Regulations and Curriculum for

Master of Technology (M. Tech.)

in

Electric Vehicle Technology

(Deemed to be University under Section 3 of UGC Act, 1956)
(Placed under Category 'A' by MHRD, Govt. of India, Accredited with 'A+' Grade by NAAC)
University Enclave, Medical Sciences Complex, Deralakatte,
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REGULATIONS GOVERNING
THE DEGREE OF MASTER OF TECHNOLOGY (M.Tech.)

UNDER OUTCOME BASED EDUCATION (OBE)

AND

CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME

OF

NMAM INSTITUTE OF TECHNOLOGY, NITTE

(Effective from academic year 2022 -23)

VISION

To build a humane society through excellence in the education and healthcare

MISSION

To develop
Nitte (Deemed to be University)
As a centre of excellence imparting quality education,
Generating competent, skilled manpower to face the scientific and social challenges with a high degree of credibility, integrity,
ethical standards and social concern

NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

Off-campus Centre, Nitte (Deemed to be University)

NITTE-574110, Karkala Taluk, Udupi District, Karnataka, India

Vision Statement

Pursuing Excellence, Empowering people, Partnering in Community Development

Mission Statement

To develop N.M.A.M. Institute of Technology, Nitte, as Centre of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

M. Tech. Regulations and Curriculum

Batch

2022 – 2024

With Scheme of Teaching & Examination

REGULATIONS: 2022

for

M. Tech. Programs

(Academic year 2022-23)

COMMON TO ALL

M.Tech. DEGREE PROGRAMS

CHOICE BASED CREDIT SYSTEM (CBCS)

Key Information

Program Title	Master of Technology, abbreviated as M.Tech. (Electric Vehicle Technology)
Short description	Two-year, four semester Choice Based Credit System (CBCS) type of Postgraduate Engineering Degree Program with English as medium of instruction
Program Code	22ENGR15D2
Revision version	2022.02 These regulations may be modified from time to time as mandated by the policies of the University. Revisions are to be recommended by the Board of Studies for **Electrical & Electronics Engineering** and approved by the Academic Council.
Effective from	12-09-2022
Approvals	• Approved in the 50th meeting of Academic Council of NITTE (Deemed to be University), held on 30-05-2022 and vide Notification of NITTE (DU), N(DU)/REG/N-MCE/2022-23/76B dated 19-08-2022. • Notification of Nitte (DU), N(DU)/REG/AC/-SA/2022-23/909 dated 24-04-2023.
Program offered at	NMAM Institute of Technology, Nitte Off Campus centre, Nitte (Deemed to be University)
Grievance and dispute resolution	All disputes arising from this set of regulations shall be addressed to the Board of Management. The decision of the Board of Management is final and binding on all parties concerned. Further, any legal disputes arising out of this set of regulations shall be limited to jurisdiction of Courts of Mangalore only

Contents

1. INTRODUCTION:

1.1 The general regulations are common to all Degree of Master of Technology Program under Outcome Based Education (OBE) and Choice Based Credit System (CBCS) conducted by Nitte (Deemed to be University), at the NMAM Institute of Technology, Nitte off Campus Centre and shall be called "Nitte (DU) Regulations for M.Tech.- 2022".

1.2 The provisions contained in this set of regulations govern the policies and procedures on the Registration of students, imparting Instructions of course, conducting of the examination and evaluation and certification of students' performance and all amendments there to leading to the said degree program(s)

1.3 This set of Regulations, on approval by the Academic Council and Governing Council, shall supersede all the corresponding earlier sets of regulations of the M.Tech. Degree program (of Nitte (DU)) along with all the amendments thereto, and shall be binding on all students undergoing M.Tech. Degree Program (s) (Choice Based Credit System) conducted at the NMAMIT, Nitte with effect from its date of approval and is applicable for students admitted to 1st year after September 2022. This set of regulations may evolve and get modified or changed through appropriate approvals from the Academic Council / Governing Council from time to time, and shall be binding on all stake holders, (the Students, Faculty, Staff of Departments of NMAMIT, Nitte). The decision of the Academic Council/ Governing Council shall be final and binding.

1.4 In order to guarantee fairness and justice to the parties concerned in view of the periodic evolutionary refinements, any specific issues or matters of concern shall be addressed separately, by the appropriate authorities, as and when found necessary.

1.5 The Academic Council may consider any issues or matters of Concern relating to any or all the academic activities of the NMAMIT courses for appropriate action, irrespective of whether a reference is made here in this set of Regulations or otherwise.

1.6 The course shall be called **Master of Technology** program abbreviated as M.Tech. (subject of specialization) – Choice Based Credit System.

2. DEFINITIONS OF KEYWORDS:

The following are the definitions/descriptions that have been followed for the different terms used in the Regulations of M.Tech. Programs:

2.1 Program: Is an educational program in a particular stream/branch of Engineering/branch of specialization leading to award of Degree. It involves events/activities, comprising of lectures/ tutorials/ laboratory work/ field work, outreach activities/ project work/ vocational training/ viva/ seminars/ Internship/ assignments/ presentations/ self-study etc., or a combination of some of these.

2.2 Branch: Means Specialization or discipline of M. Tech Degree Program, like Electrical Vehicle Technology, Structural Engineering, Machine Design, etc.

2.3 Semester: Refers to one of the two sessions of an academic year (vide: serial number 4), each session being of sixteen weeks duration (with working days greater than or equal to 90). The odd semester may be scheduled from August/September and even semester from February/March of the year.

2.4 Academic Year: Refers to the sessions of two consecutive semesters (odd followed by an even) including periods of vacation.

2.5 Course: Refers to usually referred to as 'subjects' and is a component of a program. All Courses need not carry the same credit weightage. The Courses should define learning objectives and learning outcomes. A Course may be designed to comprise lectures/ tutorials/ laboratory work/ field work/ outreach activities/ project work/ vocational training/ viva/ seminars/ term papers/ assignments/ presentations/ self-study etc.. or a combination of some of these.

2.6 Credit: Refers to a unit by which the Course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of lecture or two hours of laboratory/ practical Courses/ tutorials/ fieldwork per week etc.

2.7 Audit Courses: Means Knowledge/ Skill enhancing Courses without the benefit of credit for a Course.

2.8 Choice Based Credit System (CBCS): Refers to customizing the Course work, through Core, Elective and soft skill Courses, to provide necessary support for the students to achieve their goals.

2.9 Course Registration: Refers to formal registration for the Courses of a semester (Credits) by every student under the supervision of a Faculty Advisor (also called Mentor, Counsellor etc.,) in each Semester for the Institution to maintain proper record.

2.10 Course Evaluation: Means Continuous Internal Evaluation (CIE) and Semester End Examinations (SEE) to constitute the major evaluations prescribed for each

Course. CIE and SEE to carry 50 % and 50 % respectively, to enable each Course to be evaluated for 100 marks, irrespective of its Credits.

2.11 Continuous Internal Evaluation (CIE): Refers to evaluation of students' achievement in the learning process. CIE shall be by the Course Instructor and includes tests, homework, problem solving, group discussion, quiz, mini-project and seminar throughout the Semester, with weightage for the different components being fixed at the University level.

2.12 Semester End Examinations (SEE): Refers to examination conducted at the University level covering the entire Course Syllabus. For this purpose, Syllabi to be modularized and SEE questions to be set from each module, with a choice confined to the concerned module only. SEE is also termed as university examination.

2.13 Make Up Examination: Refers to examination conducted for the candidates who has a CIE>=35 marks and may have missed to attend the SEE covering the entire course syllabus. The standard of Make Up Examination is same as that of the SEE.

2.14 Supplementary Examination: Refers to the examination conducted to assist slow learners and/or failed students through make up courses for a duration of 8 weeks. This comprises of both the CIE & SEE and will be conducted after the completion of First year M.Tech. even semester.

2.15 Credit Based System (CBS): Refers to quantification of Course work, after a student completes teaching – learning process, followed by passing in both CIE and SEE. Under CBS, the requirement for awarding Degree is prescribed in terms of total number of credits to be earned by the students.

2.16 Credit Representation: Refers to Credit Values for different academic activities considered, as per the Table.1. Credits for seminar, project phases, project viva–voce and internship shall be as specified in the Scheme of Teaching and Examination.

Table 1: Credit Values

Theory/Lectures (L) (hours/week/Semester)	Tutorials (T) (hours/week/ Semester)	Laboratory /Practical (P) (hours/week/ Semester)	Credits (L: T:P)	Total Credits
4	0	0	4:0:0	4

3	0	0	3:0:0	3
2	2	0	2:1:0	3
2	0	2	2:0:1	3
2	2	2	2:1:1	4
0	0	2	0:0:1	1
NOTE: Activities like, practical training, study tour and participation in Guest lectures not to carry any credits.				

2.17 Letter Grade: It is an index of the performance of students in a said Course. Grades are denoted by letters O, A+, A, B+, B, C and F.

2.18 Grading: Grade refers to qualitative measure of achievement of a student in each Course, based on the percentage of marks secured in (CIE+SEE). Grading is done by Absolute Grading. The rubric attached to letter grades are as follows:

Letter Grade	O	A+	A	B+	B	C	F
Academic Level	Outstanding	Excellent	Very Good	Good	Above Average	Average	Fail

2.19 Grade Point (GP): Refers to a numerical weightage allotted to each letter grade on a 10-point scale as under.

Letter Grade and corresponding Grade Points on a typical 10 – Point scale							
Letter Grade	O	A+	A	B+	B	C	F
Grade Point	10	09	08	07	06	05	00

2.20 Passing Standards: Refers to passing a Course only when getting GP greater than or equal to 05 (as per serial number 2.20).

2.21 Credit Point: Is the product of grade point (GP) and number of credits for a Course i.e., Credit points CrP = GP × Credits for the Course.

2.22 Semester Grade Point Average (SGPA): Refers to a measure of academic performance of student/s in a semester. It is the ratio of total credit points secured by a student in various Courses of a semester and the total Course credits taken during that semester.

2.23 Cumulative Grade Point Average (CGPA): Is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points

earned by a student in various Courses in all semesters and the sum of the total credits of all Courses in all the semesters. It is expressed up to two decimal places.

2.24 **Grade Card:** Refers to a certificate showing the grades earned by a student. A grade card shall be issued to all the registered students after every semester. The grade card will display the program details (Course code, title, number of credits, grades secured) along with SGPA of that semester and CGPA earned till that semester.

2.25 **University:** Nitte (Deemed to be University), Mangalore. NMAM Institute of Technology is an off-campus centre of Nitte (DU) and located at Nitte.

3. CLAUSE	
CLAUSE	**PARTICULARS**
22NMT1.0	**DURATION AND CREDITS OF THE PROGRAM OF STUDY** There shall be one category of program: Full-time Program (FT) **Full-time Program:** The Program shall extend over a period of four semesters (2 years). First Semester: i) 16 weeks – Class Work according to the scheme. ii) 4 weeks – Revision holidays and examinations iii) 2 weeks – Vacation **Second Semester:** i) 16 weeks – Class Work according to the scheme ii) 4 weeks – Revision holidays and examinations. **Summer Semester/Vacation** i) 4 weeks — Class work, Examination & Display of Grades **Third Semester: 20 weeks** i) 8 weeks — Industrial Training/Mini Project ii) 12 weeks — Project Part-I — Industrial Training/Mini Project evaluation, Seminar on Special Topic Evaluation & Project Part-I Evaluation **Fourth Semester: 24 weeks** i) 22 weeks — Project Part-II ii) 2 weeks – Submission, viva -voce **Prescribed Number of Credits for the Program: 80**

<table>
<tr><td></td><td>The number of credits to be completed for the award of Degree shall be 80.</td></tr>
<tr><td>22NMT1.1</td><td>M.Tech Degree Programs are offered in the following specialization and the respective program hosting departments are listed below:
<table>
<tr><th><u>Program</u></th><th><u>Department</u></th></tr>
<tr><td>i) Computer Science & Engineering</td><td>Computer Science & Engineering</td></tr>
<tr><td>ii) Constructional Technology</td><td>Civil Engineering</td></tr>
<tr><td>iii) Structural Engineering</td><td>Civil Engineering</td></tr>
<tr><td>iv) VLSI Design & Embedded Systems</td><td>Electronics and Communication Engineering</td></tr>
<tr><td>v) Machine Design</td><td>Mechanical Engineering</td></tr>
<tr><td>vi) Energy Systems Engineering</td><td>Mechanical Engineering</td></tr>
<tr><td>vii) Cyber security</td><td>Computer Science Engineering</td></tr>
<tr><td>viii) Electric Vehicle Technology</td><td>Electrical and Electronics Engineering</td></tr>
</table>
The provisions of these Regulations shall be applicable to any new specialization that may be introduced from time to time and appended to the above list.</td></tr>
<tr><td>22NMT1.2</td><td>Maximum Duration for Program Completion:
A full-time candidate shall be allowed a maximum duration of 4 years from the I semester of admission to become eligible for the award of master’s degree, failing which he/she may discontinue of register once again as a fresh candidate to I semester of the program.</td></tr>
<tr><td>22NMT2.0</td><td>ELIGIBILITY FOR ADMISSION
(As per the Government orders issued from time to time):
Admission to I year/ I semester Master of Technology Program shall be open to all the candidates who have passed B.E./ B. Tech. Examinations (in relevant field) or any other recognized University/ Institution. AMIE in respective branches shall be equivalent to B.E./ B. Tech. Programs for admission to M.Tech. The decision of the equivalence committee shall be the final in establishing the eligibility of candidates for a particular Program.
For the foreign Degrees, Equivalence certificate from the Association of Indian Universities shall be a must.</td></tr>
<tr><td>22NMT2.1</td><td>Admission to M.Tech. Program shall be open to the candidates who have passed the prescribed qualifying examination with not less than 50% of the</td></tr>
</table>

	marks in the aggregate of all the years of the Degree examination. Rounding off percentage secured in qualifying examination is not permissible.
22NMT2.2	**For admissions under GATE/ NUCAT qualification** The candidates should be GATE qualified or should have appeared for the NUCAT Entrance Examination conducted by Nitte (Deemed to be University) [Nitte (DU)]
22NMT2.3	**For admissions under Sponsored Quota:** The candidates should be GATE qualified or should have appeared for the NUCAT Entrance Examination conducted by Nitte (DU)
22NMT2.4	The candidates, who are qualified in the GATE Examination for the appropriate branch of engineering, shall be given priority. They are exempted from taking NUCAT Entrance Examination. In case a GATE qualified Candidate appears for entrance examination and become qualified to claim a seat under entrance examination quota, he/she will be considered in the order of merit along with other candidates appeared for the entrance examination.
22NMT2.5	If sufficient number of GATE qualified candidates are not available, the remaining vacant seats shall be filled from amongst the candidates appeared for NUCAT Entrance Examination in the order of merit.
22NMT2.6	Engineering graduates other than the Karnataka candidates shall get their Eligibility verified from Nitte (DU) to seek admission to M.Tech. Program at NMAMIT, Nitte
22NMT2.7	**Admission to vacant seats:** Seats remaining vacant (unfilled), after the completion of admission process through GATE/NUCAT Entrance Exam, the remaining seats shall be filled by Candidates based on merit in the entrance test conducted at the Institution level. An admission Committee, consisting of the Principal, Head of the concerned Department and the subject experts, shall oversee admissions.
22NMT3.0	**REGISTRATION:** Every student after consulting his **Faculty-Advisor** in parent department is required to register for the **approved courses** with the **Departmental Post Graduate Committee (DPGC)** of Parent Department at the commencement

<table>
<tr><td></td><td>of each Semester on the days fixed for such registration and notified in the academic calendar.</td></tr>
<tr><td>22NMT3.1</td><td>Lower and Upper Limits for Course Credits Registered in a Semester.
Course Credit Assignment:
All courses comprise of specific Lecture/ Tutorial/ Practical (L-T-P) schedule. The course credits are fixed based on the following norms.
Lecture/Tutorials/ Practical:
(i) a 1-hour Lecture per week is assigned 1.0 Credit.
(ii) a 2-hour Tutorial session per week is assigned 1.0 Credit.
(iii) a 2-hour Lab. session per week is assigned 1.0 credits
For example, a theory course with L-T-P schedule of 3-2-0 hours will be assigned 4.0 credits.
A laboratory practical course with L-T-P schedule of 0-0-2 hours will be assigned 1.0 credit.
Calculation of Contact Hours / Week – A Typical Example
<table>
<tr><th colspan="5">Typical Academic Load (I & II Semester)</th></tr>
<tr><th>No. of Courses</th><th>LTP</th><th>Credits Per course</th><th>Total Credits</th><th>Contact Hours per Week</th></tr>
<tr><td>2 Lecture Courses</td><td>4-0-0</td><td>04</td><td>08</td><td>08</td></tr>
<tr><td>2 Lab Courses</td><td>0-0-2</td><td>01</td><td>02</td><td>04</td></tr>
<tr><td>1 Research based Course</td><td>0-0-4</td><td>02</td><td>02</td><td>04</td></tr>
<tr><td>3 Elective Courses</td><td>3-0-0</td><td>03</td><td>09</td><td>09</td></tr>
<tr><td>1 Audit Course</td><td>2-0-0</td><td>0</td><td>0</td><td>02</td></tr>
<tr><td>Total: 9 Courses</td><td></td><td></td><td>21</td><td>27</td></tr>
</table>
A student must register, as advised by Faculty Advisor, between a minimum of 16 credits and up to a Maximum of 28 credits. However, the minimum/ maximum Credit limit can be relaxed by the Dean (Academic) on the recommendations of the DPGC, only under extremely exceptional circumstances.</td></tr>
<tr><td>22NMT3.2</td><td>Mandatory Pre-Registration for higher semester:
In order to facilitate proper planning of the academic activities of the Semester, it is necessary for the students to declare their intention to register for courses</td></tr>
</table>

	of higher semesters (2nd and above) at least two weeks before the end of the current semester choosing the courses offered by each department in the next higher semester which is displayed on the Departmental Notice Board at least 4 weeks prior to the last working day of the semester. Students who fail to register on or before the specified date will have to pay a late fee. Registration in absentia is allowed only in exceptional cases with the permission of the Dean (Academic). Registration to a higher semester is allowed only if the student fulfills the following conditions- i) Satisfied all the academic requirements to continue with the program of studies without termination ii) Cleared all institute, hostel and library dues and fines, if any, of the previous semester. iii) Paid all required advance payments of the Institute and the hostel for the current semester. Has not been debarred from registering on any specific grounds by the Institute.
22NMT3.3	**Course Pre-Requisites:** In order for a student to register for some course(s), it may be required either to have completed satisfactorily or to have prior earned credits in some specified course(s). In such instances, the DPGC shall specify clearly, any such course pre-requisites, as part of the curriculum.
22NMT3.4	Students who do not register before the dead line day of registration may be permitted LATE Registration up to the notified day in academic calendar on payment of late fee.
22NMT3.5	REGISTRATION in ABSENTIA will be allowed only in exceptional cases on the recommendation of DPGC through the authorized representative of the student.
22NMT3.6	Medium of Instruction/Evaluation/etc. shall be English.
22NMT4.0	**COURSES:** The curriculum of the Program shall be any combination of following type of courses: i) **Professional Core Courses (PCC)** - relevant to the chosen specialization/ branch [May be split into Hard (no choice) and Soft (with

	choice), if required]. The core course is to be compulsorily studied by a student and is mandatory to complete the requirements of a program in a said discipline of study. ii) **Professional Electives Courses (PEC)** - relevant to the chosen specialization/ branch: these are the courses, which can be chosen from the pool of papers. It shall be supportive to the discipline/ providing extended scope/enabling an exposure to some other discipline / domain / nurturing student skills. iii) **Research Experience** Through Practice-I and Research Experience Through Practice-II iv) **Project Work** v) **Seminar** vi) **Audit Courses (AC):** a) The Audit course can be any credit course offered by the program to which the candidate is admitted (other than the courses considered for completing the prescribed program credits) or other programs offered in the institution, where the student is studying. b) The students are required to register for one audit course during I and II semesters. Students who have registered to audit the courses, considered on par with students registered to the same course for credit, must satisfy attendance and CIE requirements. However, they need not have to appear for SEE. c) Registration for any audit course shall be completed at the beginning of I and II semesters. The Department should intimate the Controller of Examination about the registration at the beginning of the semester and obtain a formal approval for inclusion of the audit course/s in the Grade card issued to the students vii) **Internship/ Mini Project:** Preferably at an industry/ R&D organization/IT company/ Government organization of significant repute or at the Research Centre of parent Institution for a specified period mentioned in Scheme of Teaching and Examination.
22NMT4.1	**Program Structure:** The number of credits to be registered in a semester is between 16 and 28

Minimum Credit Requirement for the M.Tech. Degree is 80.

The total course package for an M.Tech. Degree Program will typically consist of the following components.

Course type	Range %	Suggested Credits
i) Program Core Courses	20 - 25	20
ii) Program Elective Courses	18 - 20	15
iii) Elective Courses (MOOCS)	4	03
iv) Industrial Internship/Research Internship/Mini Project	10	08
v) Project	35	28
vi) Seminar	2.5	02
vii) Research Experience Through Practice	5	04
viii)Audit courses (two courses)	-	-
Total credits		80

The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the program for the above components, the semester-wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS).

The BOS will consider the proposals from the departments and make recommendations to the Academic Council for consideration and approval.

Mandatory Learning Courses:

These are courses that must be completed by the student at appropriate time as suggested by the Faculty Adviser or the DPGC. Courses that come under the category are as following:

Industrial Training:

This is a 08-credit course. A full-time student will complete the Industrial Training (or a Mini Project) at appropriate time stipulated by DPGC and register for it in the following Semester and shall also submit a bound copy of training report certified by the authority of Training Organization. The

	duration and the details, including the assessment scheme, shall be decided by the faculty advisor, with approval from DPGC. **Seminar:** This also carries 2-credits to be completed at appropriate time stipulated by DPGC. The student will make presentations on topics of academic interest, as suggested by DPGC. **Research Experience through Practice-I and Research Experience through Practice-II:** • Research Experience through Practice-I and II are 2-credit courses in the first and second semesters respectively. • The student will work under a faculty supervisor approved by the DPGC and submits a research proposal at the end of the first semester which is evaluated jointly by the faculty supervisor and a co-examiner. • Students shall be offered inputs like how to conduct a literature survey, how to identify a research problem, how to write a research paper, research report, research proposal, and systematic way of conducting research etc. • Department specific/PG Program specific skill sets required for carrying out a research work may be offered to the students like software tools for system/device simulation and analysis, software/ hardware tools for signal acquisition, data processing, control simulation, Testing/measuring equipment used in research and Testing/measuring procedure. • At the end of Research Experience through Practice-I in the first semester, M. Tech. students should be able to identify a research problem, with clear objectives and methodologies backed by extensive literature review. • Two internal examiners will evaluate the Research Experience through Practice-I out of which one will be the guide and the other examiner will a faculty member who is having expertise in the research area of the student being evaluated. The research proposal report and the research proposal presentation are evaluated for 100 marks in the first semester. • The student will work on the proposed research in the second semester and submit a research paper at the end of the second semester which is evaluated jointly by the faculty supervisor and a co-examiner.

	• In the second semester, the students are expected to carry out Mathematical modelling / Design calculations / computer simulations / Preliminary experimentation / testing of the research problems identified during Research Experience through Practice-I carried out in the first semester. At the end of the second semester, students are expected to write a full research paper based on the Mathematical modelling/ Design calculations/computer simulations/Preliminary experimentation/testing carried out during second semester. The research paper submitted by the student and the presentation of the research work carried out is evaluated for 100 marks in the second semester.
22NMT5.0	**INTERNSHIP/MINI PROJECT:** The student shall undergo Internship/Mini Project as per the Scheme of Teaching and Examination. 1. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute. 2. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship. 3. The students shall report the progress of the internship/Mini Project to the internal guide in regular intervals and seek his/her advice. 4. The Internship shall be completed during the period specified in Scheme of Teaching and Examination. 5. After completion of Internship/mini project, students shall submit a report to the Head of the Department with the approval of both internal and external guides and with the approval of internal guide if the Internship/Mini-Project is carried out in the Institute. 6. The Internship/Mini Project will be evaluated jointly by two internal examiners appointed by the Head of the Department/Controller of Examination. 7. The Internship/Mini Project report and the presentation by the student will be evaluated for 50 marks each immediately after completion of the Internship/Mini Project.

	The students are permitted to carry out the internship anywhere in India or Abroad. The Institution will not provide any kind of Financial Assistance to any student for Internship/Mini Project and for the conduct of Viva-Voce on internship.
22NMT5.1	**Failing to undergo Internship/Mini Project:** Securing a pass grade in Internship/Mini Project is mandatory as a partial requirement for the award of Degree. Internship/Mini Project Securing a pass grade in Internship/Mini Project is mandatory. If any student fails to undergo/complete the Internship/Mini Project, he/she shall be considered as fail in that Course.
22NMT6.0	**SEMINAR:** Securing a pass grade in Seminar is mandatory as a partial requirement for the award of Degree. i) Each candidate shall deliver seminar as per the Scheme of Teaching and Examination on the topics chosen from the relevant fields for about 30 minutes. The Head of the Department shall make arrangements for conducting seminars through concerned faculty members of the department. The Panel of Examiners constituted for the purpose by the Head of the Department shall award the CIE marks for the seminar.
22NMT7.0	**PROJECT WORK:** Securing a pass grade in Project Work is mandatory as a partial requirement for the award of Degree. Project work shall be on individual basis. **Project Part-I and Part-II:** **Project Part-I: (In third Semester)** The duration of the Project Part-I is of 12 weeks as notified in the academic calendar. The evaluation of the Project Part-I will be done during the end of third semester.

	Each department will prepare the Panel of Examiners in advance and also prepare the Project Part-I evaluation schedule indicating the names of the students, their USN, Title of the Project, Name of the Examiners, and time and Venue of the evaluation which will be submitted to the Controller of Examination Office in advance. Project Part-I evaluation will be done by two internal Examiners, one of them will be the Guide and other is preferably one of the experts in the area of PG Project being evaluated. The mark distribution of Project Phase-I evaluation is: 100 marks for report and 100 marks for presentation jointly awarded by the both the examiners. **Project Part-II: (In the fourth Semester)** The total duration of Project Part-II is of 22 weeks as notified in the academic calendar. There will be two Continuous Internal Evaluation of Project Part-II in fourth semester followed by Semester End Evaluation of the Project Phase-II, namely, Project Progress Evaluation-I (PPE-I), Project Progress Evaluation -II(PPE-II) and SEE. The same Panel of Examiners which was formed during Project Part-I evaluation is to be continued for the Project Progress Evaluation in the fourth semester. PPE-I and PPE-II will be scheduled as per the academic calendar and will be evaluated for 100 marks each (50 marks for report and 50 marks for presentation jointly conducted by the two internal examiners). Each department will prepare the Panel of Examiners in advance and also prepare the Project Part-II Project Progress Evaluation Schedule indicating the names of the students, their USN, Title of the Project, Name of the Examiners, and time and Venue of the evaluation as per the format which will be submitted to the Controller of Examination Office in advance. For the Off-Campus projects, the Internal Guide should visit the organization in which the M.Tech Student is carrying out his Project at least once during the project term. The candidate shall submit a soft copy of the dissertation work to the Institute. The soft copy of the dissertation should contain the entire Dissertation in monolithic form as a PDF file (not separate chapters).

	The Guide, after checking the report for completeness shall check the report for Plagiarism content. The allowable plagiarism index is less than or equal to 25%. If the check indicates a plagiarism index greater than 25%, the guide should advice the student to resubmit the dissertation after modifying the report. The report has to be once again checked for the plagiarism content and the signed hard copy of the Plagiarism Report along with the two hard copies of the dissertation is to be submitted to the Head of the Institution through the Head of the Department. The dissertation will be evaluated by two examiners, one of the examiners shall be the Guide of the candidate and the other examiner shall be an external expert in the area of the dissertation being evaluated. The guide shall submit panel of two approved external examiners to the office of the Controller of Examination through the head of the Department. The Controller of Examination will randomly select one of the external examiners and invites him/her formally for the evaluation of the dissertation and Viva-Voce examination giving sufficient time for the external examiner for reading the dissertation.
22NMT7.1	The dissertation will be evaluated by two examiners, one of the examiners shall be the guide of the candidate and the other examiner shall be preferably an external expert in the area of the dissertation being evaluated. The evaluation of the dissertation shall be made independently by each examiner.
22NMT7.2	Examiners shall evaluate the dissertation normally within a period of not more than two weeks from the date of receipt of dissertation through email.
22NMT7.3	The examiners shall independently submit the marks for the dissertation during the viva-voce examination date
22NMT7.4	Sum of the marks awarded by the two examiners shall be the final evaluation marks for the Dissertation.
22NMT7.5	(a) Viva-voce examination of the candidate shall be conducted, if the dissertation work and the reports are accepted by the external examiner. (b) If the external examiner finds that the dissertation work is not up to the expected standard and the minimum passing marks cannot be awarded, the dissertation shall not be accepted for SEE. (c) If the dissertation is rejected during the Project Part II, then the Second Examiner (external) will be appointed by the COE against whom the

	candidate has to re-present the same dissertation. The decision of the Second Examiner (external) will be final. If the second examiner (external) accepts the dissertation, then the viva-voce examination of the candidate shall be conducted as per the norms. If the second examiner (external) rejects the dissertation, then the student has to take an extension for a minimum period of 3 months and re-work on the project. After the completion of the extension period, viva-voce examination of the candidate shall be conducted as per the norms, if the dissertation work is accepted by the external examiner.
22NMT7.6	The candidate, whose dissertation is rejected, can rework on the same topic or choose another topic of dissertation under the same Guide or new Guide if necessary. In such an event, the report shall be submitted within four years from the date of admission to the Program.
22NMT7.7	Viva-voce examination of the candidate shall be conducted jointly by the external examiner and internal examiner/ guide at a mutually convenient date.
22NMT7.8	The relative weightages for the evaluation of dissertation and the performance at the viva-voce shall be as per the scheme of teaching and examination.
22NMT7.9	The marks awarded by both the Examiners at the viva-voce Examination shall be sent jointly to the office of Controller of Examination immediately after the examination.
22NMT7.10	Examination fee as fixed from time to time by the Institute for evaluation of dissertation report and conduct of viva-voce shall be remitted to the Institute as per the instructions of Dean-Academics, from time to time.
22NMT7.11	The candidates who fail to submit the dissertation work within the stipulated time have to apply for the extension of the Project duration through the Guide and the head of the department to the Office of the Controller of Examination. Such candidate is not eligible to be considered for the award of rank.
22NMT8.0	**ATTENDANCE REQUIREMENT:** 1. Each semester is considered as a unit and the candidate has to put in a minimum attendance of 85% in each subject with a provision of condoning 10% of the attendance by Principal for reasons such as medical grounds, participation in University level sports, cultural activities, seminars, workshops and paper presentation etc.

	2. The basis for the calculation of the attendance shall be the period of term prescribed by the institution in its calendar of events. For the first semester students, the same is reckoned from the date of admission to the course 3. The students shall be informed about their attendance position in the first week of every month by the College so that the students shall be cautioned to make up the shortage. 4. The head of the department shall notify regularly, the list of such candidates who fall short of attendance. The list of the candidates falling short of attendance shall be sent to the Principal with a copy to Controller of Examinations. 5. A candidate having shortage of attendance (<75%) in any course(s) registered shall not be allowed to appear for SEE of such course(s). Such students will be awarded 'N' grade in these courses. 6. He/she shall have to repeat those course(s) with 'N' grade and shall re-register for the same course(s) core or elective, as the case may be when the particular course is offered next either in a main (odd/even) or summer semester. 7. If a candidate, for any reason, discontinues the course in the middle he/she may be permitted to register to continue the course along with subsequent batch, subject to the condition that he/she shall complete the class work, lab work and seminar including the submission of dissertation within maximum stipulated period. Such candidate is not eligible to be considered for the award of rank.
22NMT9.0	**ADD/ DROP/ AUDIT OPTIONS:** 1. ADD-option: A student has the option to ADD courses for registration till the date specified for late registration. 2. DROP-option: A student has the option to DROP courses from registration until one week after the mid-semester examination. AUDIT-option: A student can register for auditing a course, or a course can even be converted from credit to audit or from audit to credit, with the consent of faculty advisor and course instructor until one week after the mid-semester exam. However, CORE courses shall not be made available for audit. It is not

	mandatory for the student to go through the regular process of evaluation in an audit course. However, the student has to keep the minimum attendance requirement, as stipulated by the corresponding DPGC for getting the 'U' grade awarded in a course, failing which that course will not be listed in the Grade Card.
22NMT10.0	**ABSENCE DURING THE SEMESTER:** **Leave of Absence** (a) If the period of leave is more than two days and less than three weeks, prior application for leave shall have to be submitted to the Head of the Department concerned, with the recommendation of the Faculty-Advisor stating fully the reasons for the leave request along with supporting documents. It will be the responsibility of the student to intimate the course instructors, Head of the Department and also Chief Warden of the hostel, regarding his absence before availing leave.
22NMT10.1	**Absence during Mid-Semester Examinations:** A student who has been absent from a Mid-Semester Examination (MSE) due to illness and other contingencies may give a request for additional MSE within two working days of such absence to the office of the respective Head of the Department (HOD) with necessary supporting documents and certification from authorized personnel. The HOD may consider such requests depending on the merits of the case, may permit the additional Mid-Semester Examination for the concerned student.
22NMT10.2	**Absence during Semester End Examination:** In case of absence for a Semester End Examination, on medical grounds or other special circumstances the student can apply for 'I' grade in that course with necessary supporting documents and certifications by authorized personnel to the Controller of Examination through Chairman of The Department. The Controller of Examination may consider the request depending on the merits of the case and permit the make-up Semester End Examination for the concerned student. The student may subsequently complete all course requirements within the date stipulated by DPGC (which

	may be extended till first week of next semester under special circumstances) and 'I' grade will then be converted to an appropriate letter grade. If such an application for the 'I' grade is not made by the student, then a letter grade will be awarded based on his in-semester performance.
22NMT11.0	**WITHDRAWAL FROM THE PROGRAM:** **Temporary Withdrawal:** A student who has been admitted to a Post Graduate Degree program of the College may be permitted to withdraw temporarily, for a period of one semester or more on the grounds of prolonged illness or grave calamity in the family etc. The student should abide by the applicable rules and regulations of the college/University at the time of Temporary Withdrawal.
22NMT11.1	**Permanent Withdrawal:** Any student who withdraws admission before the closing date of admission for the Academic Session is eligible for the refund of the deposits only. Fees once paid will not be refunded on any account. Once the admission for the year is closed, the following conditions govern withdrawal of admissions: a) A student who wants to leave the College for good, will be permitted to do so (and can take Transfer Certificate from the College, if needed), only after remitting the Tuition fees as applicable for all the remaining semesters and clearing all other dues, if any. b) Those students who have received any scholarship, stipend or other forms of assistance from the College shall repay all such amounts in addition to those mentioned in (a) above. The decision of the Principal of the Institute regarding withdrawal of a student is final and binding.
22NMT12.0	**EVALUATION SYSTEM:** **Continuous Internal Evaluation (CIE) and Semester End Evaluation (SEE)**
22NMT12.1	For all the theory and laboratory courses, the CIE marks shall be 50. For Research Experience through Practice-I, Research Experience through Practice-II, seminar, Industrial Training/Mini Project, the CIE marks shall be 100. For Project Phase-I, the CIE Marks shall be 200

	For Project Phase-II, the CIE Marks shall be 200 and for SEE 200
22NMT12.2	CIE Marks for courses shall be based on a) Tests MSE-I and MSE-II (for 30 Marks): MSE in a theory course, for 30 marks, shall be based on two tests covering the entire syllabus. Assignments, Quizzes, Simulations, Experimentations, Mini project, oral examinations, field work etc., (for 20 Marks) conducted in respective courses.
22NMT12.3	a) An additional MSE may be conducted for those students absent for valid reasons/ with prior permission. b) For those students who could not score minimum required CIE marks (25 marks), an additional MSE may be conducted, however the maximum CIE marks shall be restricted to 25 out of 50.
22NMT12.4	The candidates shall write the Tests in Blue Book/s. The Blue book/s and other documents relating to award of CIE marks shall be preserved by the Head of the Department for at least six months after the announcement of University results and made available for verification at the directions of the Controller of Examination.
22NMT12.5	Every page of the CIE marks list shall bear the signatures of the concerned Teacher and Head of the Department.
22NMT12.6	The CIE marks list shall be displayed on the Notice Board and corrections, if any, shall be incorporated before submitting to the office of the Controller of Examination (COE).
22NMT12.7	The CIE marks shall be sent to the office of the COE well in advance before the commencement of Semester End Examinations. No corrections of the CIE marks shall be entertained after the submission of marks list to the Office of the COE.
22NMT12.8	Candidates obtaining less than 50% of the CIE marks in any course (Theory /Laboratory/ Seminar/ Internship/ Project) shall not be eligible to appear for the Semester end examination in that course/s. In such cases, the Head of the Department shall arrange for the improvement of CIE marks in the course/ Laboratory when offered in the subsequent semester subject to the maximum duration allowed for completion of a M.Tech. program.
22NMT12.9	**Semester End Evaluation:** There shall be a Semester End Examination at the end of each semester.

22NMT12.10	There shall be double valuation of theory papers. The theory Answer booklets shall be valued independently by two examiners appointed by the Controller of Examination.
22NMT12.11	If the difference between the marks awarded by the two examiners is not more than 15 per cent of the maximum marks, the marks awarded to the candidate shall be the average of two evaluations.
22NMT12.12	If the difference between the marks awarded by the two examiners is more than 15 per cent of the maximum marks, the answer booklet shall be evaluated by a third Examiner appointed by the Controller of Examination. The average of the marks of nearest two valuations shall be considered as the marks secured by the candidate. In case, if one of the three marks falls exactly midway between the other two, then the highest two marks shall be taken for averaging.
22NMT12.13	**Summer Semester:** Summer semester is primarily to assist weak and/or students having N/F grade in courses, for a duration of 4 weeks after the completion of regular even SEE. The institute may also offer Add-on/ Audit Courses during this semester.
22NMT12.14	Each candidate shall obtain not less than 50% of the maximum marks (25 marks) prescribed for the CIE of each subject, including seminars. CIE Marks shall be based on assignments, tests, oral examinations and seminar (minimum of two are compulsory) conducted in respective subjects. The candidates obtaining less than 50% of the CIE marks in any subject shall not be eligible to appear for the SEE in that subject(s). Only in such cases, the Controller of Examination may arrange for reregistering the subject(s) in subsequent semester or may refer to DPGC for necessary remedial measures. The candidates shall write the Internal Assessment Test in Blue Books, and this shall be maintained by the Head of the Department for at least six months after the announcement of result and is available for verification. The CIE marks sheet shall bear the signature of the concerned Teacher and the Chairman of the Department. The CIE marks list shall be displayed on the Notice Board and corrections, if any, shall be incorporated before sending to the Controller of Examinations.
22NMT12.15	The Academic Performance Evaluation of a student shall be according to a Letter Grading System, based on the Class Performance Distribution.

	The Letter grades O, A+, A, B+, B, C and F indicate the level of academic achievement, assessed on a decimal (00) scale. The Letter grade awarded to a student in a course, for which he has registered shall be based on his performance in quizzes, tutorials, assignments etc., as applicable, in addition to two mid-semester examination and one semester end examination. The distribution of weightage among these components may be as follows: Semester End Examination (SEE) 50% Continuous Internal Evaluation (CIE) (i) Quizzes, Tutorials, Assignments etc., 20% (ii) Mid-semester Examination: 30% Any variation, other than the above distribution, requires the approval of the pertinent DPGC and Academic Council. The letter grade awarded to a student in a 0-0-P (Practical) course, is based on an appropriate continuous evaluation scheme that the course instructor shall evolve, with the approval of the pertinent DPGC. The course Instructor shall announce in the class, and/or display in the display boards or at the website, the details of the Evaluation Scheme, including the distribution of the weightage for each of the components, and method of conversion from the raw scores to the letter-grades; within the first week of the semester in which the course is offered, so that there are no ambiguities in communicating the same to all the students concerned.
22NMT12.16	**The Transitional Grades** 'I', 'W' and 'X' would be awarded in the following cases. These would be converted into one or the other of the letter grades (O-F) after the student completes the course requirements. **Grade "I":** To a student having attendance ≥85% and CIE ≥ 70%, in a course, but remained absent from SEE for valid & convincing reasons acceptable to the College, like: i. Illness or accident, which disabled him/her from attending SEE. ii. A calamity in the family at the time of SEE, which required the student to be away from the College. iii. However, the committee chaired by the Principal is authorized to relax the requirement of CIE ≥ 70% if the student is hospitalized or advised long term rest after discharge from the hospital by the Doctor.

	iv. Students who remain absent for Semester End Examinations due to valid reasons and those who are absent due to health reasons are required to submit the necessary documents along with their request to the Controller of Examinations to write Make up Examinations within 2 working days of that examination for which he or she is absent, failing which they will not be given permission. • **Grade "W":** To a student having satisfactory attendance at classes but withdrawing from that course before the prescribed date in a semester as per Faculty Advice. • **Grade "X":** To a student having attendance ≥85% and CIE ≥ 70%, in a course but SEE performance could result in a 'F' grade in the course. (No "F" grade awarded in this case, but student's performance record will be maintained separately).
22NMT12.17	**The Make Up Examination** facility would be available to students who may have missed to attend the SEE of one or more courses in a semester for valid reasons and given the 'I' grade. Also, students having the 'X' grade shall also be eligible to take advantage of this facility. The makeup examination would be held as per dates notified in the Academic Calendar. However, it should be made possible to hold a make-up examination at any other time in the semester with the permission of the Academic Council of the College. In all these cases, the standard of SEE would be the same as the normal SEE.
22NMT12.18	All the 'W' grades awarded to the students would be eligible for conversion to the appropriate letter grades only after the concerned students re-register for these courses in a main/summer semester and fulfil the passing standards for their CIE and (CIE+SEE).
22NMT12.19	The suggested passing standards are CIE to have >=50% and CIE+SEE to have a grade better or at least equal to C. For maintaining high standards, the students scoring less than 50% in CIE are advised to withdraw and to reregister for the course when offered next. The letter grade 'W' to be entered in the grade card against the subject and not to be taken into account while calculating SGPA & CGPA
22NMT12.20	**Rules for grace marks**

<table>
<tr><td></td><td>a. Grace marks up to 1% of the maximum total marks of the courses for which he/she is eligible and have registered (non-credit courses excluded) in the examination or 10 marks whichever is less shall be awarded to the failed course(s), (with a restriction of a maximum of 5 marks per course) provided on the award of such grace marks the candidate passes in that course(s)</td></tr>
<tr><td>22NMT13.0</td><td>LETTER GRADES AND GRADE POINTS:
The Institute adopts absolute grading system wherein the marks are converted to grades, and every semester result will be declared with semester grade point average (SGPA) and Cumulative Grade Point Average (CGPA). The CGPA will be calculated for every semester, except for the first semester.
The grading system with the letter grades and the assigned range of marks under absolute grading system are as given below:
<table>
<tr><th>Letter Grade</th><th>Grade- Points</th><th>Raw Scores %</th><th>Level of Academic Achievement</th></tr>
<tr><td>O</td><td>10</td><td>≥90</td><td>Out standing</td></tr>
<tr><td>A+</td><td>09</td><td>80-89</td><td>Excellent</td></tr>
<tr><td>A</td><td>08</td><td>70-79</td><td>Very Good</td></tr>
<tr><td>B+</td><td>07</td><td>60-69</td><td>Good</td></tr>
<tr><td>B</td><td>06</td><td>55-59</td><td>Above average</td></tr>
<tr><td>C</td><td>05</td><td>50-54</td><td>Average</td></tr>
<tr><td>F</td><td>00</td><td><50</td><td>Fail</td></tr>
<tr><td>U</td><td></td><td></td><td>Audited</td></tr>
</table>
A student obtaining Grade F in a Course shall be considered fail and is required to reappear in subsequent SEE. Whatever the letter grade secured by the student during his /her reappearance shall be retained. However, the number of attempts taken to clear a Course shall be indicated in the grade cards/ transcripts.
Earned Credits:
This refers to the credits assigned to the course in which a student has obtained any one of the letter grades O, A+ A, B+, B and C</td></tr>
<tr><td>22NMT14.0</td><td>PROMOTION AND ELIGIBILITY:</td></tr>
<tr><td>22NMT14.1</td><td>Promotion:
a) All students are promoted to their next semester or year of their program,</td></tr>
</table>

	irrespective of the academic performance. However, for submission for M.Tech. Major Project report in 4th semester, student should have completed all the courses up to 3rd semester
22NMT14.2	**The mandatory non-credit courses,** if any, shall not be considered for the award of class, calculation of SGPA and CGPA. However, a pass grade (PP) in the above courses is mandatory for the award of Degree.
22NMT15.0	**ELIGIBILITY FOR PASSING AND AWARD OF DEGREE:**
22NMT15.1	1. A student who obtains any grade O to C shall be considered as passed and if a student secures F grade in any of the head of passing, he/she has to reappear in that head for SEE. 2. A student shall be declared successful at the end of the program for the award of Degree only on obtaining CGPA≥5.00, with none of the courses remaining with F grade. In case, the CGPA falls below 5.00, the student shall be permitted to appear again for SEE for required number of courses (other than seminar and practical) and times, subject to the provision of University, to make up CGPA≥5.0. The student should reject the SEE results of previous attempt and obtain written permission form the Controller of Examinations to reappear to the subsequent SEE.
22NMT15.2	For a pass in a theory course, the student shall secure a minimum of 40% of the maximum marks prescribed in the Semester End Examination and 50% of marks in CIE and 50% in the aggregate of CIE and SEE marks. The minimum passing grade in a course is C.
22NMT15.3	For a pass in Internship/ Practical/ Project/ Dissertation/ Viva-voce examination, a student shall secure a minimum of 50% of the maximum marks prescribed for the SEE in Internship/ Practical/ Project/ Dissertation/ Viva-voce. The minimum passing grade in a course is C.
22NMT15.4	For a pass, a candidate shall obtain a minimum of 50% of maximum marks in Seminar.
22NMT15.5	IV Semester full time candidates having backlog courses are permitted to upload the dissertation report and to appear for SEE. The IV semester grade card shall be released only when the candidate completes all the backlog courses and become eligible for the award of Degree.

22NMT15.6	**Eligibility for Award of Degree:** A student shall be declared to have completed the Degree of Master of Technology, provided the student has undergone the stipulated course work as per the regulations and has earned the prescribed credits, as per the scheme of teaching and examination of the program
22NMT16.0	**EVALUATION OF PERFORMANCE:** **Computation of SGPA and CGPA** SGPA and CGPA: The credit index can be used further for calculating the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA), both being important academic performance indices of the student. While SGPA is equal to the credit index for a semester divided by the total number of credits registered by the student in that semester, CGPA gives the sum total of credit indices of all the previous semesters divided by the total number of credits registered in all these semesters. Both the equations together facilitate the declaration of academic performance of a student, at the end of a semester and at the end of successive semesters respectively SGPA is computed as follows: $$SGPA = \frac{\sum[(Course\ Credits) \times (Grade\ Point)]}{\substack{\text{(for all courses with letter grades including F grades in that semester)} \\ \sum[Course\ Credits] \\ \text{(for all courses with letter grades including F grades in that semester)}}}$$ CGPA is computed as follows: $$CGPA = \frac{\sum[(Course\ Credits) \times (Grade\ Point)]}{\substack{\text{(for all courses excluding those with F grades until that semester)} \\ \sum[Course\ Credits] \\ \text{(for all courses excluding those with F grades until that semester)}}}$$
22NMT16.1	**Communication of Grades:** • The SGPA and CGPA respectively, facilitate the declaration of academic performance of a student at the end of a semester and at the end of successive semesters. Both of them would be normally calculated to the

	second decimal position, so that the CGPA, in particular, can be made use of in rank ordering the students' performance in the Institute. • If two students get the same CGPA, the tie could be resolved by considering the number of times a student has obtained higher SGPA, But, if it is still not resolved, the number of times a student has obtained higher grades like O, A, B etc. could be taken into account.
22NMT16.2	**Challenge evaluation** If a student is not satisfied with the marks allotted to him/her in the semester end examinations, he/she could apply for challenge evaluation within the prescribed time specified. In such cases the answer papers will be valued by the DPGC committee and marks secured by the students in the challenge evaluation will be final.
22NMT16.3	**Grade Card:** Based on the secured letter grades, grade points, SGPA and CGPA, a grade card for each semester shall be issued. On specific request on paying prescribed fee, a transcript indicating the performance in all semesters may be issued.
22NMT16.4	**Conversions of Grades into Percentage and Class Equivalence** Conversion formula for the conversion of CGPA into percentage is given below: Percentage of marks secured, P = CGPA Earned × 10 **Illustration: for CGPA of 8.18**: P = CGPA Earned 8.18 × 10 = 81.8 %
22NMT17.0	**DEGREE REQUIREMENTS:** The Degree requirements of a student for the M.Tech Degree program are as follows: 1. College Requirements: i) Minimum Earned Credit Requirement for M.Tech. Degree is 80 ii) Satisfactory completion of all Mandatory Learning courses 2. Program Requirements: i) Minimum Earned Credit Requirements on all core courses, ii) Elective Courses and major project as specified by the DPGC. The maximum duration for a student for complying to the Degree requirements is 8 semesters from the date of first registration for his first semester.

22NMT18.0 **TERMINATION FROM THE PROGRAM/READMISSION:**

A student shall be required to leave the College without the award of the Degree, under the following circumstances:

ii) Failing to complete the degree requirements in double the duration of the program

Based on disciplinary action suggested by the Academic Council/Governing Council.

22NMT19.0 **GRADUATION REQUIREMENTS AND CONVOCATION:**

1. A student shall be declared to be eligible for the award of the Degree if he has

a) Fulfilled Degree Requirements

b) No Dues to the College, Departments, Hostels, Library Central Computer Centre and any other center

c) No disciplinary action pending against him.

2. The award of the Degree must be recommended by the Academic council and approved by Governing Council of Nitte (DU)

Convocation: Degree will be awarded in person for the students who have graduated during the preceding academic year. Degrees will be awarded in absentia to such students who are unable to attend the Convocation. Students are required to apply for the Convocation along with the prescribed fees, after having satisfactorily completed all the Degree requirements within the specified date in order to arrange for the award of the Degree during convocation.

22NMT20.0 **AWARD OF CLASS, PRIZES, MEDALS & RANKS:**

- **Award of Class:** Sometimes, it would be necessary to provide equivalence of SGPA and CGPA with the percentages and/or Class awarded as in the conventional system of declaring the results of University examinations. This can be done by prescribing certain specific thresholds in these averages for Distinction, First Class and Second Class as described below.

Percentage Equivalence of Grade Points (For a 10-Point Scale)

GPA	Percentage of Marks*	Class
≥ 7.00	≥ 70%	Distinction

	<table><tr><td>≥ 6.00</td><td>≥ 60%</td><td>First Class</td></tr><tr><td>5.0 ≥ GPA <6.00</td><td>50≥ Percentage < 60%</td><td>Second Class</td></tr></table> Percentage * = (GPA) x 10 • **For the award of Prizes, Medals and ranks**: The conditions stipulated by the Donor may be considered as per the statutes framed by the University for such awards. o An attempt means the appearance/registration of a candidate for an examination in one or more courses either in part or failing a particular examination. o A candidate who fails/remaining absent (after submitting exam application) in the main examination and passes one or more subjects/courses or all subjects/courses in the supplementary/Make-up examination such candidates shall be considered as taken more than an attempt. o Merit Certificates and University Medals/ will be awarded on the basis of overall CGPA, governed by the specific selection criteria that may be formulated by the University for such Medals / Awards o Only those candidates who have completed the Program and fulfilled all the requirements in the minimum number of years prescribed (i.e., 2 years) and who have passed each semester in the first attempt are eligible for the award of Merit Certificates and /or Ranks and University Medals. Candidates with W, N, I, X & F grades and who passes the courses in the subsequent/supplementary/make up examinations are not eligible for the award of Gold Medal or Merit Certificate.
22NMT21.0	**CONDUCT AND DISCIPLINE:** 1. Students shall conduct themselves within and outside the premises of the Institute, in a manner befitting the students of an Institution of National Importance 2. **As per the order of Honorable Supreme Court of India, ragging in any form is considered as a criminal offence and is banned, any form of ragging will be severely dealt with**. 3. The following acts of omission/ or commission shall constitute gross Violation of the code of conduct and are liable to invoke disciplinary measures:

	a) Ragging b) Lack of courtesy and decorum; indecent behavior anywhere within or outside the campus. c) Willful damage or stealthy removal of any property /belongings of the Institute /Hostel or of fellow students/ citizens d) Possession, consumption or distribution of alcoholic drinks or any kind of hallucinogenic drugs. e) Mutilation or unauthorized possession of Library books. f) Noisy and unseemly behavior, disturbing studies of fellow Students. g) Hacking in computer systems (such as entering into other Person's area without prior permission, manipulation and/or Damage of computer hardware and software or any other Cybercrime etc.,). h) Plagiarism of any nature. i) Any other act of gross indiscipline as decided by the University from time to time. j) Smoking in College Campus and supari chewing. k) Unauthorized fund raising and promoting sales 4. Commensurate with the gravity of offense, the punishment may be: reprimand, expulsion from the hostel, debarment from an examination, disallowing the use of certain facilities of the College, rustication for a specified period or even outright expulsion from the College, or even handing over the case to appropriate law enforcement authorities or the judiciary, as required by the circumstances. i) For an offence committed in a) A hostel b) A department or in a classroom c) Elsewhere, the Chief Warden, the Head of the Department and the Dean (Students Welfare), respectively, shall have the authority to reprimand or impose fine. ii) All cases involving punishment shall be reported to the Principal. 5. Cases of adoption of unfair means and/or any malpractice in an examination shall be reported to the Controller of Examination.

	○ **Note:** Students are required to be inside the examination hall 20 minutes before the commencement of examination. This is applicable for all examinations (Semester end/Supplementary/makeup) henceforth. Students will not be allowed inside the examination hall after the commencement, under any circumstances.

Department Vision

Pursuing excellence in Electrical & Electronics Engineering, creating a research environment to promote innovation and address global challenges

Department Mission

- To equip students to face global challenges by excelling in professional career and higher education.
- To offer high quality graduate and post graduate programs in electrical & electronics engineering.
- To promote excellence in research, collaborative activities and contribute to social development with ethical values.

Programme Educational Objectives (PEO)

PEO1: Excel in professional career in industry, academia and entrepreneurial ventures by applying the knowledge of power electronics.

PEO2: Engage in designing power electronics systems and contribute in multidisciplinary engineering projects.

PEO3: Inculcate and exhibit ethical values, communication skills and adapt to current trends by engaging in research by providing supportive and leadership roles.

At the end of M.Tech (Electric Vehicle Technology) program the students will have an ability to

PO1:	Independently carry out research /investigation and development work to solve practical problems
PO2:	Write and present a substantial technical report/document
PO3:	demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4:	Use modern tools to simulate and model Electrical Vehicular systems and carry out performance evaluation.
PO5:	Engage in lifelong learning with a commitment to improve knowledge in a technologically changing scenario.
PO6:	Appreciate and Practice professional ethics for sustainable development of society.
	Programme Specific Outcomes (PSO)
PSO-1	An ability to analyse and design power electronic converters used in electric vehicles
PSO-2	An ability to analyse battery parameters and design battery management system.

List Of Faculty

Sl. No	Name of Faculty	Qualification	Designation
1.	Dr. Suryanarayana K.	Ph.D.	Professor & HOD
2.	Dr. Nagesh Prabhu	Ph.D.	Professor
3.	Dr. Sathyendra Kumar	Ph.D.	Professor
4.	Dr. Rajalaxmi Samaga	Ph.D.	Professor
5.	Dr. Nayana Shetty	Ph.D.	Associate Professor
6.	Dr. Anitha Marina Colaco	Ph.D.	Associate Professor
7.	Dr. Latha Shenoy	Ph.D.	Associate Professor
8.	Mr. Naveen J.	M.Tech	Asst. Prof Gd III
9.	Mr. Pradeep Kumar	M.Tech (Ph.D.)	Asst. Prof Gd III
10.	Mr. Dinesh Shetty	M.Tech (Ph.D.)	Asst. Prof Gd III
11.	Dr. Girisha Joshi	Ph.D.	Asst. Prof Gd III
12.	Dr. Krishna Rao	Ph.D.	Asst. Prof Gd III
13.	Mr. Mahabaleshwara Sharma K.	M.Tech(Ph.D.)	Asst. Prof Gd II
14.	Mrs. Raksha Adappa	M.Tech	Asst. Prof Gd II
15.	Mrs. Soumya Rani Mestha	M.Tech (Ph.D.)	Asst. Prof Gd II
16.	Mr. Gururaj K.	M.Tech	Asst. Prof Gd II
17.	Mr. Ravikiran Rao	M.Tech	Asst. Prof Gd II
18.	Md. Abdul Raheman	M.E(Ph.D.)	Asst. Prof Gd II
19.	Mrs. Swathi Hatwar H.	M.Tech(Ph.D.)	Asst. Prof Gd II
20.	Mrs. Palimaru Aparna	M.Tech	Asst. Prof Gd I
21.	Ms. Deepa K	M.Tech	Asst. Prof Gd I
22.	Ms. Anupama B	M.Tech	Asst. Prof Gd I
23.	Ms. Nutana Shetty	M.Tech	Asst. Prof Gd I
24.	Mr. Anup Shetty	M.Tech	Asst. Prof Gd I

CREDIT DISTRIBUTION

No.	Course Category	Suggested Credits
1.	Professional Courses (PCC) – core	16
2.	Professional Courses (PEC) – elective	18
3.	Research Methodology & IPR/RETP	04
4.	Labs	04
5.	Project Work (UCC) (Phase 1 & 2)	08+20
6.	Audit Courses (2 Nos)	00
7.	Seminar on Current Topic (UCC)	02
8.	Internship (UCC)	08
	Total Credits to be earned:	**80**

NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

Scheme & Syllabus for

M. Tech. (Electric Vehicle Technology)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

2022-24

NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

Established under Section 3 of UGC Act 1956
Accredited with 'A+' Grade by NAAC

Off-Campus Centre, Nitte - 574 110, Karkala

M.Tech. (EVT): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

1st Year Scheme

I SEMESTER

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	22EVT101	Electric and Hybrid Vehicles	EEE	4	0	0	3	50	50	100	4
2	PCC	22EVT 102	Vehicle Dynamics	EEE	4	0	0	3	50	50	100	4
3	RETP	22 EVT 103	Research Experience Through Practice -I	EEE	Four contact hours /week for carrying out Research and Interaction between the faculty and students			-	100	0	100	2
4	PCC	22 EVT 104	Electric and Hybrid Vehicles Lab	EEE	0	0	2	3	50	50	100	1
5	PCC	22 EVT 105	Powertrain Lab	EEE	0	0	2	3	50	50	100	1
6	PEC	22 EVT 11X	Elective – I	EEE	3	0	0	3	50	50	100	3
7	PEC	22 EVT 12X	Elective - II	EEE	3	0	0	3	50	50	100	3
8	PEC	22 EVT 13X	Elective - III	EEE	3	0	0	3	50	50	100	3
9	AUDIT	22 EVT AU1X	Audit Course-I	EEE	2	-	-	-	-	-	-	-
				Total	**19**	**0**	**4**	**21**	**450**	**350**	**800**	**21**

II SEMESTER												
Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	PCC	22 EVT 201	Power Electronic Converters	EEE	4	0	0	3	50	50	100	4
2	PCC	22 EVT 202	EV Motor drives and control	EEE	4	0	0	3	50	50	100	4
3	RETP	22 EVT 203	Research Experience Through Practice -II	EEE	Four contact hours /week for carrying out Research and Interaction between the faculty and students			-	100	0	100	2
4	PCC	22 EVT 204	Power Electronic Converters Lab	EEE	0	0	2	3	50	50	100	1
5	PCC	22 EVT 205	EV Motor drives and control Lab	EEE	0	0	2	3	50	50	100	1
6	PEC	22 EVT 21X	Elective – IV	EEE	3	0	0	3	50	50	100	3
7	PEC	22 EVT 22X	Elective – V	EEE	3	0	0	3	50	50	100	3
8	PEC	22 EVT 23X	Elective - VI	EEE	3	0	0	3	50	50	100	3
9	AUDIT	22 EVT AU2X	Audit Course-II	EEE	2	-	-	-	-	-	-	-
				Total	**19**	**0**	**4**	**21**	**450**	**350**	**800**	**21**

Note: PCC: Professional Core Course, PEC: Professional Elective Course, AUDIT (AU): Non-credit Audit course, RETP: Research Experience Through Practice.

L –Lecture, T – Tutorial, P- Practical/ Drawing, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

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Off-Campus Centre, Nitte - 574 110, Karkala

M.Tech. (EVT): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

2nd Year Scheme

III SEMESTER												
Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawin	Duration in hours	CIEMarks	SEEMarks	Total Marks	
					L	T	P					
1	UCC	22EVT301	Industry Internship/ Research Internship/Mini Project	EEE	8 Weeks Full Time [40-45 Hrs/week]			3	100	0	100	8
2	UCC	22EVT302	Seminar on Special Topic	EEE	0	0	2	3	100	0	100	2
3	UCC	22EVT303	Project Part	EEE	12 Weeks Full Time [Minimum 30 Hrs/week]			3	200	0	200	8
				Total	**0**	**0**	**2**	**9**	**400**	**0**	**400**	**18**

Note: L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Internship: CIE Evaluation is for 100 Marks where 50 Marks is for Report and 50 Marks for the Presentation

Project Part: CIE Evaluation is for 200 Marks where 100 Marks is for Report and 100 Marks for the Presentation

IV SEMESTER												
Sl. No	**Course Type**	**Course Code**	**Course Title**	**Teaching Department**	**Teaching Hours /Week**			**Examination**				**Credits**
					Theory Lecture	**Tutorial**	**Practical/ Drawin**	**Duration in hours**	**CIEMarks**	**SEEMarks**	**Total Marks**	
					L	**T**	**P**					
1	UCC	22EVT401	Project Part -2	EEE	22 Weeks Full Time [36 Hrs/week]			3	200	200	400	20
				Total	**0**	**0**	**0**	**3**	**200**	**200**	**400**	**20**
Note: L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.												
Project Part-2: CIE Evaluation is for 200 Marks having Project Progress Evaluation (PPE) and PPE-2 each for 100 Marks.												

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Off-Campus Centre, Nitte - 574 110, Karkala

M.Tech. (EVT): Scheme of Teaching and Examinations 2022-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2022 - 23)

List of Domain Specific Skill Development Audit Course (AUDIT)	
Course Code	**Course Title**
22EVTAU11	Programming Digital Signal Controller
22EVTAU21	PCB Design

List of Electives [PEC]			
Elective - I		**Elective - II**	
Code	**Course Title**	**Code**	**Course Title**
22EVT111	Advanced Battery Technology for Electrical Vehicles	22EVT121	Automotive Electronics for EVs
22EVT112	Energy Storage Systems for EV	22EVT122	Modeling and Analysis of Electrical Machines
22EVT113	Special Electrical Machines	22EVT123	Power Semiconductor Devices
Elective - III		**Elective - IV**	
Code	**Course Title**	**Code**	**Course Title**
22EVT131	Embedded System	22EVT211	Battery Management System
22EVT132	Applied Mathematics	22EVT212	Thermal Management of EV systems
22EVT133	Digital Controller	22EVT213	Vehicle Body Engineering
Elective - V		**Elective – VI**	
Code	**Course Title**	**Code**	**Course Title**
22EVT221	PWM Controlled Power Electronic Converters	22EVT231	Automotive Computer Controlled Systems
22EVT222	Solar Battery Charging System	22EVT232*	Automotive Security
22EVT223	EV Standards & Testing	22EVT233*	Vehicle management and control
22EVT224	EVs in Smart Grid	22EVT234**	Fundamentals of Automotive Systems

* 22EVT232 and 22EVT233 are offered in association with Microchip Technology Inc.

** Elective course 22EVT234 may be registered under NPTEL

Electric and Hybrid Vehicles

Course Code:	**22EVT101**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**4:0:0**	**Credits:**	**04**
Total Teaching Hours:	**50+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce configurations of EV and HEVs
2.	To design electric vehicle & HEV for various applications
3.	To select appropriate motor and converter for EV applications
4.	To select battery, battery indication system for EV applications
5.	To develop battery charger for an EV

UNIT-I

Introduction to EV & HEV — **09 Hours**

Introduction:
Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.
EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives
EV Parameters: Weight, size, force, energy & performance parameters.

UNIT-II

EV Propulsion- Electric Motor: — **06 Hours**

Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electirc Motors for EV applications

Required Power Electronics & Control: — **06 Hours**

Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies

UNIT-III

EV Motor Drives — **11 Hours**

DC Motor: Type of wound-field DC Motor, Torque speed characteristics
DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor
Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control

UNIT-IV

HEV (Hybrid Electric Vehicle): — **08 Hours**

Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow control in all HEV configurations, Examples of HEV system performance

UNIT-V

Energy Sources & Charging:	**10 Hours**
Different Batteries and Ultra-capacitors, Battery characteristics (Discharging &Charging) Battery Chargers: Conductive (Basic charger circuits, microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication Methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.	

Course Outcomes: At the end of the course student will be able to

1.	Identify EV concepts, EV configurations and various EV parameters for better understanding of the EV technology.
2.	Analyse the EV propulsion system and electric motors for vehicular applications & power electronics converters required for their control.
3.	Analyse DC motor & induction motor drives and discuss control methods.
4.	Elaborate various hybrid electric vehicle configurations and explain the power flow control in all HEV configurations
5.	Identify different energy sources used in EV and analyse the various methods used in charging these energy sources

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT101.1			2	2				
22EVT101.2			2	3			2	
22EVT101.3			2	2				
22EVT101.4			2					
22EVT101.5			2					2

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
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.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Vehicle Dynamics

Course Code:	**22EVT102**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**4+0+0**	**Credits:**	**04**
Total Teaching Hours:	**50+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand the dynamics of vehicle ride under different riding condition.
2.	Present a problem oriented in depth knowledge of Vehicle Dynamics.
3.	address the underlying concepts and methods behind Vehicle Dynamics
4.	Calculate and refer the loads and forces associated to the vehicles.
5.	Analyse the behaviour of the vehicles under acceleration, ride and braking

UNIT-I

Basics of Vehicle Dynamics — **10 Hours**

History, vehicle classifications, fundamental approaches to vehicle dynamics modelling; SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, Brake proportioning, braking efficiency.

UNIT-II

Acceleration Performance: — **05 Hours**

Power train components; power and traction limited acceleration; transverse weight shift; front wheel drive vs rear wheel drive vs. all-wheel drive vehicles

Braking Performance: — **05 Hours**

Braking force analysis; brake design and analysis; federal regulation on braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance issues in braking

UNIT-III

Road Loads — **05 Hours**

Wind drag and car body design, rolling resistance; breakdowns of total road loads; gas mileage analysis and driving styles; Aerodynamics

Tire and Tire Dynamics — **05 Hours**

Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models

UNIT-IV

Ride & Cornering/steering — **10 Hours**

Riding comfort; perception of vibration; vibration sources; vibration transmission to the passengers;: lower speed cornering; high speed corner; cornering bicycle model; Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover

UNIT-V

Chassis and Suspension Systems — **10 Hours**

Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements: Active, Semi-

Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions.

Course Outcomes: At the end of the course student will be able to

1.	Analyse the dynamics of vehicle under different riding condition.
2.	Analyse acceleration and braking performance in electric vehicle to understand the vehicle dynamics under these conditions.
3.	Articulate road loads and tyre dynamics in electric vehicles.
4.	Interpret riding comfort & vibrations, cornering and roll over in electric vehicles to understand the vehicular dynamics.
5.	Infer on the suspension kinematics and controllable suspension elements used in electric vehicles.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT102.1	2		2		2			
22EVT102.2	2		2		2			
22EVT102.3			2	1				
22EVT102.4	2		2					
22EVT102.5	2		3					

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.
2.	The Multibody systems Approach to Vehicle Dynamics, Mike Blundell and Damian Harty, Elsevier, 2004.
3.	Vehicle Dynamics, Theory and Application, Reza N. Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e-ISBN 978-0-387-74244.
4.	Race Car Vehicle Dynamics, W.F. Milliken and D.L. Milliken, SAE, 1995, ISBN 1-56091-526-9.
5.	Reimpell, Stoll and Betzler: The Automotive Chassis: Engineering Principles.
6.	Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012
7.	Rajesh Rajamani, Vehicle Dynamics & control, Springer.
8.	R.V. Dukkipati, Vehicle dynamics, Narsova Publications.

RESEARCH EXPERIENCE THROUGH PRACTICE

Course Code:	22EVT103	Course Type	RETP
Teaching Hours/Week (L: T: P)	0:0:4	Credits	2
Total Teaching Hours	0+0+52	CIE	100

Teaching Department: Any

Course Objectives: The research purposes are

1. To foresee future problems through pursuit of truth as a "global centre of excellence for intellectual creativity".
2. To respond to current social demands, and to contribute to the creation and development of scientific technologies with the aim of realizing an affluent society and natural environment for humanity.
3. At the same time, the course aims to create excellent educational resources and an excellent educational environment through frontline researches
4. To Understand professional writing and communication contexts and genres, analyzing quantifiable data discovered by researching, and constructing finished professional workplace documents.

Individual PG Students are to be allotted to the individual faculty members based on student's area of research interest, specialization of faculty members in the beginning of the first semester.

MODULE

Defining the research problem – Selecting the problem – Necessity of defining the problem -Techniques involved in defining the problem – Importance of literature review in defining a problem – Survey of literature – Primary and secondary sources – Reviews, treatise, monographs patents – web as a source – searching the web – Identifying gap areas from literature review – Development of working hypothesis, systematic way of conducting research, write a review / research paper, research proposal, preparation of research report.

MODULE-2

- Introduction various simulation tools related to power electronics and electric vehicles
- Use of software tools (MATLAB-Simulink, MATHCAD , PSIM)
- Introduction to typesetting tool (Latex).
- At the end of the course students should submit a research proposal and should present the idea.

The Research proposal report prepared based on the work carried out by the PG Student is evaluated for 50 marks and 20 minutes presentation on the research work carried out will be evaluated for 50 marks jointly by the examiners.

Course Outcomes: At the end of the course student will be able to

1.	Identify and define the problem statement based on the literature reviewed.
2.	Formulate the objectives specific to the defined problem statement.
3.	Develop the methodology for achieving the objectives.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT103.1	2	2		3		3		
22EVT103.2	2	2		3				
22EVT103.3	2	2		3				

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Gina Wisker, "The Undergraduate Research Hand book", 2018.
E Books / MOOCs/ NPTEL	
1.	https://www.classcentral.com/course/swayam-research-methodology7760

Electric and Hybrid Vehicles Laboratory

Course Code:	**22EVT104**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P):	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand working of different electric motors drives used in Electric Vehicles.
2.	To study off-grid solar inverters and inverter stack configurations.
3.	To study the concept of solar based EV charging station.
4.	To identify components of electric and hybrid electric vehicle
5.	To understand the significance of BMS in managing energy storage.

List of Experiments

1.	Electric Rickshaw Motor kit
2.	BLDC motor-based EV
3.	PMSM based Electric vehicle
4.	Induction motor based electric vehicle.
5.	Study of off-grid solar Inverter
6.	Study of 4 Leg Semikron Stack
7.	Solar based EV Charging station.
8.	Study of electric vehicle system.
9.	Study of hybrid electric vehicle system.
10.	Demonstration of battery management System

Course Outcomes: At the end of the course student will be able to

1.	Demonstrate various electric motors drives used in Electric Vehicles.
2.	Analyse off-grid solar inverters and inverter stack configurations.
3.	Demonstrate use of solar based EV charging station
4.	Identify various components of electric and hybrid electric vehicle and analyse its performance.
5.	Demonstrate the use of BMS in managing energy storage devices of EVs

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT104.1	1	2	2	3				
22EVT104.2	1	2	2	3				
22EVT104.3	1	2	2	3				2

	22EVT104.4	1	2	2	3				
	22EVT104.5	1	2	2	3				3

1: Low 2: Medium 3: High

Powertrain Laboratory

Course Code:	**22EVT105**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P):	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To study conventional vehicle fuel economy and efficiency.
2.	To understand the working of transmission control module.
3.	To study hybrid electric vehicle (HEV) multimode reference application.
4.	To understand hybrid electric vehicle (HEV) input power-split reference application.
5.	Study of Electric Vehicle reference application using MATLAB

List of Experiments

1.	Study of Conventional Vehicle Spark-Ignition Engine Fuel Economy and Emissions using MATLAB
2.	Study of Conventional Vehicle efficiency using MATLAB
3.	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules using MATLAB
4.	Study of hybrid electric vehicle (HEV) multimode reference application using MATLAB
5.	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules to design control algorithms.
6.	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules to assess the impact of powertrain changes, such as an engine or gear ratio, on performance, fuel economy, and emissions.
7.	Study of hybrid electric vehicle (HEV) input power-split reference application using MATLAB.
8.	Study of HEV P0 reference application using MATLAB
9.	Study of HEV P1 reference application using MATLAB
10.	Study of Electric Vehicle reference application using MATLAB

Course Outcomes: At the end of the course student will be able to

1.	Use the MATLAB as a tool to analyze the performance of conventional vehicle.
2.	Analyze the working of TCM used in conventional vehicles.
3.	Analyze transmission control module shift schedules to assess the impact of Powertrain changes.
4.	Describe hybrid electric vehicle (HEV) input power-split reference application.
5.	Use Electric Vehicle reference application in MATLAB

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT105.1	1	2	2	3				
22EVT105.2	1	2	2	3				
22EVT105.3	1	2	2	3				
22EVT105.4	1	2	2	3				

	22EVT105.5	1	2	2	3				

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1) https://in.mathworks.com/help/autoblks/powertrain-reference-applications.html

Advanced Battery Technology for Electrical Vehicles

Course Code:	**22EVT111**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand electrical vehicle operation & battery basics
2.	To study the electric vehicle battery requirement and battery efficiency
3.	To explain electric vehicle battery charging methods
4.	To understand electric vehicle fast charging & discharging behaviour
5.	To understand electric vehicle battery performance

UNIT-I

ELECTRIC VEHICLE BATTERIES — **04 Hours**

Electric Vehicle Operation, Battery Basics, Introduction to Electric Vehicle Batteries, Fuel Cell Technology, Choice of a Battery Type for Electric Vehicles

ELECTRIC VEHICLE BATTERY EFFICIENCY — **06 Hours**

Effects of VRLA Battery Formation on Electric Vehicle Performance, Regenerative Braking, Electric Vehicle Body and Frame, Fluids, Lubricants, and Coolants, Effects of Current Density on Battery Formation, Effects of Excessive Heat on Battery Cycle Life, Battery Storage, The Lithium-ion Battery, Traction Battery Pack Design

ELECTRIC VEHICLE BATTERY CAPACITY — **05 Hours**

Battery Capacity, The Temperature Dependence of Battery Capacity, State of Charge of a VRLA Battery, Capacity Discharge Testing of VRLA Batteries, Battery Capacity Recovery, Definition of NiMH Battery Capacity, Li-ion Battery Capacity, Battery Capacity Tests, Energy Balances for the Electric Vehicle

UNIT-II

ELECTRIC VEHICLE BATTERY CHARGING — **05 Hours**

Charging NiMH Batteries, Rate of Charge Effect on Charge Acceptance Efficiency of Traction, Battery Packs, Environmental Influences on Charging, Charging Methods for NiMH Batteries, Charging Technology, Battery Pack Corrective Actions

ELECTRIC VEHICLE BATTERY FAST CHARGING — **06 Hours**

On-board & off-board charging, The Fast Charging Process, Fast Charging Strategies, The Fast Charger Configuration, Using Equalizing/Leveling Chargers, Inductive Charging—Making Recharging Easier, Range Testing of Electric Vehicles Using Fast Charging, Electric Vehicle Speedometer Calibration. Wireless Charging

ELECTRIC VEHICLE BATTERY DISCHARGING — **04 Hours**

Definition of NiMH Battery Capacity, Discharge Capacity Behavior, Discharge Characteristics of Li-ion Battery, Discharge of an Electric Vehicle Battery Pack, Cold-Weather Impact on Electric Vehicle Battery Discharge

UNIT-III

ELECTRIC VEHICLE BATTERY PERFORMANCE — **10 Hours**

The Battery Performance Management System, BPMS Thermal Management System, The BPMS Charging Control, High-Voltage Cabling and Disconnects, Safety in Battery Design, Battery Pack Safety—Electrolyte Spillage and Electric Shock, Charging Technology, Electrical Insulation Breakdown Detection, Electrical Vehicle Component Tests, Building Standards, Ventilation

Course Outcomes: At the end of the course student will be able to

1.	Describe battery basics and its different types used in electric vehicles.
2.	Analyze the capacity of different types of batteries used in electric vehicles.
3.	Analyze the impacts of rate of charge effect and environmental effects in different battery charging methods.
4.	Compare the fast charging and discharging behavior of different types of batteries.
5.	Analyze battery performance management systems used with respect to battery operation and safety.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT111.1			2					3
22EVT111.2			2					3
22EVT111.3			2					3
22EVT111.4			2					3
22EVT111.5			2					3

1: Low 2: Medium 3: High

Textbook:

1.	Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002

Energy Storage Systems for EV

Course Code:	**22EVT112**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand working of different types of electric vehicles.
2.	To explain the battery parameters.
3.	To understand different types of batteries.
4.	To illustrate battery charging and modelling
5.	To introduce novel and alternate energy sources.

UNIT-I

Types of Electric Vehicle — **07 Hours**

Battery electric vehicles, The IC engine/electric hybrid vehicle, fuelled electric vehicles, Electric vehicles using supply lines, Solar powered vehicles, Electric vehicles which use flywheels or super capacitors, Electric Vehicles for the Future

Battery Parameters — **08 Hours**

Electrochemical Batteries, Cell and battery voltages, Charge (or Amp hour) capacity, Energy stored, Specific energy, Energy density, Specific power, Amp hour (or charge) efficiency, Energy efficiency. Self-discharge rates, Battery geometry, Battery temperature, Battery life and number of deep cycles.

UNIT-II

Types of Batteries — **05 Hours**

Lead Acid Batteries, Nickel-based Batteries: Introduction, Nickel cadmium, Nickel metal hydride batteries, Sodium-based Batteries, Lithium Batteries, Metal Air Batteries,

Battery Charging and Modelling — **10 Hours**

Battery Charging, Battery chargers, Charge equalization, The Designer's Choice of Battery, Use of Batteries in Hybrid Vehicles, Internal combustion/battery electric hybrids, Battery/battery electric hybrids, Combinations using flywheels, Complex hybrids, Battery Modelling, the purpose of battery modelling, Battery equivalent circuit, Modelling battery capacity, Simulation a battery at a set power, Calculating the Peukert Coefficient, Approximate battery sizing

UNIT-III

Alternative and Novel Energy Sources and Stores: — **10 Hours**

Introduction, Solar Photovoltaic, Wind Power, Flywheels, Ultra capacitors, Super Capacitors, Supply Rails, Hydrogen Fuel Cells: Basic Principles, Hydrogen Storage I: Storage as Hydrogen, Hydrogen Storage II: Chemical Methods

Course Outcomes: At the end of the course student will be able to

1.	Identify various types of electric vehicles and their performance parameters.
2.	Analyse the battery parameters and their variations during charge and discharge cycles.
3.	List different types of batteries and analyse their performance parameters.
4.	Examine the battery charging requirements and develop the complete battery model.
5.	Identify novel and alternate energy sources which could be used in EVs.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT112.1					2			
22EVT112.2					2			2
22EVT112.3					2			2
22EVT112.4					2			2
22EVT112.5					2			

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2.	M. Barak (Ed.), T. Dickinson, U. Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye, "Electrochemical Power Sources: Primary & Secondary Batteries", IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.
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.

Special Electrical Machines			
Course Code:	**22EVT113**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3+0+0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce new and advanced electrical machines like, Switched Reluctance Motor, Synchronous Reluctance motor, Permanent Magnet DC (PMDC) Motor, Brushless Permanent Magnet DC (BLDC) Motors & linear electrical machine their modeling and control.

UNIT-I

Permanent Magnet Synchronous Machine and control strategies	**08 Hours**
Real-Time Model of a Two-Phase PMSM, Transformation to Rotor Reference Frames , Three-Phase to Two-Phase Transformation Unbalanced Operation , Zero Sequence Inductance Derivation , Power Equivalence, Electromagnetic Torque, Steady-State Torque Characteristics , Models in Flux Linkages, Equivalent Circuits, Per Unit Model, Dynamic Simulation, Small-Signal Equations of the PMSM. Control Strategies for a Permanent Magnet Synchronous Machine, Vector Control, Derivation of Vector Control, Drive System Schematic, Control Strategies	
Permanent Magnet Brushless DC Machines and Their Control	**07 Hours**
PM Brushless DC Machine, Modelling of PM Brushless dc Motor, Normalized System Equations, The PMBDCM Drive Scheme, Commutation Torque Ripple and Phase Advancing, Commutation Torque Ripple , Phase Advancing, Dynamic Modelling, Machine Equations, Split Supply Converter Topology, Operation of the PMBDC Motor with the Split Supply Converter, Operational Modes of the Converter	

UNIT-II

Switched Reluctance Motor (SRM)	**05 Hours**
Construction, Principle of working, Basic SRM analysis, constraints on pole arc and tooth arc, Power Converter Circuits, Control of SRM, Rotor Position sensors, Current Regulator, Microprocessor Based Control of SRM, Sensorless Control of SRM.	
Synchronous Reluctance Motor (SyRM)	**03 Hours**
Construction, Working, Control of SyRM, Advantage, Applications	
Converters for SRM Drives	**07 Hours**
Converter Configurations, Single-Switch-per-Phase Converters, (q+1) Switch and Diode Configurations, Comparison of Some Power Converters, Two-Stage Power Converter, Resonant Converter Circuits, Control of SRM Drive, Control Principle, Closed-Loop, Speed-Controlled SRM Drive	

UNIT-III

Linear Electric Machines	**10 Hours**
Linear Induction Motor (LIM) – Construction, Thrust equation, performance equation, goodness factor, Certain design aspects, Control of LIM. Linear Synchronous Motor (LSM) – Types, construction, thrust equation, control, Application. DC Linear Motor (DCLM) – types, construction, thrust equation, persistent current tubular electromagnetic launcher, induction tubular EML, DC-pulsed flat series EML, DC tubular series EML. Linear Reluctance Motor (LRM) – Construction, working, operation with DC, operation with AC. Linear Levitation Machines (LLM) – Principle of Levitation, attractive type, repulsive type, Levitation Goodness factor and stiffness.	

Course Outcomes: At the end of the course student will be able to

1.	Examine control strategies of permanent magnet synchronous machine.
2.	Analyze the control aspects of brushless DC motor

3.	Comprehend the construction and working principle of SRM and SyRM motors and their control.
4.	Analyze the converters for controlling of switched reluctance motor.
5.	Examine the basics, construction and working principle of various linear electric motors.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT113.1	2						2	
22EVT113.2	2						2	
22EVT113.3	2						2	
22EVT113.4	2						2	
22EVT113.5	2						2	

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1	R. Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives" CRC press, 2010.
2	E. G Janardanan, 'Special Electrical Machines' PHI Delhi, 2014.
3	T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.
4	R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.

Automotive Electronics for EVs

Course Code:	**22EVT121**	**Course Type:**	**PEC**

Teaching Hours/Week (L: T: P):	3:0:0	Credits:	03
Total Teaching Hours:	40+0+0	CIE + SEE Marks:	50+50

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand the electrical and electronic systems in vehicles
2.	Understand the principles of networking
3.	Explain requirements and types of bus systems
4.	Comprehend the lighting systems in vehicles
5.	Understand the auxiliaries and chassis electric systems in automobiles.

UNIT-I

Electrical And Electronic Systems in the Vehicle: **06 Hours**

Overview, Motronic engine management system, Electronic diesel control, Lighting technology, Electronic stability program, Adaptive cruise control, Infotainment System.

Basic principles of networking **03 Hours**

Network topology**,** Network organization**,** OSI reference model**,** Control mechanisms**.**

Automotive networking **05 Hours**

Cross-system functions**,** Requirements for bus systems**,** Classification of bus systems**,** Applications in the vehicle**,** coupling of networks, Examples of networked vehicles system.

UNIT-II

Bus systems **11 Hours**

CAN bus**:** Applications, Topology , Data transmission system, CAN protocol , data transfer sequence, standardization, characteristics.
LIN bus**:** Overview, Applications, Data transfer, Bus access, LIN protocol, network management, example.
MOST bus**:** Introduction, features, data transfer, administrative functions, application layer
Bluetooth**:** Overview, applications, Bluetooth versions, transmission technology, power classes, topology, physical data channel, physical connections, Architecture.

Lighting system **05 Hours**

Lighting fundamentals Lighting circuits, Gas discharge and LED lighting, Case studies, Diagnosing lighting system faults, Advanced lighting technology, New developments in lighting systems

UNIT-III

Auxiliaries in vehicles **05 Hours**

Windscreen washers and wipers, signalling circuits, Other auxiliary systems, Case studies, Diagnosing auxiliary system faults
Advanced auxiliary systems technology, new developments in auxiliary systems

Chassis Electrical systems **06 Hours**

Anti-lock brakes, Active suspension, Traction control , Automatic transmission, Other chassis electrical systems, Case studies, Diagnosing chassis electrical system faults, Advanced chassis systems technology, New developments in chassis electrical systems

Course Outcomes: At the end of the course student will be able to

1.	Identify various electrical & electronic systems in vehicles and understand their working.
2.	Discuss the basic principles of networking requirements in an automotive.
3.	Explain requirements and types of bus systems
4.	Comprehend the lighting systems in vehicles
5.	Understand the auxiliaries and chassis electric systems in automobiles

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT121.1	2		2					
22EVT121.2	2		2					
22EVT121.3	2		2					
22EVT121.4	2		2					
22EVT121.5	2		2					

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Robert Bosch GmbH, "Bosch Automotive Electrics and Automotive Electronics", 5th Edition. John Wiley & Sons Ltd, 2007.
2.	William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier, 2003.
3.	Tom Denton: "Automobile Electrical and Electronic Systems", 3rd Edition, Elsevier Butterworth-Heinemann Publication, 2004.

Modeling and Analysis of Electrical Machines

Course Code:	**22EVT122**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3+0+0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To study the basic concepts of modeling and reference frame theory
2.	To model various DC machine under transient and steady state conditions
3.	To understand the dynamic modeling of induction machines
4.	To model single-phase and three-phase transformers
5.	To know synchronous machine modeling.

UNIT-I

Basic Concepts of Modeling — **05 Hours**

Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

Reference Frame Theory — **04 Hours**

Real time model of a two-phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

DC Machine Modeling — **06 Hours**

Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations

UNIT-II

Dynamic Modeling of Three Phase Induction Machine — **07 Hours**

Generalized model in arbitrary frame, electromagnetic torque, derivation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model,

Transformer Modeling — **08 Hours**

Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit analysis of normal system, regulating transformers for voltage and phase angle control.

UNIT-III

Modeling of Synchronous Machines — **10 Hours**

Introduction, voltage equations and torque equations in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system.

Course Outcomes: At the end of the course student will be able to

1.	Elaborate basic concepts of modeling of electrical machines and discuss reference frame theory
2.	Derive the DC machine model under transient and steady state conditions
3.	Obtain the dynamic model of 3phase induction machines using reference frame theory.
4.	Derive the single-phase and three-phase transformers model & analyze the per unit model of the 3 phase transformer
5.	Illustrate the synchronous machine modeling and obtain its per unit equivalent.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT122.1	2			3				
22EVT122.2	2			3				
22EVT122.3	2			3				
22EVT122.4	2			3				
22EVT122.5	2			3				

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
2.	P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2ndEdition, Wiley(India),2010.
3.	Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.
4.	Chee-MunOng, "Dynamic Simulation of Electric Machinery using Matlab /Simulink",Prentice Hall, 1998.

Power Semiconductor Devices

Course Code:	**22EVT123**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To identify various power semiconductor devices and their ratings for various power electronic application.
2.	To understand the static and dynamic characteristics of voltage and current controlled power semiconductor devices
3.	To enable the students, the knowledge of selection of devices for different power electronics applications
4.	To understand the control and Gate Drive requirements for different power devices.

UNIT-I

Power Diodes — **05 Hours**

on-state losses, switching characteristics-turn-on transient, turn-off transient and reverse recovery transient, Schottky diodes, series and parallel connections of diodes, snubber requirements for diodes, diode snubber.

Power BJT'S — **05 Hours**

on state losses, switching characteristics, resistive switching specifications, clamped inductive switching specifications, turn-on transient, turn-off transient, storage time, base drive requirements, switching losses, device protection- snubber requirements for BJT'S and snubber design - switching aids.

Gate Turnoff Thyristor (GTO) — **05 Hours**

Basic structure and operation, GTO switching characteristics, GTO turn-on transient, GTO turn -off transient, minimum on and off state times, gate drive requirements**,** maximum controllable anode current, over current protection of GTO'S.

UNIT-II

Power MOSFET'S — **07 Hours**

Basic structure, V-I characteristics, turn-on process, on state operation, turn-off process, switching characteristics, resistive switching specifications, clamped inductive switching specifications - turn-on transient and di/dt limitations, turn-off transient, turn off time, switching losses, effect of reverse recovery transients on switching stresses and losses - dv/dt limitations, gating requirements, gate charge - ratings of MOSFET'S, FBSOA and RBSOA curves, device protection –snubber requirements, MOSFET drivers and protection, Miller region.

Insulated Gate Bipolar Transistors (IGBT'S) — **08 Hours**

Basic structure and operation, latch up IGBT, switching characteristics, resistive switching specifications, clamped inductive switching specifications - IGBT turn-on transient, IGBT turn off transient- current tailing - gating requirements -ratings of IGBT'S, FBSOA and RBSOA curves, switching losses - minimum on and off state times - switching frequency capability – over current protection of IGBT'S, short circuit protection, snubber requirements and snubber design. IGBT drivers and protection, Active clamping.

UNIT-III

New Power Semiconductor Devices — **40 Hours**

MOS gated thyristors, MOS controlled thyristors or MOS GTO'S, base resistance controlled thyristors, emitter switched thyristor, GaN and SiCdevices. Introduction to wide band gap devices.
Thermal design of power electronic equipment, heat transfer by conduction, transient thermal impedance - heat sinks, heat transfer by radiation and convection - heat sink selection for power semiconductor devices.

Course Outcomes: At the end of the course student will be able to

1.	Comprehend the types, characteristics, protection and modeling of Power Diodes, Power BJT's and Thyristors.
2.	Analyze the structure, characteristics, gate drive requirements and modeling of GTO's and TRIACS.
3.	Explain the principle of operation of MOSFET with their characteristics and effect of reverse recovery transients on switching stresses & losses
4.	Explain the principle of operation of IGBT with their characteristics and protection against over-current & short-circuit.
5.	Illustrate the construction and features of the emerging power electronic devices

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT123.1			2				1	
22EVT123.2			2				1	
22EVT123.3			2				1	
22EVT123.4			2				1	
22EVT123.5			2				1	

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rdEdition. Wiley India Pvt Ltd, 2011.
2.	G. Massobrio, P. Antognetti, "Semiconductor Device Modeling with Spice", McGraw-Hill, 2nd Edition, 2010.
3.	B. Jayant Baliga, "Power Semiconductor Devices", 1st Edition, International Thompson Computer Press, 1995.
4.	V. Benda, J. Gowar, and D. A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999.
5.	Joseph Vaithiyathil, "Power Electronics Principles and Applications" Mc Graw Hill Education,2010.

Embedded Systems

Course Code:	**22EVT131**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To familiarize the concept of embedded system
2.	To identify various processing elements of embedded system and their structure
3.	To introduce various memory elements used in embedded systems
4.	To understand various interfacing devices used with embedded systems
5.	To introduce the concept of Real Time Operating Systems

UNIT-I

Introduction — **03 Hours**

Embedded systems overview-design challenge-optimizing metrics-processor technology-IC technology

Processing Elements — **12 Hours**

Custom single purpose processor design-RT level custom single purpose processor design-optimizing custom single purpose processors -General purpose processor's software: architecture, operation, programmer's view and development environment – ASIPs - selecting a microprocessor - general purpose processor design.

UNIT-II

Memory — **06 Hours**

Introduction-memory write-ability and storage permanence, common memory types-composing memory-memory hierarchy and caches-advanced RAM.

Interfacing — **09 Hours**

Introduction-communication basics-microprocessor interfacing: I/O addressing, interrupts, DMA-Arbitration-multilevel bus architectures-advanced communication principles-serial protocols-parallel protocols-wireless protocols-Standard single purpose processor's peripherals: timers, counters, watchdog timers, UART, PWM, LCD controllers, keypad controllers, stepper motor controllers, ADC and RTC.

UNIT-III

Introduction to Real-Time Operating Systems — **10 Hours**

Software architectures, Hard and soft real time systems, Basic functions of RTOS kernel, tasks and states, tasks and data, semaphores and shared data, Message Ques, Mailboxes and Pipes

Course Outcomes: At the end of the course student will be able to

1.	Give an overview of embedded system to comprehend associated technologies
2.	Analyze various processing element in an embedded system to develop optimum design
3.	Identify the necessity of memory devices to comprehend use in embedded system
4.	Review various peripherals associated with embedded system to interface modules
5.	Outline the architectural features of RTOS to comprehend its functional capabilities

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT131.1	2							

22EVT131.2	2			3					
22EVT131.3	2			3					
22EVT131.4	2			3					
22EVT131.5	2			3					

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010
2.	Embedded System Premier, David E Simon, Addison Wesley
3.	Embedded System 2nd Edition by Raj Kamal , Tata McGraw-Hill Education
4.	Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers, 2008.
5.	Santanu Chattopadhyay, Embedded system Design, PHI Learning Pvt. Ltd., 2010
6.	Steave Heath, Embedded system Design, Second edition, 2003
7.	Daniel D. Gajski, Samar. Abdi, Andreas. Gerstlauer Embedded system design: Modeling, synthesis and verification, Springer, 2009
8.	Jonathan.W.Valvano, Embedded Microcomputer systems: Real Time Interfacing, Third edition, Cengage learning,2012

Applied Mathematics

Course Code:	**22EVT132**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce numerical methods for the solution of algebraic and transcendental
2.	To understand various techniques to get Numerical Solution of Partial Differential Equations
3.	To solve the problems pertaining to linear algebra, system of linear algebraic equations and Eigen value
4.	To introduce linear programming technique for optimizing the solution and solve problems pertaining to graph theory.

UNIT-I

Numerical Methods	**08 Hours**

Solution of algebraic and transcendental equations iterative methods based on second degree equation – Muller method (no derivation) Chebyshev method, general iteration method (first order), acceleration of convergence, system of non-linear equations and complex roots – Newton-Raphson method, polynomial equations – Birge - Vieta method and Bairstow's method.

Numerical solution of differential equations	**07Hours**

Classification of second order equations, parabolic equations- solution of one dimensional heat equation, explicit method, Crank-Nicolson method and Du Fort-Frankel method, hyperbolic equations- solution of one dimensional wave equation, Numerical solution of differential equations – Numerov method.

UNIT-II

Linear Algebra — **08 Hours**

Vector spaces, linear dependence, independence, basis and dimension, elementary properties.
System of Linear Algebraic Equations and Eigenvalue Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigenvalue problems – Gerschgorian circle, Eigenvalues and Eigenvectors of real symmetric matrices -Jacobi method, Givens method. Conditions/Tests for- positive definite, semi-definite and indefinite Matrices and comment on stability

Optimization and Graph Theory — **07 Hours**

Optimization
Linear programming- formulation of the problem, graphical method, general linear programming problem, simplex method, artificial variable technique -M-method.
Graph Theory: Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs- walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications of graphs.

UNIT-III

Interpolation and Linear Transformations — **09 Hours**

Interpolation: Hermit interpolation, spline interpolation.
Linear Transformations: Definition, properties, range and null space, rank and nullity, algebra of linear transformations- invertible, singular and nonsingular transformations, representation of transformations by matrices.

Course Outcomes: At the end of the course student will be able to

1.	Apply numerical methods for the solution of algebraic and transcendental
2.	Use various techniques to get Numerical Solution of Partial Differential Equations
3.	Analyze the problems pertaining to linear algebra and solve system of linear algebraic equations and Eigen value problems
4.	Apply linear programming technique for optimizing the solution and analyze problems pertaining to graph theory
5.	Comprehend interpolation problems and apply linear transformations techniques.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT132.1			2		2			
22EVT132.2			2		2			
22EVT132.3			2		2			
22EVT132.4			2		2			
22EVT132.5			2		2			

1: Low 2: Medium 3: High

REFERENCE BOOKS:	
1.	M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2.	M K Jain, "Numerical Solution of Differential Equations", 2nd Edition, New Age International, 2008.
3.	Dr. B.S. Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers, 1999.
4.	Dr. B.S. Grewal, "Higher Engineering Mathematics", 41st Edition, Khanna Publishers, 2011.
5.	Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
6.	Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 2011.

Digital Controller

Course Code:	22EVT133	Course Type:	PEC
Teaching Hours/Week (L: T: P):	3:0:0	Credits:	03
Total Teaching Hours:	40+0+0	CIE + SEE Marks:	50+50

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Analyse the overview of dsPIC33CH512MP508 family digital signal controller
2.	Understand the peripherals interrupt and DMA controllers.
3.	Analyse ADC and timer modules of dsPIC33CH512MP508 family controllers.
4.	Analyse PWM and I/O modules of dsPIC33CH512MP508 family controllers.
5.	Analyse I2C,SPI and CAN protocols used in the DSP.

UNIT-I

Introduction to the dsPIC33C family digital signal controller	**07 Hours**
Block diagram of dsPIC33/PIC24 Enhanced CPU, On chip memory and Peripherals, Applications and Features of dsPIC Family, Data memory, Modulo Addressing	
Interrupt Controller	**08 Hours**
Introduction, Interrupt Vector Table (IVT), interrupt control and status registers, non-maskable traps interrupt processing timing, interrupt setup procedures	

UNIT-II

Analog to Digital Converter	**05 Hours**
Introduction, Registers, Register Map, Conversion Sequence, ADC Operation, Application Examples, Operation During Power-Saving Modes, Effects of Reset **Configurable Logic Cell (CLC):** Overview and Features	
Timer 1 Module	**03 Hours**
Introduction, Control Registers, Modes of Operation, Interrupts, Operation in Power-Saving Modes	
High resolution PWM with Fine Edge Placement	**07 Hours**
Registers, Register Maps, Common Functions Register Map, PWM Generator Register Map, Architecture Overview Operation, PWM Clocking, PWM Generator (PG) Features, Common Features, Lock and Write Restrictions, Application Examples.	

UNIT-III

	10 Hours
Queued Serial Peripheral Interface: Overview, Block Diagram, Signal Description, Memory map Registers, Operating Modes **Inter-Integrated Circuit (I2C):** Features, modes of Operation, Block Diagram, Memory Map and Registers, Functional Description.	

CAN Flexible Data-Rate (FD) Protocol Module: Introduction, CAN FD Message Frames, Registers, Modes of Operation, Configuration

Course Outcomes: At the end of the course student will be able to

1.	Analyse the overview of dsPIC33CH512MP508 family digital signal controller
2.	Understand the peripherals interrupt and DMA controllers.
3.	Analyse ADC and timer modules of dsPIC33CH512MP508 family controllers.
4.	Analyse PWM and I/O modules of dsPIC33CH512MP508 family controllers.
5.	Analyse I2C, SPI and CAN protocols used in the DSP.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT133.1		2			2		2	2
22EVT133.2		2			2		2	2
22EVT133.3		2			2		2	2
22EVT133.4		2			2		2	2
22EVT133.5		2			2		2	2

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	dsPIC33Cxxx Reference manual.
2.	dsPIC33CH512MP508-Family-Data-Sheet-DS70005371D

Programming Digital Signal Controller

Course Code:	22EVTAU11	Course Type:	AUDIT
Teaching Hours/Week (L: T: P):	0:0:2	Credits:	-
Total Teaching Hours:	0+0+26	CIE + SEE Marks:	-

Teaching Department: Electrical and Electronics Engineering

Audit Course on Programming a DSC.

Topics covered include

- Architectural features of 16-bit DSC
- Registers / peripherals available
- Programming of DSC
- Simple experiments to use the peripherals, GPIO, ADC, Timer and PWM using16 bit digital signal controller

Course Outcomes: At the end of the course student will be able to

1.	Describe the architecture and pin configuration of DSC.
2.	Illustrate different control and data registers.
3.	Develop programs for the functioning of GPIO and Timers
4.	Develop programs for the functioning of PWM module
5.	Analyze and Develop program DSC for scalar control of motor.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVTAU11.1				2	3			
22EVTAU11.2				2	3			
22EVTAU11.3				2	3			
22EVTAU11.4				2	3		2	3
22EVTAU11.5				2	3		3	

1: Low 2: Medium 3: High

Power Electronic Converters

Course Code:	**22EVT201**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**4:0:0**	**Credits:**	**04**
Total Teaching Hours:	**50+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand the essentials of power conversion
2.	Design practical non isolated converters
3.	Design practical offline converters
4.	Design practical isolated converters
5.	Bidirectional converter topologies for Electric Vehicles

UNIT-I

Power Semiconductor Devices	**05 Hours**
Ideal and Typical Power Switching Waveforms, Ideal and Typical Power Device Characteristics, Unipolar Power Devices, bipolar Power Devices, MOS-Bipolar Power Devices.	
Introduction to Power Conversion	**06 Hours**
Converting power with resistors, Converting power with switches, the duty cycle factory, buck converter, boost converter, buck-boost Converter, Input filtering, RLC filter.	

UNIT-II

Non-isolated converters	**09 Hours**
Buck converter, Boost converter, Buck-Boost converter, analysis design and simulation.	

UNIT-III

Offline Converters—the front end	**11 Hours**
Rectifier Bridge: Capacitor selection, Diode Conduction Time, Rms Current in the Capacitor, Current in the Diodes, Input Power Factor, Hold-Up Time, In-Rush Current **Power Factor Correction**: Definition of Power Factor, Non-sinusoidal Signals, A Link to the Distortion, Why Power Factor Correction? Harmonic Limits, A Need for Storage, Passive PFC, Improving the Harmonic Content, The Valley-Fill Passive Corrector, Active Power Factor Correction, Constant on-time borderline mode (BCM), fixed- frequency continuous mode (CCM), Analytical control law.	

UNIT-IV

Isolated Converters	**09 Hours**
Simulations and practical designs of flyback converters, an isolated buck-boost, flyback waveforms without parasitic elements, flyback waveforms with parasitic elements, clamping the drain excursion, designing the clamping network, two-switch flyback, simulations and practical designs of forward converters, an isolated buck converter, need for a complete core reset, a two-switch configuration, two-switch forward and half-bridge driver	

UNIT-V

Bidirectional Converter Topologies for Plug-In Electric Vehicles	**08 Hours**
Introduction, Literature Survey, Bidirectional Converters, Bidirectional AC/DC Converters for Plug-In EV with Reduced Conduction Losses, Topology Explanation, Plug-In Charging Mode, Propulsion Mode, Boost Operation, Buck Operation, Regenerative Braking Operation, Boost Operation, Buck Operation	
Bidirectional Battery Charger for an Electric	**02 Hours**
Vehicle Bidirectional Power Flow Converters	

Course Outcomes: At the end of the course student will be able to

1.	Analyze the operation of different power converters.
2.	Design of non-isolated converters used in electric vehicles
3.	Design front end for practical offline converters.
4.	Analyze the operation of practical isolated converters
5.	Analyze the Bidirectional converter topologies used in Electric Vehicles

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT201.1	1	2					3	
22EVT201.2	1	2					2	
22EVT201.3	1	2					2	
22EVT201.4	1	2					2	
22EVT201.5	1	2					2	

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	B. Jayant Baliga, "Power Semiconductor Devices", 1st Edition, International Thompson Computer Press, 1995.
2.	Christophe Basso, "Switch Mode Power Supplies : SPICE Simulations and Practical Designs", McGraw-Hill,2008.
3.	L. Ashok Kumar, S. Albert Alexander, "Power Converters for Electric Vehicles", CRC Press, Taylor & Francis Group, 2021

EV Motor drives and control

Course Code:	**22EVT202**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**4:0:0**	**Credits:**	**04**
Total Teaching Hours:	**50+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand requirement of EV motors
2.	Understand suitability of electric motor & their control
3.	Understand speed control of Induction motor
4.	Understand PWM techniques of Inverter for Induction motor
5.	Understand different sensors and sensorless operation of motor

UNIT-I

EV Motors Characteristics	**03 Hours**
Requirement of EV motors, Comparison of EV motors	
DC Motor	**06 Hours**
Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation	

UNIT-II

DC Motor Dynamics & Control	**03 Hours**
Current Loop Control, Speed Control Loop	
Dynamical System Control	**09 Hours**
Gain & Phase Margins, PD Controller, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI Controller with Reference model, Comparison of conventional PI Controller with PI controller with Reference Model, 2 DOF Controller with Internal Model Control, Load Torque Observer, Feedback Linearization, Simplified Modeling of Practical Current Loop	

UNIT-III

Induction Motor	**04 Hours**
Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circle diagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor	
Induction Motor Speed Control	**05 Hours**
Rotor Field oriented control, Stator Field Oriented Control, Field Weakening Control, Variable Voltage Variable Frequency Control	
PWM and Inverter	**03 Hours**
Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation	

UNIT-IV

Permanent magnet ac motors	**08 Hours**
PMSM and BLDC, PMSM dynamic modelling, PMSM torque equations, PMSM control methods, machine sizing, current, voltage and speed limits, extending constant power speed range, current control methods.	

UNIT-V

Position & Current Sensors	**04 Hours**
Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling	

Sensor less control of ac motors	**05 Hours**
Voltage Model Estimator, Current Model Estimator, Closed-loop MRAS observer, PMSM sensor less control	

Course Outcomes: At the end of the course student will be able to

1.	Describe the characteristics of the motors use in EV.
2.	Analyze dynamics of DC motor and different controllers used in their control
3.	Describe the speed control and PWM techniques used in the control of Induction motor
4.	Analyze the operation and control of permanent magnet ac motors.
5.	Analyze sensor-less control of 3-phase ac motors.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT202.1			2		2			
22EVT202.2			2		2			
22EVT202.3			2		2		2	
22EVT202.4			2		2		2	
22EVT202.5			2		2		2	

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019
2.	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
3.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

RESEARCH EXPERIENCE THROUGH PRACTICE -2

Course Code:	2EVT203	Course Type	RETP
Teaching Hours/Week (L: T: P)	0:0:4	Credits	2
Total Teaching Hours	0+0+52	CIE	100

Teaching Department: Electrical and Electronics Engineering

Course Objectives: The research purposes are

1. To foresee future problems through pursuit of truth as a "global centre of excellence for intellectual creativity".
2. To respond to current social demands, and to contribute to the creation and development of scientific technologies with the aim of realizing an affluent society and natural environment for humanity.
3. At the same time, the course aims to create excellent educational resources and an excellent educational environment through frontline researches.
4. To Understand professional writing and communication contexts and genres, analyzing quantifiable data discovered by researching, and constructing finished professional workplace documents.

The students are expected to carry out Mathematical Modelling/Design calculations/computer simulations/Preliminary experimentation/testing of the research problems identified during Research Experience through Practice-I carried out in the first semester.

At the end of the second semester, students are expected to submit a full research paper based on the Mathematical modelling/ Design calculations/computer simulations/Preliminary experimentation/testing carried out during second semester.

The research paper prepared based on the work carried out by the PG Student is evaluated for 50 marks and 20 minutes presentation on the research work carried out will be evaluated for 50marks jointly by the examiners.

Course Outcomes: At the end of the course student will be able to

1.	Create a model/prototype through fabrication, simulation, data analysis, Experimentation for the proposed problem.
2.	Analyse and validate the results obtained.
3.	Compose a technical paper as per the given format.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT203.1	2	3	3	3		3		
22EVT203.2	2	3	3	3				
22EVT203.3	2	3	3	3				

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1. Gina Wisker, "The Undergraduate Research Hand book", 2018.

E Resource

1. https://www.coursera.org/learn/academic-writing-capstone

Power Electronic Converters Laboratory

Course Code:	**22EVT204**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P):	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand the design and operation of buck converter
2.	Understand and design synchronous and buck-boost converter powered by car battery.
3.	Understand the design and operation of rectifier with PFC.
4.	Understand the design and operation of flyback and forward converter.
5.	Understand the operation of non-isolated bidirectional onboard charger and inverter.

List of Experiments

1.	Design and simulate a voltage mode buck converter and study the effect of ESR of filter capacitor used on the performance of the converter.
2.	Design and simulate a current mode buck converter for car battery.
3.	Design and simulate synchronous buck converter and compare its efficiency with buck converter.
4.	Design and simulate a buck-boost converter operated from a car battery.
5.	Design a 100 W rectifier operated on universal mains and demonstrate the starting inrush current.
6.	Design and simulate the passive PFC for a rectifier circuit.
7.	Design and simulate flyback converter without parasitic elements.
8.	Design and simulate a two-switch forward converter using two MOSFETs and a couple of diodes to recycle the magnetizing energy.
9.	Design and simulate non-isolated bidirectional onboard charger
10.	Design and simulate DC- AC converter using IGBT.

Course Outcomes: At the end of the course student will be able to

1.	Analyze the effect ESR of filter capacitor on the performance of the buck converter.
2.	Compare the performance of synchronous buck converter with buck converter.
3.	Design rectifier operated on universal mains with the feature of PFC.
4.	Design flyback and forward converter.
5.	Analyze non-isolated bidirectional onboard charger and inverter.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT204.1	2						2	
22EVT204.2	2						2	
22EVT204.3	2						2	
22EVT204.4	2						3	
22EVT204.5	2						3	

1: Low 2: Medium 3: High

Reference Books	
1.	Christophe Basso, “Switch Mode Power Supplies : SPICE Simulations and Practical Designs”, McGraw-Hill,2008.

EV Motor Drives and Control Laboratory

Course Code:	**22EVT205**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P):	**0:0:2**	**Credits:**	**01**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To study the effect of field weakening in DC motor control
2.	To understand the open loop and closed loop control of DC motor.
3.	To study PWM generation and control of 3-phase induction motor.
4.	To understand the significance of dead time in PWM generation.
5.	To study the control of BLDC and PMSM motor

List of Experiments

1.	Model the DC motor and study the effect of field weakening on the speed.
2.	For a DC motor design suitable current PI gains so that current control bandwidth is 150 Hz and the damping coefficient is 0.7.
3.	For a DC motor, demonstrate four quadrant operation.
4.	Study the stability of the DC motor using bode plot for open loop and closed loop cases.
5.	Design and simulate Variable Voltage Variable Frequency Control for 3 phase induction motor.
6.	Generate sinusoidal PWM for single phase inverter.
7.	Generate PWM signals for H bridge inverter incorporating dead time.
8.	Simulate space vector PWM technique
9.	Study of BLDC motor drives.
10.	Study of PMSM drives.

Course Outcomes: At the end of the course student will be able to

1.	Demonstrate the effect of field weakening in DC motor control.
2.	Design open loop and closed loop control of DC motor.
3.	Analyse the control of 3 phase induction motor.
4.	Demonstrate the significance of dead time in PWM generation.
5.	Develop controllers for BLDC and PMSM drives.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT205.1	2		3					
22EVT205.2	2		3					
22EVT205.3	2		3					
22EVT205.4	2		3					
22EVT205.5	2		3					

1: Low 2: Medium 3: High

Reference Books

1	K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019

Battery Management System

Course Code:	**22EVT211**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce the various Battery Management System parts
2.	To understand basic information about batteries
3.	To measure different battery parameters
4.	To estimate state of charge of the battery
5.	To estimate state of health of the battery

UNIT-I

Battery Management System parts	**05 Hours**
The Power Module (PM), The battery, The DC/DC converter, load, communication channel, Examples of Battery Management Systems, Comparison of BMS in a low-end and high-end shaver, Comparison of BMS in two types of cellular phones	
Basic information on batteries	**06 Hours**
Battery systems, Definitions Battery design, Battery characteristics, General operational mechanism of batteries, Basic thermodynamics, Kinetic and diffusion over potentials, Double-layer capacitance, Battery voltage	
Lithium-Ion Battery Fundamentals	**04 Hours**
Battery Operation, Battery Construction, Battery Chemistry, Safety Longevity, Performance, Integration	

UNIT-II

Measurement of battery parameters	**05 Hours**
Cell Voltage Measurement, Current Measurement, Current Sensors Current Sense Measurements, Synchronization of Current and Voltage, Temperature Measurement, Measurement Uncertainty and Battery Management, System Performance	
Battery Management System Functionality	**03 Hours**
Charging, Strategies, CC/CV Charging Method, Target Voltage Method, Constant Current Method, Thermal Management, Operational Modes	

Charge Balancing	**04 Hours**
Balancing Strategies, Balancing Optimization, Charge Transfer Balancing, Flying Capacitor, Inductive Charge Transfer Balancing, Transformer Charge Balancing, Dissipative Balancing, Balancing Faults	
State-of-Charge Estimation Algorithms	**03 Hours**
Challenges, Definitions, Coulomb Counting, SOC Corrections, OCV Measurements, Temperature Compensation, Kalman Filtering, Other Observer Methods	
UNIT-III	
State-of-Health Estimation Algorithms	**05 Hours**
State of Health, Mechanisms of Failure, Predictive SOH Models Impedance Detection, Passive Methods, Active Methods, Capacity Estimation, Self-Discharge Detection Parameter Estimation, Dual-Loop System, Remaining Useful Life Estimation	
Fault Detection	**05 Hours**
Overview, Failure Detection, Overcharge/Overvoltage, Over-Temperature, Overcurrent Battery Imbalance/Excessive Self-Discharge, Internal Short Circuit Detection, Detection of Lithium Plating, Venting Detection, Excessive Capacity Loss, Reaction Strategies	

Course Outcomes: At the end of the course student will be able to

1.	Review various Battery Management System parts
2.	Clarify the basic information about batteries and demonstrate Lithium-Ion Battery Fundamentals
3.	Measure different battery parameters and analyze battery performance to identify Battery Management System Functionality
4.	Detail the need of Charge Balancing and state of charge estimation using various algorithms
5.	Estimate the state of health of the battery and discuss battery fault detection.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT211.1	2		3					3
22EVT211.2	2		3					3
22EVT211.3	2		3					3
22EVT211.4	2		3					3
22EVT211.5	2		3					3

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	H. J. Bergveld, “Battery management systems : design by modelling” University Press Facilities, Eindhoven,2001
2.	Phillip Weicker, “A Systems Approach to Lithium-Ion Battery Management”, artech house, 2014
3.	Gregory L. Plett, “Battery Management Systems: Battery Modeling”, Artech house, 2015
4.	M. Barak (Ed.), T. Dickinson, U. Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye, “Electrochemical Power Sources: Primary & Secondary Batteries”, IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.

Thermal Management of EV systems

Course Code:	**22EVT212**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand thermal management of electronics
2.	To understand the importance of thermal resistance network
3.	To understand thermal management of microelectronic packages
4.	To comprehend the concepts of cooling techniques
5.	To explain thermal management systems

UNIT-I

Introduction to thermal management of Electronics — **07 Hours**

Semiconductor Technology Trends, Temperature Dependent Failures Temperature-Dependent Electrical Failures Importance of Heat Transfer in Electronics, Thermal Design Process

Thermal Resistance Network — **08 Hours**

Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers General Resistance Network, Thermal Contact Resistance, Interface Materials, Spreading Thermal Resistance Thermal Resistance of Printed Circuit Boards (PCBs)

UNIT-II

Fins and Heat Sinks — **05 Hours**

Fin Equation, Infinitely Long Fin, Adiabatic Fin Tip Convection and Radiation from Fin Tip, Constant Temperature Fin Tip Fin Thermal Resistance, Effectiveness, and Efficiency with Variable Cross Sections. Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Heat Sink Manufacturing Processes.

Advanced Cooling Technologies — **10 Hours**

Pipes, Capillary Limit, Boiling Limit. Sonic Limit, Entrainment Limit, Other Heat Pipe Performance Limits, Heat Pipe Applications in Electronic Cooling, Thermosyphons, Liquid Cooling

UNIT-III

Thermal Specification of Microelectronic Packages — **10 Hours**

Importance of Packaging, Packaging Types, Specifications of Microelectronic Packages, Junction-to-Air Thermal Resistance, Junction-to-Case and Junction-to-Board, Thermal Resistances, Package Thermal Characterization Parameters, Parameters Affecting Thermal Characteristics of a Package

Course Outcomes: At the end of the course student will be able to

1.	Describe different types of temperature dependent failures in electronics systems.
2.	Describe series and parallel thermal layers and thermal resistance in PCB.
3.	Use suitable fins and heat sinks for a given electronic application.
4.	Compare different advanced cooling technologies.
5.	Analyse thermal specifications of microelectronic package and parameters affecting thermal characteristics of a package.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2

22EVT212.1	1		2					
22EVT212.2	1		2					
22EVT212.3	1		2					
22EVT212.4	1		2					
22EVT212.5	1		2					

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Younes Shabany," Heat Transfer: Thermal Management of Electronics" 2010 , CRC Press.
2.	Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw- Hill.
3.	"Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
4.	T. Yomi Obidi**, "**Thermal Management in Automotive applications", 2015, SAE International.

Vehicle Body Engineering

Course Code:	**22EVT213**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	Understand different aspects of car body and bus body types
2.	Understand different types and dimensions of commercial vehicle.
3.	Understand driver's cab design regulations.
4.	Know the role of various aerodynamic forces and moments, measuring instruments
5.	Know body optimization techniques for minimum drag.

UNIT-I

CAR BODY DETAILS — **07 Hours**

Types of Car body – Saloon, convertibles, Limousine, Estate Van, Racing and Sports car – Visibility regulations, driver's visibility, improvement in visibility and tests for visibility. Driver seat design -Car body construction-Various panels in car bodies. Safety aspect of car body.

BUS BODY DETAILS — **08 Hours**

Types of bus body: based on capacity, distance travelled and based on construction. – Bus body layout for various types, Types of metal sections used – Regulations – Constructional details: Conventional and integral. driver seat design- Safety aspect of bus body.

UNIT-II

COMMERCIAL VEHICLE DETAILS — **15 Hours**

Types of commercial vehicle bodies – Light commercial vehicle body. Construction details of commercial vehicle body – Flat platform body, Trailer, Tipper body and Tanker body – Dimensions of driver's seat in relation to controls – Drivers cab design – Regulations.

UNIT-III

VEHICLE AERODYNAMICS **10 Hours**

Objectives, Vehicle drag and types. Various types of forces and moments. Effects of forces and moments. Side wind effects on forces and moments. Various body optimization techniques for minimum drag. Wind tunnels – Principle of operation, Types. Wind tunnel testing such as: Flow visualization techniques, Airflow management test – measurement of various forces and moments by using wind tunnel.

Course Outcomes: At the end of the course student will be able to

1.	Describe different aspects of car body and bus body types.
2.	Illustrate different types and dimensions of commercial vehicle.
3.	Design driver's cab in relation to controls.
4.	Illustrate the role of various aerodynamic forces and moments, measuring instruments
5.	Analyse various body optimization techniques for minimum drag.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT213.1					2			
22EVT213.2					2			
22EVT213.3				2	2			
22EVT213.4					2			
22EVT213.5					2			

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Powloski, J., "Vehicle Body Engineering", Business Books Ltd., 1998.
2.	James E Duffy, "Body Repair Technology for 4-Wheelers", Cengage Learning, 2009.
3.	Miles, G.J., "Body construction and design", Illiffe Books Butterworth & Co., 1991.
4.	John Fenton, "Vehicle Body layout and analysis", Mechanical Engg. Publication Ltd., London, 1992.
5.	Braithwaite, J.B., "Vehicle Body building and drawing", Heinemann Educational Books Ltd., London, 1997.
6.	Dieler Anselm., The passenger car body, SAE International, 2000.

PWM Controlled Power Electronic Converters

Course Code:	**22EVT221**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce the concept of PWM and their application to power electronics control
2.	To study various PWM Techniques and their modeling.
3.	To know the various switching and conduction losses associated with power devices
4.	To study the concept of converters with compensation.

UNIT-I

PWM DC/DC Converters — **08 Hours**

Analysis of Galvanically Isolated Forward Converter, Boost Converter, Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Selection of Components, DC Pre-magnetization of the Core, Half-Bridge Converter, Bridge Converter, Hamilton Circuit, Ćuk Converters - Elimination of the Current Ripple, Ćuk Converters with Galvanic Isolation.

Control Modules — **06 Hours**

Basic Principles and Characteristics of PWM Control Modules - Circuit Analysis, Simple PWM, Voltage-Controlled PWM, Current-Controlled PWM- Compensated PWM.

UNIT-II

DC/AC Converters – Inverters — **08 Hours**

Single-Phase Voltage Inverters - Pulse-Controlled Output Voltage, Pulse-Width Modulated Inverters - Unipolar PWM, Three-Phase Inverters-Over modulation ($m_a > 1$), Asynchronous PWM, Space Vector Modulation - Space Vector Modulation: Basic Principles, Application of Space Vector Modulation Technique, Direct and Inverse Sequencing, Real Drive Influence. PWM techniques for current source inverter.

AC/DC Converters – Rectifiers — **07 Hours**

Rectifiers with Circuit for Power Factor Correction, Active Rectifier - Active Rectifier with Hysteresis Current Controller, PWM Rectifiers - Advanced Control Techniques of PWM Rectifiers , PWM Rectifier with Current Output, PWM Rectifiers in Active Filters, Some Topologies of PWM Rectifiers, Applications of PWM Rectifiers.

UNIT-III

AC/AC Converters — **06 Hours**

Single-Phase AC/AC Voltage Converters - Time Proportional Control, Three-Phase Converters, Frequency Converters, Direct Frequency Converters, Introduction to AC/AC Matrix Converters - Basic Characteristics, Bidirectional Switches, Realization of Input Filter, Current Commutation, Protection of Matrix Converter, Application of Matrix Converter.

Introduction to Multilevel Converters — **04 Hours**

Basic Characteristics -Multilevel DC/DC Converters, Time Interval: $nT < t < nT + DT$, $n = 0, 1, 2$, Time Interval: $nT + DT < t < (n + 1)T$, Multilevel Inverters - Cascaded H-Bridge Inverters, Diode-Clamped Multilevel Inverters, Flying Capacitor Multilevel Inverter.

Course Outcomes: At the end of the course student will be able to

1.	Use the knowledge of PWM techniques in controlling different power electronic converters.
2.	Apply the knowledge of power electronics in design and analysis of DC –DC PWM converters.
3.	Design and analyze DC –AC and AC – DC converters and control their operation using PWM techniques.

4.	Design and analyze single phase and 3-phase AC – AC converters.
5.	Design different topologies of multilevel converters.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT221.1	1		3				3	
22EVT221.2	1		3				3	
22EVT221.3	1		3				3	
22EVT221.4	1		3				3	
22EVT221.5	1		3				3	

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Branko L. Doki ć BrankoBlanu, “Power Electronics Converters and Regulators”, Springer (International Publishing, Switzerland) 3rd Edition, 2015
2.	Mohan, Undeland and Robbins, “Power Electronics: Converter, Applications and Design”, Wiley India, 2011.
3.	D. Grahame Holmes and Thomas A. Lipo “Pulse Width Modulation For Power Converters Principles and Practice” IEEE Press 2003
4.	V. T. Ranganathan, Course Notes on Electric Drives, Indian Institute of Science, Bangalore 2004
5.	Application notes and datasheets from Power Semiconductor Switch manufacturers like Infineon, MuRata
6.	G. Narayanan, NPTEL https://nptel.ac.in/courses/108/108/108108035/

Solar Battery Charging System

Course Code:	**22EVT222**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand the functioning of solar photovoltaic cells and know the ratings
2.	To know the solar array connection and estimate solar module power
3.	To understand function of charge controller and MPPT techniques
4.	To know the concept of solar PV system design and integration
5.	To explain the installation, trouble shooting and safety requirement of solar system

UNIT-I

Solar Photovoltaic	**08 Hours**

Solar Cell and its function, Solar Technologies, Solar Cell Parameters, Efficiency of Solar Cell, Solar PV Module, Rating of Solar PV Module, PV Module Parameters, Efficiency of PV Module, Measuring Module Parameter

Solar Photovoltaic Module	**06 Hours**

Array Connection of PV Module in Series and Parallel, Estimation and Measurement of PV Module Power, Selection of PV Module.

UNIT-II

Charge Controller, MPPT and Inverter — **08 Hours**

Power MOSFET and IGBT, Opto coupler, Buck and Boost Converter, Fly back Converter, Full Bridge Inverter, Voltage and Current Feedback, DC to DC power converter, DC to AC Converter, AC to DC Converter, Battery Charge controller, Maximum Power Point Tracking, Specification of Inverter and charger.

Solar PV System Design and Integration — **08 Hours**

Solar Radiation, Energy Measurements, Estimating Energy requirement, Types of Solar PV System, Design methodology for SPV system, Design of Off Grid Solar Power Plant, Case studies of 3KWp Off grid Solar PV Power Plant, Design and Development of Solar Street Light and Solar Lantern, Off Grid Solar power Plant.

UNIT-III

Installation, Trouble Shooting and Safety — **09 Hours**

Installation and Trouble shooting of Standalone Solar PV System, Maintenance of Solar PV System, Safety in installation of Solar PV System, Maintenance of Solar PV System.

Course Outcomes: At the end of the course student will be able to

1.	Describe the functioning of solar photovoltaic cells and cell parameters.
2.	Design the solar array connections and hence solar module for a given application.
3.	Analyse the function of charge controller and need for MPPT techniques.
4.	Design of off grid solar photo voltaic system.
5.	Describe the installation, trouble shooting and safety requirement of solar system

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT222.1			2					3
22EVT222.2			2					3
22EVT222.3			2					3
22EVT222.4			2					3
22EVT222.5			2					3

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Chetan Singh Solanki, Solar Photovoltaic Technology and Systems A Manual for Technicians, Trainers and Engineers, PHI , 2013

EV Standards & Testing

Course Code:	**22EVT223**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To introduce Understand different standards related to electric vehicles
2.	Understand charger an HEV standards
3.	Understand type testing of electric vehicle
4.	Understand retro fitment standards
5.	Know government policies related to EVs

UNIT-I

EV Standards	**06 Hours**
Electric power train vehicles-construction and functional safety requirements measurement of electrical energy consumption, Method of measuring the range, Measurement of net power and the maximum 30 minute power, CMVR type approval for electric power train vehicles, ISO 26262	
Charger Standard	**04 Hours**
Electric Vehicle Conductive AC Charging System, Electric Vehicle Conductive DC Charging System	
HEV Standard	**05 Hours**
CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW > 3500 kg	

UNIT-II

Retro fitment Standards	**08 Hours**
CMVR Type Approval of Hybrid Electric System Intended for Retro fitment on Vehicles of M and N Category having GVW <= 3500 kg and GVW > 3500 kg. CMVR Type Approval of Electric Propulsion Kit Intended for Conversion of Vehicles for Pure Electric Operation	
Safety Requirement of Traction Battery	**08 Hours**
Introduction to Vehicle safety standards, Rules and Regulations, Environmental impurities and safety requirements, Battery Operated Vehicles -Safety Requirements of Traction Batteries, Automotive safety components certification by various organizations (ARAI, SIAM, SAE, ASME, FMVSS).	

UNIT-III

Government Policies	**09 Hours**
National Electric Mobility Mission Plan 2020 (NEMMP2020), Faster Adoption and Manufacture of (Hybrid and Electric Vehicles) – FAME, Niti Aayog Report on Transforming Mobility	

Course Outcomes: At the end of the course student will be able to

1.	Illustrate different standards related construction and safety in electric vehicles
2.	Describe central motor vehicles rules (CMVR) type of standards for electric and hybrid electric vehicles.
3.	Describe CMVR types of standards for retro fitment of existing IC engine driven vehicles.
4.	Illustrate safety standards of traction batteries.
5.	Describe government policies like national electronic mobility plan related to EVs

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT223.1					2	3		
22EVT223.2					2	3		
22EVT223.3					2	3		
22EVT223.4					2	3		
22EVT223.5					2	3		

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Automotive Industry Standards, India, 2015-2016

Other References

1.	https://araiindia.com
2.	*https://emobility.araiindia.com*
3.	*https://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf*
4.	https://niti.gov.in/content/national-mission-transformative-mobility-and-battery-storage
5.	https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf

EVs in Smart Grid

Course Code:	**22EVT224**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

- To understand the fundamentals of Plug in Electric Vehicle technologies
- To understand the cyber security of Plug in Electric Vehicle technologies in Smart Grid
- To understand the impact of plug in electric vehicles on power system
- To understand the PEV Load and Its Impact on Static Voltage Stability
- To study the response of large-scale EV charging loads to frequency

UNIT-I

Overview of Plug-in Electric Vehicle Technologies	**04 Hours**
PEV Technologies, PEV Systems, impacts, Smart Charging Infrastructure, Integration of PEVs to Electric Grid Promotional Programs on PEVs	
Wireless Power Transfer (WPT) for Electric Vehicles (EVs)	**05 Hours**
Wireless Energy Transfer Methods, Inductive Coupling Versus Magnetic Resonance Coupling, Modelling the WPT System, WPT for EV Charging, Stationary WPT for EV Charging, Dynamic WPT for EV Charging	
Cyber Security of Plug-in Electric Vehicles in Smart Grids: Application of Intrusion	**06 Hours**
Detection Methods, Smart Grids with PEVs, Communication Infrastructure, Communication Standards, Cyber Security Challenges, Data Attacks and Intrusions in PEV Communications, Intrusion Detection Methods, Application to the Detection of Malicious PEV Penetration Level	

UNIT-II

Impact Evaluation of Plug-in Electric Vehicles on Power System.	**05 Hours**
Probabilistic PEV Charging Demand, Fast Charging Points, Probabilistic Arrivals, Probabilistic PEV Charging Demand, Probabilistic Grid Impact of Fast Chargers.	
PEV Load and Its Impact on Static Voltage Stability	**09 Hours**
Modeling of PEV Charging Load, Introduction to Power System Load Characteristics, Modeling of the PEV Charging Load, Effects of Charger Resistances on Load Model Parameters, Newton Raphson Power Flow with PEV Load, Impact of PEV Charging Load on System Static Voltage Stability, Voltage Stability Theory, Static Voltage Stability Analysis, Mitigating PEV Charging Impacts through Voltage Control, Mitigating PEV Charging Impact through Proper Planning	

UNIT-III

The Response of Large-Scale EV Charging Loads to Frequency	**11 Hours**
Introduction Characteristics of EV Charging Loads, Current Related Research of EVs on FR , EVs' Advantages in FR ,The Current Related Research of FR Based on the Coordination Among EVs, AGC, BESSs Properties of FR Resources ,Traditional FR Resources ,Large-Scale Energy Storage Devices ,EV/BESS FR Resource, Coordinated Control Strategy for EVs/BESSs ,Coordination Principle ,Implementation Method for Coordinated FR, Case Study and Results , Simulation Model and Parameters, Simulations of Power System FR The Asynchronous Response of Small-Scale Charging Facilities to Grid Frequency, Formulation of the Proposed Control Method . Demonstration of coordination, Demonstration of equality	

Course Outcomes: At the end of the course student will be able to

1.	Describe Plug in Electric Vehicle technologies and wire less power transfer for electric vehicles.
2.	Illustrate the cyber security of Plug in Electric Vehicle technologies in Smart Grid

3.	Analyse the impact of plug in electric vehicles on power system
4.	Describe the PEV Load and Its Impact on Static Voltage Stability
5.	Describe the impact of large-scale EV charging loads to grid frequency

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT224.1			2		2			
22EVT224.2			2		2			
22EVT224.3			2		2			
22EVT224.4			2		2	2		
22EVT224.5			2		2	2		

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Sumedha Rajakaruna, FarhadShahnia and Arindam Ghosh, "Plug In Electric Vehicles in Smart Grids-Integration Techniques", Springer Science + Business Media Singapore Pte Ltd., 2015.
2.	Canbing Li, Yijia Cao, YonghongKuang and Bin Zhou, "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid", Springer-Verlag Berlin Heidelberg, 2016.
3.	Qiuwei Wu, "Grid Integration Of Electric Vehicles In Open Electricity Markets", John Wiley & Sons, Ltd, 2013.

Automotive Computer Controlled Systems

Course Code:	**22EVT231**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To study and analyze various vision systems for vehicles.
2.	To understand the architecture for autonomous vehicles and study the overview of the architecture.
3.	To study the fundamentals about Autonomous vehicle with case study.

UNIT-I

Introduction of common technology	**08 Hours**
Engine related systems. Ignition system, computer-controlled petrol fuelling injection systems, Engine management systems, Anti-lock braking systems, Traction control system, Stability Control system, air conditioning, computer-controlled diesel engine system	
Computer ECM	**06 Hours**
Fundamental parts of computer, Principles of operation, Computer data, Computer interfaces, Computer memories, Adaptive operating strategy of the ECM	

UNIT-II

Sensors	**06 Hours**
Introduction of sensors and transducers Electromagnetic Sensors, Optical sensors, variable resistance type sensors, temperature sensors, Pressure sensors, variable capacitance sensors, Flow sensors, Piezoelectric sensors, Oxygen Sensor, Practical Importance of sensors	
Actuators	**04 Hours**
Introduction of Actuators, Actuators operation, Injectors, Exhaust gas recirculation actuators, motors, Solenoids, ABS actuators.	
Diagnostic tools, equipments and techniques	**05 Hours**
Diagnostic tools that connect to ECM, Digital Multi-meter, Oscilloscope, Circuit testing, Ignition system tests, Fault and error Codes, OBD II (On board diagnostic –II)	

UNIT-III

Communication protocols	**06 Hours**
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, Relevance of Protocols such as TCP/IP for automotive applications, Wireless LAN standards such as Bluetooth, IEEE 802.11x communication protocols for automotive applications.	
Infotainment Systems	**05 Hours**
Application of telematics in automotive domain, Global positioning systems (GPS) and General packet radio service (GPRS).	

Course Outcomes: At the end of the course student will be able to

1.	Describe different technologies used with respect to ignition, fueling, braking, stability in vehicles.
2.	Illustrate the different features of embedded system used in electronic control module (ECM)
3.	Describe different sensors and actuators used in vehicles.

4.	Use diagnostic tools such as digital multimeter, oscilloscope in detecting the faults using ECM.
5.	Illustrate communication protocols and infotainment systems used in vehicles.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT231.1			2					
22EVT231.2			2					
22EVT231.3			2					
22EVT231.4			2					
22EVT231.5			2			3		

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Ronald K Jurgen, “Navigation and Intelligent Transportation Systems – Progress in Technology”, Automotive Electronics Series, SAE, USA, 1998. 2. William B Ribbens, “Understanding Automotive Electronics”, 7th edition, Butter worth Heinemann Woburn -2012.
2.	References 1. Dennis Foy, Automotive Telematics, Red Hat, 2002. 2. Yilin Zhao, Vehicle Location and Navigation Systems, Artech House, 1997. 3. Jay Farrell and Matthew Barth, The Global Positioning System and Inertial Navigation, McGraw- Hill, 1999.

AUTOMOTIVE SECURITY

Course Code:	**22EVT232**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand the methods of cryptography
2.	To know the importance of embedded security
3.	To understand the network security issues in automotive network
4.	To understand the requirement of firmware resiliency in automotive application.
5.	

UNIT-I

Cryptography Introduction:	**07 Hours**

Introduction to cryptography, Classical Cryptosystem, Block Cipher
Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher.
Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.

Embedded Security: Introduction	**08 Hours**

Authentication, Integrity and Confidentiality, Properties of secure system Security elements(JIL), importance of keys in security, customization challenges, distribution of keys, tools and examples.(cryptoAuthlib)

UNIT-II

Protecting IP in cloud connected world:	**07 Hours**

Protection of IP, CODE isolation, encryption, hardware security, trustonic expertise tool for IP protection.

Automotive Network security:	**08 Hours**

Motivation for automotive network security, Automotive security, message authentication, Automotive security IC attributes, security challenges.

UNIT-III

Firmware Resiliency in Automotive application:	**10 Hours**

Automotive growth drivers, Firmware Vulnerabilities in automotive, Simplified protection, Automotive Platform firmware protection (secure boot controller).

Firmware Vulnerabilities in data centre.

Course Outcomes: At the end of the course student will be able to

1.	Comprehend the algorithms of cryptography for data and network security
2.	Analyze the importance of key security and customization challenges for embedded security
3.	Explain the importance of Protection of IP in cloud connected network
4.	Describe the importance of message authentication and security challenges and solutions for automotive network.
5.	Analyze the importance of firmware resiliency in automotive applications.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	PSO↓	
↓ Course Outcomes							1	2
22EVT232.1	3	2						
22EVT232.2	3	2						
22EVT232.3	3	2						
22EVT232.4	3	2						
22EVT232.5	3	2						

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Wiiliam Stallings, "Cryptography and Network security Principles and practices ", 4th Edition, prentice hall, November 16,2015.

E-Resources:

1.	https://onlinecourses.nptel.ac.in/noc21_cs16/preview
2.	https://www.microchip.com/en-us/solutions/embedded-security
3.	https://vimeo.com/371395354
4.	https://vimeo.com/391579350?aliId=eyJpIjoiK1V6Z1M0VTRIdVR3SmlPaCIsInQiOiJMbWxYM1prT2ZQNXhTemVoWEFkRVRBPT0ifQ%253D%253D
5.	https://vimeo.com/400991351?aliId=eyJpIjoiN2I1Z2N2c0pBNUlodmFsZyIsInQiOiJ5bFlzT3lVUnVkRjNRSlpXd0xJNmRBPT0ifQ%253D%253D
6.	SHIELDS UP! Webinar #27: Platform Firmware Resiliency in Automotive Applications (2822370) (on24.com)
7.	https://page.microchip.com/FY21Q2-ShieldsUP-HardGates_LP-ShieldsUp-Webinar3.html
8.	SHIELDS UP! Webinar #33: Data Center Security Solutions (2977322) (on24.com)

VEHICLE MANAGEMENT AND CONTROL

Course Code:	**22EVT233**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P):	**3+0+0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To understand the basic control systems in power train
2.	To recognize the electronically controlled system
3.	To understand the body electronics and lighting in electrical vehicle
4.	To identify the motor and control systems in EV
5.	To know the requirement for infotainment and display

UNIT-I

EV,HEV and Power Train	**08 Hours**

1 phase and 3 phase AC analog control, 1 phase and 3 phase AC digital control, battery pack passive balancing, DC-DC converter, automatic transmission, Battery control unit, DC fast charging, drive line components, electric power steering, fuel cell control unit, sensors in power train, Block diagram of VCU, Virtual engine sound system.

Advanced driver assistant systems(ADAS):	**07 Hours**

ADAS domain controller, automotive thermal camera, camera module without processing, conditionally automated drive controller, drive assist ECU, Drive monitoring, LiDAR.

UNIT-II

Body Electronics and Lighting :	**08Hours**

Automotive HVAC compressor Module, Automotive HVAC control module, Automotive HVAC sensors, Automotive gateway, heater module, Body control module, DC/AC inverter, door handle module, gesturing, headlight, Interior Light, Obstacle detection sensor, power distribution box, rear light, wiper module, sliding door module, smart glass module, seat comfort module, passive entry passive start.

Motor control and Drive:	**07Hours**

Motor types: ACIM control, Brushed DC motor Control, PMSM control, Stepper Motor control, Switched reluctance Motor control.

UNIT-III	
Infotainment and cluster:	**04 Hours**
Head unit, audio amplifiers, telematics, USB media Hub, wireless charging	
Display:	**04 Hours**
Graphical user interface, Human machine interface for diagnostic tools	
Timing and Synchronization:	**02 Hours**
Navigation, secure position and synchronization	
Course Outcomes: At the end of the course student will be able to	

1.	Comprehend the basics of power train modules in EV and HEV
2.	Recognize the electronically controlled system used in advanced driver assistance system
3.	Identify the body electronics and lighting requirement for EV
4.	Select the type of motors and control system for EV application
5.	Recognize the need of infotainment, display and synchronization for effective automated transport system.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / **↓ Course Outcomes**	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT233.1	2	3			3			
22EVT233.2	2	3			3			
22EVT233.3	2	3			3		3	
22EVT233.4	2	3			3		3	
22EVT233.5	2	3			3			

1: Low 2: Medium 3: High

REFERENCE BOOKS:	
1.	https://www.ti.com/applications/automotive/overview.html
2.	https://www.microchip.com/en-us/solutions/automotive-and-transportation
3.	https://www.microchip.com/en-us/solutions/motor-control-and-drive
4.	https://www.microchip.com/en-us/solutions/power-management-and-conversion
5.	https://www.microchip.com/en-us/solutions/displays
6.	Bosch Automotive Handbook, Sixth edition,2004.

Fundamentals of Automotive Systems

Course Code:	**22EVT234**	**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical and Electronics Engineering

Course Objectives:

1.	To study two stroke and four stroke engines
2.	To study automotive transmission braking and steering
3.	To study the suspensions and tyres of automotives.

UNIT-I

Automotive Engines	**15 Hours**
Classification of Internal Combustion Engines, Engine Components, Operation of Four Stroke Engines Two Stroke Engines, Engine Cycles Engine Performance, Supercharging, Combustion in Spark Ignition Engines, Combustion in Compression Ignition Engines, Carburetion, Fuel Introduction Systems, Engine Emissions, Emission Control Systems, Automotive Powertrain.	

UNIT-II

Automotive transmission, braking and steering	**15 Hours**
Automotive Clutch, Transmission, Powertrain Analysis, Transmission Matching and Introduction to Brake System, Components of Brake System, Hydraulic Brake, Air Brake, Antilock Brake System, Braking Analysis, Introduction to Steering System, Manual Steering System	

UNIT-III

Suspension and hybrid powertrain	**10 Hours**
Power Steering System, Wheel Alignment, Introduction to Suspension System, Components of Suspension System, Dependent and Independent Suspension, Introduction to Electric and Hybrid Powertrain, Tyres	

Course Outcomes: At the end of the course student will be able to

1.	Illustrate working of two stroke and four stroke IC engines
2.	Describe fuel introduction system and engine emissions in automotives
3.	Describe clutch, transmission and braking used in automotives.
4.	Analyse manual steering system used in automotives.

5.	Describe suspension and tyres used in automotives.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVT234.1			2		2			
22EVT234.2					2			
22EVT234.3					2			
22EVT234.4			2		2			
22EVT234.5					2			

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Encyclopedia of Automotive Engineering, Parts 1-6, Wiley, 2015.
2.	R. Stone and J. K. Ball, Automotive Engineering Fundamentals, SAE International, 2004.
3.	T. K. Garrett, K. Newton, and W. Steeds, The Motor Vehicle, 13th Edition, SAE International, 2001.
4.	D. B. Astow, G. Howard and J. P. Whitehead, Car Suspension and Handling, 4th Edition, SAE International, 2004
5.	R. Limpert, Brake Design and Safety, SAE International, 1992
6.	V. Ganesan, Internal Combustion Engines, 3rd Edition, Tata McGraw Hill, 2007
7.	M. Ehsani, Y. Gao and A. Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, 2nd Edition, CRC Press, 2010

PCB DESIGN

Course Code:	**22EVTAU21**	**Course Type:**	**AUDIT**
Teaching Hours/Week (L: T: P):	**0:0:2**	**Credits:**	**-**
Total Teaching Hours:	**0+0+26**	**CIE + SEE Marks:**	**-**

Teaching Department: Electrical and Electronics Engineering

UNIT-I	**06 Hours**
Introduction to Printed circuit board: fundamental of electronic components, basic electronic circuits, Basics of printed circuit board designing: Layout planning, general rules and parameters, ground conductor considerations, thermal issues, check and inspection of artwork.	
UNIT-II	**06 Hours**
Design rules for PCB: Design rules for Digital circuit PCBs, Analog circuit PCBs, high frequency and fast pulse applications, Power electronic applications, Microwave applications.	
UNIT-III	**14 Hours**
Introduction to Electronic design automation(EDA) tools for PCB designing: Brief Introduction of various simulators,SPICE and PSPICE Environment, Selecting the Components Footprints as per design, Making New Footprints, Assigning Footprint to components, Net listing, PCB Layout Designing, Auto routing and manual routing. Assigning specific text (silkscreen) to design, Creating report of design, creating manufacturing data (GERBER) for design.	

Course Outcomes: At the end of the course student will be able to

1.	Describe layout planning and general rules of PCB design.
2.	Design rules for digital circuit PCB
3.	Design rules for analog circuit PCB
4.	Describe electronic design automation tools for PCB designing.
5.	Analyze and Develop program PCB for a given application.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	PSO↓ 1	PSO↓ 2
22EVTAU21.1				2	3			
22EVTAU21.2				2	3			
22EVTAU21.3				2	3			
22EVTAU21.4				2	3			
22EVTAU21.5				2	3			

1: Low 2: Medium 3: High

TEXTBOOKS

1.	Printed circuit board design ,fabrication assembly and testing By R. S. Khandpur, Tata McGraw Hill 2006

REFERENCE BOOKS:

1.	Printed circuit Board Design and technology, Walter C. Bosshart
2.	Printed Circuits Handbook, Sixth Edition,by Clyde F. Coombs, Jr, Happy T. Holden,Publisher: McGraw-Hill Education Year: 2016
3.	Complete PCB Design Using OrCAD Capture and PCB Editor,Kraig Mitzner Bob Doe Alexander Akulin Anton Suponin Dirk Müller, 2nd Edition 2009.
4.	Introduction to System-on-Package, Rao R Tummala&MadhavanSwaminathan, McGraw Hill, 2008.
5.	EMC and Printed circuit board ,Design theory and layout, Mark I Montrose IEEE compatibility society
6.	Flexible Printed circuit board Design and manufacturing ,By Robert torzwell