automotive networking.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Ability to understand concepts of networking and protocols in automotive system |
| **CO 2** | Ability to understand technologies, standards and system architecture of CAN |
| **CO 3** | Design, simulate, emulate and analyze MOST based automotive networks |
| **CO 4** | Ability to understand the concept of automotive Ethernet |
| **CO 5** | Analyze LIN and vehicular networks |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 1 | 2 | |
| **CO 2** | 3 | 3 | 3 | 3 | 2 | 2 | |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 2 | 1 |
| **CO 4** | 3 | 3 | 3 | 3 | 2 | 2 | |
| **CO 5** | 3 | 3 | 3 | 3 | 1 | 2 | 1 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 10 |
| Analyse | 40 |
| Evaluate | 20 |
| Create | 30 |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40**

Micro project/Course based project: 20 marks

Course based task/Seminar/ Quiz: 10 marks

Test paper, 1 with10 marks. The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus

**End Semester Examination Pattern: 60**

The end semester examination will be conducted by the University.

There will be two parts; Part A and Part B.

Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222TEC101**

**Course Name: Automotive Networking**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1. Distinguish between synchronous and asynchronous transmission.
2. Write the physical layer specifications of IEEE 802.16 Wi-Max technology.
3. List out the features of TTCAN.
4. What is Power over Ethernet?



5. Draw and explain the LIN frame format

**PART B**

***Answer any 5 full question, each question carries 7 marks.***

6. Describe the need for multiplexed electrical systems.

7. Briefly explain the different elements to be considered while considering an existing backhaul network to support a millimeter wave network.

8. Briefly explain the existing IEEE 802.11x communication protocols for automotive applications.

9. Evaluate the performance of error detection and management schemes used in CAN protocol.

10. With the aid of switching diagram justify the need for packer switching in address based networking.

11. Draw and explain the frame format of MOST protocol.

12. Infer the role of MobiMESH and GLS in VANET.

**Syllabus**

**Module 1: Review of communication Networks**

Need and Types of networks, Need for standards, Review of OSI model and TCP/IP protocol stack, Network Topologies, Error detection and correction mechanisms, Encoding schemes, Serial/parallel transmission, Bit rate, Baud rate and bandwidth, Synchronous and asynchronous transmission, Introduction of IVN, Classes of IVN protocols, Multiplexed electrical systems, Vehicle multiplexing, Bitwise contention, Network elasticity, Use cases of Error processing and management.

**Module 2: Networking Protocols**

Overview of automotive communication protocols, CAN, LIN, Flex Ray, MOST, Ethernet, D2B and DSI, Communication interface with ECUs, Interfacing techniques and Interfacing with infotainment gadgets, IEEE 802.11x communication protocols for automotive applications.
IEEE 802.11 (Wi-Fi) standards and applications, HiperLAN technology, WPAN and WMAN, Space time wireless standards, IEEE 802.16 (Wi-Max standard), 3GPP-LTE standard, Millimeter wave characteristics, Channel performance at 60 GHz, Development of millimeter wave standards, Indoor and outdoor applications for millimeter wave communications, Coexistence of millimeter with wireless backhaul.



**Module 3: Controller Area Network (CAN) Protocol**

History and foundation of CAN, Main characteristics of CAN, CAN in OSI Model, CAN Data Link Layer, Principles of data exchange in CAN, Arbitration, Data Frame, Remote Frame, Error detection and management in CAN, CAN physical Layer, Bit encoding, Bit timing and synchronization, Relationship between data rate and bus length, Single wire and twin wire media, CAN repeaters, Medium-to-medium gateway, Protocol handlers, Micro-controllers and line drivers, TimeTriggered CAN (TTCAN), Comparison with other IVN protocols, CANoe based applications development.

**Module 4: Automotive Ethernet and MOST Protocol**

Ethernet, Bandwidth, Full duplex, Packet switched address based networking, Power over Ethernet and Power over data lines. Automotive Ethernet performance issues and concepts.
Media Oriented System Transport (MOST) Protocol: Emerging in car systems, Introduction to MOST, MOST goals, Features, Cables and Connectors, Data Types, Topology, Frame Format, Application Areas, System Description, Specification, Device Model, Device Implementation, Diagnostics and Case Study.

**Module 5: LIN and Intelligent Transport Vehicular Networks: Applications, Protocols and Testbeds**

Local Interconnect Network (LIN) Protocol: Introduction to LIN, LIN consortium, LIN specification, LIN features, Technical overview, Work flow concept, LIN operation, LIN frame format, Scheduling table, Network management of LIN cluster, LIN Transport Layer, LIN node configuration. Introduction to Vehicular networks, VANET vs MANET, MobiMESH architecture and GLS, Vehicular testbeds, C-VeT architecture and ORBIT.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Review of communication Networks** | |
| 1.1 | Review of OSI model and TCP/IP protocol stack, Network Topologies | 2 |
| 1.2 | Error detection and correction mechanisms, Encoding schemes, Serial/parallel transmission, Bit rate, Baud rate and bandwidth | 2 |
| 1.3 | Introduction of IVN, Classes of IVN protocols, Multiplexed electrical systems, Vehicle multiplexing, Bitwise contention | 2 |
| 1.4 | Network elasticity, Use cases of Error processing and management. | 2 |
| 2 | **Networking Protocols** | |



| | | |
|---|---|---|
| 2.1 | CAN, LIN, Flex Ray, MOST, Ethernet, D2B and DSI, Communication interface with ECUs, Interfacing techniques and Interfacing with infotainment gadgets, IEEE 802.11x communication protocols for automotive applications. | 3 |
| 2.2 | IEEE 802.11 (Wi-Fi) standards and applications, HiperLAN technology, WPAN and WMAN, Space time wireless standards, IEEE 802.16 (Wi-Max standard), 3GPP-LTE standard | 2 |
| 2.3 | Millimeter wave characteristics, Channel performance at 60 GHz, Development of millimeter wave standards, Indoor and outdoor applications for millimeter wave communications, Coexistence of millimeter with wireless backhaul. | 4 |
| 3 | **Controller Area Network (CAN) Protocol** | |
| 3.1 | CAN in OSI Model, CAN Data Link Layer, Principles of data exchange in CAN, Arbitration, Data Frame, Remote Frame, Error detection and management in CAN, CAN physical Layer | 2 |
| 3.2 | Bit encoding, Bit timing and synchronization | 1 |
| 3.3 | Single wire and twin wire media, CAN repeaters, Medium-to-medium gateway, Protocol handlers | 1 |
| 3.4 | Micro-controllers and line drivers, TimeTriggered CAN | 1 |
| 3.5 | Comparison with other IVN protocols, CANoe based applications development. | 2 |
| 4 | **Automotive Ethernet and MOST Protocol** | |
| 4.1 | Automotive Ethernet, Bandwidth, Duplexing, Packet switched address based networking | 1 |
| 4.2 | Power over Ethernet and Power over data lines. Automotive Ethernet performance issues and concepts | 2 |
| 4.3 | Media Oriented System Transport (MOST) Protocol: Emerging in car systems, Introduction to MOST, MOST goals and Features | 2 |
| 4.4 | Cables and Connectors, Data Types, Topology, Frame Format, Application Areas | 1 |
| 4.5 | System Description, Specification, Device Model, Device Implementation, Diagnostics and Case Study | 2 |
| 5 | **LIN and Intelligent Transport Vehicular Networks: Applications, Protocols and Testbeds** | |
| 5.1 | LIN protocol and consortium | 1 |
| 5.2 | LIN specification, features and frame format | 1 |
| 5.3 | Scheduling table, Network management of LIN cluster, LIN Transport Layer | 2 |
| 5.4 | Vehicular networks, VANET vs MANET | 1 |
| 5.5 | MobiMESH architecture and GLS | 1 |
| 5.6 | Vehicular testbeds, C-VeT architecture and ORBIT | 2 |



**Reference Books**


1. Behrouz Forouzan. Data Communications and Networking, McGraw-Hill. 2003
2. Gilbert Held. Inter- and Intra-Vehicle Communications, CRC Press, (2007).
3. Ronald k. Jurgen. Automotive Electronics Handbook, McGraw-Hill. 1999
4. K. C. Huang, Z. Wang. Millimeter Wave Communication systems, John Wiley &Sons.
5. Dipankar Raychaudhuri & Mario Gerla. Emerging Wireless Technologies and the Future Mobile Internet, CAMBRIDGE UNIVERSITY PRESS.
6. Charles M. Kozierok, Colt Correa, Robert B. Boatright & Jeffrey Quesnelle. Automotive Ethernet: The Definitive Guide, Intrepid Control Systems 2014.




| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222TEC102 | ADAS AND MACHINE LEARNING | PROGRAM CORE 3 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to impart comprehensive knowledge about the key enabling technologies in ADAS. Students will be able to learn the fundamental concepts and terminologies in ADAS, understand the different types of sensors, and communication protocols used in ADAS systems, and develop in-depth knowledge of machine learning and deep learning architectures for object detection and classification tasks in ADAS.

**Course Outcomes:** After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | To understand the fundamentals, concepts, and terminologies in ADAS. |
| **CO 2** | To analyze the functioning of the sensor systems and communication protocols as part of ADAS. |
| **CO 3** | To apply the knowledge of ADAS to create domain-specific applications. |
| **CO 4** | To apply the fundamentals of supervised, unsupervised, and reinforcement learning algorithms to evaluate different machine learning models for ADAS. |
| **CO 5** | To analyze and evaluate the performance of deep learning architectures for perception, classification, and object detection tasks. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | | 2 | | | |
| **CO 2** | 2 | 3 | | | 2 | | |
| **CO 3** | 3 | 2 | 3 | | 2 | 2 | 3 |
| **CO 4** | | | 3 | | 2 | 2 | 3 |
| **CO 5** | 3 | 3 | 3 | 2 | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 80% |
| Analyse | 20% |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

| | |
|---|---|
| Micro project/Course based project | : 20 marks |
| Course based task/Seminar/Quiz | : 10 marks |
| Test paper, 1 no. | : 10 marks |

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University.

There will be two parts; Part A and Part B.

Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions.

Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222TEC102**

**Course Name: ADAS and Machine Learning**

**PART A**

***Answer all questions. Each question carries 5 marks*** Marks

| | | |
|---|---|---|
| 1 | Compare Passive and Active ADAS systems. Provide examples of each type and explain their functionalities. | (5) |
| 2 | Explain the concept of Sensor Fusion in the context of ADAS. Discuss its importance and challenges. | (5) |
| 3 | Describe how the Forward Collision Avoidance system works. Discuss the key components involved and how they contribute to vehicle safety. | (5) |

| | | |
|---|---|---|
| 4 | Discuss the role of Reinforcement Learning in ADAS. Provide examples of reinforcement learning applications in autonomous driving scenarios and explain how they work. | (5) |
| 5 | Explain how Convolutional Neural Networks (CNNs) are used for image-based object detection in ADAS. Discuss the architecture and training process of a typical CNN model. | (5) |

**PART B**

***Answer any 5 questions. Each question carries 7 marks***

| | | |
|---|---|---|
| 6 | Compare and contrast different levels of vehicle autonomy. Discuss the features and requirements of each level, highlighting the challenges associated with achieving higher autonomy levels. | (7) |
| 7 | Elaborate on the working principle and applications of LiDAR technology in ADAS. Discuss its advantages and limitations compared to other sensing technologies. | (7) |
| 8 | Discuss the concept of Object Detection in ADAS using deep learning techniques. Explain the region proposal-based approach and the anchor-based approach for object detection, highlighting their respective advantages and limitations. | (7) |
| 9 | Describe the concept of Adaptive Cruise Control (ACC) and its potential benefits for traffic flow and efficiency. Discuss the challenges associated with implementing ACC in real-world driving environments. | (7) |
| 10 | Explain how Recurrent Neural Networks (RNNs) are applied to sequence modeling tasks in ADAS, such as predicting vehicle trajectories. Discuss the challenges associated with training RNNs for long sequences and propose solutions to mitigate these challenges. | (7) |
| 11 | Illustrate the role of the Kalman filter in sensor fusion for ADAS. Discuss how the Kalman filter combines measurements from multiple sensors to estimate the state of objects in the environment. | (7) |
| 12 | Suggest a machine-learning strategy to detect pedestrians in real-time driving scenarios | (7) |



## Syllabus

**Module 1**

Introduction to ADAS – Overview of ADAS, General block diagram, ADAS Technologies, Steps in ADAS Technologies, Information-based and manipulation-based ADAS systems, Active and Passive ADAS, ADAS vehicle architectures, Levels of ADAS, Advantages of ADAS, Cons of ADAS.

**Module 2**

Sensors and Communication Protocols for ADAS - Automotive Radar, Camera (Vision System), Ultrasonic Sensor, Lidar, GNSS, GPS, IMU, Sensor Data Fusion and Perception, Need for sensor data fusion, Levels of data fusion, Sensor fusion with Kalman Filter, Communication protocols: Ethernet, FPD-Link Technology, CAN Bus, PCIe technology.

**Module 3**

ADAS Applications - Adaptive Cruise Control, Adaptive Light Control, Blind Spot Detection, Lane Departure Warning, Lane Keeping Assistance, Automatic Emergency Braking, Driver Alert Systems (Driver drowsiness detection), Cross-traffic Alert, Hill Descent Control, Parking Assistance Systems, Night Vision, Surround View Camera, Forward Collision Avoidance.

**Module 4**

Machine Learning in ADAS – Basic Concepts of Machine Learning: supervised and unsupervised learning, reinforcement learning, Feature extraction using ML: Haar features, Histogram of Oriented Gradients, Local Binary Patterns, Dimensionality reduction: Principal Component Analysis, Classification: Support Vector Machine, Bayes Decision Rule, kNN classifier.

**Module 5**

Deep Learning for ADAS – Convolutional Neural Networks for visual tasks, Recurrent Neural Networks for sequential data processing, Need for data augmentation, Data augmentation techniques for images, Deep Learning for Object Detection: Region-based CNN, YOLO.

## Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to ADAS (8 hours)** | |
| 1.1 | Overview of ADAS, General block diagram of ADAS systems | 1 |
| 1.2 | ADAS Technologies and their classifications | 1 |
| 1.3 | Steps in ADAS Technologies development | 1 |
| 1.4 | Information-based and manipulation-based ADAS systems | 1 |
| 1.5 | Active and Passive ADAS systems | 1 |
| 1.6 | ADAS vehicle architectures | 1 |

| | | |
|---|---|---|
| 1.7 | Levels of ADAS automation | 1 |
| 1.8 | Advantages and disadvantages of ADAS | 1 |
| **2** | **Sensors and Communication Protocols for ADAS (8 hours)** | |
| 2.1 | Overview of Automotive Radar, Camera (Vision System) technology, Ultrasonic Sensors, Lidar technology and their applications in ADAS | 2 |
| 2.2 | GNSS and GPS for location-based services in ADAS | 1 |
| 2.3 | IMU (Inertial Measurement Unit) and its importance in ADAS | 1 |
| 2.4 | Sensor Data Fusion and Perception, Need for sensor data fusion, Levels of data fusion, Sensor fusion using Kalman Filter | 2 |
| 2.5 | Communication protocols: Ethernet, FPD-Link Technology, CAN Bus, PCIe technology | 2 |
| **3** | **ADAS Applications (8 hours)** | |
| 3.1 | Adaptive Cruise Control (ACC) and its working principle, Adaptive Light Control (ALC) and its benefits | 1 |
| 3.2 | Blind Spot Detection (BSD) and its importance in preventing accidents. | 1 |
| 3.3 | Lane Departure Warning (LDW) and Lane Keeping Assistance (LKA) | 1 |
| 3.4 | Driver Alert Systems (Driver drowsiness detection) | 1 |
| 3.5 | Parking Assistance Systems and their features, Cross-<br>traffic Alert and its significance in parking assistance | 1 |
| 3.6 | Hill Descent Control for off-road driving | 1 |
| 3.7 | Night Vision technology for enhanced visibility, Surround View Camera for better situational awareness | 1 |
| 3.8 | Forward Collision-Avoidance systems and their effectiveness, Automatic Emergency Braking (AEB) and its role in collision avoidance | 1 |
| **4** | **Machine Learning in ADAS (8 hours)** | |
| 4.1 | Basic Concepts of Machine Learning: supervised and unsupervised learning, reinforcement learning | 2 |
| 4.2 | Feature extraction using Machine Learning: Haar features, Histogram of Oriented Gradients, Local Binary Patterns | 2 |
| 4.3 | Dimensionality reduction techniques: Principal Component Analysis (PCA) | 2 |
| 4.4 | Classification algorithms: Support Vector Machine (SVM), Bayes Decision Rule, kNN classifier | 2 |
| **5** | **Deep Learning for ADAS (8 hours)** | |
| 5.1 | Convolutional Neural Networks (CNNs) for visual tasks in ADAS | 2 |
| 5.2 | Recurrent Neural Networks (RNNs) for sequential data processing in ADAS | 2 |

| | | |
|---|---|---|
| 5.3 | Need for data augmentation in Deep Learning, Data augmentation techniques for images | 2 |
| 5.4 | Deep Learning for Object Detection: Region-based CNN, YOLO (You Only Look Once) | 2 |

**Reference Books**


1. Kukkala, Vipin Kumar et al. (2018). Advanced Driver-Assistance Systems: A Path Toward Autonomous Vehicles. IEEE Consumer Electronics Magazine. 7. 18-25.

2. Li, Yan et al. Advanced Driver Assistance Systems and Autonomous Vehicles: From Fundamentals to Applications. Springer, 2022.

3. Joseph, L., & Mondal, A. K. (Eds.). (2022). Autonomous driving and advanced driver-assistance systems: applications, development, legal issues, and testing. CRC Press.

4. S. C, S. P, M. Raj and S. Raj, "Advanced Driver Assistance System (ADAS) in Autonomous Vehicles: A Complete Analysis," 2023 8th International Conference on Communication and Electronics Systems (ICCES), India, 2023, pp. 1501-1505,

5. J. Borrego-Carazo et al., "Resource-Constrained Machine Learning for ADAS: A Systematic Review," in IEEE Access, vol. 8, pp. 40573-40598, 2020.

6. Ball JE, Tang B. Machine Learning and Embedded Computing in Advanced Driver Assistance Systems (ADAS). Electronics. 2019; 8(7):748.


| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222PEC100 | MINI PROJECT | PROJECT | 0 | 0 | 4 | 2 |

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

| Sl. No | Type of evaluations | Mark | Evaluation criteria |
|---|---|---|---|
| 1 | Interim evaluation 1 | 20 | |
| 2 | Interim evaluation 2 | 20 | |
| 3 | Final evaluation by a Committee | 35 | Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement |
| 4 | Report | 15 | the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level (not more than 25% ) |
| 5 | Supervisor/Guide | 10 | |
| Total Marks | | 100 | |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222LEC103 | ADAS LAB | LABORATORY 2 | 0 | 0 | 2 | 1 |

**Preamble:** This course aims to provide a hands-on experience with tools and techniques used in Advanced Driver Assistance Systems (ADAS) and Machine Learning. Students will gain practical skills in implementing, evaluating, and optimizing ADAS algorithms and machine-learning models for real-world applications.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | To familiarize the different sensors used in ADAS systems. |
| **CO 2** | To gain hands-on experience in sensor data preprocessing. |
| **CO 3** | To enhance the mastery of machine learning techniques for feature extraction, and object detection |
| **CO 4** | To apply the knowledge of machine learning to develop expertise in lane detection and sensor fusion. |
| **CO 5** | To implement a mini-project to develop a machine-learning model for a specific application of ADAS in real life. |
| **CO 6** | To develop the student's ability to analyze observations of experiments/ simulations, interpret them, and prepare reports. |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 40 |
| Analyse | 30 |
| Evaluate | 15 |
| Create | 15 |

**Mark distribution**

| Total Marks | CIE | ESE |
|---|---|---|
| 100 | 100 | |

**Continuous Internal Evaluation Pattern:**

The laboratory courses will have only Continuous Internal Evaluation and carry 100 marks. The final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

**Tools:**

Numerical Computing Environment – MATLAB or any other equivalent tool.

**Syllabus**

| No | Topic |
|---|---|
| 1 | **Familiarization of ADAS** |
| 1.1 | Familiarization of radar sensors (e.g., short-range, medium-range, long-range) |
| 1.2 | Familiarization of camera sensors (e.g., monocular, stereo, RGB-D) |
| 1.3 | Familiarization of lidar sensors (e.g., mechanical, solid-state, flash) |
| 1.4 | Familiarization of IMU sensors (e.g., accelerometers, gyroscopes) |
| 1.5 | Familiarization of HIL simulation environment |
| 2 | **Sensor Data Preprocessing for ADAS** |
| 2.1 | Image Processing Fundamentals – Image acquisition and loading, Negative of an image |
| 2.2 | Image enhancement techniques (e.g., contrast stretching, histogram equalization) |
| 2.3 | Noise reduction (e.g., Gaussian filtering, median filtering, bilateral filtering) |
| 2.4 | Image Data augmentation techniques (e.g., Geometrical transformations, Brightness and Contrast adjustments, Color space transformations, Horizontal and vertical flipping, Random cropping and resizing) |
| 3 | **Feature Extraction and Object Detection Techniques for ADAS** |
| 3.1 | Implementing Haar-like features for pedestrian detection |
| 3.2 | Implementing Histogram of Oriented Gradients (HoG) for object detection |
| 3.3 | Implementing Local Binary Patterns (LBP) for texture classification |
| 3.4 | Implementing basic object detection algorithms (e.g., template matching, edge detection) |
| 3.5 | Implementing object detection using Haar cascades |
| 3.6 | Implementing object detection using HoG features |
| 4 | **Lane Detection and Sensor Fusion** |
| 4.1 | Implementing lane detection using edge detection (e.g., Canny edge detector) |
| 4.2 | Implementing lane detection using the Hough transform |
| 4.3 | Implementing lane detection using convolutional neural networks (CNNs) |
| 4.4 | Implementing Kalman filters for sensor fusion |
| 4.5 | Multimodal sensor fusion using Convolutional Neural Networks (e.g., lidar, sonar, and RGB camera for pedestrian detection) |
| 5 | **Implement a mini project to develop a machine learning model for a specific application of ADAS in real life, make a presentation, and submit a report** |

# SEMESTER II

# PROGRAM ELECTIVE III

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC089 | AUTOMOTIVE MICROCONTROLLERS | PROGRAM ELECTIVE 3 | 3 | 0 | 0 | 3 |

**Preamble:** This course is intended to impart knowledge in automotive microcontrollers. The course imparts knowledge in different automotive grade microcontrollers and how to choose based on application. The course also gives knowledge about automotive grade ARM Cortex STML5xx. The course gives an insight into the programming of PIC and AVRmicrocontrollers and basic knowledge in graphic processors, automotive domain controller and Infineon.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Study the different types of automotive grade microcontrollers |
| **CO 2** | Analyze a problem based on ARM Cortex programming model |
| **CO 3** | Analyze a problem based on PIC processor architecture and programming model |
| **CO 4** | Study the AVR microcontroller architecture, Graphics processing, AutomotiveDomain Controller and Aurix TC3xx Infineon |
| **CO 5** | Study the concepts of Identify a practical problem and develop a solution based on the appropriate processor and create an application note for the prescribed solution. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | | 1 | | | 2 | 2 |
| **CO 2** | 2 | | 2 | 2 | 2 | 2 | 2 |
| **CO 3** | 2 | | 2 | 2 | 2 | 2 | 2 |
| **CO 4** | 1 | | 1 | 1 | 2 | 2 | 2 |
| **CO 5** | 1 | 1 | 1 | | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 50% |
| Analyse | 30% |
| Evaluate | 20% |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer-reviewed original publications (minimum 10publications shall be referred): 15 marks

Course-based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 No.: 10 marks

Test paper shall include a minimum of 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M. TECH DEGREE EXAMINATION**
**Course Code: 222EEC089**
**Course Name: Automotive Microcontrollers**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all Questions. Each question carries 5 Marks***

1. How are automotive grade microcontrollers classified?
2. Explain the features of NVIC of STML5xxx
3. Explain the different BRANCH statements in PIC 18FXX.
4. Discuss any two hardware design issues in AVR microcontrollers.

5. Explain the features of Powertrain Domain Controller in Aurix TC3xx Infineon.

**Part B**

***Answer any five questions: Each question carries 7 marks***

6. Explain the different methods in choosing MCU for automotive applications

7. Explain the memory architecture in STM32L15xxx.

8. Explain (a) Cross assembler (b) In-circuit Emulator (c) Simulator

9. Explain the mnemonics ADIW, SBIC, RJMP,ICALL in AVR microcontrollers, with the helpof instructions.

10. Explain NVIDIA CUDA Architecture.

11. Explain the different flags in the status register of PIC18. Show the status of C,DC,Z flagsafter the addition of 38H and 2FH in the following instructions

    MOVLW 38H

    ADDLW 2FH

12. Toggle all the bits of the SFR register of PortB by sending to it the values 55H andAAH continuously. Put a time delay in between each issuing of data to PortB.

**Syllabus**

**Module 1**

**Automotive grade microcontroller:** classification**-** based on type, application, Automotive

Electronic Council Qualification (AEC-Q), significance of AEC-Q100, AEC-Q200,temperature grades.

**Automotive 32-bit MCU**: Choosing MCU for Automotive Applications, Atmel – SMARTARM based MCU, ST- SPC5 32-bit Automotive MCU, NXP Automotive MCU.

**Module 2**

**Cortex-M3/M4 Microcontroller:** Comparison of Cortex M3 and M4, STM32L15xxx ARM Cortex M3/M4 Microcontroller: Memory and Bus Architecture, Power Control, Reset and Clock Control.

STM32L15xxx Peripherals: GPIOs, System Configuration Controller, NVIC, ADC, Comparators, GP Timers, USART. Development & Debugging Tools: Software and Hardware tools like Cross Assembler, Compiler, Debugger, Simulator, In-Circuit Emulator (ICE), Logic Analyzer

**Module 3**

**PIC Processor:** 18FXX series PIC architecture, instruction set, Branch, CALL, Time delay,I/O Port programming, timer, interrupts, interfacing.

**Module 4**

**AVR Microcontrollers:** features, processor architecture- addressing modes, memory map,registers, I/O ports, timer, interrupts, hardware design issues.

**Module 5**

**Graphics Processing:** Abstraction, multi-threaded programming, Hybrid processors, GeneralPurpose-GPU, NVIDIA CUDA architecture.

**Automotive Domain Controller:** need of domain controllers**,** benefits.

**Aurix TC3xx Infineon-** features, applications, Powertrain Domain Controller (PDC)

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Automotive grade microcontroller** | |
| 1.1 | classification**-** based on type, application | 1 |
| 1.2 | Automotive Electronic Council Qualification (AEC-Q) | 1 |
| 1.3 | significance of AEC-Q100, AEC-Q200 | 1 |
| 1.4 | **Automotive 32-bit MCU**: Choosing MCU for Automotive Applications, | 1 |
| 1.5 | Atmel – SMART ARM based MCU | 1 |
| 1.6 | ST- SPC5 32-bit Automotive MCU | 1 |
| 1.7 | NXP Automotive MCU. | 1 |
| **2** | **Cortex-M3/M4 Microcontroller:** | |
| 2.1 | Comparison of Cortex M3 and M4 | 2 |
| 2.2 | STM32L15xxx | 2 |
| 2.3 | ARM Cortex M3/M4 Microcontroller: Memory and Bus Architecture | 2 |
| 2.4 | Power Control, Reset and Clock Control. | 2 |
| **3** | **PIC Processor:** | |
| 3.1 | 18FXX series PIC architecture | 2 |
| 3.2 | instruction set | 3 |
| 3.3 | Branch, CALL, Time delay, timer, interrupts, I/O Port programming | 3 |
| **4** | **AVR Microcontrollers:** | |
| 4.1 | Features, processor architecture- memory map | 2 |
| 4.2 | addressing modes | 3 |

| | | |
|---|---|---|
| 4.3 | registers, I/O ports | 2 |
| 4. 4 | timer, interrupts | 2 |
| **5** | **Graphics Processing** | |
| 5.1 | Abstraction, multi-threaded programming, Hybrid processors | 2 |
| 5.2 | General Purpose-GPU, NVIDIA CUDA architecture. | 2 |
| 5.3 | **Automotive Domain Controller:** need of domain controllers**,**benefits. | 2 |
| 5.4 | **Aurix TC3xx Infineon-** features, applications, PowertrainDomain Controller (PDC) | 2 |

**Reference Books**


1. Steve Furber, "ARM System-on-chip architecture", Pearson Education.
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C -3rdEdition - Muhammad Ali Mazidi -2015
3. Andrew N Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide",Elseveir.
4. STM32L152xx ARM Cortex M3 Microcontroller Reference Manual.
5. Joseph Yiu, “The definitive guide to ARM Cortex M3”, Elsevier, 2nd Edition, 2010.
6. “NVIDIA® CUDA™ Architecture: Introduction and Overview”, NVIDIA, 2009.
7. Microchip PIC - Microcontroller application notes / data sheets.
8. Mazidi et. al., “The PIC microcontroller and embedded systems using Assembly andC for PIC18”, Pearson, 2008.
9. David Patterson and John L. Hennessy, “Computer Architecture: A quantitativeapproach”, 5th Edition, Elsevier, 2012.
10. Dhananjay V. Gadre, “Programming and customizing the AVR microcontroller”,McGraw-Hill,2021.
11. AURIX™ 32-bit microcontrollers for automotive and industrial applications Issue2020.
12. Jonathan W. Valvano, “Embedded Systems: Introduction to ARM Cortex MMicrocontrollers”, vol.1,5th edn.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC067 | AUTOMOTIVE POWER ELECTRONICS & DRIVES | PROGRAM ELECTIVE 3 | 3 | 0 | 0 | 3 |

**Preamble:** This course focuses on the electric power requirement and control in automobiles. The student shall be able to understand the application of power electronics in automotive electrical and electronic systems which includes automotive power generation, silicon-based converter systems and electrical drives control for various motor systems.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Apply the basics of EV architecture, batteries, Power converters and motor control. |
| **CO 2** | Analyze the performance of buck, boost and buck boost DC – DC converters |
| **CO 3** | Apply the semi-conductor principles in the design of AC – DC converters |
| **CO 4** | Analyze the Control Techniques utilized in voltage Source Inverters & current Source Inverters |
| **CO 5** | Apply the torque and speed control methods in Induction Motor Drives and Switched Reluctance Motor Drives |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | 2 | 2 | | |
| **CO 2** | 2 | 2 | | 3 | 3 | | |
| **CO 3** | 2 | 2 | | 3 | 3 | | |
| **CO 4** | 2 | 2 | | 3 | 3 | | |
| **CO 5** | 2 | 2 | | 3 | 3 | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M Tech DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC067**

**Course Name: Automotive Power Electronics & Drives**

Max. Marks: 60 Duration: 2.5 Hours

**PART A**

***Answer all questions. Each question carries 5 marks*** Marks

| | | |
|---|---|---|
| 1 | Explain the conventional system of electrical distribution in automobiles. | (5) |
| 2 | Mention the application of IGBT in converter systems | (5) |
| 3 | Discuss Converter Topologies for Auxiliary Power Modules | (5) |

4 Explain the voltage and frequency Control method for voltage source inverters (5)

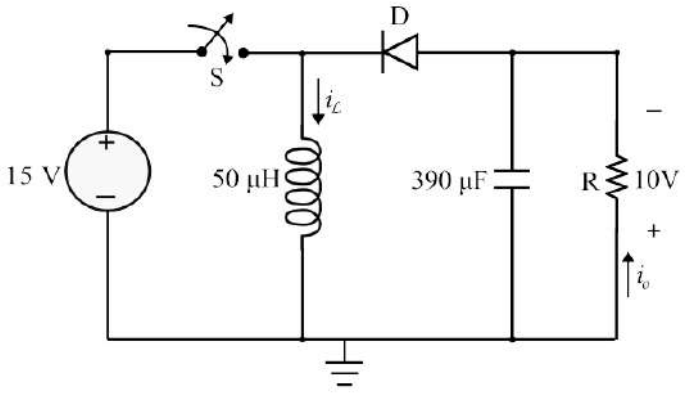
5 Describe the Torque and Speed Control of Induction Motor. (5)

**PART B**

***Answer any 5 questions. Each question carries 7 marks***

6 Explain the types and characteristics of EV batteries. Mention the battery parameters (7)

8 Question: A buck boost converter operating at 20 kHz is shown in Fig.1. The output capacitor C is sufficiently large to ensure a ripple-free output voltage. The input voltage Vin is 15 V. The converter is supplying a load of 10W. If the output voltage is required to be 10 V, find the duty ratio (D) of the switch. (7)




8 a) Describe the working and characteristics of IGBT with neat diagram (7)

b) A single-phase full bridge inverter has a resistive load of R=2.4Ω and dc input voltage is Vs=48V. Determine a) output power b) peak and average current of each transistor

9 Draw the necessary circuit diagram and waveforms and explain the working of 3-phase converter fed DC motor drive with continuous conduction only. Derive the average O/P voltage with motor load. (7)

10 a) With circuit diagram and waveforms explain the operation of full bridge inverter (7)

b) With schematics explain the principle of sinusoidal pulse width modulation.

| | | | |
|---|---|---|---|
| 11 | Explain the working of indirect AC- AC converters with neat diagram and waveforms | (7) |
| 12 | a) Explain V/F method for controlling speed of induction motor.<br>b) Discuss the Closed Loop Torque and Speed Control of the Switched Reluctance Motor Drive | (7) |

**Syllabus**

**Module1**

Introduction to Power Electronics, Power Semiconductor devices – Diodes, thyristors, BJTs, MOSFETs, IGBTs, Power electronic systems – V-I and switching characteristics, Emerging device technologies – Si, SiC and GaN power devices.

Charging systems – AC & DC charging, onboard and off board chargers, types, standards/ connectors, Normal and Fast chargers.

**Module 2**

AC-DC converters - Uncontrolled rectifiers, phase controlled rectifiers, PWM rectifiers - single and three phase.

AC-AC converters – AC voltage controllers - Phase controlled and PWM controlled, single phase and three phase, cycloconverters, matrix converters, Device selection and applications.

**Module 3**

DC-DC converters – Design and analysis of Buck, Boost, Buck-Boost, Four quadrant DC-DC converter. Switched mode and resonant DC-DC converters.

DC to AC converters – Voltage source Inverters (VSI) - single phase and three phase, Current Source Inverters (CSI) – three phase square wave and PWM type, multilevel inverters.

**Module 4**

DC Motors – Series, parallel, series – parallel, torque-speed characteristics, Speed control - Voltage control, Field control, closed loop operation.

AC Asynchronous motors – Induction motors – single phase and three phase, Analysis, Steady state performance characteristics; Torque and Speed Control – variable speed drive operating modes, Scalar control – open loop and closed loop, Vector control - Field Oriented control, Direct Torque control.

**Module 5**

AC Synchronous motors – PMSM, BLDC – Performance characteristics and analysis, Control principles and strategies, Torque and Speed control with sensors, sensorless techniques.

SRM - drive system, Performance characteristics, torque production, modes of operation, Torque and speed control – open loop and closed loop torque control, Sensorless control – types.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | | |
| 1.1 | Introduction to Power Electronics | 1 |
| 1.2 | Power Semiconductor devices – Diodes, thyristors, BJTs, MOSFETs, IGBTs, Power electronic systems – V-I and switching characteristics | 3 |
| 1.3 | Emerging device technologies – Si, SiC and GaN power devices. | 1 |
| 1.4 | Charging systems – AC & DC charging, onboard and off board chargers, types, standards/ connectors, Normal and Fast chargers | 2 |
| 2 | | |
| 2.1 | AC-DC converters - Uncontrolled rectifiers, phase controlled rectifiers, PWM rectifiers - single and three phase | 3 |
| 2.2 | AC-AC converters – AC voltage controllers - Phase controlled and PWM controlled | 2 |
| 2.3 | single phase and three phase, cycloconverters, matrix converters, Device selection and applications | 2 |
| 3 | | |
| 3.1 | DC-DC converters – Design and analysis of Buck, Boost, Buck-Boost, Four quadrant DC-DC converter | 3 |
| 3.2 | Switched mode and resonant DC-DC converters | 2 |
| 3.3 | DC to AC converters – Voltage source Inverters (VSI) - single phase and three phase | 2 |
| 3.4 | Current Source Inverters (CSI) – three phase square wave and PWM type, multilevel inverters | 2 |
| 4 | | |
| 4.1 | DC Motors – Series, parallel, series – parallel, torque-speed characteristics | 2 |
| 4.2 | Speed control - Voltage control, Field control, closed loop operation | 2 |
| 4.3 | AC Asynchronous motors – Induction motors – single phase and three phase, Analysis, Steady state performance characteristics | 2 |
| 4.4 | Torque and Speed Control – variable speed drive operating modes, Scalar control – open loop and closed loop | 2 |
| 4.5 | Vector control - Field Oriented control, Direct Torque control | 2 |
| 5 | | |

| | | |
|---|---|---|
| 5.1 | AC Synchronous motors – PMSM, BLDC – Performance characteristics and analysis | 2 |
| 5.2 | Control principles and strategies, Torque and Speed control with sensors, sensorless techniques | 2 |
| 5.3 | SRM - drive system, Performance characteristics, torque production, modes of operation | 1 |
| 5.4 | Torque and speed control – open loop and closed loop torque control, Sensorless control – types | 2 |

**References**


1. Trzynadlowski, Andrzej M. Introduction to modern power electronics. John Wiley & Sons, 2015.
2. Husain, Iqbal. Electric and hybrid vehicles: design fundamentals. CRC press, 2021.
3. PC Sen, Principles of Electric Machines and Power Electronics, 3rd Edition, Wiley 2013.
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
5. Emadi, Ali, ed. Handbook of automotive power electronics and motor drives. CRC press, 2017.
6. Bimal K Bose, Modern Power Electronics and AC Drives, Pearson Education, second Edition, 2003.
7. Bimal.K. Bose, "Power Electronics and Variable frequency drives", Standard Publishers Distributors, New Delhi, 2000
8. A. Khajepour, S. Fallah and A. Goodarzi, "Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.
9. Hybrid Electric Vehicle System Modelling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
10. R Krishnan, Electric motor drives: Modelling, Analysis, and Control, 2013
11. Husain, Iqbal. Electric and hybrid vehicles: design fundamentals. CRC press, 2021.
12. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
13. Emadi, Ali, Advanced Electric Drive Vehicles, CRC Press, 2014.


| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC090 | IMAGE PROCESSING AND COMPUTER VISISON | PROGRAM ELECTIVE 3 | 3 | 0 | 0 | 3 |

**Preamble:** Image processing is a method to perform certain operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs — and take actions or make recommendations based on that information. Students will be able to learn image processing fundamentals, understand the different types of algorithms in image processing and computer vision, develop in-depth knowledge of image and video processing tasks such as image representation, image transforms, image enhancement, Image restoration, image segmentation and image compression.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Understand and apply the fundamentals, concepts and terminologies in image processing and computer vision. |
| **CO 2** | Understand and analyse the principles of image restoration and segmentation and illustrate the methods and algorithms for image restoration and segmentation. |
| **CO 3** | Understand and analyse the principles of image compression and video processing and illustrate the methods and algorithms for image compression and video processing. |
| **CO 4** | Analyze and evaluate the performance of depth estimation and multi-camera views for computer vision. |
| **CO 5** | Evaluate critically the techniques for motion analysis and optical flow in computer vision |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | | 2 | | | |
| **CO 2** | 2 | 2 | | | 3 | | |
| **CO 3** | | | | | 2 | 2 | 3 |
| **CO 4** | 3 | 2 | | | 2 | 2 | 2 |
| **CO 5** | 3 | 2 | | 3 | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 20% |
| Analyse | 40% |
| Evaluate | 20% |
| Create | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC090**

**Course Name: Image processing and Computer Vision**

**Max marks 60** **Time 2.5 hours**

**PART A**

***Answer all questions, each carries 5 marks***

| | | |
|---|---|---|
| 1 | Explain the properties of Fourier transform specific to image processing. | **(5)** |
| 2 | Explain basic principles of LoG and DoG filters. Discuss the merits and demerits compared with other type of filters. Discuss the shape of LoG(x, y, σ) with an indicative plot. | **(5)** |
| 3 | Explain the basic principles of transform coding. Give the block schematic of a transform coder. Compare the performance of different transforms based coders with a graph. | **(5)** |
| 4 | Illustrate the concept of depth estimation. What is stereo dept estimation ? | **(5)** |
| 5 | Comment on Phong Lighting Model. Why shading is important in computer vision? Disccuss Phong shading | **(5)** |

**PART B**

***Answer any 5 full question, each question carries 7 marks***

| | | |
|---|---|---|
| 6 a | Compare and contrast spatial and spectral domain processing of images. Discuss some applications that require these type of processing. Write a MATLAB program snippet for generating a checker box pattern of size 8x8 | **(4)** |
| 6b | Briefly explain edges in images. What do you mean by edge magnitude and edge direcion? Discuss some techniques for edge sharpening. | **(3)** |
| 7a | Let f represents a M × N image. If the DFT and IDFT of f is given by P f Q and P −1f Q−1 respectively, then give expression for all transformation matrices. | **(3)** |
| 7b | Let f (x, y) be a continous image function. The image is sampled at points x = j△x, y = k△y, for j = 1, ..., M and k = 1, ..., N. Where △x and △y are sampling intervals. Find expression for the sampled image fs (x, y). Also represent the sampled image in the frequency domain. (Hint: Assume ideal sampling | **(4)** |

| | | |
|---|---|---|
| | using shifted dirac functions δ.) | |
| 8a | Explain the significance of Weiner filter in image restoration. Obtain expression for Wiener filter transfer function. | **(4)** |
| 8b | List the steps involved in image restoration using Weiner filter. With a neat block schematic explain the digital implementation of Wiener filter. | **(3)** |
| 9a | For the number plate identification of vehicles, the pre-processing step uses segmentation. Explain a suitable technique for this. Illustrate how do you arrive on thresholds ? | **(4)** |
| 9b | Explain region merging technique. Discuss the criterion for merging two different regions in an image. | **(3)** |
| 10a | Discuss the principles of fixed length and variable length encoding techniques. The word MISSISSIPPI RIVER is to be encoded using Huffman coding technique. Draw the Huffman tree and determine the Huffman code for the same. | **(4)** |
| 10b | Compare and contrast lossy and loss-less compression techniques. Discuss entropy based compression techniques. Also explain fundamental properties of information. | **(3)** |
| 11a | What is homography estimation? Explain the significance of homography matrix. | **(3)** |
| 11b | Illustrate how RANSAC helps in estimating a mathematical model from a data set that contains outliers. | **(4)** |
| 12a | Explain how to segment the foreground objects from the background of a sequence? Discuss the principles of background subtraction. | **(3)** |
| 12b | What do you mean by motion estimation? How do we estimate parameters? | **(4)** |

**Syllabus**

**Module 1 (image Representation)**

Image Representation: Gray scale and colour images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image representation using SIFT, GIST and HOG features. Image enhancement - Filters in spatial and frequency domains, histogram- based processing, homomorphic filtering

**Module 2 (Image Restoration and Segmentation)**

Image Restoration: Degradation models, PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods. Image segmentation: pixel classification, bi-level thresholding, multi level thresholding. Edge detection, Edge sharpening, edge profiles, Edge operators, LoG, DoG, Hough Transform.

**Module 3 (Image Compression and video Processing)**

Fundamentals Concepts of compression of image: Compression Models- Information theoretic perspective- Fundamental Coding theorem- Lossless compression: Huffman coding-Arithmetic coding-bit plane coding, run length coding- Lossy compression: Transform coding- Image Compression standards. Video processing: Representation of digital video, Spatio-temporal sampling: Motion estimation: video filtering: Video compression, video coding standards.

**Module 4 (Depth Estimation and Muti Camera Views)**

Depth Estimation and multi camera views: Perspective, binocular stereopsis: Camera and epipolar geometry: homography, resctification. DLT, RANSAC, 3-D reconstruction framework: auto calibration

**Module 5 (Motion Analysis)**

Motion Analysis: Background subtraction and modelling, Optical flow, KLT, Spatio-temporal analysis, dynamic stereo; motion parameter estimation. Light at surfaces-Phong Model, shape from texture, color, motion and edges

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Image Representation** | |
| 1.1 | Image Representation: Gray scale and colour Images, image sampling and quantization. | 2 |
| 1.2 | Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. | 2 |
| 1.3 | Image representation using SIFT, GIST and HOG features. | 2 |
| 1.4 | Image enhancement - filters in spatial and frequency domains, histogram- based processing, homomorphic filtering. | 3 |
| **2** | **Image Resoration and Segmentaton** | |
| 2.1 | Image Restoration: Degradation Models, PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering. | 2 |
| 2.2 | Wiener filtering and maximum entropy-based methods. | 2 |
| 2.3 | Image Segmentation: Pixel classification, Bi-level thresholding, Multi- level thresholding | 3 |
| 2.4 | Edge detection, edge sharpening, edge profiles, edge operators, LoG, DoG. Hough transform. | 2 |
| **3** | **Image Compression and video Processing** | |
| 3.1 | Fundamental Concepts of Image Compression: Compression models- Information theoretic perspective - Fundamental coding theorem. | 2 |
| 3.2 | Lossless Compression: Huffman Coding- Arithmetic coding – Bit plane coding - Run length coding. | 3 |
| 3.3 | Lossy compression: Transform coding - Image compression | 3 |

| | | |
|---|---|---|
| 3.4 | Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards. | 3 |
| **4** | **Depth estimation and Multi-camera views** | |
| 4.1 | Depth estimation and Multi-camera views: Perspective, Binocular Stereopsis. | 2 |
| 4.2 | Camera and Epipolar Geometry; Homography, Rectification. | 2 |
| 4.3 | DLT, RANSAC, 3-D reconstruction framework | 3 |
| 4.4 | Auto-calibration. | 2 |
| **5** | **Motion Analysis** | |
| 5.1 | Motion Analysis: Background Subtraction and Modeling. | 2 |
| 5.2 | Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo. | 2 |
| 5.3 | Motion parameter estimation. | 1 |
| 5.4 | Light at Surfaces: Phong Model, Shape from Texture, color, motion and edges. | 2 |

**Text Books**


1. Fundamentals of Digital Image Processing, A. K. Jain, Prentice Hall of India, 1989.
2. Digital Image Processing , R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education, 2nd Edition, 2002.
3. Computer Vision algorithms and Applications, Richard Szeliski, Springer, New York, 2nd Edition, 2022.


**Reference Books**


1. Digital Image Processing, 4th Edition, Wiley Inderscience, W K Pratt, Prentice Hall 2007.
2. Digital Image processing, A Rosenfold and A C Kalk, Vol 1 and 2, Prentice Hall 2014.
3. Digital image Restoration, H C Andrew and b R Hunt, Prentice Hall, 1977.
4. Machine Vision, R jain, R kasturi and G, B Schunk, Mc Graw Hill International Edition 1995.
5. Digital Video Processing, A M Tekalp, Prentice Hall,1995.
6. Handbook of Image & Video Processing, A Bovik, Academic Press 2000.
7. Dictionary of Computer Vision and image processing, Second Edition, R B Fisher, T P Breckon, K Dawson Howe et al, ISBN: 9781119941866, John Wiley& Sons Ltd, 2016.


| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC091 | AUTONOMOUS VEHICLES | PROGRAM ELECTIVE 3 | 3 | 0 | 0 | 3 |

**Preamble:** This course is designed to gain a deep understanding of autonomous vehicle fundamentals, master system architecture, safety assurance, advanced controls, and vehicle dynamic modelling.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Understand the fundamentals of Autonomous Vehicles. |
| **CO 2** | Identify system architecture and safety assurance for Autonomous Vehicles |
| **CO 3** | Develop advanced controls for Autonomous vehicles |
| **CO 4** | Apply vehicle dynamic modelling for the development of autonomous vehicles |
| **CO 5** | Evaluate the performance of different systems in autonomous vehicles through simulation |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 3 | 3 | 2 | 2 | |
| **CO 2** | 3 | 2 | 3 | 3 | 2 | 2 | |
| **CO 3** | 3 | 2 | 3 | 3 | 2 | 2 | |
| **CO 4** | 3 | 2 | 3 | 3 | 2 | 1 | |
| **CO 5** | 3 | 2 | 3 | 3 | 3 | 1 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 60 |
| Analyse | 20 |
| Evaluate | 20 |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC091**

**Course Name: Autonomous Vehicles**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Describe the various levels of autonomous vehicles and provide examples for each level.

2 Explain how V2X communications enhance the safety and efficiency of autonomous vehicles.

3 What is Predictive Speed Assist (PSA)? Explain its importance in autonomous vehicle control.

4 Compare the Bicycle Model and the Tire Model in the context of vehicle dynamic modelling for lateral control.

5 What is the importance of simulating lane control with vision-based perception in autonomous vehicles? Describe the process briefly.

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Describe how Advanced Driver Assistance Systems (ADAS) contribute to the development of fully autonomous vehicles.

7 Design a basic layout for the internal networking of an autonomous vehicle, including CAN, LIN, GigaEthernet, and USB interfaces.

8 Analyze the benefits and challenges of using ROS in the development of autonomous vehicle software.

9 Describe the derivation process of Curve Speed Control in autonomous vehicles and its integration with velocity control logic.

10 Explain the concept of Model Predictive Control (MPC) and its application in autonomous vehicle controller design.

11 Develop a simulation scenario to test the lane control system of an autonomous vehicle using vision-based perception.

12 Analyze the process of fusing sensor detections and discuss how it improves the accuracy of autonomous vehicle simulations.

**Syllabus**

**Module 1:**

Fundamentals of Autonomous Vehicles: History of self driving cars, Levels of Autonomous vehicles, Advanced Driver Assistance Electronic Systems, Connected Car Technology- Connectivity Fundamentals, Navigation and Other Applications. Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory.

Autonomous Vehicle Applications - Off-road Mining, Logistics and Supply Chain Agricultural Activities, Smart Mobility.

**Module 2:**

Hardware Architecture for Autonomous Vehicles – Sensors, Processing Units, V2X/ Cloud Communications, Mobile platforms/Actuators/ Displays.

Internal networking interfaces: CAN, LIN, GigaEthernet and USB.

Software frameworks and standards: AUTOSAR, ROS and RTOS.

Software Architecture for Autonomous Vehicles – Algorithms, Data collection, UI/UX and infotainment, Real-time and critical control software.

Safety Assurance for Autonomous Vehicles

**Module 3:**

Advanced Controls: Predictive Speed Assist - Introduction to Predictive Speed Assist and Intelligent Speed Assist, Curve Speed Control Derivation, Pseudo Code for PSA and ISA Integration of PSA with Velocity Control Logic, Control for Roundabout Scenarios, Minimum Risk Manuevers.

**Module 4:**

Vehicle Dynamic Modelling: Lateral Control Model Elements and Overview, Bicycle Model, Tire Model, State Equation for Lateral Control Model, Introduction to MPC. Controller Design using MPC, Integration and Modelling using simulation software.

**Module 5:**

Simulation: Driving Scenario designer, integrate driving scenarios, Simulate controls and perception systems, simulate lane control with vision based perception, import custom automation algorithms, Visualize Live Map recorded data.

Automated Driving - Labelling of ground truth data, Visualizing sensor data, Detecting lanes and vehicles, Fusing sensor detections, Generating driving scenarios and modelling sensors.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | | |
| 1.1 | Fundamentals of Autonomous Vehicles: History of self driving cars, Levels of Autonomous vehicles | 2 |
| 1.2 | Advanced Driver Assistance Electronic Systems, Connected Car Technology- Connectivity Fundamentals, Navigation and Other Applications. | 2 |
| 1.3 | Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory. | 2 |
| 1.4 | Autonomous Vehicle Applications - Off-road Mining, Logistics and Supply Chain Agricultural Activities, Smart Mobility. | 2 |
| **2** | | |
| 2.1 | Hardware Architecture for Autonomous Vehicles – Sensors, Processing Units, V2X/ Cloud Communications, Mobile platforms/Actuators/ Displays. | 2 |
| 2.2 | Internal networking interfaces: CAN, LIN, GigaEthernet and USB. | 2 |
| 2.3 | Software frameworks and standards: AUTOSAR, ROS and RTOS. | 3 |
| 2.4 | Software Architecture for Autonomous Vehicles – Algorithms, Data collection, UI/UX and infotainment | 2 |
| 2.5 | Real-time and critical control software. | 1 |

| | | |
|---|---|---|
| | Safety Assurance for Autonomous Vehicles | |
| **3** | | |
| 3.1 | Advanced Controls: Predictive Speed Assist - Introduction to Predictive Speed Assist and Intelligent Speed Assist, Curve Speed Control Derivation | 2 |
| 3.2 | Pseudo Code for PSA and ISA Integration of PSA with Velocity Control Logic | 3 |
| 3.3 | Control for Roundabout Scenarios, Minimum Risk Manuevers. | 3 |
| **4** | | |
| 4.1 | Vehicle Dynamic Modelling: Lateral Control Model Elements and Overview | 2 |
| 4.2 | Bicycle Model, Tire Model, State Equation for Lateral Control Model, Introduction to MPC | 2 |
| 4.3 | Controller Design using MPC, Integration and Modelling using simulation software | 2 |
| **5** | | |
| 5.1 | Simulation: Driving Scenario designer, integrate driving scenarios | 2 |
| 5.2 | Simulate controls and perception systems, simulate lane control with vision based perception | 2 |
| 5.3 | Import custom automation algorithms, Visualize Live Map recorded data | 1 |
| 5.4 | Automated Driving - Labelling of ground truth data, Visualizing sensor data, Detecting lanes and vehicles | 2 |
| 5.5 | Fusing sensor detections, Generating driving scenarios and modelling sensors. | 1 |

**Text Books**


1. George Dimitrakopoulos, Aggelos Tsakanikas, Elias Panagiotopoulos, “Autonomous Vehicles Technologies, Regulations, and Societal Impacts”, Elsevier Publication, 2021.
2. Dietmar P.F. Möller, Roland E. Haas, “Guide to Automotive Connectivity and Cybersecurity: Trends, Technologies”, Springer Publication, 2019.
3. Hanky Sjafrie, “Introduction to Self-Driving Vehicle Technology”, 1st Edition, Chapman and Hall/CRC, 2019.


# SEMESTER II

# PROGRAM ELECTIVE IV

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC092 | DEEP LEARNING | PROGRAM ELECTIVE 4 | 3 | 0 | 0 | 3 |

**Preamble:** Study of this course provides the learners an overview of the concepts and algorithms involved in deep learning. The course covers the basic concepts in deep learning, optimization techniques, regularization techniques, convolutional neural networks, recurrent neural networks, graphical models, deep generative models. This course helps the students to implement deep learning algorithms to solve real-world problems.

**Prerequisite**: Nil

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Use the standard regularization and optimization techniques for the effective training of deep neural networks. |
| **CO 2** | Build convolutional Neural Network (CNN) models for different use cases. |
| **CO 3** | Apply the concepts of Recurrent Neural Network (RNN), Long Short Term Memory (LSTM), Gated Recurrent Unit (GRU) for solving problems. |
| **CO 4** | Construct Bayesian networks, Markov networks and apply computational techniques to draw inferences. |
| **CO 5** | Illustrate the concepts of auto encoder, sampling algorithms, deep generative models and transfer learning. |
| **CO 6** | Design, develop, implement and present innovative ideas on deep learning concepts and techniques to solve real-world problems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | | | 3 | 3 | 3 | 3 | |
| **CO 2** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 3** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 4** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 5** | 3 | | 3 | 3 | 3 | 3 | |
| **CO 6** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 70%-80% |
| Analyze | 30%-40% |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks.

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M. TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC092**

**Course Name: Deep Learning**

Max. Marks: 60 Duration: 150 Minutes

**PART A**

***Answer ALL Questions. Each Carries 5 mark.***

1. A 2 × 2 image is represented by the following pixel value matrix.

$$\begin{bmatrix} 5 & 4 \\ 2 & 7 \end{bmatrix}$$

This image is given to a 3-layer neural network, that is, two hidden layers and oneoutput layer. Draw schematic diagram of the network.
Assuming all inter-connection weights having values 1, bias having value 0, the hidden layers having 3 neurons each, and a simple activation function of the form $\frac{1}{1+x}$ being used, compute output for one round of forward propagation.

2. In Convolutional Neural Networks, there is no need to perform feature extraction. Justify with an example.
3. Explain your understanding of unfolding a recursive or recurrent computation into a computational graph. List three differences between LSTM and GRU.
4. Sketch the core idea of the Monte Carlo method. What is a sample? What is a direct sampling method? Why can't it be used directly to do any inference? What is rejection sampling? What is its major disadvantage?
5. How does the variational auto-encoder(VAE) architecture allow it to generate new data points, compared to auto-encoder, which cannot generate new data points?

**PART B**

***Answer any 5 questions: Each question carries 7 marks***

6. Differentiate gradient descent with and without momentum. Give equations for weight updation in GD with and without momentum. Illustrate plateaus, saddle points and slowly varying gradients.
7. (a) Consider an activation volume of size 13×13×64 and a filter of size 3×3×64. Discuss whether it is possible to perform convolutions with strides 2, 3 and 5. What happens if the stride of the convolutional layer increases? What can be the maximum stride? Justify your answer.

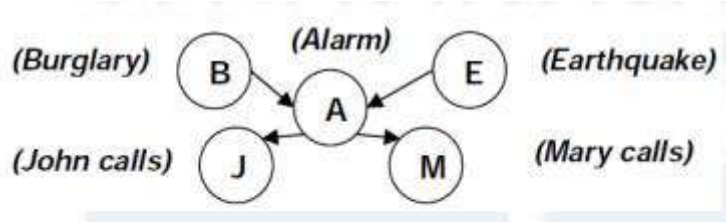
   (b) How backpropagation is used to learn higher-order features in a convolutional Network?

8. The vanishing gradient problem is more pronounced in RNN than in traditional neural networks. Give reason. Discuss a solution for the problem.

9. Shown below is the Bayesian network corresponding to the Burglar Alarm problem, P(J | A) P(M | A) P(A | B, E) P(B) P(E). The probability tables show the probability that variable is True, e.g., P(M) means P(M = t). Calculate

   i) P( J ∧ M ∧ A ∧ ¬B ∧ ¬E )

   ii) P( J )




| P(E) |
|---|
| .002 |

| A | P(M) |
|---|---|
| t | .70 |
| f | .01 |

| B | E | P(A) |
|---|---|---|
| t | t | .95 |
| t | f | .94 |
| f | t | .29 |
| f | f | .001 |

| P(B) |
|---|
| .001 |

| A | P(J) |
|---|---|
| t | .90 |
| f | .05 |

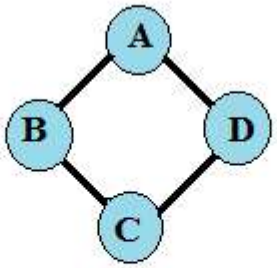
10. Compare Boltzmann Machine with Deep Belief Network.

11. (a) Training error of the deep learning model trained for the classification problem was found to be very low but generalization error was high. Identify the problem and suggest techniques to reduce this generalization error.

    (b)Initializing the weights of a neural network with very small or large random numbers is not advisable. Justify.

12. Consider the simple Markov network given below. Let A,B,C and D be binary random variables representing four people's beliefs as to whether the earth is round (1 for believes, 0 for does not believe). Determine the probability of only person D believes that the earth is round.

| A | B | $\phi_{AB}$ |
|---|---|---|
| 0 | 0 | 50 |
| 0 | 1 | 5 |
| 1 | 0 | 5 |
| 1 | 1 | 50 |




| A | D | $\phi_{AD}$ |
|---|---|---|
| 0 | 0 | 5 |
| 0 | 1 | 50 |
| 1 | 0 | 50 |
| 1 | 1 | 5 |

| B | C | $\phi_{BC}$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 5 |
| 1 | 0 | 45 |
| 1 | 1 | 50 |

| C | D | $\phi_{CD}$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 15 |
| 1 | 0 | 40 |
| 1 | 1 | 50 |

## Syllabus

**Module 1: Introduction to Deep learning**

Introduction to deep learning, Deep feed forward network, Training deep models - introduction, setup and initialization issues, Vanishing and exploding gradient problems, Optimization techniques - Gradient Descent (GD), Stochastic GD, GD with momentum, GD with Nesterov momentum, AdaGrad, RMSProp, Adam. Regularization Techniques -L1 and L2 regularization, Early stopping, Dataset augmentation, Parameter tying and sharing, Ensemble methods, Dropout.

**Module 2: Convolutional Neural Networks**

Convolutional Neural Networks –Architecture, Convolution and Pooling operation, Motivation, Variants of convolution functions, Structured outputs, Data types, Efficient convolution algorithms, Training a Convolutional Network, Applications of Convolutional Networks, Case study of Convolutional Architectures – AlexNet

**Module 3: Recurrent neural networks**

Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, challenges of training Recurrent Networks, gated RNNs LSTM and GRU, Applications of RNNs.

**Module 4: Graphical Models and Sampling**

Graphical models - Bayesian network, Markov networks, Inference on chains and factor graphs. Monte Carlo Methods – Basics of Monte Carlo Sampling, Importance sampling, Markov chain Monte Carlo methods(MCMC), Gibbs sampling.

**Module 5: Advanced Deep learning Topics**

Autoencoders, Variational AutoEncoder, Deep generative models - Boltzmann machines, Restricted Boltzmann Machines, Deep Belief Networks, Deep Boltzmann Machines, Generative Adversarial Networks, Auto-Regressive Networks. Transfer Learning and Domain Adaptation.

## Course Plan

| No | Topic | No. of Lectures (40 Hours) |
|---|---|---|
| **1** | **Module 1: Introduction to deep learning** | **9** |
| 1.1 | Introduction to deep learning, Deep feed forward network | 1 |
| 1.2 | Training deep models - Introduction, setup and initialization issues | 1 |
| 1.3 | Vanishing and exploding gradient problems | 1 |
| 1.4 | Concepts of optimization, Gradient Descent (GD) | 1 |
| 1.5 | Stochastic GD, GD with momentum, GD with Nesterov momentum | 1 |
| 1.6 | AdaGrad, RMSProp, Adam | 1 |
| 1.7 | Concepts of Regularization, L1 and L2 regularization | 1 |

| | | |
|---|---|---|
| 1.8 | Early stopping, Dataset augmentation | 1 |
| 1.9 | Parameter tying and sharing, Ensemble methods, Dropout | 1 |
| **2** | **Module 2: Convolutional Neural Network** | **9** |
| 2.1 | Convolutional Neural Networks, Architecture | 1 |
| 2.2 | Convolution and Pooling operation with example | 1 |
| 2.3 | Motivation | 1 |
| 2.4 | Variants of convolution functions | 1 |
| 2.5 | Structured outputs, Data types | 1 |
| 2.6 | Efficient convolution algorithms | 1 |
| 2.7 | Training a Convolutional Network | 1 |
| 2.8 | Applications of Convolutional Networks | 1 |
| 2.9 | Case study of Convolutional Architectures – AlexNet | 1 |
| **3** | **Module 3: Recurrent Neural Network** | **7** |
| 3.1 | Recurrent neural networks – Computational graphs | 1 |
| 3.2 | RNN design, Encoder – decoder sequence to sequence architectures | 1 |
| 3.3 | Deep recurrent networks, Recursive neural networks | 1 |
| 3.4 | Challenges of training Recurrent Networks | 1 |
| 3.5 | LSTM | 1 |
| 3.6 | GRU | 1 |
| 3.7 | Applications of RNN | 1 |
| **4** | **Module 4: Graphical Models and Sampling** | **6** |
| 4.1 | Graphical models - Bayesian network | 1 |
| 4.2 | Markov network | 1 |
| 4.3 | Inference on chains and factor graphs | 1 |
| 4.4 | Monte Carlo Methods – Basics of Monte Carlo Sampling | 1 |
| 4.5 | Importance sampling | 1 |
| 4.6 | Markov chain Monte Carlo methods (MCMC), Gibbs sampling | 1 |
| **5** | **Module 5: Advanced Deep learning Topics** | **9** |
| 5.1 | Autoencoders | 1 |
| 5.2 | Variational Autoencoder | 1 |
| 5.3 | Deep generative models - Boltzmann machines | 1 |
| 5.4 | Restricted Boltzmann Machines | 1 |
| 5.5 | Deep Belief Networks | 1 |
| 5.6 | Deep Boltzmann Machines | 1 |
| 5.7 | Generative Adversarial Networks | 1 |
| 5.8 | Auto-Regressive Networks | 1 |
| 5.9 | Transfer Learning and Domain Adaptation. | 1 |

**References**


1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.

2. Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer InternationalPublishing AG, part of Springer Nature 2018.

3. Christopher M. Bishop. Pattern recognition and machine learning. Springer 2006.

4. David Foster. Generative Deep Learning - Teaching Machines to Paint, Write,Compose, and Play. O'Reilly Media, Inc., June 201


| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC093 | VEHICLE SAFETY AND COMFORT SYSTEMS | PROGRAM ELECTIVE 4 | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to impart comprehensive knowledge of the various safety, driver assistance and infotainment feature of modern vehicles.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO1** | Apply the fundamentals of vehicle safety and braking systems |
| **CO2** | Develop various driver assistance systems based on the requirements of modern vehicles |
| **CO3** | Build different passenger / driver convenience systems |
| **CO4** | Develop automotive occupant protection systems |
| **CO5** | Analyse the security and infotainment systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 2 | 2 | |
| **CO 2** | 3 | 3 | 3 | 3 | 2 | 2 | |
| **CO 3** | 3 | 3 | 3 | 3 | 2 | 2 | |
| **CO 4** | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | 2 | 1 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC093**

**Course Name: Vehicle Safety and Comfort Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Differentiate between active and passive safety systems in vehicles with suitable examples.

2 Describe the function and benefits of adaptive cruise control systems.

3 Explain the components and working of a power sunroof drive system.

4 Discuss the role and mechanism of front airbags in occupant protection.

5 Draw the block diagram of electronic vehicle immobilizer system and explain.

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Compare the structure and functioning of drum brakes and disc brakes. What are the advantages and disadvantages of each type?

7 Explain the working principle of electronic stability programs (ESP). How do they contribute to vehicle safety?

8 With the help of block diagram, explain the various functions of vehicle navigation system.

9 Describe the working of an electronically controlled air conditioning system. What are its main components and their functions?

10 Explain the working mechanism of rollover protection systems. How do they enhance the safety of vehicle occupants during rollover incidents?

11 Discuss the operation of a central locking system in modern vehicles. What are the key components involved?

12 Briefly describe about the integration of smartphones in modern vehicle infotainment systems. What are the benefits and potential challenges associated with this integration?

**Syllabus**

**Module 1 – Safety & Braking Systems**

Introduction to Vehicle Safety – Active & Passive safety systems – examples, Basics of vehicle operation – Driver behaviour, Driving behaviour.

Car Braking Systems – Classification, Methods of operation, Components. Wheel Brakes – Overview, Drum brakes, Disc brakes, Brake pads, shoes and discs. Antilock Braking systems, Traction Control systems, Electronic Stability Programs.

**Module 2 - Driver Assistance Systems**

Driving assistance systems- Critical driving situations, Causes of accidents and possible action, Applications, Convenience and safety functions, Sensors for all round electronic visibility. Parking Systems.

Driver Assistance Systems – Vehicle navigation, Night vision systems, Parking and Maneuvering systems, Adaptive cruise control, Information and warning systems, Lane assistance, Lane change assist, Emergency braking systems.

**Module 3 – Comfort & Convenience Systems**

Drive and adjustment systems - Power-window drives -components – working - Power-window motors, Power-window control, Power sunroof drives- diagnose power window problem, Electrical Seat and Steering column adjustment.

Climate control systems - Heating, ventilation and air conditioning – Electronic heater control, Electronically controlled air conditioning system.

**Module 4 – Occupant Protection systems**

Occupant-protection systems - Seat belts and seat-belt pretensioners, Front airbag, Side airbag, Rollover protection systems- structure and working principle. Active and automatic protection. Seat occupancy sensing.

**Module 5 – Security & Infotainment Systems**

Vehicle security systems - Acoustic signaling devices applications, Locking Systems, Central locking System, Biometric Systems. Anti-theft systems - Electronic vehicle immobilizer, Theft-alarm system.

Infotainment systems – Display and control, Instrumentation cluster, Smartphone connection, Radio and TV reception, Traffic telematics.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Safety & Braking Systems** | |
| 1.1 | Introduction to Vehicle Safety – Active & Passive safety systems – examples | 2 |
| 1.2 | Basics of vehicle operation – Driver behaviour, Driving behaviour | 2 |
| 1.3 | Car Braking Systems – Classification, Methods of operation, Components. Wheel Brakes – Overview, Drum brakes, Disc brakes, Brake pads, shoes and discs. | 3 |
| 1.4 | Antilock Braking systems, Traction Control systems, Electronic Stability Programs | 2 |
| 2 | **Driver Assistance Systems** | |
| 2.1 | Driving assistance systems- Critical driving situations, Causes of accidents and possible action, Applications, Convenience and safety functions | 2 |
| 2.2 | Sensors for all round electronic visibility. Parking Systems. | 1 |
| 2.3 | Driver Assistance Systems – Vehicle navigation, Night vision systems, Parking and Maneuvering systems | 2 |
| 2.4 | Adaptive cruise control, Information and warning systems, Lane assistance, Lane change assist, Emergency braking systems | 3 |
| 3 | **Comfort & Convenience Systems** | |
| 3.1 | Drive and adjustment systems - Power-window drives - components – working - Power-window motors, Power-window control. | 2 |
| 3.2 | Power sunroof drives - diagnose power window problem, Electrical Seat and Steering column adjustment. | 3 |

| | | |
|---|---|---|
| 3.3 | Climate control systems - Heating, ventilation and air conditioning – Electronic heater control, Electronically controlled air conditioning system. | 3 |
| 4 | **Occupant Protection systems** | |
| 4.1 | Occupant-protection systems - Seat belts and seat-belt pretensioners | 2 |
| 4.2 | Front airbag, Side airbag, Rollover protection systems-structure and working principle | 3 |
| 4.3 | Active and automatic protection. Seat Occupancy sensing. | 2 |
| 5 | **Security & Infotainment Systems** | |
| 5.1 | Vehicle security systems - Acoustic signaling devices applications, Locking Systems, Central locking System, Biometric Systems. | 3 |
| 5.2 | Anti-theft systems - Electronic vehicle immobilizer, Theft-alarm system. | 2 |
| 5.3 | Infotainment systems – Display and control, Instrumentation cluster, Smartphone connection, Radio and TV reception, Traffic telematics. | 3 |

**References**


1. Bosch, "Safety, Comfort & Convenience Systems" 7th Edition – 2016.
2. William B. Ribbens, “Understanding Automotive Electronics, Elsevier Newnes, 6th Edition, 2012.
3. Bosch, “Automotive Handbook”, 11th Edition, Wiley, 2022.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC094 | DIGITAL TWIN FOR AUTOMOTIVE SYSTEMS | PROGRAM ELECTIVE 4 | 3 | 0 | 0 | 3 |

**Preamble:** This course covers a comprehensive curriculum, including theoretical foundations of digital twin, implementation of building digital twin, connected and automated vehicles use cases and advanced applications in smart electric vehicles, ensuring a holistic understanding of digital twin technology.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand the basics concepts in digital twin |
| **CO2** | Identify the Enabling technologies and tools for digital twin |
| **CO3** | Apply theoretical knowledge in building digital twin |
| **CO4** | Analyze the Use cases of Digital Twin for Connected and Automated Vehicles |
| **CO5** | Apply Digital twin technology in smart electric vehicles |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | |
| **CO 2** | 3 | 3 | 2 | 3 | 3 | | |
| **CO 3** | 3 | 3 | | 3 | 3 | | |
| **CO 4** | 3 | 3 | 2 | 3 | | 3 | 1 |
| **CO 5** | 3 | 3 | 2 | 3 | | 3 | 1 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred): 15 marks

Course based task/Seminar/Data Collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC094**

**Course Name: Digital Twin for Automotive Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Define Digital Twin. Explain the basic concepts of digital twin with neat figures

2 Explain how enabling technologies contribute to the development of digital twin models.

3 Explain with figure the steps in building digital twin.

4 Explain the key challenges and complexities associated with implementing digital twins in the automotive industry.

5 List the commercial project domains that have implemented digital twin technology for electric vehicles.

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Explain Digital Twin Prototype (DTP) and Digital Twin Instance (DTI) with respect to Digital Twin.

7 Explain the five-dimension digital twin model.

8 Explain BIM with neat sketch? Mention the advantages of BIM & Machine Learning integration.

9 Explain the Digital Twin Framework for Connected and Automated Vehicles,

10 Explain how Digital Twin Technology optimizes and monitors electric vehicles?

11 Explain Digital Twin as a Service (DTaaS),

12 Explain the challenges and gaps in the application of digital twins in connected and automated vehicles.

**Syllabus**

**Module I: Concept of Digital Twin**

Define Digital Twin, Evolution of Digital Twins, Relating Digital Twins, Industrial Automation, & IIoT. Industrial applications of digital twin, Digital twin concepts, Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, augmented digital twin, Smart & Connected design, Accelerating industry 4.0 using Digital Twin.

**Module II: Enabling technologies and tools for digital twin**

Five-dimension digital twin model, Application fields of digital twin, Functions, and practice emphasis of digital twin,

Framework of enabling technologies for digital twin, Enabling technologies for: cognizing and controlling physical world, digital twin modelling, digital twin data management, digital twin services, connections in digital twin.

Tools for digital twin, Tools for: cognizing and controlling physical world, digital twin modelling, digital twin data management, digital twin service applications, connections in digital twin.

**Module III: Building digital Twin**

Digital Twin Architecture and Standards, Conceptual Digital Twin Reference Model. Steps in building digital twin, Demands and definitions of digital twin software

platform: Digital twin model, Digital twin data, Digital twin algorithm, IoT connection, Virtual-reality interaction, Virtual simulation, Visualization. Integration of IOT & CAD, Integration of IOT, BIM data & machine Learning,

Components of Digital Twins, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms, Concurrent engineering & digital twin. A Digital Twin as a Service (DTaaS)- reference architecture model in Industry 4.0.

**Module IV: Use cases of Digital Twin for Connected and Automated Vehicles**

Digital Twins in Automotive Industry, A Vehicle's Meta-Life, Basic simulation methodologies. Digital Twin Framework for Connected and Automated Vehicles, Examples of Digital Twins: - Transition Applications, Automated Driving System Testing, Cyber-Physical Systems, Parallel Driving, Vehicle to Cloud Based Advanced Driver Assistance Systems. Opportunities and Challenges: - Safety Critical Services, Traffic Management Centres, Digital Maps, Onboard Diagnostics, Logistics

**Module V: Digital twin technology in smart electric vehicles**

Significance of digital twin technology within the smart vehicle domain, Strategies for implementing digital twin systems, Archetype modelling, Synopsis of smart vehicle digital twin technologies, Advanced driver assistance systems, Vehicle health monitoring and management, Battery management systems and intelligent charging, Vehicle power electronic converters, Electric power drive system, Challenges, obstacles and limitations, Time series behaviour modeling with digital twin, Future scope, trends, and opportunities

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Concept of Digital Twin** | |
| 1.1 | Define Digital Twin, Evolution of Digital Twins, Relating Digital Twins, Industrial Automation, & IIoT. Industrial applications of digital twin, | 2 |
| 1.2 | Digital twin concepts, Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, augmented digital twin, Smart & Connected design, accelerating industry 4.0 using Digital Twin. | 6 |
| 2 | **Enabling technologies and tools for digital twin** | |
| 2.1 | Five-dimension digital twin model, Application fields of digital twin, Functions, and practice emphasis of digital twin | 2 |
| 2.2 | Framework of enabling technologies for digital twin, enabling technologies for: cognizing and controlling physical world, digital twin modelling, digital twin data management, digital twin services, connections in digital twin. | 3 |

| | | |
|---|---|---|
| 2.3 | Tools for digital twin, Tools for: cognizing and controlling physical world, digital twin modelling, digital twin data management, digital twin service applications, connections in digital twin. | 3 |
| 3 | **Building Digital Twin** | |
| 3.1 | Digital Twin Architecture and Standards, Conceptual Digital Twin Reference Model. Steps in building digital twin, Demands and definitions of digital twin software platform: | 2 |
| 3.2 | Digital twin model, Digital twin data, Digital twin algorithm, IoT connection, Virtual-reality interaction, Virtual simulation, Visualization. Integration of IOT & CAD, Integration of IOT, BIM data & machine Learning, | 3 |
| 3.3 | Components of Digital Twins, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms, Concurrent engineering & digital twin. | 3 |
| 3.4 | A Digital Twin as a Service (DTaaS)- reference architecture model in Industry 4.0. | 1 |
| 4 | **Use cases of Digital Twin for Connected and Automated Vehicles** | |
| 4.1 | Digital Twins in Automotive Industry, A Vehicle's Meta-Life, Basic simulation methodologies. Digital Twin Framework for Connected and Automated Vehicles, | 2 |
| 4.2 | Examples of Digital Twins: - Transition Applications, Automated Driving System Testing, Cyber-Physical Systems, Parallel Driving, Vehicle to Cloud Based Advanced Driver Assistance Systems. | 3 |
| 4.3 | Opportunities and Challenges: - Safety Critical Services, Traffic Management Centres, Digital Maps, Onboard Diagnostics, Logistics | 2 |
| 5 | **Digital twin technology in smart electric vehicles** | |
| 5.1 | Significance of digital twin technology within the smart vehicle domain, Strategies for implementing digital twin systems, Archetype modelling, | 2 |
| 5.2 | Synopsis of smart vehicle digital twin technologies, Advanced driver assistance systems, Vehicle health monitoring and management, Battery management systems and intelligent charging, Vehicle power electronic converters, Electric power drive system, | 4 |
| 5.3 | Challenges, obstacles and limitations, Time series behaviour modelling with digital twin, Future scope, trends, and opportunities | 2 |

**Text Books**


1. Digital Twin: Possibilities of the new Digital twin technology, Anand Iyer, 2017,
2. Digital Twin Development & Deployment on the Cloud, Ist edition, Nassim Khaled Bibin Pattel Affan Siddiqu, ISBN: 9780128216316, ELSEVIER, pages 592
3. Digital Twin Technologies & Smart Cities, Maryam Farsi, Alireza Daneshkhah, Amin Hosseinian-Far, Hamid Jahankahani, Springer, ISBN 978-3-030-18731-6


4. Digital Twin Technology: Fundamentals and Applications, Manisha Vohra (Editor)
5. Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee, ISBN 978-0-12- 817630-6, ELSEVIER, pages 257
6. Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj & Preetha Evanjaline, ELSEVIER, pages 257, ISBN 978-0-12-818756-2, ISSN 0065- 2458
7. Digital Twin Driven Smart Design by Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, ELSEVIER, ISBN 978-0-12-818918-4, Pages 333
8. Handbook Of Digital Enterprise Systems: Digital Twins, Simulation and Ai, by Wolfgang Kühn, world scientific publishing co., ISBN 978-981-120-073-1, Pages 229.
9. Digital Twin Complete Self-Assessment Guide, 1976302927, 9781976302923, Geradus Blokdyk, CreateSpace Independent Publishing Platform, 2017, Pages 120.
10. Digital Twin: A Complete Guide For The Complete Beginner by Vijay Raghunathan (Author), Santanu Deb Barma (Author)

**References**


1. Aheleroff, Shohin, Xun Xu, Ray Y. Zhong, and Yuqian Lu. "Digital twin as a service (DTaaS) in industry 4.0: An architecture reference model." Advanced Engineering Informatics 47 (2021): 101225.
2. Bhatti, Ghanishtha, Harshit Mohan, and R. Raja Singh. "Towards the future of smart electric vehicles: Digital twin technology." Renewable and Sustainable Energy Reviews 141 (2021): 110801. [Module 5]
3. Liu, Mengnan, et al. "Review of digital twin about concepts, technologies, and industrial applications." Journal of Manufacturing Systems 58 (2021): 346-361.
4. Rasheed, Adil, Omer San, and Trond Kvamsdal. "Digital twin: Values, challenges and enablers from a modeling perspective." IEEE Access 8 (2020): 21980-22012.
5. Qi, Qinglin, et al. "Enabling technologies and tools for digital twin." Journal of Manufacturing Systems 58 (2021): 3-21.
6. Wang, Kai, Yamin Wang, Yizheng Li, Xiaohui Fan, Shanpeng Xiao, and Lin Hu. "A review of the technology standards for enabling digital twin." Digital Twin 2 (2022): 4.
7. Zhang, Tianle, Xiangtao Liu, Zongwei Luo, Fuqiang Dong, and Yu Jiang. "Time series behavior modeling with digital twin for Internet of Vehicles." EURASIP Journal on Wireless Communications and Networking 2019 (2019): 1-11.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC095 | ROS FOR NEXTGEN VEHICLES | PROGRAM ELECTIVE 4 | 3 | 0 | 0 | 3 |

**Preamble:** The Robot Operating System (ROS) stands out as a robust and versatile framework that facilitates the development, integration, and deployment of robotic systems, including next-generation vehicles. This course aims to provide students with a solid understanding of ROS and its applications in the context of autonomous vehicles, equipping them with the knowledge and skills necessary to contribute to this exciting field.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Apply manoeuvrability, workspace and kinematic models for mobile Robots |
| **CO 2** | Understand basic concepts of ROS. |
| **CO 3** | Utilize the concepts of processing sensor data using ROS nodes |
| **CO 4** | Interpret various AI/ML techniques for enhanced perception |
| **CO 5** | Apply the concepts of ROS in the design of autonomous car |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | 3 | | | |
| **CO 2** | 3 | | | 3 | | | |
| **CO 3** | 3 | | | 3 | 3 | | |
| **CO 4** | 3 | 2 | | 3 | 3 | | |
| **CO 5** | 3 | 3 | | 3 | 3 | 3 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks.

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M. TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC095**

**Course Name: ROS for NextGen Vehicles**

Max. Marks: 60 Duration: 2.5 Hours

**PART A**

***Answer ALL Questions. Each Carries 5 mark.***

1. Explain the concept of manoeuvrability in the context of mobile robots.
2. Describe about the tools available for 3D visualization in ROS?
3. What methods can be used to simulate sensor data in ROS?
4. How does ROS support object detection and recognition?
5. Describe the process of map representation in autonomous car navigation.

**PART B**

***Answer any 5 questions: Each question carries 7 marks***

6. Compare and contrast legged robots and wheeled robots in terms of their advantages, disadvantages, and applications.
7. Explain the structure of the ROS file system, detailing the purpose of packages, stacks, messages, and services.
8. Explain the process of developing sensor drivers for various sensors like LIDAR, RADAR, and cameras to interface with ROS nodes.
9. Discuss the mechanisms by which ROS enables real-time processing of sensor data, considering factors such as computational efficiency and message passing.
10. Explore the mechanisms within ROS that facilitate seamless communication between nodes, including topics, publishers, subscribers, and ROS parameter server.
11. Describe techniques for obstacle avoidance in autonomous cars, including reactive methods, predictive methods, and hybrid approaches.
12. Explain the role of data fusion in autonomous car navigation, including sensor fusion techniques and their impact on overall navigation performance.

**Syllabus**

**Module 1: Introduction**:

Types of Mobile Robots – Legged Robots, Gait Analysis, Wheeled Robots, Kinematic models for Mobile Robots, Manoeuvrability, Dynamic Path Planning, Scenario based control, path planning and sensor fusion, Workspace & Motion control, Sensors & Actuators for Mobile Robots, Sizing and Torque Calculations.

**Module2: The ROS Architecture**

Introduction to ROS - ROS Basic Concepts: Nodes, topics, parameters, services - Simple ROS programs to publish and subscribe messages. Understanding the ROS File system level-packages, stack, messages, services. Understanding the ROS community level. Debugging and visualization: debugging nodes and messages, visualisation of images and 3D visualisation.

**Module 3: Sensor Integration**

Integration of various sensors: LIDAR, RADAR, cameras with ROS. Developing sensor drivers and interfacing with ROS nodes. Simulation of sensor data in ROS environment. Processing sensor data using ROS nodes.

**Module 4: Perception in ROS**

Object detection and recognition using ROS. Integration of AI/ML techniques for enhanced perception. Communication Protocols-Understanding communication protocols in ROS, Implementing efficient data exchange between nodes.

**Module 5: Design of Autonomous CAR**

Sensors for Navigation: Camera, GPS, IMU, Lidar, Odometry, Place Recognition, Extraction based on Range Data. Localization: Noise and Aliasing, Belief Representation, Map Representations, Probabilistic Map based localization, Autonomous Map Building. Planning and Reacting, Path Planning, Obstacle Avoidance, Navigation Architectures, Data Fusion.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction** | |
| 1.1 | Types of Mobile Robots – Legged Robots, Gait Analysis | 2 |
| 1.2 | Wheeled Robots, Kinematic models for Mobile Robots, | 2 |
| 1.3 | Manoeuvrability, Dynamic Path Planning, Scenario based control, path planning and sensor fusion | 2 |
| 1.4 | Workspace & Motion control, Sensors & Actuators for Mobile Robots, Sizing and Torque Calculations. | 2 |
| 2 | **The ROS Architecture** | |
| 2.1 | Introduction to ROS - ROS Basic Concepts: Nodes, topics, parameters, services - Simple ROS programs to publish and subscribe messages. | 2 |
| 2.2 | Understanding the ROS File system level-packages, stack, messages, services. | 2 |
| 2.3 | Understanding the ROS community level. | 2 |
| 2.4 | Debugging and visualization: debugging nodes and messages, visualisation of images and 3D visualisation. | 3 |
| 3 | **Sensor Integration** | |
| 3.1 | Integration of various sensors: LIDAR, RADAR, cameras with ROS. | 2 |
| 3.2 | Developing sensor drivers and interfacing with ROS nodes. | 2 |
| 3.3 | Simulation of sensor data in ROS environment. | 2 |
| 3.4 | Processing sensor data using ROS nodes | 1 |
| 4 | **Perception in ROS** | |
| 4.1 | Object detection and recognition using ROS. | 2 |
| 4.2 | Integration of AI/ML techniques for enhanced perception. | 2 |
| 4.3 | Communication Protocols-Understanding communication protocols in ROS | 2 |
| 4.4 | Implementing efficient data exchange between nodes | 2 |
| **5** | **Design of Autonomous CAR** | |
| 5.1 | Sensors for Navigation: Camera, GPS, IMU, Lidar, Odometry, Place Recognition, Extraction based on Range Data. | 2 |
| 5.2 | Localization: Noise and Aliasing, Belief Representation, Map Representations, Probabilistic Map based localization, Autonomous Map Building . | 3 |
| 5.3 | Planning and Reacting, Path Planning, Obstacle Avoidance, Navigation Architectures, Data Fusion. | 3 |

**Textbooks**

1. R. Siegwart and Illah R. Nourbakhsh, “Introduction to Autonomous Mobile Robots”, MIT Press, 2004
2. Jason M. O’Kane, "A Gentle Introduction to ROS" ISBN 978-14-92143-23-9.
3. Aaron Martinez & Enrique,” Learning ROS for Robotics Programming” Fernández, PACKT Publishing.
4. Gerald Cook (2011), Mobile Robots: Navigation, Control and Remote Sensing, Wiley.
5. "ROS Robotics Projects" by Lentin Joseph.

**Reference Books**

1. "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" by Morgan Quigley, Brian Gerkey, and William D. Smart
2. "Mastering ROS for Robotics Programming" by Lentin Joseph.
3. "Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy" by Tanmay Bakshi and Ryan Gill.
4. "ROS by Example: Basics, Volume 1" by R. Patrick Goebel.
5. Carol Fairchild "ROS Robotics by Example"
6. "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" by Morgan Quigley, Brian Gerkey, and William D. Smart.

# SEMESTER II

# INDUSTRY/ INTERDISCIPLINARY ELECTIVE

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC087 | PERCEPTION SYSTEMS | INDUSRTY/ INTERDISCIPLINARY ELECTIVE | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to develop the skill sets required for the industry in the development of advanced automotive perception systems.

**Course Outcomes:**

After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Understand the fundamentals of automotive perception systems |
| **CO 2** | Develop different sensor fusion techniques |
| **CO 3** | Analyze the object detection and tracking techniques and algorithms for advanced driver assistance |
| **CO 4** | Construct various environmental models and decision making methods for autonomous vehicles |
| **CO 5** | Solve the different ethical and regulatory considerations for advanced perception systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 80 |
| Analyse | 20 |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks.

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC087**

**Course Name: Perception Systems**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Explain the basic principles of LiDAR technology and its application in autonomous vehicles

2 Define sensor fusion. Discuss the challenges involved in integrating data from LiDAR, radar, and cameras in autonomous vehicles.

3 Discuss the importance of stereo vision and depth perception in object detection for autonomous vehicles.

4 Define semantic segmentation. How is it utilized for environment modeling in autonomous driving?

5 Briefly explain the ethical and regulatory considerations involved in the deployment of autonomous vehicles.

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Compare and contrast the sensor technologies LiDAR, radar, and cameras used in automotive perception systems. Discuss their advantages and limitations.

7 Explain the principles of Kalman Filters and Extended Kalman Filters. How are they applied in sensor fusion for autonomous vehicles?

8 Compare the performance metrics used to evaluate object detection algorithms like YOLO, SSD, and Faster R-CNN. Which metrics are most relevant for automotive applications?

9 Discuss the role of reinforcement learning in decision-making for autonomous vehicles. Provide examples of its applications in complex driving scenarios.

10 Explain the advancements in 3D perception and point cloud processing technologies. How do these advancements enhance the capabilities of autonomous vehicles?

11 How do sensor fusion techniques aid in overcoming the challenges of data synchronization and calibration in automotive perception systems? Provide examples.

12 Analyze the ethical implications of using AI-based decision-making algorithms in autonomous vehicles. What are the key ethical principles that should guide their development and deployment?

**Syllabus**

**Module 1: Introduction to Automotive Perception Systems**

Overview of Automotive Perception Systems, Sensor technologies LiDAR, radar, cameras, IMU, GPS. Basic principles of perception algorithms. Applications in autonomous vehicles and advanced driver assistance systems (ADAS). Fundamental Concepts in Computer Vision - Image processing techniques, Feature extraction and object recognition, Stereo vision and depth perception.

**Module 2: Sensor Fusion Techniques**

Sensor Fusion, Sensor Data Integration, Principles of sensor fusion, Data synchronization and calibration, Challenges in combining data from different sensors, Kalman Filters and Extended Kalman Filter, Basics of Kalman filtering, Application to sensor fusion in automotive perception, Introduction to Extended Kalman Filters for nonlinear systems

**Module 3: Object Detection and Tracking**

Object Detection Algorithms, Overview of popular object detection algorithms (e.g., YOLO, SSD, Faster R-CNN), Performance metrics and evaluation criteria. Multiple

Object Tracking (MOT), Tracking algorithms and techniques, Handling occlusions and uncertainties in tracking.

**Module 4: Environmental Modeling and Decision Making**

Environmental Modeling, Semantic segmentation for scene understanding, Road and lane detection, Terrain and obstacle modeling. Decision Making in Autonomous Vehicles-Decision trees and rule-based systems, Reinforcement learning for decision-making, Ethical considerations and safety in decision-making algorithms.

**Module 5: Advanced Topics in Perception Systems**

Advanced Topics and Emerging Technologies, 3D perception and point cloud processing, Sensor technologies beyond LiDAR and radar (e.g., thermal imaging, ultrasonics), Ethical and Regulatory Considerations, Legal and ethical aspects of autonomous vehicles, Regulatory standards and compliance.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Automotive Perception Systems** | |
| 1.1 | Overview of Automotive Perception Systems, Sensor technologies LiDAR, radar, cameras, IMU, GPS. | 2 |
| 1.2 | Basic principles of perception algorithms. Applications in autonomous vehicles and advanced driver assistance systems (ADAS) | 2 |
| 1.3 | Fundamental Concepts in Computer Vision-Image processing techniques, Feature extraction and object recognition, Stereo vision and depth perception | 2 |
| 1.4 | Assignment: Research and present a case study on a specific automotive perception system. Implement a simple image processing algorithm using Python or MATLAB. | |
| **2** | **Sensor Fusion Techniques** | |
| 2.1 | Sensor Fusion, Sensor Data Integration, Principles of sensor fusion, Data synchronization and calibration | 2 |
| 2.2 | Challenges in combining data from different sensors, Kalman Filters and Extended Kalman Filter, Basics of Kalman filtering | 2 |
| 2.3 | Application to sensor fusion in automotive perception, Introduction to Extended Kalman Filters for nonlinear systems | 2 |
| 2.4 | Assignment: Develop a sensor fusion algorithm for combining data from LiDAR and radar sensors. Simulate a Kalman filter for tracking the position of multiple objects in a video stream. | |
| **3** | **Object Detection and Tracking** | |

| | | |
|---|---|---|
| 3.1 | Object Detection Algorithms, Overview of popular object detection algorithms (e.g., YOLO, SSD, Faster R-CNN), Performance metrics and evaluation criteria. | 2 |
| 3.2 | Multiple Object Tracking (MOT), Tracking algorithms and techniques, | 2 |
| 3.3 | Handling occlusions and uncertainties in tracking | 2 |
| 3.4 | Assignment: Implement an object detection algorithm using a deep learning framework. Evaluate and compare the performance of multiple object tracking algorithms. | |
| **4** | **Environmental Modeling and Decision Making** | |
| 4.1 | Environmental Modeling, Semantic segmentation for scene understanding, Road and lane detection, Terrain and obstacle modeling | 2 |
| 4.2 | Decision Making in Autonomous Vehicles-Decision trees and rule-based systems | 2 |
| 4.3 | Reinforcement learning for decision-making, Ethical considerations and safety in decision-making algorithms | 2 |
| 4.4 | Assignment: Develop a semantic segmentation model for classifying different objects in a given scene. Implement a basic decision-making algorithm for a simulated autonomous vehicle. | |
| **5** | **Advanced Topics in Perception Systems** | |
| 5.1 | Advanced Topics and Emerging Technologies, 3D perception and point cloud processing, | 2 |
| 5.2 | Sensor technologies beyond LiDAR and radar (e.g., thermal imaging, ultrasonics) | 3 |
| 5.3 | Ethical and Regulatory Considerations, Legal and ethical aspects of autonomous vehicles, Regulatory standards and compliance | 3 |
| 5.4 | Assignment: Explore and present a research paper on a recent advancement in automotive perception. Analyze and discuss the ethical implications of a specific perception system. | |

**Reference Books**


1. "Advanced Topics in Computer Vision" edited by George A. Tsihrintzis and Ioannis Pitas
2. "Autonomous Vehicles: Ethics, Legal and Privacy Issues" by Subhajit Basu
3. "Computer Vision: Algorithms and Applications" by Richard Szeliski
4. "Autonomous Vehicle Technology: A Guide for Policymakers" by James M. Anderson and Nidhi Kalra
5. "Semantic Segmentation and Computer Vision" by Anil Batra
6. "Autonomous Vehicles: Intelligent Transport for Smart Cities" by Kara M. Kockelman
7. "Deep Learning for Computer Vision" by Rajalingappaa Shanmugamani
8. "Multiple Object Tracking: A Literature Review" by Junaid Ahmed and SaeedAnwar


| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 222EEC088 | AUTOMOTIVE DIAGNOSTICS | INDUSRTY/ INTERDISCIPLINARY ELECTIVE | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to develop the skill sets required for the industry in the field of automotive diagnostics.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Understand the fundamentals of automotive diagnostics |
| **CO 2** | Identify the different features of Unified Diagnostic Services |
| **CO 3** | Develop the services and functions related to automotive diagnostics and communication protocols |
| **CO 4** | Identify the different features of Diagnostic Trouble Codes |
| **CO 5** | Apply the functionalities related to the On-Board Diagnostics |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO 2** | 1 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO 3** | 1 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO 4** | 1 | 2 | 3 | 3 | 3 | 2 | 3 |
| **CO 5** | 1 | 2 | 3 | 3 | 3 | 2 | 3 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 100 |
| Analyse | |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks.

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the respective College.

There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module; having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**SECOND SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 222EEC088**

**Course Name: Automotive Diagnostics**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer all questions, each carries 5 marks.***

1 Explain the need for diagnostics in modern vehicles. How do On Board Diagnostics (OBD) systems contribute to vehicle maintenance?

2 Describe the UDS Service ID (SID) and its significance in Unified Diagnostic Services.

3 Describe the Hard Reset and Soft Reset functionalities in ECU reset service according to BS ISO 14229-1:2013. How do they differ in terms of application and impact on the ECU?

4 Define Diagnostic Trouble Codes (DTCs). What is the difference between pending DTCs and confirmed DTCs?

5 Explain the purpose and function of the Routine Control (0x31) service in UDS. How is it used in automotive diagnostics?

**PART B**

***Answer any 5 full questions, each question carries 7 marks.***

6 Compare and contrast the diagnostic protocols KWP2000 and CAN. Discuss their respective advantages and limitations in automotive diagnostics.

7 Describe the Positive Response and Negative Response in UDS. How do these responses ensure reliable communication in diagnostics?

8 Explain the Tester Present (0x3E) service in UDS. Why is it important for maintaining communication between the diagnostic tool and the ECU?

9 Define the terms Pre-failed and Pending DTC as per ISO 15765-3. How do these states impact the interpretation of diagnostic results and subsequent repairs?

10 Explain the Routine Control (0x31) service within the Routine Functional Unit as described in BS ISO 14229-1:2013. What types of routines can be controlled, and how do they enhance vehicle diagnostics?

11 Explain the composition of P-Codes in the OBD-II protocol based on Bosch's "CAN Specification" and ISO 15765-3. How are these codes used in diagnosing vehicle issues?

12 Examine the role of CAN Bus error handling mechanisms. How do these mechanisms contribute to the robustness and reliability of the CAN protocol?

**Syllabus**

**Module 1:**

Introduction to Automotive Diagnostics, Need for Diagnostics in vehicles – On Board Diagnostics – Off Board Diagnostics – Diagnostic Trouble Code (DTC) – Different Diagnostic Protocols – KWP2000 – Diagnostics on CAN Protocol – Unified Diagnostic Services (UDS): ISO 14229-1 – ISO/OSI layer CAN Protocol layers – Diagnostic OSI Model - CAN Message Format – CAN Bus Arbitration Scheme – CAN Control System Resistive Structure – CAN Bus Error Handling – Tools for CAN Protocols – Open Diagnostics Data Exchange (ODX) – Benefits of ODX in Automotive Development Process.

**Module 2:**

UDS Frame format – UDS Service ID (SID) – UDS Sub Function Byte – Data Identifiers (DID) – Service request message – Positive Response – Negative Response – Negative Response Codes (NRCs) – UDS Protocol Addressing Methods – Physical Addressing – Functional Addressing – Diagnostics communication over CAN and other transport protocols.

UDS Diagnostic Functional Units and Service List – Diagnostic and Communication Management functional unit and its Services – Diagnostic Session Control Service(0x10) – Server diagnostic session state diagram – default session – programming session – and extended session.

**Module 3:**

ECU Reset (0x11) Service – Security Access (0x27) Service – UDS security access layer and seed-key mechanism – Communication Control (0x28) Service – Tester Present (0x3E) – Control DTC Settings(0x85) – Data Transmission Functional Unit and its Services – Read Data by Identifier (0x22) service – Write Data by Identifier (0x2E) – Read Memory by Address (0x23) – Write Memory by Address(0x3D)

**Module 4:**

Stored Data Transmission Functional Unit – Clear Diagnostic Information (0x14) – Read DTC Information (0x19) and its subfunctions – DTC Status Mask – DTC Snapshot Data – DTC Extended Data – Terminologies associated with DTC: Test Pass – Test Fail – Pre-failed – Pending DTC – Confirmed DTC – DTC Aging – Interpretation of Diagnostic Trouble Codes (DTCs) and diagnostic information.

**Module 5:**

Routine Functional Unit: Routine Control (0x31) – Upload/Download Functional Unit and its services – Request Download(0x34) – Request Upload (0x35) – Transfer data (0x36) – Request Transfer Exit (0x37).

Overview of the On-Board Diagnostics – Second Generation (OBD-II) protocol – P-Code Composition – OBD-II Connector Pin Configuration.

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | | |
| 1.1 | Introduction to Automotive Diagnostics, Need for Diagnostics in vehicles – On Board Diagnostics – Off Board Diagnostics | 2 |
| 1.2 | Diagnostic Trouble Code (DTC) – Different Diagnostic Protocols – KWP2000 – Diagnostics on CAN Protocol – Unified Diagnostic Services (UDS): ISO 14229-1 – ISO/OSI layer | 2 |
| 1.3 | CAN Protocol layers – Diagnostic OSI Model – CAN Message Format – CAN Bus Arbitration Scheme | 2 |
| 1.4 | CAN Control System Resistive Structure – CAN Bus Error Handling – Tools for CAN Protocols | 1 |
| 1.5 | Open Diagnostics Data Exchange (ODX) – Benefits of ODX in Automotive Development Process. | 1 |
| **2** | | |
| 2.1 | UDS Frame format – UDS Service ID (SID) – UDS Sub Function Byte – Data Identifiers (DID) – Service request message – Positive Response – Negative Response – Negative Response Codes (NRCs) | 2 |

| | | |
|---|---|---|
| 2.2 | UDS Protocol Addressing Methods – Physical Addressing – Functional Addressing – Diagnostics communication over CAN and other transport protocols. | 2 |
| 2.3 | UDS Diagnostic Functional Units and Service List – Diagnostic and Communication Management functional unit and its Services | 2 |
| 2.4 | Diagnostic Session Control Service(0x10) – Server diagnostic session state diagram – default session – programming session – and extended session. | 3 |
| 3 | | |
| 3.1 | ECU Reset (0x11) Service – Security Access (0x27) Service – UDS security access layer and seed-key mechanism | 2 |
| 3.2 | Communication Control (0x28) Service – Tester Present (0x3E) – Control DTC Settings(0x85) | 2 |
| 3.3 | Data Transmission Functional Unit and its Services – Read Data by Identifier (0x22) service – Write Data by Identifier (0x2E) | 2 |
| 3.4 | Read Memory by Address (0x23) – Write Memory by Address(0x3D) | 2 |
| **4** | | |
| 4.1 | Stored Data Transmission Functional Unit – Clear Diagnostic Information (0x14) – Read DTC Information (0x19) and its subfunctions | 2 |
| 4.2 | DTC Status Mask – DTC Snapshot Data – DTC Extended Data – Terminologies associated with DTC: Test Pass – Test Fail – Pre-failed | 3 |
| 4.3 | Pending DTC – Confirmed DTC – DTC Aging – Interpretation of Diagnostic Trouble Codes (DTCs) and diagnostic information | 2 |
| **5** | | |
| 5.1 | Routine Functional Unit: Routine Control (0x31) – Upload/Download Functional Unit and its services | 2 |
| 5.2 | Request Download(0x34) – Request Upload (0x35) – Transfer data (0x36) – Request Transfer Exit (0x37) | 2 |
| 5.3 | Overview of the On-Board Diagnostics – Second Generation (OBD-II) protocol – P-Code Composition – OBD-II Connector Pin Configuration. | 3 |

**Reference Books**


1. BS ISO 14229-1:2013 “Road vehicles – Unified diagnostic services (UDS). Part 1: Specification and requirements”
2. Bosch. “CAN Specification”, Version 2.0, Robert Bosch GmbH, 1991.
3. ISO 15765-3 – “Road vehicles – Diagnostics on CAN – Part 3: Implementation of diagnostic services”


4. ISO 15765-2 – “Road vehicles – Diagnostics on CAN – Part 2: Network layer services”
5. ISO 14230-1: 1999 – “Road vehicle – Diagnostics Systems – Keyword Protocol 2000Part 1: Physical layer”
6. ISO 14230-2: 1999 – “Road vehicles – Diagnostics Systems – Keyword Protocol 2000 Part 2: Data link layer”
7. ISO 14230-3: 1999 – “Road vehicles – Diagnostics Systems – Keyword Protocol 2000Part 3: Application layer”
8. ISO 22901-1: 2008 “Road vehicles – Open diagnostic data exchange (ODX) – Part 1: Data model specification”
9. Vector: “Introduction to CAN” [Website], http://elearning.vector.com/index.php?&wbt_ls_seite_id=489557&root=378422&seite=vl_can_introduction_en

# SEMESTER III

**Discipline: ELECTRONICS AND COMMUNICATION**

**Stream : ECx (Automotive Electronics)**

(with Industry collaboration – Tata Elxsi)

## MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but

shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

# SEMESTER III

## AUDIT COURSE

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 223AGE013 | ASPICE AND FUNCTIONAL SAFETY | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** This course is designed to provide students a thorough understanding of safety standards in the automotive industry.

**Course Outcomes:** The Cos shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Apply the theoretical knowledge of functional safety standards to assess and solve contemporary challenges in automotive safety. |
| **CO 2** | Build advanced verification techniques to evaluate and ensure the reliability of safety-related hardware components in accordance with Part 5 of ISO 26262. |
| **CO 3** | Apply automotive safety integrity levels allocation principles to devise and construct software for safety-critical automotive systems, aligning with the guidelines in Part 6 of ISO 26262. |
| **CO 4** | Develop the Automotive SPICE framework, process attributes, and base practices to enhance software development processes, ensuring compliance with automotive industry standards. |
| **CO 5** | Apply Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) techniques to systematically identify and address safety vulnerabilities in automotive systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 1 | 3 | 2 | 2 | 3 |
| **CO 2** | 2 | 2 | 1 | 3 | 2 | 2 | 3 |
| **CO 3** | 2 | 2 | 1 | 3 | 2 | 2 | 3 |
| **CO 4** | 2 | 2 | 1 | 3 | 2 | 2 | 3 |
| **CO 5** | 2 | 2 | 1 | 3 | 2 | 2 | 3 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 100 |
| Analyse | |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies) :15marks

Seminar/Quiz :15marks

Test paper :10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**THIRD SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 223AGE013**

**Course Name: ASPICE and Functional Safety**

**Max. Marks: 60** **Duration: 2.5 Hours**

***Answer any 5 questions, each question carries 12 marks.***

1. Define safety goals and ASIL levels. How are they determined and why are they essential in automotive functional safety?
2. Explain the role of hardware design and reliability analysis in achieving functional safety. Provide a detailed example.
3. Describe the key steps involved in the verification and validation of safety-related software.
4. Explain the role of process attributes, base practices, and work products in the ASPICE framework.
5. How does the ASPICE framework aid in managing the software development lifecycle? Discuss with relevant examples.
6. Compare and contrast Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA). Provide examples of scenarios where each method would be appropriately applied.
7. Provide an overview of the various parts of ISO 26262:2018 and discuss their relevance to functional safety in automotive systems.

## Syllabus

### Module 1: Automotive Functional Safety Introduction

- Overview of ISO 26262:2018 and its significance in automotive safety.
  i. History and evolution of functional safety standards.
  ii. Understanding the safety lifecycle and its relevance
- Safety lifecycle, Hazard Analysis, and Risk Assessment (HARA)
- Safety goals, ASIL levels, and safety requirements.
- Functional Safety Concepts, Technical Safety Concepts

### Module 2: Hardware Safety (Part 5 of ISO 26262)

- Hardware safety requirements.
- Hardware design and reliability analysis.
- Verification techniques for safety-related hardware.

### Module 3: Software Safety (Part 6 of ISO 26262)

- Software safety requirements and ASIL allocation.
- Software design for safety-critical systems.
- Verification and validation of safety-related software.

### Module 4: Automotive SPICE (ASPICE) Basics

- Automotive Process Landscape
- Legislation and Regulations, Standards for Automotive
- Product Lifecycle Management
- Understanding Automotive SPICE framework
- Process attributes, base practices, and work products.
- Software development processes with ASPICE
- Continuous Improvement

### Module 5: Safety Analysis Techniques and Process

- Failure Modes and Effects Analysis (FMEA).
- Fault Tree Analysis (FTA).
- Walkthrough of other parts of ISO26262:2018

## Course Plan

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Automotive Functional Safety Introduction** | |
| 1.1 | Overview of ISO 26262:2018 and its significance in automotive safety. History and evolution of functional safety standards. Understanding the safety lifecycle and its relevance | 2 |
| 1.2 | Safety lifecycle, Hazard Analysis, and Risk Assessment (HARA) | 2 |
| 1.3 | Safety goals, ASIL levels, and safety requirements. | 2 |
| 1.4 | Functional Safety Concepts, Technical Safety Concepts | 2 |
| 2 | **Hardware Safety (Part 5 of ISO 26262)** | |

| | | |
|---|---|---|
| 2.1 | Hardware safety requirements. | 2 |
| 2.2 | Hardware design and reliability analysis. | 3 |
| 2.3 | Verification techniques for safety-related hardware | 3 |
| 3 | **Software Safety (Part 6 of ISO 26262)** | |
| 3.1 | Software safety requirements and ASIL allocation. | 3 |
| 3.2 | Software design for safety-critical systems. | 3 |
| 3.3 | Verification and validation of safety-related software. | 3 |
| 4 | **Automotive SPICE (ASPICE) Basics** | |
| 4.1 | Automotive Process Landscape, Legislation and Regulations, Standards for Automotive | 2 |
| 4.2 | Product Lifecycle Management, Understanding Automotive SPICE framework, Process attributes, base practices, and work products. | 3 |
| 4.3 | Software development processes with ASPICE, Continuous Improvement | 2 |
| **5** | **Safety Analysis Techniques and Process** | |
| 5.1 | Failure Modes and Effects Analysis (FMEA) | 2 |
| 5.2 | Fault Tree Analysis (FTA) | 3 |
| 5.3 | Walkthrough of other parts of ISO26262:2018 | 3 |

**Reference Books**


1. "ISO 26262: A Practical Handbook" by David Ward and Andrew BanksBosch. “CAN Specification”, Version 2.0, Robert Bosch GmbH, 1991.
2. "ISO 26262: Road vehicles – Functional safety" (ISO Standard)
3. "Systematic Development of Reliable Computing Systems" by Hermann Kopetz.
4. "Software Engineering for Embedded Systems: Methods, Practical Techniques, and Applications" by Robert Oshana
5. "Automotive SPICE in Practice: Surviving Implementation and Assessment" by Jürgen Kaufmann and Oliver Laitenberger
6. "Automotive SPICE: Process Assessment Model for the Automotive Industry" by Automotive SIG
7. "Effective FMEAs: Achieving Safe, Reliable, and Economical Products and Processes using Failure Mode and Effects Analysis" by Carl Carlson
8. "Fault Tree Analysis: A History" by William Vesely

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 223AGE014 | AUTOSAR | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** This course is designed to provide students a holistic understanding of automotive software, its architecture, and the pivotal role of AUTOSAR in shaping the future of in-vehicle computing. The course gives an overview of software development life cycles specific to the automotive industry, the need for standardized architectures, and the transformative impact of AUTOSAR on modern vehicle electronics.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 Cos. After the completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Explain the significance of standardized software architecture in the automotive industry and identify challenges in non-standardized legacy architectures. |
| **CO 2** | Identify the layered architecture of AUTOSAR, evaluating the functionalities of each layer and their impact on system design. |
| **CO 3** | Apply the fundamentals for AUTOSAR development and integration flow of AUTOSAR software. |
| **CO 4** | Evaluate the design and functionality of software components and compositions in AUTOSAR, validating their performance against specified requirements. |
| **CO 5** | Apply AUTOSAR concepts to implement solutions in real ECU networks, addressing use cases and challenges through practical application. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | 2 | 2 | 3 | 2 | 2 | 2 |
| **CO 2** | 1 | 2 | 2 | 3 | 2 | 2 | 2 |
| **CO 3** | 1 | 2 | 2 | 3 | 2 | 2 | 2 |
| **CO 4** | 1 | 2 | 2 | 3 | 2 | 2 | 2 |
| **CO 5** | 1 | 2 | 2 | 3 | 2 | 2 | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination % |
|---|---|
| Apply | 100 |
| Analyse | |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies) :15marks

Seminar/Quiz :15marks

Test paper :10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**THIRD SEMESTER M.TECH DEGREE EXAMINATION**

**Stream: M.Tech in Automotive Electronics**

**Course Code: 223AGE014**

**Course Name: AUTOSAR**

**Max. Marks: 60** **Duration: 2.5 Hours**

***Answer any 5 questions, each question carries 12 marks.***

1. Discuss the software development life cycle in the context of automotive software and ECU software architecture. Why is each phase important?
2. Explain the Autosar methodology and templates, and how they contribute to the standardization of automotive software development.
3. Describe the development, configuration, and integration flow of Autosar software. How do static and generated files fit into this process? Analyze their roles.
4. Evaluate the leading tool chains used in Autosar. Discuss their roles and importance in the development process. What are the advantages and disadvantages of these tools?
5. Explain the Run Time Environment (RTE) in Autosar ASW. How does it facilitate communication between software components?
6. Discuss the fundamentals of the Communication stack in Autosar BSW. Why is it essential for automotive software? Analyze its components and functionality.

7. Design a use case where Complex Device Drivers in Autosar BSW are implemented. Provide examples of their implementation and describe their role in the ECU network.

**Syllabus**

**Module 1: Introduction to Automotive Software and Autosar**

- Basics of Automotive Software and ECU Software architecture
- Software Development life cycle
- Need for standardized software architecture
- Why Autosar?
- Conventional software (Legacy) Architecture Vs AUTOSAR Architecture
- Autosar consortium – Members and Partners

**Module 2: Autosar Architecture**

- Autosar Layered Architecture
- Autosar Methodology and Templates
- Virtual Function Bus
- Inter ECU and Intra ECU Communication
- Autosar Application Interfaces

**Module 3: Autosar Methodology**

- What are the various chapters and structures of SRS document
- Pre-compile, Link-time and Post-Build Time configurations
- Autosar Methodology Overview - Static and Generated Files
- Application Interfaces
- Development, Configuration and Integration Flow of Autosar Software
- Role and use of a configuration tool
- Leading Tool Chains used in Autosar

**Module 4: Autosar ASW**

- Software components and compositions
- Ports, Interfaces and Connectors
- Run Time Environment

**Module 5: Autosar BSW**

- Introduction to MCAL IO Hardware abstraction: ADC, DIO, MCU, PORT, PWM
- Memory Mapping
- Memory Abstraction - EEPROM, Flash, RAM, NVM
- System Services – RTOS fundamentals
- Fundamentals of Communication stack and Diagnostics stack

- Introduction to Complex Device Drivers
- Introduction to Autosar Adaptive
- Implementation in ECU Network (Use Cases)

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Automotive Software and Autosar** | |
| 1.1 | Basics of Automotive Software and ECU Software architecture, Software Development life cycle | 2 |
| 1.2 | Need for standardized software architecture, Why Autosar? | 2 |
| 1.3 | Conventional software (Legacy) Architecture Vs AUTOSAR Architecture, Autosar consortium – Members and Partners | 3 |
| 2 | **Autosar Architecture** | |
| 2.1 | Autosar Layered Architecture, Autosar Methodology and Templates | 3 |
| 2.2 | Virtual Function Bus, Inter ECU and Intra ECU Communication | 2 |
| 2.3 | Autosar Application Interfaces | 2 |
| 3 | **Autosar Methodology** | |
| 3.1 | What are the various chapters and structures of SRS document, Pre-compile, Link-time and Post-Build Time configurations, | 3 |
| 3.2 | Autosar Methodology Overview - Static and Generated Files, Application Interfaces, Development | 2 |
| 3.3 | Configuration and Integration Flow of Autosar Software, Role and use of a configuration tool, Leading Tool Chains used in Autosar | 3 |
| 4 | **Autosar ASW** | |
| 4.1 | Software components and compositions | 3 |
| 4.2 | Ports, Interfaces and Connectors | 2 |
| 4.3 | Run Time Environment | 2 |
| **5** | **Autosar BSW** | |
| 5.1 | Introduction to MCAL IO Hardware abstraction: ADC, DIO, MCU, PORT, PWM | 2 |
| 5.2 | Memory Mapping, Memory Abstraction - EEPROM, Flash, RAM, NVM, System Services – RTOS fundamentals | 3 |
| 5.3 | Fundamentals of Communication stack and Diagnostics stack | 3 |

| | | |
|---|---|---|
| 5.4 | Introduction to Complex Device Drivers, Introduction to Autosar Adaptive, Implementation in ECU Network (Use Cases) | 3 |

**Reference Books**


1. "Automotive Software Engineering" by Joerg Schauff and Tilo Noack.
2. "AUTOSAR Compendium" by Markus Kucera
3. "AUTOSAR: Architecture and Automotive Software" by Volker Scheible and Armin Happel
4. "AUTOSAR: ECU Development Process Using Generic Modules" by Ali M. Shaban
5. "Automotive Embedded Systems Development: Basics of AUTOSAR" by M. J. Usher, C. K. Jones
6. "AUTOSAR: Software Layered Architecture" by G. N. Srinivasa Prasad
7. "AUTOSAR: Basic Software Modules (BSW)" by S. V. Subrahmanyam


| CODE 223AGE100 | ACADEMIC WRITING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | NIL |

**Preamble:** Learning academic writing sharpens minds, teaches students how to communicate, and develops their thinking capacities and ability to understand others. Writing is thinking, and every student deserves to be a strong thinker. It can also make them think more carefully about what they write. Showing work to others can help to foster a better culture of learning and sharing among students. It also gives students a sense of how they are contributing to the body of work that makes up an academic subject.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Understand the principles of scientific/ academic writing |
| **CO 2** | Analyse the technique of scientific writing from the reader's perspective |
| **CO 3** | Apply the concepts of setting expectations and laying the progression tracks |
| **CO 4** | Evaluate the merits of a title, abstract , introduction, conclusion and structuring of aresearch paper |
| **CO 5** | Justify the need using a project proposal or a technical report |
| **CO 6** | Prepare a review paper, an extended abstract and a project proposal |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | | 3 | 1 | | | | |
| **CO 2** | | 3 | 1 | | | | |
| **CO 3** | | 3 | 1 | | | 2 | |
| **CO 4** | | 3 | 1 | | | | |
| **CO 5** | | 3 | 2 | 2 | | 2 | |
| **CO 6** | 1 | 3 | 3 | 2 | | 2 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 40% |

| | |
|---|---|
| Analyse | 30% |
| Evaluate | 30% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:** 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module ofwhich student should answer any Vive. Each question can carry 12 marks.

**Model Question paper**

| | | | |
|---|---|---|---|
| | | **SET1** | **Total Pages:** |
| Reg No.:_____ | | Name:_____ | |
| **APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**<br>THIRD SEMESTER M.TECH DEGREE EXAMINATION | | | |
| **Course Code: 223AGE100** | | | |
| **Course Name: Academic Writing** | | | |
| Max. Marks: 60 | | Duration: 2.5 Hours | |
| ***Answer any five full questions, each carries 12 marks.*** | | | |
| 1 a) | Make clear-cut distinctions between 6 factors that take their toll on readers'<br>memory. | | 6 |
| 1 b) | How can you sustain the attention of the reader to ensure continuous reading? | | 6 |
| 2 a) | What are the different methods by which you can create expectations in the<br>reader? | | 6 |
| 2 b) | Give an account of the topic and non-topic based progression schemes. | | 6 |

| | | |
|---|---|---|
| 3 a) | Bring out the differences between an abstract and the introduction of a research paper. | 8 |
| 3 b) | How are the title of the research paper and its structure related? | 4 |
| 4 | What are 7 principles for including visuals in your research paper. What are the recommended constituents of a conclusion segment of a research paper? | 12 |
| 5 | Give a detailed description of the process and contents of a project proposal for funding. | 12 |
| 6 a) | What are the contexts recommended for choosing between active and passive voices in technical writing? | 8 |
| 6 b) | What are the different visual forms that are relevant in a research paper and how do you choose them? | 4 |
| 7 | Give the design of a research paper with the purposes each part serves. | 12 |
| | **** | |

**Syllabus and Course Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

**Syllabus:**

| **CODE** 223AEC003 | **ACADEMIC WRITING** | **Audit** |
|---|---|---|
| Module No. | Topics in a module | Hours |
| 1 | Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences : all that take their toll on readers' memory. | 6 |
| 2 | Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption | 6 |
| 3 | How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings | 6 |
| 4 | Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing | 6 |

| | | |
|---|---|---|
| 5 | Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report. | 6 |

**Course Plan:**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences all take their toll on readers' memory. | |
| 1.1 | The Reading tool-kit to reduce memory required; reduce reading time | 1 |
| 1.2 | Acronyms, Pronouns, Synonyms; Background, broken couple, words overflow | 1 |
| 1.3 | Sustain attention: Keep the story moving forward; Twists, shouts, Pause to clarify, recreate suspense | 2 |
| 1.4 | Keep the reader motivated: Fuel and meet Expectations; Bridge knowledge gap: ground level; Title words; Just In Time to local background | 2 |
| 2 | Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption | |
| 2.1 | Setting expectations of the reader from Grammar, from theme | 1 |
| 2.2 | Progression tracks for fluid reading: Topic & stress; topic and non topic based progression tracks; pause in progression | 2 |
| 2.3 | Detection of sentence fluidity problems: No expectations/ Betrayed expectations | 2 |
| 2.4 | Controlling reading energy consumption: the energy bill; Energy fuelling stations: Pause | 1 |
| 3 | How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings | |
| 3.1 | Title: Face of the paper: Techniques, Qualities & Purpose of title; Metrics | 1 |
| 3.2 | Abstract: Heart of the paper: 4 parts; coherence; tense of verbs, precision; purpose & qualities of the abstract; Metrics | 2 |
| 3.3 | Structure: Headings & sub-headings: Skeleton of the paper: principles for a good structure; Syntactic rules; Quality & Purpose of structures; Metrics | 1 |
| 3.4 | Introduction: Hands of the paper: Start, finish; scope, definitions; answers key reader questions; As a personal active story; Traps, qualities; Metrics | 2 |
| 4 | Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing | |

| | | |
|---|---|---|
| 4.1 | Visuals as the voice of your paper: principles; purpose & qualities ofvisuals; metrics | 2 |
| 4.2 | Conclusion: contents; purpose, quality; metrics; Abstracts Vs. Conclusion; examples, counter-examples | 1 |
| 4.3 | References, Bibliography: Styles, punctuation marks, quotes, citations | 1 |
| 4.4 | Grammar in Technical writing: Articles, Syntax, Main and subordinateclauses; Active & passive voices; some commonly made mistakes in technical writing. | 2 |
| 5 | Techniques of writing: An extended abstract, a project proposal, a research paper, atechnical report. | |
| 5.1 | Extended abstract: abstract and keywords, introduction and objective,method, findings and argument, conclusion and suggestions and references. | 1 |
| 5.2 | Project Proposal:Types, executive summary, background includingstatus, objectives, solution, milestones, deliverables, timelines, resources, budgeting, conclusion | 2 |
| 5.3 | Research paper: writing an overview article: provide a comprehensive foundation on a topic; explain the current state of knowledge; identify gaps in existing studies for potential future research; highlight the mainmethodologies and research techniques | 2 |
| 5.4 | Writing Technical Reports: Title page; Summary; Table of contents;Introduction; Body; Figures, tables, equations and formulae; Conclusion; Recommendations. | 1 |
| | | 30 |

**Reference Books**


1. SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide: Jean-Luc Lebrun, World ScientiVic Publishing Co. Pte. Ltd., 2011

2. How to Writeand Publisha ScientiVic Paper: Barbara Gastel and Robert A. Day, Greenwood publishers, 2016

3. Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors.
   www.sti.nasa.gov/publish/sp7084.pdf
   www.sti.nasa.gov/sp7084/contents.html

4. Everything You Wanted to Know About Making Tables and Figures. http://abacus.bates.edu/%7Eganderso/biology/resources/writing/HTWtableVigs.html


| 223AGE001 | ADVANCED ENGINEERING MATERIALS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** This course is designed in a way to provide a general view on typically used advanced classes of engineering materials including metals, polymers, ceramics, and composites.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse the requirement and find appropriate solution for use of materials. |
| **CO 2** | Differentiate the properties of polymers, ceramics and composite materials. |
| **CO 3** | Recognize basic concepts and properties of functional materials. |
| **CO 4** | Comprehend smart and shape memory materials for various applications. |
| **CO 5** | Appraise materials used for high temperature, energy production and storageapplications. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | ✓ | | | | ✓ | ✓ | |
| **CO 2** | ✓ | | | | ✓ | ✓ | |
| **CO 3** | ✓ | | | | ✓ | ✓ | |
| **CO 4** | ✓ | | | | ✓ | ✓ | |
| **CO 5** | ✓ | | | | ✓ | ✓ | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 60% |
| Apply | 20% |
| Analyse | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task :
15 marks
Seminar/Quiz : 15
marks
Test paper, 1 no. : 10
marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:** 60 marks

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. Each question can carry 12 marks.

**Model Question paper**

AUDIT COURSE

**223AGE001 - ADVANCED ENGINEERING MATERIALS**

**(Answer any five questions. Each question carries 12 Marks)**

| | | |
|---|---|---|
| **1.** | a) State the relationship between material selection and processing. | **5** |
| | b) Write about the criteria for selection of materials with respect to the cost and service requirements for engineering applications. | **7** |
| **2.** | a) Differentiate thermosetting and thermoplastics with suitable examples. | **5** |
| | b) Briefly discuss about the properties and applications of polymer nano composite materials. | **7** |
| **3.** | a) Write about the potential application areas of functionally graded b materials. | **5** |
| | b) With a neat sketch describe any one processing technique of functionally graded materials. | **7** |
| **4.** | a) “Smart materials are functional”? Justify the statement. | **5** |
| | b) Explain the terms electrostriction and magnetostriction with its application. | **7** |

| | | |
|---|---|---|
| **5.** | a) What are the factors influencing functional life of components at elevated temperature? | **5** |
| | b) What are super alloys and what are their advantages? | **7** |
| **6** | a) What is a shape memory alloy? What metals exhibit shape memory characteristics? | **4** |
| | b) Explain about the detection capabilities and uses of pyroelectric sensors. | **8** |
| **7** | a) Differentiate between conventional batteries and fuel cells. | **4** |
| | b) Explain the construction and working of a Li-ion battery. | **8** |

**Syllabus**

| Module | Content | Hours | Semester Exam Marks (%) |
|---|---|---|---|
| **I** | Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing. | **5** | **20** |
| **II** | Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications.<br>Nano Composites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications. | **7** | **20** |
| **III** | Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs. | **6** | **20** |
| **IV** | Smart Materials: Introduction, smart material types –pyroelectric sensors, piezoelectric materials, electrostrictors and magnetostrictors, shape memory alloys – associated energy stimulus and response forms, applications. | **5** | **20** |
| **V** | High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications.<br>Energy Materials: materials for batteries. | **7** | **20** |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Selection of materials for engineering applications** | |
| 1.1 | Benefits of advanced materials, classification of materials,importance of materials selection | 2 |
| 1.2 | Selection of materials for different properties, strength,toughness, fatigue and creep | 1 |
| 1.3 | Selection for surface durability, corrosion and wear resistance | 1 |
| 1.4 | Relationship between materials selection and processing | 1 |
| **2** | **Classification of non-metallic materials & nano composites** | |
| 2.1 | Rubber: properties, processing and applications. | 1 |
| 2.2 | Plastics: thermosetting and thermoplastics, applications and properties. | 2 |
| 2.3 | Ceramics: properties and applications. | 1 |
| 2.4 | Introduction to nano composites, classification | 1 |
| 2.5 | Processing and characterisation techniques applicable topolymer nanocomposites. | 2 |
| **3** | **Functionally graded materials** | |
| 3.1 | General concept, Potential Applications of FGMs | 2 |
| 3.2 | Classification of FGMs | 1 |
| 3.3 | FGMs processing techniques: powder metallurgy route, melt-processing route | 2 |
| 3.4 | Limitations of FGMs | 1 |
| **4** | **Smart materials** | |
| 4.1 | Introduction to smart materials, types | 1 |
| 4.2 | Pyroelectric sensors-material class, stimulus, detectioncapabilities and uses | 1 |
| 4.3 | Piezoelectric materials- material class, stimulus, sensing andactuating applications | 1 |
| 4.4 | Electrostrictors and magnetostrictors - material class, stimulus,micro positioning capabilities and applications | 1 |
| 4.5 | Shape memory alloys (SMAs) - material class, stimulus, temperature sensing and high strain responses, applications. | 1 |
| **5** | **High Temperature Materials and Energy Materials** | |
| 5.1 | Characteristics of high-temperature materials, superalloys ashigh-temperature materials | 1 |
| | superalloys - properties and applications | 2 |

| | | |
|---|---|---|
| 5.2 | Introduction to lithium-ion battery (LIBs), operating mechanisms and applications | 2 |
| 5.3 | Introduction to Zn-based battery system, types and existingchallenges | 2 |

**Reference Books**


1. DeGarmo et al, “Materials and Processes in Manufacturing”, 10th Edition, Wiley, 2008.
2. R.E. Smallman and A.H.W. Ngan, Physical Metallurgy and Advanced Materials,Seventh Edition, Butterworth-Heinemann, 2007
3. Vijayamohanan K. Pillai and Meera Parthasarathy, “Functional Materials: A chemist’sperspective”, Universities Press Hyderabad (2012).
4. M.V. Gandhi, B.S. Thompson: Smart Materials and Structures, Chapman & Hall, 1992.
5. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
6. Inderjit Chopra, Jayant Sirohi, “Smart Structures Theory”, Cambridge University Press,2013

| 223AGE002 | FORENSIC ENGINEERING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Audit Course | 3 | 0 | 0 | - |

**Preamble:** This course explores various aspects of Forensic Engineering and different methods, tools and procedures used by Engineers to investigate and analyze. The students will learn to develop their awareness in Forensic Engineering.

**Pre-requisite:** Nil

**Course Outcomes:**

After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify the fundamental aspects of forensic Engineering |
| **CO 2** | Apply forensic Engineering in Practical work flow and Investigation |
| **CO 3** | Apply methods and analysis in Forensic Investigation |
| **CO 4** | Develop practical strategies and standards of Investigation |
| **CO 5** | Create an awareness in criminal cases and create Engineering expertise in courtroom on forensic Engineering |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 3 | 3 | 3 | 3 | |
| **CO 2** | 2 | 2 | 3 | 3 | 3 | 3 | 1 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | 3 | |

**Assessment Pattern**

| Bloom's Category | Continuous Internal Evaluation | End Semester Examination |
|---|---|---|
| Apply | 40 % | 60 % |
| Analyse | 40 % | 40 % |
| Evaluate | 20 % | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation: 40 marks**

Course based task :15marks

Seminar/Quizz :15marks

Test paper :10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutesand will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**THIRD SEMESTER M. TECH DEGREE EXAMINATION**

**Course Code: 223AGE002**

**Course Name: FORENSIC ENGINEERING**

**Max. Marks: 60** **Duration: 2.5 Hours**

**PART A**

***Answer any 5 questions, each question carries 12 marks.***

**Marks**

| | | | |
|---|---|---|---|
| 1. | (a) | What are the uses of forensic engineering in legal laws ? | (7) |
| | (b) | Discuss the professional responsibility of a forensic Engineer . | (5) |
| 2. | (a) | What are the steps in preliminary on site Investigation ? | (7) |
| | (b) | With suitable examples, explain photo cataloguing? | (5) |
| 3. | (a) | Discuss STEP method . | (7) |
| | (b) | Explain root cause Analysis | (5) |
| 4. | (a) | Detail about EDAX Method. | (7) |
| | (b) | Enlist the uses of NDT in forensic Analysis with example | (5) |
| 5. | (a) | Differentiate NFPA & FMV Standards | (7) |
| | (b) | Briefly discuss the term Email Phishing ? | (5) |
| 6 | | Define the responsibility and duty of a forensic expert in the court. | (12) |
| 7 | | Explain Forensic Engineering workflow with examples | (12) |

**Syllabus and Course Plan**

| Module No | Topic | No. of Lectures (Hours) |
|---|---|---|
| **1** | **Module 01: Introduction to Forensic Engineering (6 Hours)** | |
| 1.1 | Forensic Engineering-Definition, Investigation Pyramid, Eyewitness Information, Role in Legal System | 2 |
| 1.2 | Scientific Method-Applying scientific methods in Forensic Engineering-Engineer as expert Witness-Scientific methods and legal system | 2 |
| 1.3 | Qualification of Forensic Engineer-Technical- Knowledge- Oral-written-Communication- other skills-Personality Characteristics | 1 |
| 1.4 | Ethics and professional responsibilities. | 1 |
| **2** | **Module 02: Forensic Engineering Workflow and Investigation Methods(6 Hours)** | |
| 2.1 | Forensic Engineering Workflow-Team &planning-preliminary onsite investigation. Sampling-selection of sample-collection-packing-sealing of samples. | 2 |
| 2.2 | Source and type of evidence - Paper documentation-digitaldocumentation-electronic data. Physical Evidence-Collection ofphotograph-cataloguing -Recognizing the Evidence-organizing- Evidence Analysis -Reporting | 2 |
| 2.3 | Investigation Methods- Cause and Causal mechanism analysis-Time andevent sequence-STEP method. Human Factors, Human errors - Analysisof Operative Instruction and working Procedures | 2 |
| **3** | **Module 03: Physical Product Failure & Analytical Methods (6 Hours)** | |
| 3.1 | Introduction to typical Forensic Engineering Tool box-NDT, Crackdetection and human eye -Hardness testing- and Destructive testing Methods with case studies | 2 |
| 3.2 | Indirect stress strain Analysis-Brittle lacquer technique, ContactRadiography-Metallography-EDAX method | 1 |
| 3.3 | Forensic Optical Microscopy-Examination- Magnification-USBMicroscopy -Wifi Enabled microscopy -Reflected microscopy | 2 |
| 3.4 | Novel Tools and System -Contour Method-Flash Thermography-Thermographic signal reconstruction (TSR)-Electromagnetically inducedacoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only | 1 |
| **4** | **Module 04: Cyber Forensic , Civil ,Electrical Accidents & Standards (6 Hours)** | |
| 4.1 | Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics with Email Crimes-Cyber Laws | 3 |

| | | |
|---|---|---|
| 4.2 | Different types of Forensic accident investigations- Civil Engineering-Structural- Road accidents -Fire accidents - Water related accidents- Electrical accidents and Investigation methods | 2 |
| 4.3 | Protocol for forensic Investigations-Standard guides-scope significance -use -procedures- reports. Standards – ASTM standards -FMV Standards -SAE Standards -Relevant Standards -NFPA Standards -International Standards | 1 |
| **5** | **Module 05: Engineer in the Court room& Criminal Cases (6 Hours)** | |
| 5.1 | Role of an Engineering Expert-Report-pre trial meetings-Alternativedispute resolution-Single joint expert. Engineer in the court room | 2 |
| 5.2 | Criminal Cases-Introduction-Counterfeitcoins-fraudulent roadaccidents-Fraudulent Insurance claims. | 2 |
| 5.3 | Cyber Crimes and Cases- SIM Swapping -ATM Cloning-Microsoft Internal Spam- Intellectual property cases. | 2 |

**Reference Books**


1. Colin R Gagg, *Forensic EngineeringThe Art &Craft of a failure detective* , Taylor & FrancisPublishing, 2020
2. Luca Fiorentini ,Luca Marmo *Principles of Forensic Engineering Applied to IndustrialAccidents* , Wiley, 2019
3. Harold Franck, Darren Franck , *Forensic Engineering Fundamentals* ,Taylor &Francis publishing 2013
4. Randall K Noon , *Forensic Engineering Investigation*, CRC press limited , 2001
5. Stephen E Petty , *Forensic Engineering: Damage assessment for residential andcommercial structures* CRC press 2nd edition , 2017
6. Joshua B Kardon , *Guideliness for forensic Engineering practice* , ASCE, 2012
7. Richard W. Mclay and Robert N. Anderson, *Engineering standards for forensicApplications* , Academic Press; 1st edition 2018
8. Max M Houck ,*Forensic Engineering (Advanced forensic Science ),* Academic press 1stedition 2017
9. Niranjan Reddy - Practical Cyber Forensics. *An Incident-based Approach to ForensicInvestigations-Apress (2019)*
10. Peter Rhys Lewis, Ken Reynolds, Colin Gagg - *Forensic Materials Engineering Case Studies-CRC Press (2003) (1)*

| 223AGE003 | DATA SCIENCE FOR ENGINEERS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | 0 |

**Preamble:** This course covers essentials of statistics and Linear Algebra and how to prepare the data before processing in real time applications. The students will be able to handle missing data and detection of any outliers available in the dataset. This course explores data science, Python libraries and it also covers the introduction to machine learning for engineers.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Study Data Science Concepts and statistics |
| **CO 2** | Demonstrate Understanding of Mathematical Foundations needed for Data Science |
| **CO 3** | Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset |
| **CO 4** | Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression |
| **CO 5** | Build real time data science applications and test use cases |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | 2 | | | 2 | |
| **CO 2** | 2 | | 2 | 1 | | 2 | |
| **CO 3** | 2 | | 2 | 2 | 2 | 2 | |
| **CO 4** | 2 | | 2 | 2 | 3 | 2 | |
| **CO 5** | 2 | | 2 | 3 | 3 | 3 | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 50% |
| Apply | 30% |
| Analyse | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

AUDIT COURSE

**223AGE003 - DATA SCIENCE FOR ENGINEERS**

**(Answer any five questions. Each question carries 12 Marks)**

| | | |
|---|---|---|
| 1 | a ) It is observed that 50% of mails are spam. There is software that filters spam mail before reaching the inbox. It accuracy for detecting a spam mail is 99% and chances of tagging a non-spam mail as spam mail is 5%. If acertain mail is tagged as spam finds the probability that it is not a spam mail. | 5 |
| | b ) Depict the relevance of measures of central tendency in data wrangling with a suitable example | 7 |
| 2 | a) Calculate the inverse of the Matrix $\begin{matrix} 2 & 4 & -6 \\ 7 & 3 & 5 \\ 1 & -2 & 4 \end{matrix}$ | 4 |
| | b)Find all Eigenvalues and Corresponding Eigenvectors for the matrix if $\begin{matrix} 2 & -3 & 0 \\ 2 & -5 & 0 \\ 0 & 0 & 3 \end{matrix}$ | 8 |
| 3 | a) A statistician wants to test the hypothesis H0: $\mu = 120$ using the alternative hypothesis Hα: $\mu > 120$ and assuming that $\alpha = 0.05$. For that, he took the sample values as n =40, $\sigma = 32.17$ and $\bar{x} = 105.37$. Determinethe conclusion for this hypothesis? | 5 |
| | b) Hypothesis testing is an integral part of statistical inference, list out the various types of hypothesis testing and also mentions their significances indata science. | 7 |

| | | |
|---|---|---|
| 4 | a) Brief in detail directional and non-directional hypothesis | 6 |
| | b) Differentiate null and alternate hypothesis and also elaborate on type 1 and type 2 errors | 6 |
| 5 | a) Explain the concepts of Tuple, List and Directory in python with example | 6 |
| | b) Elucidate reinforcement learning and application in real world. | 6 |
| 6 | a) What is Feature Engineering , demonstrate with an example | 6 |
| | b) Describe in detail different steps involved in data preprocessing. | 6 |
| 7 | a) Illustrate supervised learning model with linear regression model | 5 |
| | a) Predict the probability for the given feature vector if an accident will happen or not? Weather condition: rain, Road condition: good, Traffic condition: normal, Engine problem: no, the task is to predict using Naïve Bayes classification. | 7 |

| SNo. | Weather condition | Road condition | Traffic condition | Engine problem | Accident |
|---|---|---|---|---|---|
| 1 | Rain | bad | high | no | yes |
| 2 | snow | average | normal | yes | yes |
| 3 | clear | bad | light | no | no |
| 4 | clear | good | light | yes | yes |
| 5 | snow | good | normal | no | no |
| 6 | rain | average | light | no | no |
| 7 | rain | good | normal | no | no |
| 8 | snow | bad | high | no | yes |
| 9 | clear | good | high | yes | no |
| 10 | clear | bad | high | yes | yes |

**Syllabus**

| Module | Content | Hours | Semester Exam Marks (%) |
|---|---|---|---|
| I | **Statistics for Data science**<br>Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation,<br>Gaussian/Normal Distribution, covariance, correlation. | 6 | 20 |
| II | **Linear Algebra**<br>Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices,Inverse ofMatrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition | 6 | 20 |
| III | **Hypothesis Testing**<br>Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error,Type2 Error, Types of Hypothesis Test Z Test, Chi-Square | 6 | 20 |
| IV | **Exploratory Data Analysis**<br>Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration,Data-Reduction,Data Transformation | 6 | 20 |

| | | | |
|---|---|---|---|
| **V** | **Machine Learning and Python for Data Science** Python Data structures-List, Tuple, Set, Dictionary, Pandas, Numpy, Scipy, Matplotlib, Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning,Regression, Classification, Naïve-Bayes | **6** | **20** |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Statistics for Data science** | |
| 1.1 | Probability: Basic concepts of probability, conditional probability, total probability | 1 |
| 1.2 | independent events, Bayes' theorem, random variable, Population | 1 |
| 1.3 | Sample, Population Mean, Sample Mean, Population Distribution | 1 |
| 1.4 | Sample Distribution and sampling Distribution, Mean, Mode,Median, Range, Propositional logic and predicate logic | 1 |
| 1.5 | Measure of Dispersion, Variance, Standard Deviation | 1 |
| 1.6 | Gaussian/Normal Distribution, covariance, correlation. | 1 |
| **2** | **Linear Algebra** | |
| 2.1 | Vectors and their properties, | 1 |
| 2.2 | Sum and difference of Vectors, distance between Vectors | 1 |
| 2.3 | Matrices,Inverse of Matrix, | 2 |
| 2.4 | Determinant of Matrix, Trace of a Matrix, Dot Product, EigenValues, Eigen Vectors, Single Value Decomposition | 2 |
| **3** | **Hypothesis Testing** | |
| 3.1 | Understanding Hypothesis Testing, Null and AlternateHypothesis | 1 |
| 3.2 | Non-directional Hypothesis, Directional Hypothesis CriticalValue Method, P-Value Method, | 2 |
| 3.3 | Types of Errors-Type1 Error,Type2 Error, | 1 |
| 3.4 | Types of Hypothesis Test Z Test, Chi-Square, | 2 |
| **4** | **Exploratory Data Analysis** | |
| 4.1 | Data Collection –Public and Private Data | 1 |
| 4.2 | Data Cleaning-Fixing Rows and Columns | 1 |
| 4.3 | Missing Values | 1 |
| 4.4 | Standardizing values | 1 |
| 4.5 | Invalid values, filtering data | 1 |
| 4.6 | Data Integration, Data Reduction, Data Transformation | 1 |
| 5 | **Machine Learning and Python for Data Science** | |

| | | |
|---|---|---|
| 5.1 | Python Data structures-List, Tuple, Set, | 1 |
| 5.2 | Dictionary, Pandas, Numpy, Matplotlib | 2 |
| 5.3 | Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning | 1 |
| 5.4 | Regression, Classification | 1 |
| 5.5 | Naïve-Bayes | 1 |

**Reference Books**


1. Python Data Science Handbook. Essential Tools for Working with Data, Author(s): JakeVanderPlas, Publisher: O'Reilly Media, Year: 2016
2. Practical Statistics for Data Scientists: 50 Essential Concepts, Author(s): Peter Bruce,Andrew Bruce, Publisher: O'Reilly Media, Year: 2017
3. Practical Linear Algebra for Data Science, by Mike X Cohen, Released September2022, Publisher(s): O'Reilly Media, Inc.
4. Data Science from Scratch 'by Joel Grus, Released, April 2015, Publisher(s): O'ReillyMedia, Inc.
5. Hands-On Exploratory Data Analysis with Python, by Suresh Kumar Mukhiya,Usman Ahmed, Released March 2020,Publisher(s): Packt Publishing.

| 223AGE004 | DESIGN THINKING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:**

This course offers an introductory exploration of fundamental engineering concepts and techniques, the design process, analytical thinking and creativity, as well as the fundamentals and development of engineering drawings, along with their application in engineering problems.

**Course Outcomes:**

After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify and frame design challenges effectively. |
| **CO 2** | Generate creative ideas through brainstorming and ideation |
| **CO 3** | Iterate on designs based on user insights |
| **CO 4** | Apply Design Thinking to real-world problems and projects. |

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | | | | 2 | | 2 | 2 |
| **CO 2** | 2 | | 2 | 2 | | | 2 |
| **CO 3** | | 2 | | 2 | | 2 | 2 |
| **CO 4** | 2 | | 2 | 3 | 2 | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 40 |
| Analyse | 30 |
| Evaluate | 30 |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks
Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:** 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

| | | | |
|---|---|---|---|
| | | **SET1** | **Total Pages:** |
| Reg No.:_____ | | Name:_____ | |
| **APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**<br>THIRD SEMESTER M.TECH DEGREE EXAMINATION | | | |
| **Course Code: 223AGE004** | | | |
| **Course Name: DESIGN THINKING** | | | |
| Max. Marks: 60 | | Duration: 2.5 Hours | |
| ***Answer any five full questions, each carries 12 marks.*** | | | |
| 1 a) | How can a multidisciplinary team collaborate effectively to implement design principles? | | 7 |
| 1 b) | What are the key differences between human-centred design and other design methodologies? | | 5 |
| 2 a) | How do you measure the success of a design project in terms of user satisfaction and impact? | | 7 |
| 2 b) | How does the iterative nature of the design process contribute to better outcomes | | 5 |
| 3 a) | What are the fundamental principles of effective brainstorming, and how do they differ from traditional problem-solving approaches? | | 7 |

| | | |
|---|---|---|
| 3 b) | What are some key principles of ergonomic design, and how do they contribute to the usability and comfort of products? | 5 |
| 4 a) | Enumerate some examples of successful and unsuccessful market testing scenarios, and what lessons can be learned from these experiences to improve future product or service launches? | 7 |
| 4b) | What is the primary purpose of creating prototypes in the design and development process? | 5 |
| 5 | What strategies and methodologies can designers use to embrace agility and respond quickly to changing user needs and market dynamics? | 12 |
| 6 | Illustrate any four examples of successful bio-mimicry applications in various industries. | 12 |
| 7 | What ethical considerations should designers keep in mind when designing for diverse user groups? | 12 |
| **** | | |

**Syllabus:**

**Module 1**

Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centred design process. Design space, Design Thinking in a Team Environment, Team formation.

**Module 2**

Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.

**Module 3**

Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.

**Module 4**

Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest

**Module 5**

Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges

**Corse Plan Syllabus and Corse Plan** (For 3credit courses, the content can be for 40 hrs. and for2credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30hours).

| No | Topic | No. of lectures |
|---|---|---|
| **1** | **Design process:** | |
| 1.1 | Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking. | 3 |
| 1.2 | Role of design thinking in the human-centred design process. Design space, | 2 |
| 1.3 | Design Thinkin in a Team Environment, Team formation. | 2 |
| **2** | **Design Thinking Stages:** | |
| 2.1 | Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. | 2 |
| 2.2 | The importance of empathy, Building a user-centred mindset. | 2 |
| 2.3 | Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications. | 3 |
| **3** | **Ideation** | |

| | | |
|---|---|---|
| 3.1 | Generating Ideas, Brainstorming techniques. | 2 |
| 3.2 | Application of Aesthetics and Ergonomics in Design. Bio-mimicry. | 3 |
| 3.3 | Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas. | 2 |
| **4** | **Prototyping and testing** | |
| 4.1 | Use of prototyping, Types of prototypes, Rapid prototyping techniques. | 3 |
| 4.2 | User testing and feedback collection,Iterative prototyping, testing to gauge risk and market interest | 2 |
| **5** | **IPR in design** | |
| 5.1 | Entrepreneurship/businessideas, Patents and Intellectual Property. | 2 |
| 5.2 | Agility in design, Ethical considerations in design. Overcoming common implementation challenges | 2 |

**Reference Books**


1. Christoph Meinel, Larry Leifer and Hasso Plattner- "Design Thinking: Understand – Improve – Apply", Springer Berlin, Heidelberg, 2011.
2. Thomas Lockwood and Edgar Papke – "Design Thinking: Integrating Innovation, Customer Experience, and Brand Value", Allworth Press, 2009.
3. Pavan Soni – "Design Your Thinking", Penguin Random House India Private Limited, 2020.
4. Andrew Pressman- "Design Thinking : A Guide to Creative Problem Solving for Everyone", Taylor & Francis, 2018.
5. N Siva Prasad, "Design Thinking Techniques an Approaches" Ane Books Pvt. Ltd.,2023

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 223AGE005 | FUNCTIONAL PROGRAMMING IN HASKELL | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** This course introduces a functional programming approach in problem solving. Salient features of functional programming like recursion, pattern matching, higher order functions etc. and the implementation in Haskell are discussed.

**Course Outcomes:**

After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Understand the functional programming paradigm which is based on the mathematics oflambda calculus. |
| **CO 2** | Develop Haskell programs using functions, guards and recursive functions |
| **CO 3** | Apply the concept of tuples, lists and strings in Haskell programming |
| **CO 4** | Apply the concept of algebraic data types, abstract data types, modules, recursive data typesand user defined data types in Haskell programming |
| **CO 5** | Develop Haskell programs with files for reading input and storing output |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | | | | | 3 | | |
| **CO 2** | 2 | | | 2 | 3 | | |
| **CO 3** | 2 | | | 2 | 3 | | |
| **CO 4** | 2 | | | 2 | 3 | | |
| **CO 5** | 2 | | | 2 | 3 | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Apply | 40% |
| Analyse | 40% |
| Evaluate | 20% |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60**

**marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

| | | | |
|---|---|---|---|
| | | | **Total Pages:** |
| Reg No.:_____ | | Name:_____ | |
| **APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**<br>THIRD SEMESTER M.TECH DEGREE EXAMINATION | | | |
| **Course Code: 223AGE005** | | | |
| **Course Name: Functional Programming in Haskell** | | | |
| Max. Marks: 60 | | Duration: 2.5 Hours | |
| ***Answer any five full questions, each carries 12 marks.*** | | | |
| 1 a. | Explain the basic differences between imperative style programming and functional style programming. | | 3 |
| 1 b. | Analyse each of the following lambda expressions to clarify its structure. If the expression is a function, identify the bound variable and the body expression, and then analyse the body expression. If the expression is an application, identify the function and argument expressions, and then analyse the function and argument expressions:<br>i) λa.(a λb.(b a))<br>ii) λx.λy.λz.((z x) (z y))<br>iii) (λf.λg.(λh.(g h) f) λp.λq.p) | | 9 |

| | | |
|---|---|---|
| 2 a. | Design a recursive function to find $2^n$ where n is a natural number. | 4 |
| 2 b. | Explain various forms of function definitions in Haskell with the help of examples. | 8 |
| 3 a. | Explain any three list operations along with function definitions and examples. | 6 |
| 3 b. | Write a program to duplicate only even numbers among the elements of a list using a Haskell function by (i) Recursion (ii) List Comprehension and explain.<br>Example : λ> dupli [1, 2, 3] ANS: [2,2] | 6 |
| 4 | Write Recursive definitions along with an explanation for the below arithmetic operations. Illustrate the recursive flow with the help of a diagram.<br>i. add x y<br>ii. mult x y<br>iii. div x y | 12 |
| 5 | Write the Haskell code to split a list into two lists such that the elements with odd index are in one list while the elements with even index are in the other list. | 12 |
| 6 a | Give the type definition of a binary tree along with explanation of two functions on binary trees. | 6 |
| 6 b | Define a queue data type in Haskell along with any two operations on it with examples. | 6 |
| 7 a. | Explain the basic steps of reading from files and writing to files in Haskell. | 4 |
| 7 b. | Write a Haskell program to read from the file "input.txt", display the contents on the screen and write the contents to another file "output.txt". | 8 |
| | **** | |

**Syllabus and Corse Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

**Module 1 (5 Hrs)**

**Introduction to Functional Programming**: Programming language paradigms, imperative style programming, comparison of programming paradigms.
Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as

functions, Functional programming Languages. Haskell basics, GHCi interpreter.

**Module 2 (6 Hrs)**

**Programming in Haskell:** Expressions and evaluation, Lazy evaluation, let expressions, scopes.

Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions.

types, definitions, currying and uncurrying, type abstraction.

Function definitions, pattern matching, guards, anonymous

functions, higher order functions. Recursion, Programming

exercises.

**Module 3 (7 Hrs)**

**Data types: tuples and lists**: Tuples , Lists: building lists, decomposing lists, functions on lists, built-in functions on lists, primitive and general recursion over lists, infinite lists.

Strings: functions on strings.

Polymorphism and overloading, conditional polymorphism

**Module 4 (6 Hrs)**

Type classes, Algebraic data types, Modules, Recursive data types.

User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors.

**Module 5 (6 Hrs)**

Functor, Applicative functor, Monad

**Programming with actions:** Functions vs actions, Basics of input / output, the do notation, interacting with the command line and lazy I/O, File I/O.

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Functional Programming** | |
| 1.1 | Programming language paradigms, imperative style programming, comparison of programming paradigms | 1 |
| 1.2 | Functional programming, Functions - Mathematical concepts and terminology | 1 |
| 1.3 | Lambda calculus | 1 |

| | | |
|---|---|---|
| 1.4 | Function definitions, programs as functions, Functional programmingLanguages | 1 |
| 1.5 | Haskell basics, GHCi interpreter | 1 |
| 2 | **Haskell basics** | |
| 2.1 | Expressions and evaluation, Lazy evaluation | 1 |
| 2.2 | let expressions, scopes, Basic data types in Haskell | 1 |
| 2.3 | operators, infix operators, associativity and precedence, Arithmetic functions | 1 |
| 2.4 | types, definitions, currying and uncurrying, type abstraction. | 1 |
| 2.5 | Function definitions, pattern matching, Guards | 1 |
| 2.6 | anonymous functions, higher order functions, Recursion | 1 |
| 3 | **Data types: tuples and lists** | |
| 3.1 | Tuples , Lists: building lists, decomposing lists | 1 |
| 3.2 | functions on lists, built-in functions on lists | 1 |
| 3.3 | primitive and general recursion over lists | 1 |
| 3.4 | infinite lists | 1 |
| 3.5 | Strings: functions on strings | 1 |
| 3.6 | Polymorphism and overloading | 1 |
| 3.7 | conditional polymorphism | 1 |
| 4 | **User defined data types** | |
| 4.1 | Type classes, Algebraic data types, Modules | 1 |
| 4.2 | Recursive data types | 1 |
| 4.3 | User defined data types, Records | 1 |
| 4.4 | Stacks, Queues | 1 |
| 4.5 | Binary trees | 1 |
| 4.6 | Constructors, Destructors | 1 |
| 5 | **Programming with actions** | |
| 5.1 | Functor, Applicative functor, | 1 |
| 5.2 | Monad | 1 |
| 5.3 | Programming with actions: Functions vs actions, Basics of input /output, the do notation | 1 |
| 5.4 | interacting with the command line and lazy I/O | 1 |
| 5.5 | File I/O | 2 |

**Reference Books**

1. Richard Bird, "Introduction to functional programming using Haskell', second edition, Prentice hall series in computer science

2. Bryan O'Sullivan, Don Stewart, and John Goerzen, “Real World Haskell”.
3. Richard Bird, “Thinking Functionally with Haskell”, Cambridge University Press, 2014
4. Simon Thompson, “Haskell: The Craft of Functional Programming”, Addison-Wesley, 3rd Edition, 2011
5. H. Conrad Cunningham, “Notes on Functional Programming with Haskell”, 2014
6. Graham Hutton, “Programming in Haskell”, Cambridge University Press, 2nd Edition, 2016
7. Alejandro Serrano Mena, “Practical Haskell: A Real-World Guide to Functional Programming”, 3rd Edition, Apress, 2022
8. Miran Lipovaca, “Learn You a Haskell for Great Good!: A Beginner's Guide”, No Starch Press, 2011.

| 223AGE009 | Principles of Automation | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | 0 |

**Preamble:**

This course deals in detail with the various aspects of automation such as sensors, actuators, controllers, mechanical and electrical elements and their integration for automating new and existing manufacturing and process industries and applications. This course will be beneficial to students in designing automation schemes for industries and to design automated systems

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the fundamentals of sensor systems and to choose a suitable sensor systemfor the given application based on the evaluation of the constraints. |
| **CO 2** | Explain the fundamentals of signal conditions and to design a suitable signalconditioning scheme for given application. |
| **CO 3** | Describe the characteristics of various actuator systems and to decide the righttype of actuator for the given application. |
| **CO 4** | Describe the importance of an industrial robot and fundamentals of numericalcontrol in automation. |
| **CO 5** | Explain the fundamentals of controllers used in industrial automation and toconstruct simple automation schemes by ladder logic programs. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | 2 | 2 | 2 | | |
| **CO 2** | 2 | | 2 | 2 | 2 | | |
| **CO 3** | 2 | | 2 | 2 | 2 | | |
| **CO 4** | 2 | | 2 | 2 | 2 | | |
| **CO 5** | 2 | | 2 | | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 70 % |
| Apply | 30 % |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern**:**60 marks**

The examination will be conducted by the respective College. The examination will be for 150minutes and will contain 7 questions, with minimum one question from each module of whichstudent should answer any five. Each question can carry 12 marks.

Model Question Paper

**223AGE009 Principles of Automation**

Time 2.5 Hrs Marks 60

***Answer any five questions Each carries 12 marks***

1. (a) Differentiate the static and dynamic characteristics of a temperature sensor and explain how it affects the selection of a suitable temperature sensor. (6 marks)
   (b) Explain the working of a strain-gauge. (6marks)

2. (a) Explain why anti-aliasing filters are used in analog to digital converters. (3 marks)
   (b) Design a first order low pass filter with a cutoff frequency of 2 kHz. (9 marks)

3. (a) What are the factors to consider while deciding choosing between hydraulic, pneumatic or electrical actuation systems for an automation scheme? (4 marks)
   (b) Explain the working of a three-way pressure reducing valve. (4 marks)
   (c) Explain the working of solenoids. In what applications would you use a Solenoid valve. (4 marks)

4. (a) Explain the principle of the Touch sensor and also mention how they are used in robots. (5 marks)
   (b) Explain the basic terminologies in robotic system and also explain the componentsof robotic system. (7 marks)

5. (a)With neat schematic explain the architecture of the PLC. (6 marks)
   (b) Explain the use of an up-down counter in PLC with a suitable example. (6 marks)

6. (a) Write short note on SCADA. What is difference PLC and SCADA? (3 marks)

   (b)Construct a ladder logic for controlling a process tank as per the logic given below;
   i.The tank should be filled by a valve V1 when low level float switch L1 is ON and an external input S1 is received.

ii. V1 should be closed when the liquid level reaches a high-level float switch L2.

iii. An agitator motor should be turned on after a delay of 5sec after L2 is triggered.

iv. After agitating for 30mins, contents of the tank should be emptied by openinganother valve V2.

v. The temperature should be maintained at 70℃ using a thermostat T1 and Heater H

(9 marks)

7. (a) Explain the levels of Automation.

(6 marks)

(b) Explain the working of Flow sensor (6 marks)

**Syllabus and Course Plan**

| No | Topics | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Industrial Automation** | |
| 1.1 | Basic Elements of an Automated System, Levels of Automation | 2 |
| 1.2 | Hardware components for Automation: Sensors, classification, Staticand dynamic behaviour of sensors. | 2 |
| 1.3 | Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors | 4 |
| 2 | **Signal conditioning** | |
| 2.1 | Need for signal conditioning, Types of signal conditioning. | 2 |
| 2.2 | Signal conditioning using operational amplifier-Amplifier (Invertingand Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter. | 2 |
| 2.3 | Signal conditioning for data acquisition systems, anti-aliasing filters,Analog–Digital Conversions, Analog-to-Digital Converters (ADC)-Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits | 4 |
| 3 | **Actuators** | |
| 3.1 | Types of actuators- mechanical, electrical, pneumatic and hydraulicactuators. (Basic working principle) | 2 |
| 3.2 | Mechanical systems for motion conversion, transmission systems | 3 |
| 3.3 | Solenoids, Electric and stepper motors control. | 3 |
| 4 | **Robotics and Automated Manufacturing Systems** | |
| 4.1 | Robot Anatomy and Related Attributes: Joints and Links, CommonRobot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts) | 3 |

| | | |
|---|---|---|
| 4.2 | Robot Control Systems, Applications of Industrial Robots-Materialhandling | 4 |
| 4.3 | Fundamentals of Numerical control (NC) Technology | 1 |
| 5 | **Discrete Control and Programmable Logic Controllers** | |
| 5.1 | Discrete Process Control: Logic and Sequence control | 2 |
| 5.2 | Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming thePLC (Basic concepts only) | 4 |
| 5.3 | Introduction to Distributed control system (DCS) and SupervisoryControl and Data Acquisition Systems (SCADA) | 2 |

**Reference Books**


1. Mikell Groover, Automation, Production Systems, and Computer-IntegratedManufacturing, 5th Edition, Pearson, 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems",TataMcGraw HillEdition2005.
3. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
4. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and ElectricalEngineering" - PrenticeHall- 2013 - 5th Edition.
5. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design",7th Edition, McGraw Hill, 2019.
6. Krishna Kant, Computer Based Industrial Control-, EEE-PHI,2nd edition,2010.
7. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
8. Salivahanan, S., and VS Kanchana Bhaaskaran. Linear integrated circuits. McGraw-Hill Education, 2nd edition, 2014.
9. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education,2005
10. Chapman and Hall, "Standard Handbook of Industrial Automation", Onsidine DM C &Onsidine GDC", NJ, 1986

| 223AGE010 | REUSE AND RECYCLE TECHNOLOGY | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** "Reuse and Recycle Technology" typically focuses on sustainable practices and technologies aimed at reducing waste, conserving resources, and promoting environmental responsibility.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices |
| **CO 2** | Describe and Analyze waste generation and management. |
| **CO 3** | Apply the knowledge of various reuse strategies and their application in differentindustries and Analyze various recycling technologies |
| **CO 4** | Appraise the methods of E-waste management and Eco friendly packaging |
| **CO 5** | Comprehend Environmental Regulations and Policies**,** Understand the importanceof environmental regulations and policies in addressing environmental challenges |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|---|---|---|---|---|---|---|
| **CO 1** | | | 3 | | | |
| **CO 2** | | | | 3 | | |
| **CO 3** | | | | 3 | | |
| **CO 4** | | | | | 3 | |
| **CO 5** | | | 3 | | | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 60% |
| Apply | 20% |
| Analyse | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:** 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

AUDIT COURSE

**223AGE010 - REUSE AND RECYCLE TECHNOLOGY**

***Answer any five full questions, each carries 12 marks.***

| | | |
|---|---|---|
| **1.** | (a) What are the 3 pillars of sustainability?<br>*(b)* What is sustainable waste management? What makes sustainable waste<br>management so important? | 5<br><br>7 |
| **2.** | (a)How do the three categories of municipal solid waste differ?<br>*(b)* Discuss the municipal waste collection and management? | 5<br>7 |
| **3.** | (a)Explain the major differences between Reuse and Recycle?<br>*(b)* Give an overview of recycling technologies used for any two materials. Discuss the Process involved. | 5<br>7 |
| **4.** | (a)What are the common source of E-waste<br>*(b)* What are the challenges and opportunities in E-waste management | 5<br>7 |
| **5.** | (a)What is the case law for waste recycling in India<br>*(b)* Discuss sustainable packaging and its environmental impacts | 5<br>7 |
| **6.** | Explain the various environmental regulations in India for addressing Environmental challenges | 12 |
| **7.** | a) Give examples of water reuse technologies in circular economy<br>b) How can we reduce e-waste with sustainable solutions | 5<br>7 |

**Syllabus**

| Module | Content | Hours | Semester Exam Marks (%) |
|---|---|---|---|
| I | **Introduction to Sustainability**, Understanding sustainability and its importance, The three pillars of sustainability: Environmental, Social, and Economic. Biodiversity conservation, Climate change and mitigation Sustainable resource management. | 6 | 20 |
| II | **Waste Management,** Definition and classification ofwaste, Waste Generation and Composition**,** Waste Collection and Transportation, Waste Segregation andSorting. Waste Disposal Methods Historical perspectives on waste management, The three Rs:Reduce, Reuse, and Recycle. | 6 | 20 |
| III | **Recycling and Reuse:** Importance of reuse, Application of reuse in various industries, Challenges and opportunities in reuse, Overview of recycling technologies, Circular economy, Sorting and processing of recyclable materials, Advanced recycling methods. Emerging technologies in recycling. | 6 | 20 |
| IV | **E-waste Recycling,** Challenges and environmentalimpact of electronic waste, E-waste recycling methodsand regulations, Sustainable electronics design, **Sustainable Packaging,** Packaging materials and their environmental impact, Eco-friendly packaging alternatives, Packaging design for sustainability | 6 | 20 |
| V | **Environmental Regulations and Policies,** Understandthe importance of environmental regulations and policies in addressing environmental challenges,National and international waste and recycling regulations, Compliance and enforcement, Industrystandards and certifications | 6 | 20 |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Sustainability (6)** | |
| 1.1 | Understanding sustainability and its importance | 1 |
| 1.2 | The three pillars of sustainability: Environmental, Social, andEconomic. | 3 |

| | | |
|---|---|---|
| 1.3 | Biodiversity conservation, Climate change and mitigation | 1 |
| 1.4 | Sustainable resource management | 1 |
| **2** | **Waste Management (6)** | |
| 2.1 | Definition and classification of waste | 1 |
| 2.2 | Waste Generation and Composition | 1 |
| 2.3 | Waste Collection and Transportation. | 1 |
| 2.4 | Waste Segregation and Sorting. | 1 |
| 2.5 | Waste Disposal Methods | 1 |
| 2.6 | Historical perspectives on waste management, The three Rs:Reduce, Reuse, and Recycle. | 1 |
| **3** | **Recycling and Reuse (6)** | |
| 3.1 | Importance of reuse, Examples of reuse in various industries. | 1 |
| 3.2 | Challenges and opportunities in reuse | 1 |
| 3.3 | Overview of recycling technologies, Sorting and processing ofrecyclable materials | 2 |
| 3.4 | Advanced recycling methods | 1 |
| 3.5 | Emerging technologies in recycling. | 1 |
| **4** | **E-waste Recycling (6)** | |
| 4.1 | Challenges and environmental impact of electronic waste | 1 |
| 4.2 | E-waste recycling methods and regulations | 1 |
| 4.3 | Sustainable electronics design | 1 |
| 4.4 | Packaging materials and their environmental impact | 1 |
| 4.5 | Eco-friendly packaging alternatives | 1 |
| 4.6 | Packaging design for sustainability | 1 |
| **5** | **Environmental Regulations and Policies (6)** | |
| 5.1 | Importance of environmental regulations and policies inaddressing environmental challenges | 2 |
| 5.2 | National and international waste and recycling regulations | 2 |
| 5.3 | Industry standards and certifications, Compliance andenforcement | 2 |

**Reference Books**


1. Sustainable Engineering: Concepts, Design and Case Studies, David T. Allen, PearsonPublication.
2. A Comprehensive Book on Solid Waste Management with Application, Dr. H.S.Bhatia , Misha Books, 2019
3. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonoughand Michael Braungart.
4. "Recycling of Plastic Materials" edited by Vijay Kumar Thakur
5. E-waste: Implications, Regulations and Management in India and

Current Global BestPractices, Rakesh Johri, TERI

6. "Sustainable Packaging", Subramanian Senthilkannan Muthu , Springer Nature.
7. **I**ndian Environmental Law: Key Concepts and Principles " Orient Black swan PrivateLimited, New Delhi.

| 223AGE011 | SYSTEM MODELLING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** Study of this course provides the learners a clear understanding of fundamental concepts in simulation and modelling. This course covers the different statistical models, importance of data collection and various types of simulations. The course helps the learners to find varied applications in engineering, medicine and bio-technology.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse the requirement and find appropriate tool for simulation. |
| **CO 2** | Differentiate the different statistical models. |
| **CO 3** | Discuss the different techniques for generating random numbers. |
| **CO 4** | Analyse the different methods for selecting the different input models.. |
| **CO 5** | Discuss the different measures of performance and their estimation |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|---|---|---|---|---|---|---|
| **CO 1** | 2 | | 1 | 1 | 2 | |
| **CO 2** | 2 | | 1 | 1 | 1 | |
| **CO 3** | 1 | | | | | |
| **CO 4** | 1 | | 1 | 1 | | |
| **CO 5** | 2 | | 1 | 1 | 1 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 60% |
| Apply | 20% |
| Analyse | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

## Model Question paper

AUDIT COURSE

**223AGE011 – SYSTEM MODELLING**

***Answer any five questions Each carries 12 marks***

**PART A**

1. a. Discuss the advantages and disadvantages of simulation. (5 marks)

   b. What are the areas of applications of simulation (7 marks)

2. a.A bus arrives every 20 minutes at a specified stop beginning at 6:40 A.M. and continuing until 8:40 A.M. A certain passenger does not know the schedule, but arrives randomly (uniformly distributed) between 7:00A.M. and 7:30 A.M. every morning. What is the probability that the passenger waits more than 5 minutes for abus? (5 marks)
   b. A production process manufactures computer chips on the average at 2% nonconforming. Every day, a random sample of size 50 is taken from the process.
   If the sample contains more than two nonconforming chips, the process will be stopped. Compute the probability that the process is stopped by thesampling scheme. (7 marks)

3. a.Discuss the different types of tests for random numbers. (5 marks)

   b. Generate random numbers using multiplicative congruential method with X0 =5, a 11, and m = 64. (7 marks)

4. a. What are the different methods of data collection. (4marks)

   b. Records pertaining to the monthly number of job-related injuries at an underground coalrnine were being studied by a federal agency. The values for the past 100 months were as follows:

| Injuries per Month | Frequency of Occurrence |
|---|---|
| 0 | 35 |
| 1 | 40 |
| 2 | 13 |
| 3 | 6 |
| 4 | 4 |
| 5 | 1 |
| 6 | 1 |

(a) Apply the chi-square test to these data to test the hypothesis that the underlyingdistribution is Poisson. Use the level of significance $\alpha == 0.05$.

(b) Apply the chi-square test to these data to test the hypothesis that the distributionis Poisson with mean 1.0. Again let $\alpha = 0.05$. ·

b) What are the differences between parts (a) and (b), and when might each case arise? (8 marks)

5. a.What is the difference between validation and verification. (5 marks)
   b. Discuss the different measures of performance and their estimation (7 marks)
6. a. Discuss the different methods of parameter estimation (5 marks)
   b. With an example, describe the Poisson process. (7 marks)
7. a. Distinguish between discrete and continuous systems (5 marks)
   b.What are the different components of a simulation system (7 marks)

## Syllabus

| Module | Content | Hours | Semester Exam Marks (%) |
|---|---|---|---|
| I | When simulation is the appropriate tool. Advantages and disadvantages of Simulation; Areas of application, Systems and system environment; Components of a system; Discrete and continuous systems, Model of a system; Types of Models, Discrete-Event System Simulation, Steps of a simulation study. | 6 | 20 |
| II | Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only) | 6 | 20 |
| III | Properties of random numbers; Generation of pseudo- random numbers, Techniques for generating random numbers, Tests for Random Numbers | 6 | 20 |

| | | | |
|---|---|---|---|
| **IV** | Data Collection; Identifying the distribution with data, Parameter estimation, Goodness of Fit Tests, Fitting a non-stationary Poisson process, Selecting input modelswithout data, Multivariate and Time-Series input models. | **6** | **20** |
| **V** | Measures of performance and their estimation, Outputanalysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibrationand validation | **6** | **20** |

**Course Plan**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction** | |
| 1.1 | When simulation is the appropriate tool | 1 |
| 1.2 | Advantages and disadvantages of Simulation; | 1 |
| 1.3 | Areas of application, Systems and system environment; | 1 |
| 1.4 | Components of a system; Discrete and continuous systems, | 1 |
| 1.5 | Model of a system; Types of Models, | 1 |
| 1.6 | Discrete-Event System Simulation, Steps of a simulation study | 1 |
| **2** | **Statistical Models in Simulation** | |
| 2.1 | Review of terminology and concepts, Empirical distributions. (basic idea only) | 1 |
| 2.2 | Useful statistical models, | 1 |
| 2.3 | Discrete distributions. | 1 |
| 2.4 | Continuous distributions, | 1 |
| 2.5 | Poisson process | 1 |
| 2.6 | Empirical distributions | 1 |
| **3** | **Random Number Generation** | |
| 3.1 | Properties of random numbers; | 1 |
| 3.2 | Generation of pseudo-random numbers, | |
| 3.3 | Techniques for generating random numbers | 1 |
| 3.4 | Techniques for generating random numbers(cont) | 1 |
| 3.5 | Tests for Random Numbers | 1 |
| 3.6 | Tests for Random Numbers(cont) | 1 |
| **4** | **Input Modelling** | |
| 4.1 | Data Collection; | 1 |
| 4.2 | Identifying the distribution with data. | 1 |
| 4.3 | Parameter estimation, Goodness of Fit Tests | 1 |
| 4.4 | Fitting a non-stationary Poisson process | 1 |
| 4.5 | Selecting input models without data, | 1 |

| | | |
|---|---|---|
| 4.6 | Multivariate and Time-Series input models | 1 |
| **5** | **Measures of Performance and their Estimation** | |
| 5.1 | Measures of performance and their estimation | 1 |
| 5.2 | Measures of performance and their estimation(cont) | 1 |
| 5.3 | Output analysis for terminating simulations | 1 |
| 5.4 | Output analysis for steady-state simulations | 1 |
| 5.5 | Verification, calibration and validation | 1 |
| 5.6 | Verification, calibration and validation(cont) | 1 |

**Textbooks:**

1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event SystemSimulation, 5th Edition, Pearson Education, 2010.

**Reference Books:**

2. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course,Pearson Education, 2006.
3. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007
4. System Modelling and Response by Ernest O. Doebelin
5. Averill M Law, “Simulation Modeling and Analysis”, McGraw-Hill Inc,2007
GeoffreyGorden, “System Simulation”,Prentice Hall of India,1992.

| 223AGE012 | EXPERT SYSTEMS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | AUDIT COURSE | 3 | 0 | 0 | - |

**Preamble:** The course aims to provide an understanding of the basic concepts of Artificial Intelligence (AI) and Expert Systems. The course also covers the knowledge representation in expert systems, classes of expert systems, applications of expert systems.

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the concepts of Artificial Intelligence and different ways ofknowledge representations. |
| **CO 2** | Explain the components of expert systems, development stages of expert systemsand tools available for expert system design. |
| **CO 3** | Apply the concept of knowledge representation in expert systems |
| **CO 4** | Differentiate the classes of expert systems and examine properties of existingsystems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | | 2 | 1 | 2 | 2 | |
| **CO 2** | 1 | | 1 | 3 | 2 | 2 | |
| **CO 3** | 1 | | 1 | 2 | 2 | 2 | |
| **CO 4** | 2 | | 2 | 2 | 3 | 2 | |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Understand | 60% |
| Apply | 20% |
| Analyse | 20% |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 40 | 60 | 2.5 hours |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 mark.

| | | |
|---|---|---|
| | | |
| **APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**<br>THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024 | | |
| **Course Code: 223AGE012** | | |
| **Course Name: EXPERT SYSTEMS** | | |
| Max. Marks: 60 | | Duration: 2.5 Hours |
| ***Answer any five full questions, each carries 12 marks.*** | | |
| 1 | a) What are the types of AI? Explain with examples . | 6 |
| | b) What do you mean by knowledge in AI and explain the different ways of knowledge representation used in AI? | 6 |
| 2. | a) Write note on semantic network. | 6 |
| | b) What are Predicates? Explain its syntax and semantics. | 6 |
| 3. | a) Write notes on different tools available for expert system design. | 6 |
| | b). What are the different stages in the development of an expert system? | 6 |
| 4. | a) Illustrate Conceptual Dependencies with an example. | 6 |
| | b) Illustrate with an example the Structured Knowledge representation ofan Expert System. | 6 |
| 5. | a) What do you mean by Frame based Expert System? Explain | 6 |
| | b)Explain the architecture of MYCIN | 6 |
| 6. | a)Explain Fuzzy based expert systems | 6 |
| | b) Explain the neural network based expert systems | 6 |
| 7. | a) Explain any two applications of expert systems? | 6 |
| | b)What are the limitations of expert system ? Explain | 6 |

**Syllabus**

| Module | Content | Hours | Semester Exam Marks (%) |
|---|---|---|---|
| I | Overview of Artificial Intelligence (AI): Definition & Importance of AI.<br><br>Knowledge general concepts: Definition and Importance of knowledge, Knowledge-Based Systems, Knowledge organization, Knowledge Manipulation and acquisition.<br><br>Knowledge Representation: Introduction, Syntax and Semantics- Propositional logic and predicate logic. | 6 | 20 |
| II | Basic concepts of expert systems-Introduction to expert systems, Components of expert systems. Features of Expert System, Stages in the development of expert system, Types of tools available for expert system design | 6 | 20 |
| III | Knowledge representation in expert systems: Structured Knowledge representation: Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation. | 6 | 20 |
| IV | Classes of expert systems: Rule-based expert systems,Example- MYCIN, Frame-based expert system, terminologies, IF-THEN structure.<br>Fuzzy and Neuralnetwork based expert systems(basic concepts) | 7 | 20 |
| V | Currents trends in expert systems, Advantages and limitations of expert systems, Applications of expert systems. | 5 | 20 |

**Course Plan**

| No | Topics | No. of Lectures |
|---|---|---|
| 1 | **Overview of Artificial Intelligence& Knowledge general concepts** | |
| 1.1 | Definition & Importance of AI | 1 |
| 1.2 | Definition and Importance of Knowledge, | 1 |
| 1.3 | Knowledge-Based Systems, Knowledge Organization | 1 |
| 1.4 | Knowledge Manipulation and acquisition | 1 |
| 1.5 | Knowledge Representation: Introduction, Syntax and Semantics | 1 |
| 1.6 | Propositional logic and predicate logic | 1 |
| **2** | **Basic concepts of expert systems** | |
| 2.1 | Introduction to Expert System, Components of expert systems | 2 |
| 2.2 | Features of Expert System, Stages in the development of expert system | 2 |
| 2.3 | Types of tools available for expert system design | 2 |
| **3** | **Knowledge representation in expert systems** | |
| 3.1 | Structured Knowledge representation | 1 |
| 3.2 | Graphs, Frames and Related Structures | 2 |
| 3.3 | Associative Networks, Conceptual Dependencies | 2 |
| 3.4 | Examples of structured knowledge representation | 1 |
| **4** | **Classes of expert systems** | |
| 4.1 | A rule-based expert system -Introduction | 1 |
| 4.2 | MYCIN | 1 |
| 4.3 | IF-THEN structure | 1 |
| 4.4 | Frame-based expert system | 2 |
| 4.5 | Fuzzy based expert systems | 1 |
| 4.6 | Neural network based expert systems | 1 |
| **5** | **Currents trends and applications of expert systems** | |
| 5.1 | Currents trends of expert systems | 2 |
| 5.2 | Advantages and limitations of expert systems | 1 |
| 5.3 | Applications of expert systems | 2 |

**Reference Books**


1. E. Rich & K. Knight - Artificial Intelligence, 2/e, TMH, New Delhi, 2005.
2. P.H. Winston - Artificial Intelligence, 3/e, Pearson Edition, New Delhi, 2006.
3. D.W. Rolston - Principles of AI & Expert System Development, TMH, New Delhi
4. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE) ", McGraw Hill –2010
5. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', PrenticeHall of India Pvt. Ltd,2007
6. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education seriesin AI', 3rd Edition, 2009.
7. I. Gupta, G. Nagpal · Artificial Intelligence and Expert Systems, Mercury Learningand Information -2020

**INTERNSHIP**

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

**Objectives**

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

**Benefits of Internship**

**Benefits to Students**

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.

- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

**Benefits to the Institute**

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

**Benefits to the Industry**

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

**Types of Internships**

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

**Guidelines**

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy
    - Feedback from employer / internship mentor
    - Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

**Continuous Internal Evaluation: 50 marks**

| | |
|---|---|
| Student's diary | - 25 Marks |
| Evaluation done by the industry | - 25 Marks |

**Student's Diary/ Daily Log**: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations,

impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

**The format of student's diary**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
|---|---|
| 1 | |
| 2 | |
| 3 | |

*Signature of Industry Supervisor* *Signature of Section Head/HR Manager*

*Office Seal*

**Attendance Sheet**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

| Month & Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | ... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | |
| Month & Year | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| Month & Year | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

*Signature of Industry Supervisor* *Signature of Section Head/HR Manager*

*Office Seal*

**Note:**

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

**Evaluation done by the Industry (Marks 25)**

**Format for Supervisor Evaluation of Intern**

Student Name :_____Date:_____

Supervisor Name :_____Designation:_____

Company/Organization :_____

Internship Address: _____

Dates of Internship: From_____To _____

***Please evaluate intern by indicating the frequency with which you observed the following parameters:***

| **Parameters** **Marks** | Needs improvement (0 – 0.25 mark) | Satisfactory (0.25 – 0.50 mark) | Good (0.75 mark) | Excellent (1 mark) |
|---|---|---|---|---|
| Behavior | | | | |
| Performs in a dependable Manner | | | | |
| Cooperates with coworkers and supervisor | | | | |
| Shows interest in work | | | | |
| Learns quickly | | | | |
| Shows initiative | | | | |
| Produces high quality work | | | | |
| Accepts responsibility | | | | |
| Accepts criticism | | | | |
| Demonstrates organizational skills | | | | |
| Uses technical knowledge and expertise | | | | |
| Shows good judgment | | | | |
| Demonstrates creativity/originality | | | | |
| Analyzes problems effectively | | | | |
| Is self-reliant | | | | |
| Communicates well | | | | |
| Writes effectively | | | | |
| Has a professional attitude | | | | |
| Gives a professional appearance | | | | |
| Is punctual | | | | |
| Uses time effectively | | | | |

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

*Signature of Industry Supervisor* *Signature of Section Head/HR Manager*

*Office Seal*

**End Semester Evaluation (External Evaluation): 50 Marks**

| | | |
|---|---|---|
| Internship Report | - | 25 Marks |
| Viva Voce | - | 25 Marks |

**Internship Report**: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

**RESEARCH PROJECT/DISSERTATION**

**Research Project:** Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

**Dissertation:** All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

**Mark Distribution:**

**Phase 1: Total marks: 100, only CIA**

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 223PEC100 | DISSERTATION PHASE I | Project Work | 0 | 0 | 17 | 11 |

**COURSE OBJECTIVES:**

Dissertation is aimed to bridge the gap between theoretical knowledge and practical application, fostering a well-rounded skill set that prepares students for success in their future engineering careers. Engineering projects often simulate real-world engineering scenarios. This exposure allows students to become familiar with industry practices, standards, and expectations and preparing them for the challenges they might face in their future careers. Depending on the nature of the project, students may acquire practical skills related to specific tools, software, or equipment. This hands-on experience can be highly beneficial when transitioning to a professional engineering role.

Dissertation Phase I can help to identify the problem based on the area of interest through proper literature survey and to foster innovation in design of products, processes or systems based on the identified problem. perform feasibility study by creative thinking and requirement analysis in finding viable solutions to engineering problems

All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or in any CSIR/Industrial/ R&D organization/any other reputed institute which have facilities for dissertation work in the area proposed.

**Course Outcomes:**

After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify and define a relevant and significant problem or challenge in the relevantfield |
| **CO2** | Formulate research methodologies for the innovative and creative solutions |
| **CO 3** | Plan and execute tasks utilizing available resources within timelines, following<br>ethical professional and financial norms |
| **CO 4** | Organize and communicate technical and scientific findings effectively in writtenreports, oral presentation, and visual aids |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 |
|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 3 | 2 | 2 | 3 | 2 |
| **CO 2** | 3 | | 3 | 3 | 3 | 2 | |
| **CO 3** | 3 | | 2 | | 3 | 3 | 2 |
| **CO 4** | | 3 | 3 | 2 | | | 2 |

**Continuous Internal Assessment (CIA) Total Marks: 100**

The evaluation committee comprises

1- Project Coordinator(s)

2- A Senior faculty member

3- Supervisor of the student

**Pattern:**

| | |
|---|---|
| Zeroth evaluation by the Evaluation Committee | - |
| Interim evaluation by the Evaluation Committee | 20 marks |
| Final evaluation by the Evaluation Committee | 40 marks |
| Project Phase - I Report (By Evaluation Committee) | 20 marks |
| Project progress evaluation by supervisor | 20 marks |

The Plagiarism level in the project report shall be less than 25%.

**Interim Review**

Literature Survey (CO1- 5 marks)
Comprehension and Problem Identification (CO2-5 marks)
Objective Identification (CO2-5 marks)
Document Preparation and Presentation (CO4-5 marks)

**Final Review**

Literature Survey (CO1-10 marks)
Project Design (CO2-10 marks)
Execution of tasks by utilizing available resources within timelines (CO3 – 10 marks)
Presentation and document preparation (CO4-10 marks)

**Evaluation by the supervisor**

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action.

**Student's Diary/ Log book**: The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

The minimum attendance for completing the course is 75%. The pass minimum for the course is 50% for CIA.

**SYLLABUS:**

| DETAILS | HOURS |
|---|---|
| 1. Literature study/survey of published literature on the assigned topic<br>2. Formulation of objectives<br>3. Formulation of hypothesis/ design/ methodology<br>4. Formulation of work plan and task allocation.<br>5. Design documentation<br>6. Preliminary analysis/Modelling/Simulation/Experiment/ Design/ Feasibility study<br>7. Preparation of Phase 1 report | 150 |

**Dissertation outside the Institute:** For doing dissertation outside the Institution, the following conditions are to be met:

i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
ii. The student has to get prior approval from the DLAC and CLAC.
iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned Internal supervisor.
vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.

**Internship leading to Dissertation:** The M. Tech students who after completion of 6 to 8 weeks internship at some reputed organizations are allowed to continue their work as dissertation for the third and fourth semester after getting approval from the CLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech dissertation. These students will be continuing as regular students of the Institute in third semester for carrying out all academic requirements as per the curriculum/regulation. However, they will be permitted to complete their dissertation in the Industry/Organization (where they have successfully completed their internship) during fourth semester. They

should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the external organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area. The student has to furnish his /her monthly progress as well as attendance report signed by the external guide and submit the same to the concerned internal guide. The external guide is to be preferably present during all the stages of evaluation of the dissertation.

**Dissertation as part of Employment**: Students may be permitted to discontinue the programme and take up a job provided they have completed all the courses till second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R&D facility, or in the Institute. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PG) through HoD. The application shall be vetted by CLAC before granting the approval. When the students are planning to do the dissertation work in the organization with R&D facility where they are employed, they shall submit a separate application having following details:

i. Name of R&D Organization/Industry
ii. Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
iii. Name and designation of a faculty member of the Institute as internal supervisor with his/her consent
iv. Letter from the competent authority from the Organization/Industry granting permission to do the dissertation
v. Details of the proposed work
vi. Work plan of completion of project

DLAC will scrutinize the proposal and forward to CLAC for approval. When students are doingdissertation work along with the job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the Institute). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of assessment and grading of the dissertation will be the same as in the case of regular students. The course work in the 3rd semester for such students are to be completed as per the curriculum requirements (i) MOOC can be completed as per the norms mentioned earlier (ii) Audit course are to be carried out either in their parent Institution or by self-learning. However, for self- learning students, all assessments shall be carried out in their parent institution as in the caseof regular students.

# SEMESTER IV

**Discipline: ELECTRONICS AND COMMUNICATION**

**Stream : ECx (Automotive Electronics)**

(with Industry collaboration – Tata Elxsi)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 224PEC100 | DISSERTATION PHASE II | Project Work | 0 | 0 | 24 | 16 |

All categories of students in track 1 are to carry out the DISSERTATION PHASE II in the institute they are studying or in any Industrial/ R&D organization/any other reputed institute which have facilities for dissertation work in the area proposed. DISSERTATION PHASE II shall not compulsorily continuation of DISSERTATION PHASE I. The student has to publish a research article in a conference or a reputed journal before appearing for the end-semester examination. The eligibility criteria for registering to the end semester examination are attendance in the course and no pending disciplinary action. The minimum attendance for appearing for the end semester examination is 75%. Students who do not meet these eligibility criteria are ineligible (identified by FE grade) to appear for the ESE. Students, who have completed a course but could not appear for the end semester examination, shall be awarded 'AB' Grade, provided they meet other eligibility criteria The pass minimum for the course is 45% for ESE and 50% for (CIA and ESE) put together.

**Continuous Internal Assessment (CIA) Total Marks: 100**

The evaluation committee comprises

2- Project Coordinator(s)
3- A Senior faculty member
4- Supervisor of the student

**Pattern (CIA)**

| | |
|---|---|
| Zeroth evaluation by the Evaluation Committee | - |
| Interim evaluation by the Evaluation Committee | 30 marks |
| Final evaluation by the Evaluation Committee | 50 marks |
| Project progress evaluation by supervisor | 20 marks |

**Evaluation by the supervisor**

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action.

**Student's Diary/ Log book**: The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

**End Semester Evaluation (ESE) Total Marks: 100**

The evaluation committee comprises

1- Project Coordinator(s)
2- An external expert (from Industry or research/academic institute)
3- Supervisor of the student

**Pattern (ESE)**

1. **Innovation and Originality (10 marks):**

Assessment of the uniqueness and innovation demonstrated in the project work. Original contributions, if any, to the field or problem area.

2. **Implementation and Execution (20 marks):**

Evaluation of the actual implementation or execution of the project, including:

Quality of work done
Demonstrated skills and techniques applied
Adherence to project timelines and milestones

3. **Project Documentation (25 marks):**

Comprehensive project report evaluation including: Introduction and problem statement
Literature review
Methodology and approach Results and analysis
Conclusion and recommendations References and citations
Details of the publications Plagiarism certificate

The Plagiarism level in the project report shall be less than 25%.

4. **Presentation and Defence (40 marks):**

Oral presentation of the project to a panel of examiners, including:

Clarity and effectiveness of the presentation
Ability to explain the project objectives, methodologies, and findings
Handling questions and providing satisfactory answers during the defence

5. **Publication of the work either in a conference or in a journal (5 marks)**

**SYLLABUS:**

| DETAILS | HOURS |
|---|---|
| 1. Literature study/survey of published literature on the assigned topic<br>2. Topic Selection and Proposal<br>3. Formulation of objectives<br>4. Research and Planning<br>5. Formulation of work plan and task allocation.<br>6. Execution<br>7. Documentation and Reporting<br>8. Project Showcase reflecting on the project experience and lessons learned | 200 |

**Dissertation outside the Institute:** For doing dissertation outside the Institution, the followingconditions are to be met:

i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
ii. The student has to get prior approval from the DLAC and CLAC.
iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.
vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.