VIGNAN'S
Foundation for Science, Technology & Research
(Deemed to be UNIVERSITY)
-Estd. u/s 3 of UGC Act 1956

R22 Academic Regulations

In Compliance with NEP 2020

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PREFACE

'You are born to Blossom' – What an inspiring title the book authored by APJ Abdul Kalam and Arun K Tiwari carries. The journey to blossom has got to be heralded by education. The purpose of education is to ensure that the 'Life Blossoms'. Earning a degree and getting a placement should be the just happening things, and should not become the only celebrated goals for education. In the book cited above, Honourable Kalam, Former President of India, underscores that "The scheme of civil society depends on Educating young people to become enlightened citizens and adults who are responsible, thoughtful and enterprising"

VIGNAN aims to seed these concepts in every learner who transits through this temple of learning. The doctrine of VIGNAN entitled R-22 contains the principles of policies laid down by the University, to realize the spirit of "Blossoming the lives" providing a foundation-strong professional education on the ethos of 'Creative learning for Critical thinking and Critically analysing for Creative decision making'. Certainly, our University is one of the earliest Universities, in fact the University is a trend setting one in completely internalising the concepts of the policies brought out in National Education Policy (New Educational Policy) NEP-2020, and inculcating the spirit in R-22. The R-22 document articulates the Academic Regulations of the University, which is being presented now and shall be inforce with immediate effect from the academic year 2022-23, not only for those who have joined in 2022, also the aspirants of 2021-22 are enabled into the navigation.

R-22 presents a novel design for the academic pursuit, making an exploratory cross disciplinary traversal for a learner who should find learning both holistic and experiential. The learner is ensured to enjoy the continuity in learning and the learner is supported to align and realign, enroute utilising the benefits of constructive feedbacks that s/he receives because of continuous assessment. S/he will be empowered to enjoy the opportunities to explore, experiment and experience.

R-22 eliminates the melancholy of examinations. The expected severity of breakdown due to the anxiety of examination system is replaced by an affectionate assessment system, increasing the effectiveness in accomplishing the outcomes.

In brief, NEP-2020 compliant revised academic regulation of the University – the R-22, is VIGNAN's commitment to alleviate the acuteness in the present educational practices. It intends to provide a strategic solution to the critical observation made by Bharat ratna awardee, Professor. CNR Rao – "India has exam system, not education system. When will young people stop taking exams and do something worthwhile?" (Thought for the Day, Times of India 13.08.2022)

Here is R-22, which assures that the learners at VIGNAN are bound to do something worthwhile – very much worthwhile.

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R22 M.Tech.
2 YEAR
PG PROGRAMME

REGULATIONS - TABLE OF CONTENTS

* Programme will be offered based on satisfactory strength of students willing to register, after receiving the formal AICTE approval.

R22 M.Tech. 2 YEAR PG PROGRAMME

Academic Regulations, Curriculum and Course Contents

R22 M.Tech. 2 YEAR PG PROGRAMME

EXECUTIVE ABSTRACT

R22 - Academic regulations, Curriculum and course contents, is an articulation of the VFSTR deemed to be University's commitment towards NEP-2020, with a view that it enables student(s) to maintain the spirit of continuous learning and continuous assessment to replace the normal tendency of preparing just before a test or an examination. The proposed framework accomplishes multi-disciplinary holistic education, continuous assessment along with multiple honorable exit options if a student falls short to complete the requirements to earn the degree within the stipulated period including the permissible spill over period.

R22 is oriented towards holistic education at the postgraduate level that includes integrated and rigorous exposure to professional domains, as well as sufficient flexibility in curricular structures that allow students to choose electives from the wide choice of courses. Such holistic and diverse education will assist the candidate in transforming into all-rounded persons. Similarly, in line with NEP-2020, more weight is given to continuous/ formative assessment, in the frame work of an Integrated learning model comprising Learning – Thinking – Understanding – Skilling – Applying – Creating. Emphasis on continuous formative assessment with a creative summative assessment will facilitate the candidate to "Move away from high stake examinations – towards more continuous and comprehensive evaluation".

The M.Tech. degree offered will be for two years' (4 semesters) duration with lateral exit options within this period, with suitable certifications that will enable the candidate to have a professional career and as well as serves as a reminder to return and update his / her qualification in the future. In line with NEP-2020, following one year of study and the completion of the required credits, an Engineering PG Diploma degree will be conferred. However, the intention of the learners is not to join for the award of the PG diploma with lateral exit, but to acquire a M.Tech. degree.

Salient features of the regulation

- Continuous learning
- Continuous assessment
- Add-on certification
- Honorable exit option
- Onward Continuation to Ph.D. Program
- Sabbatical Semester Drop option to pursue innovation, incubation, entrepreneurial and advanced exploratory activities and subsequent re-entry

1 INTRODUCTION

This document contains the academic regulations, scheme of assessments, curriculum, detailed syllabi, course contents with text / reference books recommended, course outcomes, skills acquired and the projects / assignments that are to be performed for each course for the conduct of 2-year M.Tech. degree programmes. The various M.Tech. degree programmes under different schools in VFSTR are as listed below. The character codes indicated in paranthesis are their branch disciplinary code.

I. School of Agriculture & Food Technology

- Food Processing Technology (FT)
- Farm Machinery (FM)

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II. **School of Biotechnology & Pharmaceutical Sciences**
- Biotechnology (BT)

III. **School of Computing & Informatics**
- Computer Science & Engineering (CSE)

IV. **School of Conventional Engineering**
- Structural Engineering(SE)
- Machine Design (MD)

V. **School of Electrical, Electronics & Communication Engineering**
- Embedded Systems (ES)
- VLSI (VLSI)
- Power Electronics and Drives (PED)

1.1 Definition

For the purpose of R22 regulation, definitions as follows shall apply:

- **"Degree"** shall refer to the M.Tech. Degree Program.
- **"Course"** shall refer to such Course(s) for which a student shall earn Credits after due assessment as per the laid provisions. Project is also treated as a Course.
- **"Academic activities"** shall refer to the activities like Lecture (Physical Lecture Session), Tutorial (Participatory discussion / Self-Study / Desk Work / Quiz / Seminar Presentation, *etc* activities that make the student absorb & assimilate, the delivered contents effectively) and Practical / Practice sessions (includes Hands on Experience / Lab experiments / Field Studies / Case Studies *etc* activities that enable the student to acquire the requisite skill).
- **"Continuous Assessment"** shall refer to the assessment of the student spread over the entire semester on the various constituent components of the prescribed course.
- **"Semester"** shall refer to a period covering the two assessment periods *viz* Formative and Summative Assessment period. A semester would generally be spread over twenty weeks.
- **"Course Drop"** shall refer to a student having to undertake a repeat of the Course(s) not being able to complete the Credit requirements of the Course(s), under the conditions stipulated in the regulation.
- **"Supplementary Examinations"** shall refer to the examination(s) conducted to allow the student to appear in the un-cleared Semester - End summative assessment component.
- **"Blank Semester"** shall refer to a Semester in which a student either does not register for any course at the beginning of the Semester OR chooses to DROP all courses OR is so compelled to DROP all the courses, as the case may be.
- **"Semester Drop"** shall refer to availing a blank semester. However, if drop is availed to pursue a creative extension activity, then it is defined as **semester sabbatical**.
- **"Spill Over Semester"** shall refer to the additional semester(s) beyond the completion of prescribed normal semesters.
- **"AAA Section"** shall refer to the Academics, Assessment and Awards Section of the Institute.
- **"Attendance"** refers to the Physical personal presence in an academic activity session.
- **"Summer Semester"** refers to a Semester that is scheduled to be held during the intervening period of Even and Odd Semester (*i.e*. Summer Vacation period).
- **"Themes"** refer to the courses offered in a particular stream other than offered by the regular departments, for example NCC, Entrepreneurship, Fitness and Living, *etc*.
- **"School"** refers to a division of institute dealing with two or more specific areas of discipline / study comprising of the departments related with exclusive emphasis on trans-disciplinary research.
- **"Department"** refers to a division of institute dealing with a specific area of discipline / study.

- **"HoD"** refers to the Head of the respective Department, where the student is enrolled for his / her Branch of Study.
- **"Center"** refers to a structured unit within the school / department established with the purpose to carry out advanced research.
- **"Grade Point"** refers to the quantification of the performance of a candidate in a particular course as defined herein.
- **"SGPA"** refers to the Semester Grade Point Average and is calculated as detailed in the regulations subsequently.
- **"CGPA"** refers to the Cumulative Grade Point Average and is calculated as detailed in the regulations subsequently.
- **"Division"** refers to the Division awarded to the student as per the mechanism detailed in the regulations subsequently.
- **"Internship"** refers to onsite Practical Training offered by reputed companies / Institutions, in India or abroad. To be undertaken with (or seeking) prior approval of the respective HoD.
- **"Project"** refers to a course executed by a candidate on a specific research problem at VFSTR / any organization of repute. To be undertaken with (or seeking) prior approval of the respective HoD.
- **"Credit equivalence and credit transfer committee"** refers to the committee designated to look into for credit equivalence and credit transfer.
- **"Honorable Exit Option"** refers to the Exit Options available to students, when they are unable to complete the prescribed two-year M.Tech. Degree program in four successive years.

1.2 Academic Administration

The academic programmes of VFSTR are governed by the rules and regulations approved by the Academic Council from time to time. The various academic activities are conducted following a fixed time schedule duly approved by the Academic Council in line with the AICTE / UGC regulations. The academic activities of VFSTR are followed meticulously as specified in the academic calendar as approved by the Academic Council. This academic calendar is shared with all the stake holders well before the beginning of the respective academic year. The curriculum and the course contents of all the programmes are discussed by the respective Board of Studies (BoS), analyzed and recommended for implementation. The Academic Council, being the highest statutory body, chaired by the Vice-Chancellor, meets at least twice or thrice a year and discusses, suggests and approves all the important academic matters related to curriculum and course contents in particular including the recommendations of BoS.

The intended revision in regulations (R22) was in principle accepted and recommended by the Academic Council in its 32nd meeting on 10-12-2022. Subsequently respective Board of Studies brought necessary recommendations accordingly, which were duly placed before the Academic Council in its 33rd meeting on 17-6-2023.

1.3 Program Duration

For the branch disciplines listed in section (1), the regular courses including theory and practical are offered over a period of two years in four semesters. The normal duration to complete the M.Tech. program is two years. However, a student can avail the benefit of spill over period for 2 years, that is the maximum duration of four years can be availed by a candidate to complete the M.Tech. programme in a slower pace if he / she desires. The candidate failing to complete the requirements will be considered for the honorable exit as applicable

1.4 Courses and Credits

The term course is used in a broader sense to refer to so called papers such as 'theory subject', 'laboratory', 'inter-departmental project', 'major-project' etc. A course can be of theoretical and / or of practical nature, and certain number of credits are allotted to it depending on the

number of hours of instruction per semester. For a course offered in a semester, one hour of lecture (L) instructions carried out in a week is considered equivalent to one credit, whereas two hours of practical (P) sessions done in a week are considered equivalent to one credit. Depending on the course two hours of tutorial (T) sessions may be considered equivalent to one credit. A student earns these credits when he / she successfully completes the course.

1.4.1 Content Delivery of a Course

Content delivery of a Course in the M.Tech. Degree Program shall be through, either or all, of the following methods:

i. **Lecture** - refers to Lecture Session(s) through classroom contact session wherein students will learn by listening. Denoted by "L".

ii. **Tutorial** - refers to transaction(s) consisting of Participatory discussion / Self-study / Desk work / Brief presentations by students along with such other novel methods that enable a student to efficiently & effectively absorb and assimilate the contents delivered in the lecture sessions. Denoted by "T".

iii. **Practice** - refers to Practice / Practical sessions and it consists of Hands-on- Experience / Laboratory Experiments / Field Studies / Case Studies / Minor / Major Project, that equip the students to acquire the much required skill component. Denoted by "P".

1.5 M.Tech. Degree

All students formally and conventionally enroll for M.Tech. degree programme. They have to earn **68** credits for the award of degree as specified in the Curriculum. However, additionally he/she can opt to earn up to 12 more credits as Add-on credits, to earn the academic benefits as specified below.

1.5.1 M.Tech. with Add-on Certification

If a candidate earns add-on 12 credits in the respective discipline, then he/ she will be eligible for the award of M.Tech. in YY Engineering with Add-on Certification.

Note: The consolidated transcript will contain the credits and grade details of all courses amounting to 68 + up to 12 credits.

1.6 Composition of an Academic year

An academic year is composed of an Odd semester (20 – 22 weeks), an Even semester (20 – 22 weeks) and a Summer semester (6 – 8 weeks). The regular semester that begins in July / August is known as odd / first semester and the one that begins in December / January is known as even / second semester (Figure 1). The instructional days for a regular semester shall be a minimum of 90 working days exclusive of days earmarked for summative assessment.

YEAR OF 12 MONTHS											
1	2	3	4	5	6	7	8	9	10	11	12
July/ Aug.	Aug./ Sept.	Sept./ Oct.	Oct./ Nov.	Nov./ Dec.	Dec./ Jan.	Jan./ Feb.	Feb./ Mar.	Mar./ Apr.	Apr./ May	May/ June	June/ July
ODD SEM/ FIRST SEM					EVEN SEM/ SECOND SEM					SUMMER SEM	

Figure 1: Distribution of semesters during an Academic Year.

1.6.1 Before the commencement of the semester, a candidate has to pay the stipulated tuition fee and submit an application detailing the courses he / she intended to register, valid for that respective Odd / Even semester. The maximum number of credits per semester will be 25 credits inclusive add-on credits. The intended semester wise coverage will be as presented in the curriculum.

1.6.2 **Summer semester** is a short duration semester program that will be generally conducted during the semester break between even semester and odd semester. The students having 'R' (Repeat grade) courses may register for the course work during this semester to get a chance for successfully completing the 'R' courses. In general, supplementary assessments are conducted in the later part of the summer semester. However, the courses offered in summer semester and the number of courses a student can register are subjected to academic and administrative convenience. A student may register up to a max. of 12 credits in a summer semester.

1.6.3 Exception to the routine practice of registering for 'R' courses in summer semester, a student can register in a course offered by a visiting expert during the summer vacation which may be equivalent to a department elective or an Add-on-course. The candidates can register for such courses within the scope of 12 credits. Candidate may also avail summer semester for summer internship opportunities, which may be considered as Add-on credits.

1.7 Semester wise provisions

A student may register for a max of 25 credits per semester as prescribed or otherwise he/she may include the Repeat courses in the event of having not successfully completed a course or courses in the earlier semester. However, a student may also opt to go in a slower pace to earn the credits less than the prescribed max of 25, including even 'Dropping' a semester for special reasons.

It should be clearly underscored that a candidate should on priority register for Repeat (R) credits if any, during a regular semester, within the said scope of 25 credits; in case he / she cannot be sure of completing or could not complete the 'R' credits in Summer semester.

1.7.1 During the first two years from the date of admission to M.Tech., a candidate has to pay the semester / annual fees as prescribed irrespective of the less number of credits that he / she would register or even opt to Drop a semester.

1.7.2 If a candidate gets into spillover semester beyond two years up to a maximum of four years he / she has to pay semester fee proportional to the credits that he/ she registered in that spill over semester as prescribed from time to time.

1.7.3 A candidate has to pay additional fee proportional to the number of credits for registering in a summer semester as prescribed from time to time.

2. CURRICULUM

Each School offers different M.Tech. degree programmes and the departments concerned prescribes semester-wise curriculum encompassing different courses. Every course offered will be designated in a L-T-P structure. The theory courses comprise of L (and / or T & P hours) whereas the practical courses include instructions (T) and practical sessions (P). Amalgamation of theory courses with practical sessions is predominantly seen in this curriculum.

2.1 Distribution of credits

The overall distribution of credits for various categories of courses in the curriculum of M.Tech. programmes is represented in Table (1) as given below.

Table 1 : Credits Distribution for Various categories of courses.

Category of Courses	Credits (%)	AICTE Recommendation (%)
Professional Core	29.4	29.4
Electives	17.6	22.1
Inter disciplinary courses	8.8	7.4
Projects	44.1	41.2

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2.2 Organization of course contents

Courses offered in the program is composed of two modules covering all the course contents required for a candidate to obtain knowledge and skill. Content in each module is further distributed among two units; wherein Unit -1 contains 'Fundamentals and Broad perceptive' of the module. Unit-2 comprises of the extension / advanced topics of Unit-1 as well as necessary practice models for validation / applying the knowledge gained during L/T sessions. The modular period is about 8 weeks. The first unit in a module may be covered in 2 to 3 weeks and the second unit of the module maybe of 5 to 6 weeks (Figure 2). By the end of each module a candidate must be in a position to translate his/ her L-based knowledge into P-based skill as prescribed in the curriculum. Individual formative assessment shall be in place for each module and a single semester-end summative assessment for the course composed of both the modules.

YEAR OF 12 MONTHS											
1	**2**	**3**	**4**	**5**	6	7	8	9	**10**	**11**	**12**
July/ Aug.	Aug./ Sept.	Sept./ Oct.	Oct./ Nov.	Nov./ Dec.	Dec./ Jan.	Jan./ Feb.	Feb./ Mar.	Mar./ Apr.	Apr./ May	May/ June	June/ July
ODD SEM/ FIRST SEM					EVEN SEM/ SECOND SEM					SUMMER SEM	

Module- I		**Module- II**			**Module- I**		**Module- II**			
U1	**U2**	U1	U2		U1	U2	U1	U2		

Figure 2: Unit-wise distribution of course contents in a module and their mapping with Academic Calendar; U= Unit.

3. CHOICE BASED CREDIT SYSTEM

Each branch discipline of the M.Tech. programme comprises of a set of courses - professional core, electives, projects and audit courses. VFSTR offers flexibility for students to choose courses of their choice and obtain the credits satisfying the minimum credits criterion in each category as given in Table-1.

3.1 Professional Core

Professional Core courses are individualized for each programme and they are mandatory for every student opting for that branch discipline. These are designed to offer the essential fundamental knowledge and skills required for that specific programme.

3.2 Electives

A candidate has a choice to choose the elective courses. A list of elective courses are pooled together, enabling a candidate to choose the electives from a pool. There may be more than one pool in certain disciplines aligned to a specific theme. Otherwise also he/ she can exercise the choice to choose electives from across the pools. There may be courses which may not be listed under any pool, which are called 'Free elective courses'.

Elective courses offered for each programme are categorized as 'program electives' that are aimed at offering the advanced/ additional knowledge in the chosen branch discipline.

Care should be exercised while opting for program elective courses and Add-on certification courses that is a course opted as program elective should not be registered as a course under Add-on certification courses and vice versa.

Apart from 68 credits, additionally candidate has to earn 12 credits for Add-on certification. Of these 8 credits may be earned through MOOCs offered via Swayam platform. A student may also be permitted to earn more elective credits through MOOCS. This will promote self-learning and drive students towards innovative learning approaches.

To facilitate the process of acquiring the elective credits through MOOCS, VFSTR has constituted "Online course committee" at Central level with 1-2 members represented from each of the department to guide students in selection of courses and to assist them with further steps if required until completion of the courses.

3.3 Inter disciplinary courses

Courses such as Cyber security, Research Methodology & IPR and employment Orientation/ Soft skills program are offered in the first and second semester of the programme. As per UGC guidelines cyber security course is introduced as compulsory course. The M.Tech. students are encouraged to participate in research activity of both academia and industry, hence research methodology & IPR could be an important course to offer.

The 50-hour Employment Orientation Program (EOP) for M.Tech degree students is conducted with the help of in-house and invited experts. It is aimed at improving presentation skills in general and pedagogical skills in particular.

3.4 Teaching Assistantship

Candidates after undergoing Employment Orientation Programme in the first semester of the program should enroll for the 'Teaching assistantship' course during their second semester to earn 2 credits. Each candidate will assist faculty in handling a 'P-based activities' for B.Tech. students, developing teaching abilities like handling the sessions, interaction with students for clarification of doubts and assessment capabilities. The candidate performance will be assessed in the same lines.

3.5 Inter Departmental Project

These projects are designed and executed by students during the first year second semester of their program. By doing these projects, students will get an idea of how technologies or processes, prototype or working model can be developed by culmination of technologies from courses of different programs. The minimum duration of inter-departmental project during each of the semester is 90 hours including writing of project report and submission for assessment. A batch of 2-3 students from same or across the departments can take part in each of the inter-departmental projects. Performance will also be assessed in the modular framework for formative and semester-end summative with a weightage of 2 credits

3.6 Project

Students may opt for Project work in lieu of internship for two complete semesters during second year. Such students may avail research-internship support from any institution well known for research and development (R&D). They may also take up project work in VFSTR itself. Each candidate has to submit interim reports and a final report which are mandatory requirements towards the partial fulfillment of project credits requirements. It bears a weightage of 13 credits for the work executed in the third and fourth semesters totalling up to 26 credits. During the project work the student under the guidance of a faculty member(s) will involve in an innovative design / research through the application of his / her knowledge gained in various courses studied. He / she is therefore expected to present a survey of literature on the topic, work out a project plan and carry it out through experimentation / modelling / simulation / computation. Through such a project work, the student is expected to demonstrate system analysis, design, presentation and execution skills. Performance in the project will also be assessed in the modular framework for formative and summative assessments.

3.7 Internship

A student can undertake internship in lieu of project work in industry for two complete semesters during second year in lieu of major project work. It bears a weightage of 13 credits for the work executed in the third and fourth semesters totalling up to 26 credits. This is aimed at training students in solving / understanding real-life problems through application of engineering analysis, design, evaluation and creation, particularly in association with practitioners and experts in the industry. The procedures for obtaining the internship placements and allocation of the same to the students are as per University. Even during internship, a student is preferably expected to carry out a focused study on one topic / problem in consultation with the interning institute. Internship progress report should be submitted periodically and finally a detailed internship report should be submitted duly certified by a mentor from the internship institute. Performance in the internship will also be assessed in the modular framework for formative and summative assessments.

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4. ATTENDANCE

It is mandatory for the student to attend the course work in each semester as per the academic schedule of that semester. VFSTR expects 100% attendance. However, the attendance in each course shall not be less than 75 % of the aggregate of all L, T, P sessions conducted in that course.

a) The attendance calculations will be periodically reviewed at the end of every 4 weeks. The details of attendance status will be shared with the parents / guardian. The final status of attendance will be reported at end of 15th week granting the advantage of the attendance for the 16th week for the purpose of attendance shortage calculations.

b) The shortage of attendance may be condoned up to 10% on the ground of ill-health, social obligations, participating / representing in sports/cultural events, placement activities etc.

c) Documentary evidence like medical reports and certificates issued by concerned bodies is to be produced on time as support for the attendance shortage due to ill-health. These cases are subjected to the scrutiny of a committee constituted for this purpose by the Vice-Chancellor. The decision of the committee shall be final.

d) Prior approval has to be taken from the HoDs for the other types of leaves.

e) The courses where the student shortage of attendance was not condoned shall be considered as 'Repeat' category courses and will be under 'R' grade in the student's semester transcript. Student should re-register for these courses during the summer semester or whenever the course is offered next time during regular semesters. These re-registrations are subjected to the regulations at the time of re-registration. In case of core courses, the same core has got to be re-registered. However, in case of an elective a candidate may exercise a choice of choosing different elective in place of 'R' graded elective.

The students who are put into 'R' grade will not be allowed to take up the summative assessment in that semester. In case due to lack and/or delay in information, if he/she appears for the summative assessment in that course, office of AAA is empowered to cancel the attended exams. The scores obtained either in formative or summative assessment will not be considered for grading.

5. ASSESSMENT

Teaching-Learning and Assessment should go hand in hand and complement each other. Continuous assessment plays a vital role to enable the student to get synchronized with the teaching-learning process. Assessment mechanism adopted in the institute is aimed at testing the learning outcomes in tune with the outcome based model of education. The focus, is thus on assessing whether the outcomes are realized by the end of the course.

The performance of a student in each course is assessed on a continuous basis during the semester through various in-semester and end-semester assessment models. The marks awarded through continuous assessment are referred to as Formative assessment marks. The marks awarded through end-semester tests are referred to as Summative assessment marks (Figure 3). Both the formative and summative assessment marks are considered for awarding the final marks and the grade point in a particular course.

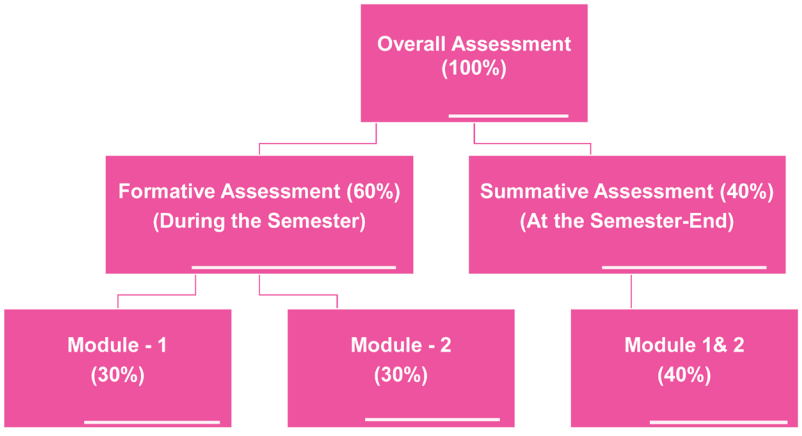

Figure 3: Categories of assessments in place for R22.

5.1 Marks distribution

For each course, the maximum sum of formative and summative assessment marks put together is 100, in the ratio of 60:40, respectively.

5.2 Qualifying criteria

To be declared successful in a course, a student must secure at least a grade 4.5 in a scale of 10 based on the total maximum marks which is inclusive of formative and summative assessment. The students should also get 40% from the maximum marks allotted for formative and summative assessments individually.

The hierarchy of qualifying criteria is as follows:

i. Attendance compliance should be 75% or within condonable range; else the candidate is put into 'R' grade.

ii. In formative assessment, a candidate should secure a minimum of 40% i.e. 24 marks out of 60; else the candidate is put into 'R' grade.

iii. In summative assessment, a candidate should secure a minimum of 40% i.e. 16 marks out of 40; else the candidate is put into 'I' (Incomplete) grade.

iv. Collectively the candidate should secure a min. grade of 4.5 in a scale of 10 after relative grading; else the candidate has to choose either 'R' or 'I' grade duly being counselled.

v. Every semester, candidate should score a min. of 5 Semester Grade Point Average (SGPA) in every semester individually with the successfully completed courses. In case a candidate fails to score the min. SGPA, then he / she shall voluntarily drop a few Courses to ensure a SGPA of 5. He / she after duly counselled has to choose either 'R' or 'I' grade for the dropped courses.

The candidates with 'R' grade should re-register for 'R' courses either in Summer semester or in a regular semester as and when the courses are offered. The candidates in 'I' grade are allowed to appear for supplementary summative assessment whenever the semester-end assessments are conducted.

To assess special projects / courses, not fitting into the categories described here, a suitable assessment procedure will be evolved in consultation with experts of that area and adjudicated by the committee constituted for that purpose. The decision given by the committee will be final. The appended assessment scheme shall be announced by the course coordinator during the commencement of course.

YEAR OF 12 MONTHS											
1	**2**	**3**	**4**	**5**	6	7	8	9	**10**	**11**	**12**
July/ Aug.	Aug./ Sept.	Sept./ Oct.	Oct./ Nov.	Nov./ Dec.	Dec./ Jan.	Jan./ Feb.	Feb./ Mar.	Mar./ Apr.	Apr./ May	May/ June	June/ July
ODD SEM/ FIRST SEM					EVEN SEM/ SECOND SEM					SUMMER SEM	

Module- I		**Module- II**			**Module- I**		**Module- II**			
U1	**U2**	**U1**	**U2**		**U1**	**U2**	**U1**	**U2**		
Formative Assessment				SA	Formative Assessment				SA	

Figure 4: Schedules of formative and summative assessments in line with Academic calendar. SA = Summative assessment.

5.3 L-based courses integrated with P/T

5.3.1 Formative Assessment

The scheme of formative assessment is designed to promote the continuous learning. Scheme consists of assessments planned at institute level and assessment that may be scheduled by

the course instructor (Figure 4). Institute level assessments shall be scheduled by the office of AAA. Respective Faculty Member(s) shall declare the schedule of Continuous Laboratory Assessments (CLA), Quiz, Tutorials, Assignments, Seminars, Discussions, etc. Some of the components may also however take place in an unscheduled manner like Surprise Tests. However, students shall be made aware of the assessment modalities that are going to be followed in a course by the faculty, under information to the HoD.

To monitor the progress of students, continuous assessment comprising of five targets (T1, T2, T3, T4 and T5) is advocated in each module for a maximum of 60 marks. For a class, formative assessment commences by the announcement of module bank containing 10 problems for each module in a course. Nature of problems in the module bank shall be at the level of creative / exploratory / design / thought provoking covering the complete syllabus of a module at advanced / challenging level.

The purpose of creating module bank of 10 problems is to assign one problem to each student or to a batches of 2 members. The batches are composed of randomly picked up candidates. These batches remain same for all courses and also for the P-sessions in the courses in that semester and are created in the beginning of that semester.

The purpose of assigning one problem to two batches is to create a healthy competitive spirit between the two batches.

The modality of evaluation of five targets is listed here under:

a) **T1**: During 5th or 6th week of each module a classroom test shall be conducted. T1 consists of two parts: A and B.

Part A consists of one random problem from the module bank and varies from batch to batch. All the questions in the module bank shall be distributed among students and students shall know the question to be answered only on the day of test in the examination hall.

Part B consists of one common problem at fairly application/ advanced level **(not at all prior notified)** from outside the module bank for all the students.

T1 shall be paper based and proctored test for a period of 60 min (maximum) which shall be assessed for 30 marks and downscaled to 10 marks.

For the students who for justifiable reasons could not attend the classroom test on the scheduled day, a re-test maybe conducted. However, Part-B will contain a new question and Part-B will have higher weightage than part-A or full weightage could even be allotted for Part-B in such an event

b) **T2**: Immediately follows T1. Students in a specified batch who now have received the same question during T1 will work further on that problem for T2.

T2 is primarily an extension of problem received in T1 for carrying out validation study: Case studies / Simulations / Experimentation. Each batch shall interact with the course instructor to finalize the nature of validation and expected to complete the exercise within 10 to 15 days after T1.

Course instructor should ensure assigning a different case study / a different scope for validation study for each batch in case the same problem is assigned to two batches.

Course instructor shall assess every student in a batch for a max. of 10 marks based on his observation, interaction and/or reviewing (based on at least two reviews).

c) **T3**: T3 shall be conducted during the last week of each module. Student batches are expected to submit a report, clearly documenting the work executed during T2. The report should be in IEEE / APA format and additionally a voice in-built PPT should be prepared and submitted.

The report and presentation shall be assessed by the course instructor for 10 marks for every student. In certain cases, a course instructor can call a batch for a physical presentation also.

d) **T4**: T4 is a comprehensive module test, conducted for 30 min. comprising of 20 multiple choice questions (MCQs) covering the holistic content of module. T4 shall be evaluated for a max. of 10 marks @ ½ mark for each question. T4 will be conducted in ON-LINE mode.

There shall be two tests in each course in a day and the best performance of the tests shall be considered for awarding the marks.

Two sets of question papers each containing 20 questions should be set. The theme of the questions could be similar across the sets. When the test is administered online, every student receives the questions in shuffled sequence and also the choices in shuffled sequence. Therefore, the choice like both 'a' & 'b' above, neither 'a' nor 'b', all the three a, b, c will not be set.

e) **T5:** T5 assessment is based on Practice or Tutorial assignments. Implementation, Report presentation and Discussion shall happen in a continuous mode throughout the module period.

At least 4 such continuous lab practice assessments (CLPA) / assignments per module shall be conducted by course instructor. The marks will be @ 5 marks per assignment totalling up to 20 per module.

f) The scores of the targets are to be normally announced within three working days on completion of the assessment and the performance is to be discussed in the class.

g) The total marks per module is 60 - T1 (out of 10), T2 (out of 10), T3 (out of 10), T4 (out of 10) and T5 (out of 20).

h) Total marks for both the modules from formative assessment will be added up to 120, which will be ***suitably mapped down*** to a max. of 60 marks. The mapping policy should be decided by the lead instructor / instructors in consultation with the HoD. The mapping policy should be shared with Dean AAA for the purpose of documentation.

i) The marks scored in Module-1 for a max. of 60 should be entered / submitted latest by 9th week and of Module-2 latest by 17th week of the semester. Consolidated score for a max. of 120 ***suitably mapped down*** to a max. of 60 marks should be submitted latest by 18th week of semester enabling the declaration of 'R'- grade before the commencement of summative assessment.

j) A candidate put under 'R'- grade will not be permitted to take up the summative assessment.

5.3.2 Summative Assessment

a) An instructor may choose one of the two formats for conducting summative assessment for L-based courses integrated with T/P.

i) 15 + 25 marks format or 20 + 20 marks format (following b, c, d below).
ii) 40 marks format (following c, d below).

b) **If summative assessment is in two parts format:**

i) Part-I will be the assessment of capstone project which is pre-assigned during the module-2 period or will be the exploratory review assessment of all lab practice assignments.

ii) Part-II will be based on a written examination for a max. marks of 80, as in c & d below, which is ***scaled down*** to 25 or 20 based on the selected pattern of format.

iii) A candidate should attend both the parts of summative assessments; else he will be put into 'I' grade.

c) For each L-based course integrated with T/P, the summative assessment shall be conducted by the Institute for a duration of 150 min. and for a maximum of 80 marks. Contents for summative assessment shall cover the breadth and depth of the complete syllabus that is mentioned in the two modules of a course.

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d) The question paper for end-semester theory examination consists of two parts as given in Table (2).

Table 2: L-based Summative Assessment Question Paper Pattern.

Part No.	No. of Questions	Marks for each Question	Marks	Choice
A	4	10	40	No
B	2	20	40	No
Total Marks			80	

e) The questions will be comprehensive covering the entire course syllabus and any single question should not necessarily be limited to any particular unit / module.

f) These marks are ***suitably mapped down*** to a score of 40.

g) Total marks of summative assessment will be for a max. of 40 irrespective of format of evaluation.

h) The award of 'I' grade is solely based on marks scored in summative assessment out of 40, if he/she does not score a min. 16 out of 40 (40%).

5.4 P-based Courses

The detailed information consisting of experiments, batch formations, experiment schedules, etc., will be displayed / informed to the student in the first week of the semester so that the student comes prepared for the lab sessions. Copies of the manual will be made available to the students along with the schedule. The manual will consist of the list of equipments, detailed procedure to conduct the experiment, format for record writing, outcomes for each experiment and possible set of short questions to help students gain critical understanding. The courses like Cyber security, Research Methodology & IPR will also be treated as P-based courses.

5.4.1 Formative Assessment

During practice sessions, a brief viva-voce is conducted for each student on the experiment he/she is carrying out on that day. Some of the parameters that could be included in the Continuous Practice Assessment (CPA) are given in Table (3). The set of parameters may slightly differ from one laboratory to the other, and will be announced before the commencement of the practice session. These parameters are assessed for each laboratory session.

Table 3: Suggested parameters for Continuous Practice Assessment (CPA).

S. No	Component	Marks
1	Report of about 1 page on proposed experimental layout and background theory before the start of lab session	4
2	Viva and interaction to evaluate understanding of concepts	4
3	Experimentation and data collection	4
4	Analysis of experimental data and interpretation	4
5	Finalized report submitted in the next week	4
Total		**20**

This assessment is carried out for each practical session and the total marks of all practical sessions will be ***suitably mapped down*** to a max. of 60.

5.4.2 Summative Assessment

End semester examination for each practical course is conducted jointly by two examiners. The examiners are appointed by Dean, AAA from the panel of examiners suggested by the respective Heads of the Department. In some cases, one of the examiner may be from outside the institution and will be identified as external examiner. The scheme of assessment may vary depending on the nature of laboratory, which shall be shared with student by the

laboratory in-charge. The summative assessment will be conducted for a max. marks of 40. The general scheme of assessment is given in Table (4).

Table 4: Suggested end-semester summative assessment pattern for P-based courses.

Component	Marks		
	Examiner 1	Examiner 2	Total
Objective & Procedure write up including outcomes	4	4	08
Experimentation and data collection	4	4	08
Computation of results	4	4	08
Analysis of results and Interpretation	4	4	08
Viva Voce	0	8	08
Total Marks	16	24	40

5.5 Assessment and Grading of MOOCs based elective

Whenever a candidate opts for a course through MOOCS offered via Swayam platform, he / she has to learn and undergo assessment as per norms set by VFSTR for such MOOCs Courses. Upon the declaration of the result, that the candidate has successfully completed the course, the candidate is said to have earned the credits under credit equivalence and credit transfer.

5.6 Inter Departmental Project

Inter departmental project work is undertaken in the 2nd semester for earning 2 credits by each candidate. It is expected that the inter- departmental Projects result in publication of a technical paper in a peer-reviewed journal. For this purpose, Dean R&D and Heads of Department will identify faculty mentors who will guide the students by conducting workshops on drafting of research article, communication, process of peer-review, publication, etc. The faculty will support the students by all means to get the technical findings published in peer-reviewed journals.

5.6.1 Formative Assessment

The assessment will be carried in two reviews in a systematic way. The detailed assessment guidelines and scheme are to be announced along with the assessment schedule as mentioned in the Table (5).

Table 5: Schedule and parameters followed for formative assessment.

No of Module	Schedule	No of reviews	Points to be considered	Formative assessment marks
Module -1	7th – 8th week	Review -1	• Identification of specific area out of broad areas under the supervisor • Identification of outcomes in line with programme objectives. • Feasibility of contributing to the attainment of outcomes • Identification of tools / equipment / surveys / training needs / etc..	30
Module – 2	15th–16th week	Review -2	• Presentation of results, analysis and conclusions • Meeting of objectives defined in first review • Preparation of report • Understanding by individual students on the overall project • Submission of technical article	30

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5.6.2 Summative Assessment

Summative assessment will be done jointly by two examiners. The examiners are appointed by Dean, AAA from the panel of examiners suggested by the respective Head of the Departments. In some cases, one of the examiner may be from outside the institution and will be identified as external examiner. The scheme of assessment will be report (15 marks), presentation (10 marks) and demonstration (15 marks) respectively. Points to be considered during the review.

a) Presentation of results, analysis and conclusions
b) Meeting of objectives defined in first review
c) Preparation of report
d) Understanding by individual students on the overall project
e) Individual student contribution
f) Progress of project as per schedule
g) Submission of technical article/ prototype realization

5.7 Project

Those students who do not opt for the internship, carry out their major project at VFSTR and submit their report which is a mandatory requirement for the award of degree. These projects are usually done individually during third and fourth semesters, under the guidance of a faculty member. Every candidate, in consultation with the guide, should define the project and also the probable procedure of carrying it out and submit the same to a committee consisting of 2 to 3 faculty members appointed by Head of the Department. This is to avoid the repetition and also to come up with a roadmap for completion of the project within the time stipulated. The students are encouraged to select topics related to ongoing research and consultancy projects. The students are expected to carry out and present a survey of literature on the topic, work out a project plan and its implementation through experimentation / modelling / simulation / computation. They are also expected to exhibit system analysis, design, and presentation and evaluation skills.

5.7.1 Formative Assessment

The progress of project is reviewed twice in a semester by the Project Review Committee (PRC) and formative assessment marks are awarded based on these reviews. The Project review committee consists of

a) Head of Department or his/her nominee – Chairperson
b) A senior faculty member identified by the HoD – member
c) Project supervisor – member

Review schedules of PRC are to be announced by the department immediately after the commencement of semester. The review presentations are open to all the students of that section and attendance is compulsory. The first review should be of 15 minutes / student; second review should be around 30 minutes / student. Before every review every student should submit their PPT along with a brief report of not exceeding two pages. It is to be expected by the committee that student communicates / publishes research article based on the project work prior to graduation either in a peer-reviewed journal or top-notch conference. Based on the recommendations of the committee, he / she is expected to continue same research problem in the third and fourth semesters to derive possible solutions. The following aspects may be considered by the committee for assessment Table (6).

Table 6: Schedule and suggested parameters to be considered for formative assessment.

Semester	Module	Schedule	Review	Points to be considered	Max. Marks
Semester III	Module -1	7th – 8th Week	First review	• Identification of specific area out of broad areas. • Identification of outcomes in line with programme objectives • Feasibility of contributing to the attainment of outcomes	20
	Module -2	15th – 16th Week	Second review	• Identification of tools / equipment / training needs / etc. • Understanding by individual students on the overall aspect of the project • Completion of literature survey • Design of project set up	40
Semester IV	Module -1	7th – 8th Week	First review	• Acquisition / learning of the tool required • Readiness of the layout of the project report • Progress review as per mechanism / schedule identified • Preparation of draft manuscript for publication	20
	Module -2	15th – 16th Week	Second review	• Presentation of results and conclusions • Meeting of objectives defined in first review • Submission of draft report • Understanding by individual students on the overall project • Progress of project as per schedule • Progress of the publication	40

5.7.2 Summative Assessment

At the end of III & IV semesters, summative assessment of the project will be conducted in two phases.

Phase–I: This is an evaluation for a max of 20 marks. A committee of two members comprising of HoD's nominee and Guide will assess the project work which will involve going through the project report (6 marks), project presentation (7 marks) and demonstration of the project (7 marks).

Phase–II: A final presentation and defense assessment for a max. of 20 marks will be carried out by one-man committee composed of an external expert who is chosen by the Dean AAA from a panel of examiners suggested by the HoD. The format for evaluation will involve going through the project report's quality (6 marks), presentation (6 marks) and interaction and defense (8 marks).

The qualifying marks will be finalized considering the marks scored in both the phases (I & II) of summative assessment.

Publication in a top-notch conference / peer-reviewed journal is mandatory for evaluating the project for 100% weightage.

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In case the candidate is placed in 'I' grade, he/she has to appear for both Phase-I and Phase-II assessments, which will be held within the 15 days after declaration of results. In the consecutive assessment also if the candidate fails to secure min. required score, then he / she will be placed in 'R' grade.

5.8 Internship

Internship work is undertaken by a student in an industry, under the joint supervision of industry personnel and an internal faculty member. Sixty percentage of the marks of Internship are allotted through continuous evaluation as formative assessment and the remaining 40% are based on summative assessment.

Table 7: Assessment scheme for Internship reviews.

Semester	Module	Schedule	Review	Formative assessment marks
Semester III	Module -1	7th – 8th Week	First review	20
	Module - 2	15th – 16th Week	Second review	40
Semester IV	Module - 1	7th – 8th Week	First review	20
	Module - 2	15th – 16th Week	Second review	40

a) The progress of internship work is reviewed twice in every semester by the "Internship Review- Committee (IRC)" and marks for formative assessment are awarded based on these reviews.

b) The IRC consists of Head of Department or his/her nominee (Chairperson), the internal and external (industry) supervisors.

c) The IRC may not be the same for all students; however, the same IRC should exist for entire duration of the internship program of any single student.

d) The schedule and the scheme of evaluation are to be announced with internship notification. The internship reviews may take place at the place of internship or at the university, as decided by the interning organization or may be conducted in the blended mode.

5.8.1 Formative assessment: Internal reviews at the place of internship

The internal supervisor will interact with the guide allotted at internship offering industry based on the schedule given to conduct the reviews. Scheduled reviews can be conducted by IRC on online mode for discussion/ presentation. The marks shall be distributed for each student in the scheduled reviews as given in Table (7).

a) Students should submit a report (not more than two pages) explaining about the progress of their work, mentioning clearly details like the machines or software handled / adopted, type of data collected and his/her understanding and contribution in the programme, and the same has to be presented before the supervisors.

b) The candidate should clearly present the completion of stipulated assignments set by the industry supervisor for that period.

c) The evaluation will be based on a & b above and also based on regularity and discipline maintained in the internship venue.

Table 8: Suggested scheme of assessment for every review

Component	First review	Second review
Regularity and interaction	5	10
Application of knowledge	3	6
Gaining of new knowledge /skills / literature survey	3	6
Internship progress	5	10
Report	4	8
Total marks	**20**	**40**

5.8.2 Summative assessment – Internship

At the end of III and IV semesters, the student shall submit a comprehensive report of internship covering the work done and make a final presentation in two phases as follows:

Phase–I: A committee of two members comprising of internal supervisor and HoD's nominee will assess the overall internship participation by the candidate and his final report through presentation made by the intern. The internship report (6 marks), presentation (7 marks) and overall impression (7 marks) during the internship will be evaluated respectively.

Phase–II: A final presentation and defense assessment for a max. of 20 marks will be carried out by one-man committee composed of an external expert who is chosen by the Dean AAA from a panel of examiners suggested by the HoD. The format for evaluation will involve going through the project report's quality (6 marks), presentation (6 marks) and interaction and defense (8 marks).

The qualifying marks will be finalized considering the marks scored in both the phases (I & II) of summative assessment.

Publication in a top-notch conference / peer-reviewed journal is mandatory for evaluating the Internship for 100% weightage.

In case the candidate is placed in 'I' grade, he / she has to appear for both Phase-I and Phase-II assessments, which will be held within the 15 days after declaration of results. In the consecutive assessment also if the candidate fails to secure min. required score, then he / she will be placed in 'R' grade.

6. SEMESTER-END ASSESSMENT ACTIVITIES

6.1 Setting of semester-end summative assessment question papers will be coordinated by the instructor assigned for a particular course. Two sets of question papers will be submitted latest by 12th week of the semester.

6.2 There shall be 'Summative Assessment Question Paper Scrutiny Committee' which would be constituted with external experts. Experts are empowered to modify / rephrase the questions to maintain a high standard of the semester-end assessment. The review should be completed by the 14th week of the semester. The review process will be coordinated by a committee of School Dean, HoDs and external experts.

6.3 The question wise marks scored in the summative assessment out of a total of 80 will be made available online within two weeks from the last date of examination and would be kept active for 24 hours. Latest by the end of 48 hours from the instant of notification any candidate can submit an appeal online providing question wise claim.

6.4 Claims for re-assessment on P-based courses are not allowed.

6.5 The appeals will be attended within next three working days. Fees for appeal, as decided from time to time, has to be remitted online along with the appeal.

6.6 Final results and grades will be computed as explained in the next section.

6.7 Final results and grades shall be announced within four weeks of completion of the last examination of the summative assessment (within two weeks from the last date of appeal). Grades are published on the University website, and also informed to the parents and students through SMS.

6.8 Provisional Grade cards will be issued within two weeks after the announcement of grades. Grade card will contain three parts. Part 1: Details of successfully completed courses. Part 2: Details of 'I' grade courses. Part 3: Details of 'R' grade courses.

7 COMPUTATION OF GRADING

7.1 Formative assessment decides the list of 'R'- candidates. Therefore, these candidates will not be considered for grading computation. Summative assessments decide the list of 'I' candidates. Therefore, these candidates will not be considered for grading computation.

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7.2 The candidates who have successfully completed both formative and summative assessments will be considered for computation of relative grading.

7.3 Threshold value (**Th**) for relative grading in each course is arrived after studying the marks distribution in that course by a committee constituted by office of Dean AAA. The threshold value is decided by the upper bound marks of the major chunk of the class keeping the top outlier scores away from consideration (the least upper bound). The threshold value will be slightly greater than upper bound marks or may be equal to the upper bound marks.

7.4 The total marks (**m**) = marks scored in the formative assessment + marks scored in the summative assessment is transformed into relative grade expressed accurate to two decimal places as follows:

Relative grade point (P) = (m/Th) X 10 [and limited to 10]

7.5 If students require course wise percentage equivalence, then the calculation will be based on the following

Course wise percentage equivalence = (m/Th) X100
[truncated to two-digit integer and limited to 100]

7.6 After relative grading, a student is assigned a 'Letter Grade (G)' for each course as per Table (9). The grade and the corresponding letter grade represent the outcomes and assessments of a student's performance in a course.

Table 9: Grading information

Relative Grading Range (P)	Category	Grade (G)
≥ 9.50	Outstanding	O
≥ 8.50 to 9.49	Excellent	S
≥ 7.00 to 8.49	Very good	A
≥ 6.00 to 6.99	Good	B
≥ 5.00 to 5.99	Fair	C
≥ 4.50 to 4.99	Marginal	M
Transitional Grade	Repeat	R
Transitional Grade	Incomplete	I

8. SUPPLEMENTARY EXAMINATIONS

8.1 The supplementary examinations shall be conducted once in summer semester. Notifications will be released by the AAA section informing the students about registration procedures, details of fee and timetables. Apart from these examinations the students who have courses with 'I'-grade can also write the supplementary examinations along with regular semester-end examinations of that academic (Odd / Even) semester.

8.2 Whenever a candidate clears courses with 'I' grade in a supplementary examination that are conducted during a regular semester, the Threshold value for computing his / her grade will be obtained from the same batch in which he / she had completed his / her formative assessment.

8.3 Whenever a candidate clears courses with 'R' / 'I' grade in a summer semester, the Threshold value for computing his / her grade will be carry forwarded from the preceding Odd / Even semester for the respective courses.

8.4 Whenever a candidate clears courses with a 'R' grade in a regular semester along with his/ her junior batch then for this candidate the Threshold value will be corresponding to his/her junior batch for computing grade.

8.5 The results of summative assessment of Project / Internship will be announced only if the candidate successfully earn all the credits in courses registered during the program. If the candidate is with 'R' / 'I' graded courses the results will be kept under **'Announced Later (L)'** status and will be announced only after candidate clears these courses.

9. GRADE POINT AVERAGE

The Academic Performance of a student in every semester is indicated by the Semester Grade Point Average (SGPA) and finally by Cumulative Grade Point Average (CGPA).

9.1 SGPA

The Semester Grade Point Average (SGPA) shall be computed using the formula given below:

$$SGPA = \frac{\sum_{i=1}^{n} C_i P_i}{\sum_{i=1}^{n} C_i}$$

Where

n = number of courses a student successfully completed in the semester under consideration

Pi = Grade points secured for the i^{th} course registered in the semester under consideration.

Ci = the number of credits assigned to i^{th} course registered in the semester under consideration.

9.2 CGPA

The Cumulative Grade Point Average (CGPA) shall be computed after successful completion of the programme. The CGPA shall be expressed in different flavors to reflect M.Tech. of 68 credits, and Add-on certification up to 12 credits.

Accordingly, the computations will be as below:

$$\text{CGPA} = \frac{\sum_{j=1}^{m} C_j P_j}{\sum_{j=1}^{m} C_j}$$

Where

m = total number of courses prescribed for the completion of the programme

Pj = grade points secured for the j^{th} course.

Cj = the number of credits assigned to j^{th} course

and Σ Cj = 68

Σ Cj = 08 for CGPA calculations in case of M.Tech. with Add-on certification

Σ Cj = 12 for CGPA calculations of specialization part in case of M.Tech. with Add-on certification

Percentage equivalence of SGPA & CGPA = (SGPA or CGPA) X10

10. AWARD OF CLASS

The students who have become eligible for award of degree shall be classified based on their CGPA secured, as per the Table (10) given below:

Table 10 : Class/ Division information.

Sl. No.	CGPA	Class / Division
1	8.0 and above	First Class with Distinction
2	6.5 and above but less than 8.0	First Class
3	6.0 and above but less than 6.5	Second Class
4	Less than 6.0	Pass Class

a) For the purpose of rewarding the accomplishers with ranks and awards, toppers in each branch discipline are identified, based on their academic performance (CGPA) in the following categories:

i) Ranking in M.Tech.

ii) Ranking in M.Tech. with Add-on certification

b) In addition, the 'Chairman's gold medal' and other 'Endowment Awards' are awarded to

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the 'outstanding students' based on the overall performance which includes academic, co-curricular and extra-curricular activities, campus placements and competitive examinations. A committee appointed by the Vice-Chancellor will recommend the eligible student for the award, selected from the nominations received from the departments.

c) In addition, the institution may recognize exceptional performance such as music, dance, sports etc. and display of exceptional bravery from time to time.

d) Only such candidates who complete 68 credits (+12 credits) in the first 4 successive semesters shall be eligible to receive awards/ ranks.

e) The candidates availing spill over semesters will not be eligible for the award of merit scholarships.

11. AWARD OF DEGREE

On successful completion of prescribed requirements of the programme, the degree shall be conferred during the convocation of the VFSTR.

For the conferment of degree, the student has to fulfill the following requirements:

a) a bonafide student and undergone the course work of not less than two academic years and not more than four academic years from the date of joining.

b) successfully completed all the courses as prescribed in the respective curriculum.

c) acquired a minimum eligible credits i.e. 68 credits for the award of M.Tech. degree.

d) obtained no due certificates as prescribed by VFSTR.

e) no in-disciplinary proceedings pending against him / her.

Consequent upon being convinced, following an enquiry, the Academic council may resolve to withdraw the degree / diploma / any other certification provided by the institute. The aggrieved may however prefer for a review of such decision by the Academic Council, citing cogent reasons for review or go in for an appeal to the, BoM of the institute.

12. Honorable exit with Engineering PG Diploma

In line with NEP-2020, an optional exit is provided for a candidate who has earned a min. of 40 credits and has completed all the requirements up to the end of two semesters.

Engineering PG Diploma will be awarded in respective branches of specialization. In case the candidate fails to earn 40 credits, a suitable certification will be awarded during his / her exit from M.Tech. degree.

Semester-wise transcript and a consolidated transcript will be given to the candidates during their exit from the registered program.

Such a candidate who has exited can seek re-entry to complete M.Tech. by surrendering the Engineering PG Diploma. A committee constituted by Vice-Chancellor will scrutiny all such re-entry requests and recommend the plan of action. However, the max. duration of programme should be limited to four years and further extension beyond the stipulated max. duration of study has to be approved by Academic Council, if the candidate appeals for an extension.

13. Onward Continuation to Ph.D. Program

As per the section 6.2 of R-22 Ph.D. regulations, candidates pursuing M.Tech. at VFSTR, who have completed all the courses prescribed for the first 2 semesters with a minimum of 60% or equivalent CGPA may be considered for onward continuation to Ph.D. program with a provisional admission to Ph.D.

For such candidates, a faculty mentor is allocated after the provisional admission. Mentor could become a Research Supervisor for the Ph.D program after confirmation of Ph.D admission at VFSTR, which is after formally completing M.Tech degree requirements.

Candidate in consultation with the faculty mentor shall identify the broad area of research topic and can utilize the M.Tech Project as a preliminary work before commencing the intensive research work during Ph.D programme. The M.Tech project work under the guidance of faculty mentor should satisfy all the mandates prescribed in the regulations of M.Tech. However, candidate is required to hold a Master's degree in Engineering / Technology with a minimum of 60% or equivalent CGPA before being formally admitted into the Ph.D program

14. Volunteer 'Drop' with Sabbatical Semester option

A candidate may exercise his option to voluntarily exit from M.Tech. programme temporarily for a semester during the M.Tech. programme, by registering for a 'DROP option' in the beginning of the semester after completion of first two semesters. The DROP can be exercised to take up special Internship / Innovation / Exploratory / Entrepreneurship / Advanced research / Start-up and such related activities. Under such circumstances a candidate can normally avail DROP over two successive semesters. Such 'Drop' semester will be identified as Sabbatical semesters.

Such a candidate has to pay the regular semester fee if such a Drop option is utilized during the first 4 semesters of M.Tech., and has to pay a nominal semester maintenance fee during the spillover period, if a candidate has not yet completed the credit requirements.

Upon returning from such a temporary exit, a candidate may continue his M.Tech. studies utilizing the provision of spillover period. A candidate may also submit a claim for Credit equivalence for the activities undertaken during the sabbatical period. The equivalence committee would evaluate and assess the academic equivalence of the work carried out and would recommend the credit equivalence and credit transfer to be granted together with the grades that could be attributed, if applicable. However, the max. duration of programme should be limited to four years and further extension beyond the stipulated max. duration of study has to be approved by Academic Council, if the candidate appeals for an extension.

14.1 Volunteer 'Drop' with Semester Drop option

A candidate may exercise his option to voluntarily exit from M.Tech. programme temporarily for a semester during the M.Tech. programme, by registering for a 'DROP option' in the beginning of the semester to meet the family / personal exigencies. All the norms as mentioned in the section (14) shall be applicable for the candidates utilizing semester drop option.

15. INTERPRETATION OF RULES

a. The academic rules and regulations should be read as a whole for the purpose of any interpretation.

b. For the matter(s) NOT covered herein above or for unforeseen circumstances, but arising during the course of the implementation of the above regulations. The Vice-Chancellor shall be authorized to remove the difficulties and decide upon the matters. The same shall be reported in the next meeting of Academic Council for ratification and subsequently informed to BoM.

c. The Institution may change or amend the academic rules and regulations or curriculum at any time, and the changes or amendments made shall be applicable to all the students with effect from the dates, notified by the Institution.

d. Procedure and explanation to any section can be floated by the office of Dean AAA as applicable from time to time with due approval by the chairman of Academic Council.

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R22 - M.Tech. - Course structure

I Year I Semester

Course Code	Course Title	L	T	P	C
	Professional Core - 1	2	2	2	4
	Professional Core – 2	2	2	2	4
	Professional Core – 3	2	2	2	4
	Department Elective – 1	2	-	2	3
	Department Elective – 2	2	-	2	3
	Cyber security	1	2	-	2
	Employment Orientation Program	-	2	2	2
Total		**11**	**10**	**12**	**22**
		33 Hrs			

I Year II Semester

Course Code	Course Title	L	T	P	C
	Professional Core – 4	2	2	2	4
	Professional Core – 5	2	2	2	4
	Department Elective – 3	2	-	2	3
	Department Elective – 4	2	-	2	3
	Research Methodology & IPR	1	2		2
	Inter Departmental project	-	1	3	2
	Teaching assistantship	-	-	4	2
Total					20
	Add-on certification course -1	3	-	2	4
Total		11	7	17	24
		35 Hrs			

II Year I Semester

Course Code	Course Title	L	T	P	C
	Project / Internship	-	2	24	13
	Add-on certification course -2 (MOOCs / Self-Study Course)	4	-	-	4
Grand Total		**4**	**2**	**24**	**17**

II Year II Semester

Course Code	Course Title	L	T	P	C
	Project / Internship	-	2	24	13
	Add-on certification course -3 (MOOCs/ Self-Study Course)	4	-	-	4
Grand Total		**4**	**2**	**24**	**17**

M.Tech.

(Electric Vehicle Technology)

2024 Regulation Course Structure

I Year - I Semester

S. No.	Course Title	L	T	P	C
1	Power Electronic Converters for EV	2	2	2	4
2	EV Motor Drives and Control	2	2	2	4
3	Hybrid And Electric Vehicles	2	2	2	4
4	Department Elective – 1	2	-	2	3
5	Department Elective – 2	2	-	2	3
6	Cyber security	1	2	-	2
7	Employment Orientation Program	-	2	2	2
	Grand Total	**11**	**10**	**12**	**22**
		33			**22**

I Year - II Semester

S. No.	Course Title	L	T	P	C
1	EV Charging Infrastructure and Analysis	2	2	2	4
2	Energy Storage and Management System	2	2	2	4
3	Department Elective – 3	2	-	2	3
4	Department Elective – 4	2	-	2	3
5	Research Methodology & IPR	1	2		2
6	Interdepartmental project	-	1	3	2
7	Teaching assistantship	-	-	4	2
	Total				20
8	Add-on certification course -1	3	-	2	4
	Grand Total	11	7	17	**24**
		35			**24**

II Year - I Semester

S. No.	Course Title	L	T	P	C
1	Project / Internship	-	2	24	13
2	Add-on certification course -2 (MOOCs / Self-Study Course)	4	-	-	4
	Grand Total	**4**	**2**	**24**	**17**

II Year - II Semester

S. No.	Course Title	L	T	P	C
1	Project / Internship	-	2	24	13
2	Add-on certification course -3 (MOOCs / Self-Study Course)	4	-	-	4
	Grand Total	**4**	**2**	**24**	**17**

Department Electives Courses

Sl. No.	Course Title-Department Electives	L	T	P	C
1	Machine Learning	2	-	2	3
2	Intelligent Transport Systems	2	-	2	3
3	Sensors for EV system	2	-	2	3
4	Electric Vehicle System Engineering and Policy	2	-	2	3
5	Vehicle Dynamics	2	-	2	3
6	Embedded System Design	2	-	2	3
7	Industrial Internet of Things	2	-	2	3
8	Advanced Control Systems for EV	2	-	2	3
9	Switching Power Supplies	2	-	2	3
10	Control Techniques for EV Converters	2	-	2	3
11	Energy Conversion Systems for EV	2	-	2	3
12	Automotive Safety	2	-	2	3
13	Smart Grid Interface of EV	2	-	2	3

1st SEMESTER

1. Power Electronic Converters for EV

Hours Per Week :

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE: Power Electronics

COURSE DESCRIPTION AND OBJECTIVES:

These courses provides the systematic approach for transient and steady state analysis of power electronic converters with passive and active loads and analyze the advanced converters such as multi-level inverters and compare different PWM techniques for their control.

MODULE-1

UNIT-I

AC/DC Rectifiers: Operation of Single-Phase Uncontrolled Rectifier, Single Phase Fully Controlled Rectifiers, Three Phase Uncontrolled Rectifier, Three Phase Fully Controlled Rectifier with RL and RLE load. Performance Parameters of controlled converters – Input Displacement Factor, Distortion Factor, Power Factor and Total Harmonic Distortion Power Factor Improvement Techniques, Multipulse Converters.

UNIT-II

Pulse Width Modulated Inverters: Concept of Switched Mode Inverters, Pulse-Width- Modulated Switching Scheme, Square-Wave Switching Scheme, PWM Of Single-Phase Inverters, PWM of Three Phase Inverter, Effect of Blanking Time on Voltage in PWM Inverters, Concept of Zero Vector in PWM, Space Vector PWM, Hysteresis Current Control, Rectifier Mode of Operation of PWM Inverter Matrix Converter – Principle, Operation and Modulation Schemes of Matrix Converter.

PRACTICES:

1. Performance analysis of Single-phase controlled AC-DC two-pulse converter (R, RL, RLE-Load).
2. Performance analysis of Three-phase controlled AC-DC six-pulse converter (R, RL, RLE-Load).
3. PWM control of DC-AC inverters.
4. Harmonic mitigations of VSI

MODULE-2

UNIT-III

SwitchedModePowerSupplyStep-Down(Buck)Converter,Step-up(Boost)Converter, Buck-BoostConverter,Cukdc-dcConverter,FullBridgedc-dcConverter,Isolated Converters-Forward Converter, Flyback Converter.

UNIT-IV

Modeling and Control of Power Electronic Converters Types of models – Switched model, average model, large signal and small signal model, Switched model of power electronic converter, Classical average model of converter, generalized average model, Control Principles of Power

Electronic Converters used in Electric Vehicles, Linear Control Approaches for Power Converters – A case study.

PRACTICES:

1. Duty ratio-controlled non isolated dc-dc converters (buck, boost, buck-boost)
2. Duty ratio-controlled isolated dc-dc converters (flyback, forward cuk)
3. Average model of switched mode convereters
4. Large signal model of switched mode convereters

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Differentiate** between operational behavior of IGBT and MOSFET and applications of devices.	Apply	1	1, 3
2	**Analyze** performance parameters of uncontrolled and controlled rectifiers.	Apply	2	1, 3
3	**Evaluate** different PWM schemes of Voltage Source Inverters.	Create	1	1, 3
4	**Design** different switched mode power supplies.	Create	1	1, 3
5	**Develop** a typical driver for power electronic switch.	Analyze	2	1, 3

TEXT BOOKS:

1. Mohan, Ned, and Tore M. Undeland. Power electronics: converters, applications, and design. John wiley& sons, 2007.
2. Rashid, Muhammad H., ed. Power electronics handbook. Butterworth-Heinemann, 2017.
3. Bose, Bimal K. Modern power electronics and AC drives. Vol. 123. Upper Saddle River, NJ: Prentice hall, 2002.

REFERENCEBOOKS:

1. Mohan, Ned. Power electronics: a First Course. Wiley, 2011.
2. Sen, Paresh Chandra. Thyristor DC drives. John Wiley & Sons, 1981.

2. EV Motor Drives and Control

Hours Per Week :

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE: Electric Machines

COURSE DESCRIPTION AND OBJECTIVES:

This course provides a comprehensive understanding of electrical drives, motor control, and power electronics as applied to electric vehicles (EVs). Students will learn about various motor types, control strategies, and power electronics converters in EV propulsion systems.

MODULE-1

UNIT-I

Introduction to Electric Vehicles: Electric Drive-train, Tractive effort in normal driving, Energy consumption concept of Electric Drive Trains and its Architecture-Electric Propulsion unit.

Transmission and Drive Train Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric Vehicles Propulsion and Braking -Longitudinal Dynamics Equation of Motion.

UNIT-I I

Conventional methods of D.C. motor speed control, single phase and three phase converter fed D.C motor drive. Four quadrant operations using dual converter fed DC motor drives.

Chopper fed drives, input filter design. Braking and speed reversal of DC motor drives using choppers, Multiphase choppers.

PRACTICES:

1. Develop a simulation model to analyze Electric Motor Regenerative Braking Characteristics for different Driving Cycles.
2. Design and speed control of AC to DC converter fed DC motor drive.
3. Design and speed control of DC to DC converter fed DC motor drive
4. Design and control of DC motor drive under four quadrants

MODULE-2

UNIT-III

Speed and Torque Control using Drives

AC Drives and its Operational Strategies: Variable frequency operation of three phase induction machine, Scalar control methods for constant power an constant torque modes, Vector control of induction machine, Methods of field sensing and estimation, Field orientation methods: Implementation of IRFO scheme using current controlled PWM, VSI and implementation of DSFO scheme using CSI.

UNIT-V

BLDC drives-various speed control strategies – closed loop control – Autonomous control. Control strategies of regenerative braking in drives. Speed control of AC drives.
Permanent magnet synchronous machine for EV power train, Non-Salient & Salient Drives, Generic

Model, Steady State Analysis, Field Oriented Control.
Switched Reluctance Machine for EV power train. Operating principles, Analysis of SRM drives and speed control. Multi-input EV drives concepts and their operation.

PRACTICES:

1. Simulation study and analyze the performance of speed control of PMDC and BLDC motor drives in EV.
2. Simulation study of lv/high current electric motor drives with bldc or pmsm drive.
3. Simulation study and analyze the performance of speed control of induction motor drives in ev.
4. Simulation study and analyze the performance of speed control of srm / pmsm drives in ev.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Interpret** the significance of speed-torque characteristics of electrical drives and methods to modify the characteristics.	Apply	1	1, 3
2	**Evaluate** the performance of AC/DC and DC/DC converter fed DC motor drive	Evaluate	1	1, 3
3	**Implement** VSI fed v/f controlled AC motor drive	Create	2	1, 3
4	**Analyze** the speed control of BLDC and PMSM drives	Analyze	2	1, 3

TEXT BOOKS:

1. Bima lK Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002
2. Vedam Subramanyam, “Electric Drives–Concepts and Applications”, Tata Mc Graw Hill, 1994.
3. Vedam Subramanyam, “Electric Drives–Concepts and Applications”, Tata Mc Graw Hill, 1994.
4. Murphy J.M. DandTurnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, Delhi, 2001.

REFERENCEBOOKS:

1. R. Raja Singh, Energy Conservation Strategies for Asynchronous Machine Drives, Lap Lambert Academic Publishing, Germany, 2021.
2. Gopal K Dubey, “Fundamentals of Electrical Drives”, CRC Press, Second Edition, 2015.

3. Hybrid and Electric Vehicles

Hours Per Week :

L	T	P	C
2	2	2	4

COURSE DESCRIPTION AND OBJECTIVES:

This course provides an in-depth introduction to the technology behind Hybrid and electric vehicles (EVs). Students will gain a solid foundation in the principles, components, and systems that make up EVs, as well as the environmental and societal implications of adopting electric transportation.

MODULE-1

UNIT-I

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies - Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

UNIT-II

Hybrid and Electric Drive-trains: Basic concept of traction, introduction to various drive-train topologies, power flow control in drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles.

PRACTICES:

- Developing real-life drive cycles for 2-wheelers, 3-wheelers, cars and buses
- Extracting features from the drive cycles for sizing motors and converters;
- Control of motors using the drive cycles.

MODULE-2

UNIT-I

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Analysis of various energy storage devices – Battery, Fuel Cell, Super, Flywheel - Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor and power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT-II

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, comparison and implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV).

PRACTICES:

- Study of accessories required for scooter hybrid conversion
- Lithium batteries and battery pack design for electric & hybrid vehicle application
- Power train sizing calculation procedure and practice problems

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyze the performance characteristic and model dynamics of hybrid and electric vehicles	Analyze	1	
2	Analyze the architecture of drive trains and electric propulsion units of electric and hybrid vehicles	Analyze	1	
3	Analyze various energy storage devices used in hybrid and electric vehicles and select the electric drive system	Analyze	2	
4	Explore energy management strategies used in hybrid and electric vehicles	Analyze	2	

TEXT BOOKS:

1. I. Husain, Electric and Hybrid Electric Vehicles, CRC Press, 2003
2. M. Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2005

REFERENCEBOOKS:

1. C. C. Chan and K. T. Chau, Modern Electric Vehicle Technology, Oxford Science Publication, 2001 Industrial Power and Automation, Department of Electrical Engineering, NIT Calicut - 673601 93
2. Gianfranco, Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market, Pistoia Consultant, Rome, Italy, 2010

2nd
SEMESTER

1. EV Charging Infrastructure and Analysis

Hours Per Week :

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE: Basic Electrical and Electronics Engineering; Electrical Machines; Power Electronics.

COURSE DESCRIPTION AND OBJECTIVES:

Course objective is to learn various charging techniques and charges are available to charge the battery of EVs and learn about BMS requirements, and the requirements for sensing and high-voltage control in detail.

MODULE–1

UNIT-1 **8L+0T+8P=16 Hours**

CHARGING METHODS:

Electric Vehicle Technology and Charging Equipment's - Basic charging Block Diagram of Charger - Difference between Slow charger and fast charger - Slow charger design rating - Fast charger design rating.

UNIT-2 **8L+0T+8P=16 Hours**

TYPES OF CHARGERS:

AC charging and DC charging - On board and off board charger specification - Type of Mode of charger Mode 2, Mode 3 and Mode 4 - EVSE associated charging time calculation - Selection and sizing of fast and slow charger (AC & DC) - AC Pile Charger, DC Pile Charger.

PRACTICES:

- Slow charger design rating.
- Fast charger design rating.
- EVSE associated charge times calculation.

MODULE–2

UNIT-1 **8L+0T+8P=16 Hours**

EVSE COMMUNICATION:

Power Module selection and technical specification - Selection of EVSE Communication Protocol (PLC / Ethernet / Modbus/ CAN Module) - Communication gateway - Specification of open charge point protocol (OCCP 1.6/2.0) - Bharat DC001 & AC001 Charger specification - Communication Interface between charger and CMS (Central Management System) - Payment apps.

UNIT-2 **8L+0T+8P=16 Hours**

CHARGING COMMUNICATION:

Selection of AC charger type-1, type-2 and type-3 - Communication between AC charger and EV - Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2 - Communication methodology of DC fast chargers.

PRACTICES:

- Preparation of EV Charger Single Line Diagram.
- Selection of relay and calculation.
- Preparation of EV Charger Electric.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Discuss about the different types of charging methods.	Apply	1	1, 2, 9, 11
2	Apply the concepts of battery management system and design the battery pack.	Apply	2	1, 5, 7, 9, 11
3	Describe about the types of chargers.	Analyze	1	1, 2, 3, 6, 9, 11
4	Model different EV service equipments.	Create	2	1, 2, 3, 7, 9, 11

TEXT BOOKS:

1. "Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators.
2. MehrdadEhsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2010.

REFERENCE BOOK:

1. Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.

2. ENERGY STORAGE AND MANAGEMENT SYSTEM

Hours Per Week :

L	T	P	C
2	2	2	4

PRE-REQUISITE KNOWLEDGE: Basic Electrical and Electronics Engineering; Electrical Machines; Power Electronics.

COURSE DESCRIPTION AND OBJECTIVES:

Course objective is to learn some of the principal advantages of lithium-ion cells versus standard electrochemical battery cells, what their primary components are, and how they work.

MODULE - 1

UNIT-I 8L+0T+8P=16 Hours

ENERGY STORAGE SYSTEM BATTERIES:

Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

UNIT-II 8L+0T+8P=16 Hours

BATTERY CHARACTERISTICS & PARAMETERS:

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

PRACTICES:

- Study and understand types and rating of Battery.
- Study of Charging and discharging characteristics.
- Comparative Study of Lead acid and Li-ion battery.

MODULE - 2

UNIT-I 8L+0T+8P=16 Hours

BATTERY MODELLING:

General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model, Simulation examples.

UNIT-II 8L+0T+8P=16 Hours

BATTERY PACK &BATTERY MANAGEMENT SYSTEM:

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal

management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

PRACTICES:

- Study of Cell balancing algorithm for Lithium-ion Battery.
- Study and understand Control parameters of battery.
- Compute battery-pack of given energy and power.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Apply the concepts of battery management system and design the battery pack.	Apply	2	1, 5, 7, 9, 11
2	Discuss about the different types of energy storage system.	Analyze	1	1, 2, 3, 4, 7, 9, 11
3	Describe about the battery characteristic & parameters	Analyze	1	1, 2, 3, 4, 5, 6, 9, 11
4	Model different types of batteries	Create	2	1, 5, 7, 9, 11

TEXT BOOKS:

1. G. Pistoia, J.P. Wiaux, S.P. Wolsky, “Used Battery Collection and Recycling”, Elsevier, 2001. (ISBN: 0-444-50562-8)”.
2. Guangjin Zhao, “Reuse and Recycling of Lithium-Ion Power Batteries”, John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9).

REFERENCES:

1. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, “Thermal Management of Electric Vehicle Battery Systems”, JohnWiley& Sons Ltd., 2016.
2. Arno Kwade, Jan Diekmann, “Recycling of Lithium-Ion Batteries: The LithoRec Way”, Springer, 2018. (ISBN: 978-3-319-70571-2).

DEPARTMENT ELECTIVES

1. MACHINE LEARNING TECHNIQUES FOR ELECTRICAL ENGINEERING

L	T	P	C
2	-	2	3

MODULE – 1
Supervised Learning

UNIT-01
Regression: Simple Linear Regression; Multiple Linear Regressions; Non - Linear Regression,
Classification: K-Nearest Neighbors, Decision Trees, Logistic Regression: Univariate Logistic Regression; Multivariate Logistic Regression, *Naive Bayes.*

UNIT-02:
Support Vector Machine (SVM): SVM - Maximal Margin Classifier; SVM - Soft Margin and Hard Margin Classifiers; Kernels.
Ensembles methods*:* Bagging & Boosting, AdaBoost; Gradient Boosting; Random Forests.

PRACTICES:
- Case study 1: Estimating Solar Wind Energy Production.
- Case study 2: Short-Term Load Forecasting.
- Case study 3: Fault Detection in Power System.
- Case study 4: Classification of Electrical Low Voltage Cable Degradation.
- Case Study 5: Speed Control of DC Shunt Motor

MODULE -2
Unsupervised Learning

UNIT-01:
Curse of Dimensionality: *Feature selection*, *Dimensionality Reduction* - Principal Component Analysis (PCA); Singular Value Decomposition (SVD); t-Distributed Stochastic Neighbor Embedding (t-SNE).

UNIT-02:
Clustering: Introduction to Clustering; Different clustering methods (Distance, Density, Hierarchical); K Means Clustering; constructing a hierarchical cluster.

PRACTICES:
- Case Study 1: Dimensionality reduction for monitoring electrical consumption of academic buildings.
- Case Study 2: Compression of the original power system transient stability assessment dataset.
- Case Study 3: Clustering of Electricity consumption behavior.
- Case Study 4: Fault diagnosis in power transformer using Clustering Analysis

TEXT BOOKS:

1. Machine Learning, Tom Mitchell, McGraw Hill, 1997, ISBN: 978-0070428072
2. Python for Machine Learning, Sebastian Raschka and VahidMirjalili, ISBN: 978-1783555130
3. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, AurélienGéron, ISBN: 978-1491962299

REFERENCE BOOKS:

1. Pattern Recognition and Machine Learning, Christopher M. Bishop, ISBN: 978-0387310732
2. The Hundred-Page Machine Learning Book, AndriyBurkov, ISBN: 978-1999579500

.

2. Intelligent Transport Systems

Hours Per Week :

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: AI techniques, Data Structures, Communication systems.

COURSE DESCRIPTION AND OBJECTIVES:

Course objective is to develop a digital map, Positioning module, direction module, wireless communication module and autonomous navigation system for electric vehicles.

MODULE–1

UNIT-1 8L+0T+8P=16 Hours

DIGITAL MAP DATABASE MODULE:

Introduction to Modern Vehicle Location and Navigation - Basic Representations - Reference Coordinate Systems - Standards - Proprietary Digital Map Databases - Digital Map Compilation.

Positioning Module - Introduction-Dead Reckoning-Global Positioning System - Sensor fusion - Conventional map matching - Fuzzy logic Based Map matching - Other Map matching algorithms - Map aided Sensor calibration.

UNIT-2 8L+0T+8P=16 Hours

DIRECTION MODULE:

Shortest Path - Heuristic Search - Bidirectional Search - Hierarchical search - other algorithms - Guidance while En Route - Guidance while off Route - Guidance with dynamic information.

PRACTICES:

Develop the digital map database module for 4 wheeler.
Develop the positioning module for 4 wheeler.
Develop direction module for 4 wheeler.

MODULE–2

UNIT-1 8L+0T+8P=16 Hours

WIRELESS COMMUNICATION MODULE:

Introduction - Communication Subsystem Attributes - Existing Communication Technologies - Communication Subsystem Integration.

UNIT-2 8L+0T+8P=16 Hours

AUTONOMOUS LOCATION AND NAVIGATION:

Introduction – Vehicle Location: Standalone Technologies - Radio Technologies - Satellite Technologies - Vehicle Navigation: Coping with complex requirements - Dual use navigation and entertainment components - Centralized location and Navigation Introduction - Automatic Vehicle Location: Centralized and Distributed Approach- Dynamic Navigation: Centralized and Distributed.

PRACTICES:

Develop autonomous location and navigation.
To develop a digital map module for a 4 wheeler.
Develop a proto type autonomous EV.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Identify digital map database module.	Apply	1	1, 2, 7, 9, 11
2	Make use of the positioning module.	Apply	1	1, 2, 6, 7, 9, 11
3	Examine the direction module.	Analyze	1	1, 5, 7, 9, 11
4	Categorize the wireless communication modules.	Analyze	2	1, 5, 7, 9, 11
5	Develop autonomous location and navigation.	Create	2	1, 2, 3, 4, 7, 9, 11

TEXT BOOKS:

1. "Intelligent Vehicle Technologies Theory and Applications"– L Vlacic, M Parent, F Harashima- Butterworth Heinemann, 2018.
2. "Vehicle location and Navigation Systems" – Yilin Zhao – Artech House Inc., 2017.

REFERENCE BOOKS:

1. Sussman Joseph, "Perspectives on Intelligent Transportation Systems (ITS)", New York, NY: Springer, 2010.
2. Mashrur A. Chowdhury, and Adel Sadek, "Fundamentals of Intelligent Transportation Systems Planning", Artech House, Inc., 2003.

3. Electric Vehicle Sensors Technology

Hours Per Week :

L	T	P	C
2	-	2	3

COURSE DESCRIPTION AND OBJECTIVES:

This course explores the role of sensors and communication technologies in electric vehicles (EVs). Students will gain an understanding of the sensors used in EVs, their applications, and how communication systems facilitate efficient and safe operation.

MODULE-1

UNIT-I

Basics of Sensors:

Difference between sensor, transmitter, and transducer - Primary measuring elements –selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission-Types of signal: Pneumatic signal; Hydraulic signal; Electronic Signal.

Principle of operation, construction details, characteristics and applications of the potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor.

UNIT-II

Types of Sensors:

Optical sensors, variable resistance type sensors, temperature sensors, Pressure sensors, variable capacitance sensors, Flow sensors, Hall Effect, hot wire, thermistor, piezoelectric, piezo resistive, based sensors. lambda sensor, detonation sensor,

Actuators:

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Injectors, stepper motors, relays, AB Sactuators, electro hydraulic actuators, Exhaust gas recirculation actuators

MODULE-2

UNIT-I

Automotive Safety Systems Sensors: Preventive design, designing for minimum injury in an accident, seat belts, seat belt pre-tensioner with load limiter, airbags, electronic vehicle stability (traction control system, Hill Hold) and occupant sprotection system, pedestrian protection, isocar seat fix, child-lock. Miscellaneous: SHVS system, lane departure warning, adaptive cruise control, automatic emergency braking system, 360ºdegree camera.

UNIT-II

Sensors and Communication:

LiDAR, RADAR, Camera-specifications and utilization, CANOBD, communication V2V, VI, V2X, Internet of Cars.

ADAS Applications:

Simultaneous localization and motion, path planning, ambience awareness, driver drowsiness and intent detection, machine learning algorithms for automotive applications.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Understand different technologies used with respect to Sensor.	Understand	1	1, 2, 7, 9, 11
2	Describe different sensors used in vehicles.	Apply	1	1, 2, 6, 7, 9, 11
3	Identify different actuators used in vehicles.	Analyze	1	1, 5, 7, 9, 11
4	Use diagnostic tools such as digital multi meter, oscilloscope in detecting the faults using ECM.	Analyze	2	1, 5, 7, 9, 11
5	Illustrate communication protocols and infotainment systems used in vehicles.	Create	2	1, 2, 3, 4, 7, 9, 11

TEXT BOOKS:

1. Jiri Marek, Hans Peter Trah, “Sensors Applications, Sensors for Automotive Technology “by Wiley,1st Edition.2003.
2. Ronald K Jurgen, “Navigation and Intelligent Transportation Systems – Progress in Technology”, Automotive Electronics Series, SAE, USA, 1998.
3. William B Ribbens, “Understanding Automotive Electronics”, 7th edition, Butter worth Heinemann Woburn-2012.

REFERENCEBOOKS:

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.

5. Vehicle Aerodynamics

Hours Per Week :

L	T	P	C
2	-	2	3

MODULE-1

UNIT-I

Basics of Vehicle Dynamics: History, vehicle classifications, fundamental approaches to vehicle dynamics modeling; 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: 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 Braking force analysis; braked sign and analysis; federal regulation on braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance

UNIT-III

Road Loads: Wind drag and car body design, rolling resistance; break downs of total road loads; gas mileage analysis and driving styles; Aerodynamics.
Tire and Tire Dynamics: Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models

PRACTICES:

1. Develop a simulation model to analyse the effect of Rolling Resistance on vehicle range and Performance
2. Develop a simulation model to analyze the effect of vehicle mass on vehicle range and Performance
3. Develop a simulation model to analyze the effect of Aerodynamic drag and Hill Climbing force on vehicle range and Performance

MODULE-2

UNIT-IV

Ride & Cornering / steering: 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 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.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Understand** the dynamics of vehicle ride under different riding condition.	Understand	1	1, 2, 7, 9, 11
2	**Present** a problem oriented in depth knowledge of Vehicle Dynamics.	Apply	1	1, 2, 6, 7, 9, 11
3	**Address** the underlying concepts and methods behind Vehicle Dynamics	Analyze	1	1, 2, 7, 9, 11
4	**Calculate** and refer the loads and forces associated to the vehicles.	apply	2	1, 2, 6, 7, 9, 11
5	**Analyze** the behavior of the vehicles under acceleration, ride and braking.	Analyze	2	1, 2, 7, 9, 11

TEXT BOOKS:

1. Vehicle Dynamics, Theory and Application, Reza N.Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e-ISBN 978-0-387-74244-1.
2. The Multi body systems Approach to Vehicle Dynamics, Mike Blundell and Damian Harty, Elsevier, 2004.

REFERENCEBOOKS:

1. Reimpell, Stoll and Betzler: The Automotive Chassis: Engineering Principles
2. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.

6. Embedded System Design

Hours Per Week :

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Basics of Analog and Digital Electronics

COURSE DESCRIPTION AND OBJECTIVES:

The course aims at having fundamental understanding of Microprocessor and Controller architectures. It also exposes the variety of peripherals and the way they must be interfaced with the processors/controllers. Communication standards used in automotive industry are also stressed upon in this course. Programming to accomplish the functionality with the usage of IDE, SDK/EDK s are also being explored. The course also targets to Testing procedures and processes which are integral part of design and development. These aspects of Microcontrollers and embedded Systems are studied with the prospect of EV.

MODULE-1

UNIT-I

Introduction: General Processor Architecture Microprocessors and Controllers (PIC, AVR and ARM), ARM Processor Fundamentals, ARM and THUMB

Instruction Set.

Memory-Mapped Peripherals: UART, D/A converter, Configuring GPIOS, Keyboard, LED, LCD Interfacing

UNIT-II

Efficient Programming Overview of C Compilers and Optimization : Basic C Data Types, C Looping, Structures , Register Allocation, Function Calls, Pointer Aliasing, Structure Arrangement, Bit-fields, Unaligned Data and Endianness, Division, Floating Point, Inline Functions and Inline Assembly, Portability Issues, Writing Assembly Code, Profiling and Cycle Counting, Instruction Scheduling, Register Allocation, Conditional Execution, Looping Constructs, Bit Manipulation, Efficient Switches, Handling Unaligned Data.

MODULE-2

UNIT-I

Embedded Communication Standards in Automotive Communication Systems: Characteristics and Constraints, In- Car Embedded Networks, Middleware Layer, Open Issues for Automotive Communication Systems, Flex Ray Communication, Flex Ray Protocol, Flex Ray Application; Data Consistency Issues, CAN centrate and Re CAN centrate: Star Topologies for CAN, CANEL y, FTT-CAN: Flexible Time-Triggered Communication on CAN, Flex CAN: A Deterministic, Flexible, and Dependable Architecture for Automotive Networks, Other Approaches to Dependability in CAN.

UNIT-II

Testing: Dynamic Testing, Current Practice, Structuring the Testing Process, Model versus Code-Based Testing, Test Activities and Testing Techniques, Testing in the Development Process, Test Planning

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Discover** the different Microprocessor/ Controller Architectures and can **choose** appropriate architecture for the given application	apply	1	1, 2, 7, 9, 11
2	**Design Program and Evaluate** the functionality at different levels.	design	1	1, 2, 7, 9
3	**Compare** and follow Embedded Communication Standards.	Analyze	2	1, 2, 7, 9, 11
4	**Discuss** and apply the test processes and planning	Analyze	2	1, 2, 7, 9

TEXT BOOKS:

1. Andrew N. Sloss “ARM System Developer’s Guide Designing and Optimizing System Software”, Elsevier Inc., ISBN :1-55860-874-5
2. William Hohl, “ARM Assembly Language Fundamentals and techniques”, Springer, ISBN 13: 978-1-4822-2986-8

REFERENCEBOOKS:

1. Richard Zurawski, “Automotive Embedded Systems Handbook”, CRC Press, ISBN 13: 978-0-8493-8026-6.
2. M. Kathiresh, R. Neelaveni, “Automotive Embedded Systems: Ke Technologies.

7. Internet of Things (IoT)

Hours Per Week :

L	T	P	C
2	-	2	3

COURSE DESCRIPTION AND OBJECTIVES:

ToprovideagoodunderstandingofInternetofThings(IoT)andit'senvisioneddeployment domains.

Toprovideanunderstandingofsmartsensors/actuatorswiththeirinternetconnectivityforexperimentation and designing systems.

To impart knowledge in the design and development of IoT systems with enable ement ensuring security and assimilated privacy

MODULE-1

UNIT-I

Internet of Things: Introduction, Wireless sensor networks need for IoT, Edge resource pooling and caching, client side control, and configuration, Basics of Networking, Smart objects as building blocks for IoT, Embedded systems platforms for IoT, IO drivers.

UNIT-II

Operating system for IoT: requirement of OS, examples: mbed, Contiki, RIOT
IoT Communication Protocols: IPV6, 6LowPAN, CoAP, MQTT, Machine-to-Machine Communications.

UNIT-III

Software Defined Networks (SDN): From Cloud to Fog and MIST networking for IoT Communications, Principles of Edge / P2P networking, Cloud and Fog Eco system for IoT Review of architecture, Security and privacy in Fog

MODULE-2

UNIT-IV

Data base for IoT:
OLAP and OLTP, NoSQL databases, Row and column Oriented databases, Introduction to Columnar DBMS C Store, Run: Length and Bit vector Encoding, Integrating Compression, and Query Execution in Columnar databases.

UNIT-V

Radar sensor Detectors for vehicle safety: Introduction to Radar sensor detectors, Types (Long range, medium, short range and ultra-short, mechanically Scanning LIDAR), Working, benefits.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Identify** the Components that forms part of IoT Architecture.	apply	1	1, 2, 7, 9, 11
2	**Evaluate** the appropriate protocol for communication between IoT.	Apply	1	1, 2, 6, 7, 9, 11
3	**Setup** the connections between Cloud to Fog and MIST networking.	Analyze	1	1, 2, 7, 9, 11
4	**Analyze** the database for IoT.	apply	2	1, 2, 6, 7, 9, 11
5	**Describe** the Radar sensor and detectors for vehicle safety.	Analyze	2	1, 2, 7, 9, 11

TEXT BOOKS:

1. A Bahaga, V. Madisetti,“Internet of Things-Hands on approach”, VPT publisher, 2014.
2. McEwen, H. Cassimally, “Designing the Internet of Things” ,Wiley, 2013.
3. Joe Biron & Jonathan Follett, Foundational Elements of an IoT Solution–The Edge, The Cloud and Application Development, Oreilly,1st Edition, 2016.

REFERENCEBOOKS:

1. The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, Lucas Darnell, 2016.
2. The Internet of Things – Opportunities and Challenges http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTfor Cap.pdf
3. Wireless Connectivity for the Internet of Things – One size does not fit allhttp://www.ti.com/lit/wp/swry010/swry010.pdf.

8. ADVANCED CONTROL SYSTEMS FOR EV

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Control Systems.

COURSE DESCRIPTION AND OBJECTIVES:
This course introduces the mathematical modelling, different methods of analysis and design of nonlinear systems. The objective of the course is to understand the concept of state variable analysis, controllability and observability, and applying them for stability analysis techniques.

MODULE–1

UNIT-1 **12L+0T+8P=20 Hours**

STATE SPACE ANALYSIS:
State space representation, Solution of state equation, State transition matrix, Canonical forms – Controllable, Observable and jordan canonical forms.
Tests for controllability and observability for continuous time systems.

UNIT-2 **12L+0T+8P=20 Hours**

MODAL CONTROL:
Effect of state feedback on controllability and observability, Design of state feedback control through pole placement, Full order observer and reduced order observer.

PRACTICES:
- Time response analysis of nonlinear system using MATLAB.
- State space modeling of DC generator.
- Design of state feedback controller and simulation for a motor using MATLAB.
- Design of state observer and simulation for a motor using MATLAB.

MODULE–2

UNIT- 1 **12L+0T+8P=20 Hours**

DESCRIBING FUNCTION ANALYSIS AND STABILITY ANALYSIS:
Describing Function Analysis: Introduction to nonlinear systems, Types of nonlinearities, Describing functions, Describing function analysis of nonlinear control systems.
Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems, Direct method of Lyapunov for the linear and nonlinear continuous time autonomous systems.

UNIT- 2 **12L+0T+8P=20 Hours**

PHASE-PLANE ANALYSIS:
Introduction to phase-plane analysis, Method of isoclines for constructing trajectories, Singular points, Phase-plane analysis of nonlinear control systems.

PRACTICES:
- Study of characteristics of non linearities.
- Describing function analysis of non linear system using MATLAB.
- Phase-plane analysis of non linear system using MATLAB.
- Lyapunov stability analysis of non linear system using MATLAB.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Model the given electrical/electro-mechanical systems in state space and find its solution.	Apply	1	1,2,6,9,11
2	Model nonlinear systems, and analyse stability using describing function method.	Apply	1,2	1,2,9,11
3	Analyse the stability of various nonlinear systems using the phase plane trajectory.	Apply	2	1,2,3,9,11
4	Identify the stability of the given linear and nonlinear system using Lyapunov stability theory.	Evaluate	2	1,2,9,11
5	Design pole placement controller and/or observer for the given system to achieve desired specifications.	Create	2	1,2,3,9,11

TEXTBOOKS:

1. M. Gopal, " Modern Control System Theory", New Age International Publishers, 5th edition, 2015.
2. Katsuhiko Ogata, " Modern Control Engineering " ,5th edition, Prentice Hall of India Private Ltd., New Delhi, 2010.

REFERENCEBOOKS:

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", 2nd edition, New Age International (P) Limited, 2010.
2. Benjamin C Kuo, "Automatic Control system", 1st edition, Prentice Hall of India Private Ltd., New Delhi, 2009.

9. Switching Power Supplies

Hours Per Week :

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Power Electronics.

COURSE DESCRIPTION AND OBJECTIVES:
This course introduces the analysis of various SMPS based converters and their modeling. The objective of course is to understand the concept of SMPS and choose proper SMPS based converters for building drivers.

MODULE-1

UNIT-I

Introduction to Non-isolated dc-dc converter: Buck Converter, Boost Converter, Buck-Boost Converter, Cuk Converter, SEPIC converters. Continuous conduction mode and discontinuous conduction mode analysis. Non-idealities in the SMPS. Isolated dc-dc converters: Flyback Converter, Forward Converter, Push-Pull Converter, Half bridge Converter and Fullbridge Converter topologies.

UNIT-II

Resonant Converters: Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load Resonant Converters, Resonant-Switch Converters, Zero-Voltage-Switching, Clamped-Voltage Topologies, Resonant-dc-Link Inverter switch Zero-Voltage Switchings, High-Frequency-Link Integral- Half-Cycle Converters.

UNIT-III

Reactive Elements in Power Electronic Systems: Introduction, Electromagnetic, Design of Inductor, Design of Transformer, Capacitors for Power Electronic Application, Types of Capacitors

PRACTICES:

- Study the difference between linear power supplies and switch mode power supplies.
- Study the performances of frequency with modulation and pulse with modulation.
- Derive the minimum inductance required for CCM mode of operation in flyback converter.
- Derive the minimum inductance required for CCM mode of operation in forward converter.

MODULE-2

UNIT-IV

Modeling and control of SMPS: Introduction, Duty cycle and current model control, canonical model of the converter, Averaged Model of the Converter, Generalized State Space Model of the Converter, Dynamic Model of Converters Operating in DCM.

UNIT-V

ControlofSwitchedModeConverters(SMPS):Introduction,ClosedLoopControl,ClosedLoopPerformanceFunctions,EffectofInputFilterontheConverterPerformance,DesignCriteriafor Selection of Input Filter.

PRACTICES:

- Study the digital hysteresis current controller.
- Study the voltage mode pulse width controller.
- Derive the transfer function of half bridge inverter using small signal analysis.
- Derive the transfer function of full bridge inverter using small signal analysis.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Analyze** an equivalent circuit model of Switched mode power supply for steady-state analysis.	**Analyze**	1	1, 3
2	**Design** of magnetic components (i.e., inductor and transformer) for converters used in power supply.	Create	1,2	1, 3
3	**Compare** the operation of resonance switching power converters with traditional converters.	Apply	2	1, 3
4	**Develop** feedback controller to regulate DC output of power supply and obtain it frequency response.	Evaluate	2	1, 3
5	**Analyze** the performance of SMPS with various input filters.	Create	2	1, 3

TEXT BOOKS:

1. L.Umanand,"Power Electronics Essentials and Applications", Wiley India Ltd., 2009.
2. V.Ramanarayanan, Switched Mode Power Conversion,2007.
3. Abraham Pressman, Switching Power supply Design, Mc Graw Hill

REFERENCEBOOKS:

1. Ned Mohan, Tore M.Undeland and William P.Robbins, "Power Electronics–Converters, Applications and Design", John Willey & sons ,Inc., 3rd ed., 2003.
2. Keith H Billings – Switch mode power supply handbook–1 stedition 1989 Mc-Grawhill Publishing Company.

10. OPTIMIZATION TECHNIQUES

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Basic arithmetic and Algebra, soft computing techniques.

COURSE DESCRIPTION AND OBJECTIVES:
Analyze the advantages and disadvantages associated with the large-scale optimization techniques when applied to problems from Electrical and Computer Engineering applications. Implement selected optimization algorithms commonly used in machine learning and other areas of Electrical and Computer Engineering. Design and implement appropriate optimization approaches for specific Electrical and Computer Engineering applications.

MODULE – 1

UNIT – 1 **12L+8T+0P=20 Hours**

Introduction to Optimization

- Introduction, Historical development.
- Statement of an Optimization Problem.
- Classification of Optimization Problems.
- Optimum design concepts: Definition of Global and Local optima – Optimality criteria Linear programming.
- Review of Linear programming methods for optimum design – Post optimality analysis.

UNIT – 2 **12L+8T+0P=20 Hours**

Non-Linear programming: Unconstrained Optimization

- Gradient-based methods:
  - o Cauchy's steepest descent method.
  - o Newton's method.
  - o Conjugate gradient method.
- Steepest descent method.
  Non-Linear programming: Constrained Optimization
- Direct methods.
- Indirect methods (Penalty function methods).

PRACTICES:

- The rectangle of the largest area that can be enclosed in a fence of the given length.
- The largest volume box with the given surface area.
- Solve Non-linear Programming problems of some kinds.
- Implement the Linear programming techniques using C or any other optimization software.

MODULE – 2

UNIT – 1 **12L+8T+0P=20 Hours**

Modern methods of Optimization-I

- Genetic Algorithms.
- Simulated Annealing.
- Neural-Network-based Optimization.
- Fuzzy optimization techniques.
- Tabu Search.

UNIT – 2 **12L+8T+0P=20 Hours**

Modern methods of Optimization-II

- Particle Swarm Optimization.
- Ant Colony Optimization.
- Meta-heuristics - Nature-inspired Optimization.

PRACTICES:

- Shortest route taken by a salesperson visiting various cities during one tour.
- Optimizing the usage of power in a residential building.
- Implement the different evolutionary algorithms techniques using C or any other optimization software.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Apply different types of Optimization Techniques in engineering problems and learn the linear programming methods for optimum design.	Apply	1	1, 2, 9, 11
2	Implement constrained Optimization methods.	Apply	1	1, 2, 3, 5, 9, 11
3	Apply Unconstrained Optimization methods.	Apply	1	1, 2, 3, 5
4	Implement modern optimization techniques such as Genetic Algorithms, Ant colony optimization, etc.	Apply	2	1, 2, 5, 9, 11
5	Demonstrate optimization techniques to solve real-time problems.	Analyse	2	1, 2, 3, 9, 11, 12

TEXT BOOKS:

1 Rao S. S. – 'Engineering Optimization, Theory and Practice' – New Age International Publishers – 2012 – 4th Edition.

2 Igor Griva, Stephen G. Nash, Ariela Sofer – 'Linear and Nonlinear Optimization' - Society for Industrial and Applied Mathematics, Philadelphia, March 2009.

REFERENCE BOOKS:

1 K Deb, "Multi Objective Optimization Using Evolutionary Algorithms", John Wiley and Sons, ISBN: 0-471-87339-X, July 2001.

2 Yang, Xin-She, "Optimization techniques and applications with examples", John Wiley & Sons, ISBN 10: 1119490626, 2018.

3 Ke-Lin Du, M. N. S. Swamy, "Search and Optimization by Metaheuristics: Techniques and Algorithms Inspired by Nature", Birkhäuser Basel, ISBN: 3319411926, 2016.

11. Energy Conversion Systems for EV

Hours Per Week :

L	T	P	C
2	-	2	3

MODULE-1

UNIT-I

Gas Turbines: Classification of gas turbine, simple open cycle gas turbine Ideal and actual cycle (Brayton Cycle) for gas turbine, optimum pressure ratio for maximum specific output in actual gas turbine regeneration, reheat and inter cooling and effect of these modification on efficiency and output, closed cycle gas turbine

UNIT-II

Propulsion Devices: Types of jet engines, Ram Jet, Pulsejet, Turbojet, Turbo propulsion, principle and operation, energy flow through jet and variation of pressure and temperature, thrust equation, specific thrust and velocity of fluid, thermodynamics of turbojet, efficiency & performance, parameters affecting performance, after burn, injection of water & alcohol mixture.
Rocket Propulsion: Classifications, Types of rocket engines, liquid propellant rockets, efficiency and performance.

UNIT-III

Renewable Energy Resources: Introduction to world energy scenario, renewable energy resources, solar energy, earth sun angles, resolution, solar measurement, collection of solar energy, flat plate and focusing collector analysis, calculations and same design parameters, applications of solar energy.
Solar Photovoltaic System: photovoltaic effect, efficiency of solar cells, semiconductor materials for solar cells, solar photovoltaic system.

MODULE-2

UNIT-IV

Bio Mass: gasifiers, gobar gas plant, types of applications, biomass conversion technologies, biogas generation.
Wind Energy: basic principles of wind energy conversion, wind energy estimation, site selection consideration, basic components of wind energy conversion system, classification, advantages & dis advantages of WECS.

UNIT-V

Additional Renewable Energy Resources: Tidal energy and OTEC-principle, resources and availabilities, energy conversion technologies. Fuels cell technology, principle of MHD power system, types of MHD system, advantages, and materials for MHD system. Geothermal energy, nature of geothermal fields, geo thermal sources, prime movers for geothermal energy.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Demonstrate** a basic understanding of jet and rocket engine design, function and performance.	Apply	1	1, 2, 7, 9, 11
2	**Describe** the technology of each of the sources of renewable energy.	Apply	1	1, 2, 6, 7, 9, 11
3	**Design** renewable energy systems that meet specific energy demands, economically feasible, and have a minimal impact on the environment	Analyze	1	1, 5, 7, 9, 11
4	**Compare** different non-conventional energy resources and choose the most appropriate based on local conditions	Analyze	2	1, 5, 7, 9, 11
5	**Explain** economic issues around renewable energy sources.	Create	2	1, 2, 3, 4, 7, 9, 11

TEXT BOOKS:

1. S.P. Sukhatme, Solar Energy-Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996.
2. Kothari D.P., Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd.
3. G.D.Rai, Non-Conventional Energy Sources, Khanna Publishers.

REFERENCEBOOKS:

1. S.M.Yahya, Turbine compressors and Fans, TMH.
2. J.K.Jain, Gas Turbine Theory & Jet Propulsion, Khanna Publishers.

12. Automotive Safety

Hours Per Week :

L	T	P	C
2	-	2	3

MODULE-1

UNIT-I

Introduction Design of the body for safety, energy equation, engine location, and deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.

UNIT-II

Safety Concepts Active safety: driving safety, conditional safety, perceptibility safety, operating safety passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact

UNIT-III

Safety Equipments Seat belt, regulations, automatic seat belt tightened system, collapsible steering column, tilt able steering wheel, air bags, electronic system for activatingair bags, bumper design for safety.

MODULE-2

UNIT-IV

Collision Warning And Avoidance Collision warning system, causes of rear endcollision, frontal object detection, rear vehicle object detection system, object detection system withbrakingsystem Interactions.

UNIT-V

Comfort And Convenience System Steering and mirror adjustment, central locking system , Garage door opening system, type pressure control system, rain sensor system, environment information system

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Comprehend** application of passive and active safety for vehicle	Apply	1	1, 2, 7, 9, 11
2	**Describe** importance of ergonomics in automotive safety and human response to impact	Apply	1	1, 2, 6, 7, 9, 11
3	**Design** vehicle safety system	Analyze	1	1, 5, 7, 9, 11
4	**Describe** various regulations of vehicle safety and safety testing methods.	Apply	2	1, 5, 7, 9, 11

TEXT BOOKS:

1. Bosch-“AutomotiveHandbook”-5thedition-SAEpublication-2000.
2. J.Powloski-“VehicleBodyEngineering”-Businessbookslimited,London-1969.

REFERENCEBOOKS:

1. Ronald.K.Jurgen-“AutomotiveElectronicsHandbook”-Secondedition-McGraw-HillInc., 1999.
2. J.Y.Wong, Theory of Ground Vehicles, Awiley Inter science Publications.

13. Smart Grid Interface of EV

Hours Per Week :

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Smart Grid

COURSE DESCRIPTION AND OBJECTIVES:

To study the possible methods of integration of Electric Vehicle in smart grid networks.

To study the effects of smart grid on the Electric Vehicle.

To give students an insight to the ever-evolving world of Smart Grid & Electric Vehicles.

MODULE-1

UNIT-I

Introduction to Smart Grid: Smart Grid Architecture, Standards for Smart Grid System, Elements and Technologies of Smart Grid System Distributed Generation Resources.

UNIT-II

Communication Protocols in Smart Grid : Open Charge Point Protocol (OCPP),ISO15118, Open ADR (Open Automated Demand Response), Modbus, IEC, 61850, IEEE2030.5, Smart Grid Communication Standards(e.g., Zigbee, Wi-Fi, Cellular).

V2G Technology: Working of V2G Technology**,** Charging Phase, Discharging Phase, Bidirectional Communication, Benefits of V2G Technology, Grid Stability, Peak Load Management, Renewable Energy Integration, Revenue Generation, Environmental Benefits.

MODULE-2

UNIT-I

Renewable Energy Integration:

Renewable Energy Forecasting, Dynamic Pricing and Incentives, Real-Time Grid Monitoring, Demand Response Coordination and Interface for coordinating EV charging with renewable energy generation in smart grid, optimizing charging times to coincide with periods of high renewable energy availability.

UNIT-II

Data Analytics and Optimization – Smart Charging Algorithms, algorithms to minimize energy costs for EV owners while maximizing the use of renewable energy and maintaining grid stability, algorithms to forecast EV charging demand, optimize charging schedules.

COURSE OUTCOMES:

Upon successful completion of the course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Elaborate** elements of Smart Grid along with terminologies associated with it.	Apply	1	1, 2, 3, 5, 9, 11
2	**Explain** the communication protocols used in Smart Grid.	Apply	2	1, 2, 3, 5, 9, 11
3	**Analyze** Impact of EV on smart grid in terms of grid stability.	**Analyze**	2	1, 2, 3, 5, 9, 11
4	**Evaluate** the role of renewable energy interface in demand response coordination in EV.	Create	1, 2	1, 2, 3, 5, 6, 9, 11
5	**Assess** the smart charging algorithms to forecast EV charging demand.	Apply	1	1, 2, 3, 5, 9, 11

TEXT BOOKS:

1. S.Borlase,"Smart Grids, Infrastructure, Technology and Solutions", CRC Press,1st Edition.
2. Lars T. Berger, Krzysztof Iniewski, "Smart Grid Applications, Communications and Security(WSE)",Wiley–IEEE Press, 2nd Edition.
3. Salman, S.K., 2017. Introduction to the Smart Grid: Concepts, Technologies and Evolution(Vol.94). IET

REFERENCEBOOKS:

1. Lu,J.andHossain,J.,2015.Vehicle-to-grid: linking electric vehicles to the smart grid. Institution of Engineering and Technology.
2. Rajakaruna, S., Shahnia, F. and Ghosh, A. eds., 2014. Plug In Electric Vehicles in Smart Grids: Integration Techniques. Springer.
3. Rajakaruna, S., Shahnia, F. and Ghosh, A.eds.,2014.Plug in electric vehicles in smartgrids: charging strategies. Springer.

14. SOFT COMPUTING TECHNIQUES IN ELECTRICAL ENGINEERING

L	T	P	C
2	-	2	3

PREREQUISITE KNOWLEDGE: Engineering Mathematics and any programming language.

COURSE DESCRIPTION AND OBJECTIVES:

- Soft computing refers to principle components like fuzzy logic, neural networks and genetic algorithm, which have their roots in Artificial Intelligence.
- Identifying and describing the soft computing techniques and their roles in building intelligent machines.
- Recognize the feasibility of applying a soft computing methodology for a electrical engineering problem.

MODULE-1

UNIT-1 **8L+8T+0P=16 Hours**

INTRODUCTION TO SOFT COMPUTING:

Concept of computing systems. “Soft” computing versus “Hard” computing. Characteristics of Soft computing. Some applications of Soft computing techniques.

UNIT-2 **8L+8T+0P=16 Hours**

ARTIFICIAL NEURAL NETWORKS:

Biological neurons and its working. Simulation of biological neurons to problem solving. Different ANNs architectures. Training techniques for ANNs. Applications of ANNs to solve some real life problems.

PRACTICES:

- Design of Neural network controller for DC motor.
- Design of Neural network controller for Power System Problem.

MODULE–2

UNIT-1 **8L+8T+0P=16 Hours**

FUZZY LOGIC:

Introduction to Fuzzy logic. Fuzzy sets and membership functions. Operations on Fuzzy sets. Fuzzy relations, rules, propositions, implications and inferences. Defuzzification techniques. Fuzzy logic controller design. Some applications of Fuzzy logic.

UNIT-2 **8L+8T+0P=16 Hours**

GENETIC ALGORITHMS:

Concept of “Genetics” and “Evolution” and its application to probabilistic search techniques. Basic GA framework and different GA architectures. GA operators: Encoding, Crossover, Selection, Mutation, etc. Solving single-objective optimization problems using GAs.

PRACTICES:

- Design of Fuzzy Logic controller for DC motor.
- Design of Fuzzy Logic controller for Magnetic suspension system.
- Optimizing PID controller parameters using GA.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Solve problems of electrical engineering using back propagation algorithm.	Apply	1	1, 2, 3, 5, 9, 11
2	Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems.	Apply	2	1, 2, 3, 5, 9, 11
3	Apply genetic algorithms to combinatorial optimization problems.	Apply	2	1, 2, 3, 5, 9, 11
4	Choose existing software tools to solve real problems using a soft computing approach.	Create	1, 2	1, 2, 3, 5, 6, 9, 11

TEXT BOOKS:

1. Neural Networks, Fuzzy Logis and Genetic Algorithms : Synthesis, and Applications, S. Rajasekaran, and G. A. Vijayalakshmi Pai, Prentice Hall of India, 2007.
2. Soft Computing, D. K. Pratihar, Narosa, 2008.

REFERENCE BOOKS:

1. Fuzzy Logic: A Pratical approach, F. Martin, Mc neill, and Ellen Thro, AP Professional, 2000.
2. Fuzzy Logic with Engineering Applications (3rdEdn.), Timothy J. Ross, Willey, 2010.
3. Foundations of Neural Networks, Fuzzy Systems, and Knowldge Engineering, Nikola K. Kasabov, MIT Press, 1998.
4. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press, 2000.
5. Genetic Algorithms In Search, Optimization And Machine Learning, David E. Goldberg, Pearson Education, 2002.