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.

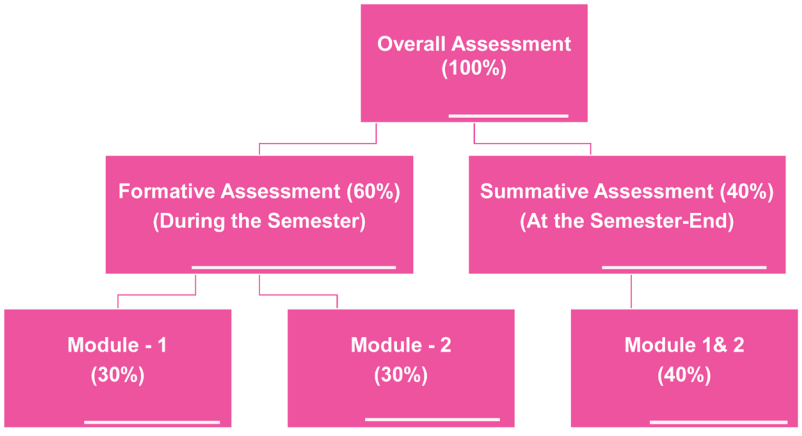

Figure 3: Categories of assessments in place for R22.

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**

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

COURSE STRUCTURE AND SYLLABUS

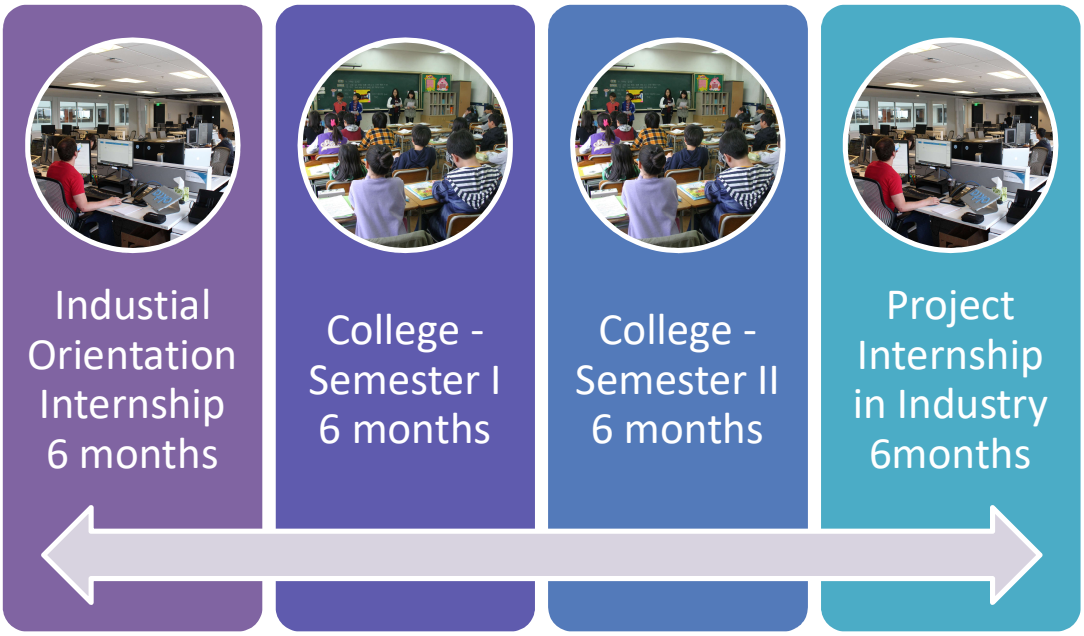
M.Tech IoT

(Applicable for batches admitted from 2023-2024)

Vignan's Foundation for Science, Technology & Research
(Deemed to be University),
Vadlamudi
Guntur-522213
Andhra Pradesh

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

COURSE STRUCTURE



(L – Lecture, T – Tutorial/Target, P – Practice)

I Year – Semester I

S. No.	Category	Subject	L	T	P	Credits
01	22EIB101	Industrial Orientation Internship	-	-	26	13
		Total Credits	**-**	**-**	**26**	**13**

I Year – Semester II

S. No.	Category	Subject	L	T	P	Credits
01	22EIB102	Internet of Things (IoT)	2	2	2	4
02	22EIB103	Advanced Microcontrollers – I	2	2	2	4
03	22EIB104	Measuring Principles and Sensors	2	2	2	4
04	22EIB105	Algorithms Design with Data structures	2	2	2	4
05	22EIB106	Data communications and networks	2	2	2	4
06	22EIB107	Cybersecurity in IoT	1	2	-	2
07	22EIB108	Business Systems	1	2	-	2
		Total Credits	12	14	10	**24**
			36			

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

II Year – Semester I

S. No.	Category	Subject	L	T	P	Credits
01	22EIB201	Advanced Microcontrollers – II	2	2	2	4
02	22EIB202	Data Analytics	2	2	2	4
03	22EIB203	IoT Edge (Embedded System) Design – Aggregator	2	2	2	4
04	22EIB204	IoT Edge (Embedded System) Design – Edge Processor / Gateway	2	2	2	4
05	22EIB205	IoT Edge (Embedded System) Design – Control System	2	2	2	4
07	22EIB206	Research Methodology and Development Life Cycle	1	2	-	2
08	22EIB207	EOP	2		2	2
		Total Credits	14	12	12	**24**
			38			

II Year – Semester II

S. No.	Category	Subject	L	T	P	Credits
01	22EIB208	Project Internship in Industry	-	-	26	13
		Total Credits	**-**	**-**	**26**	**13**

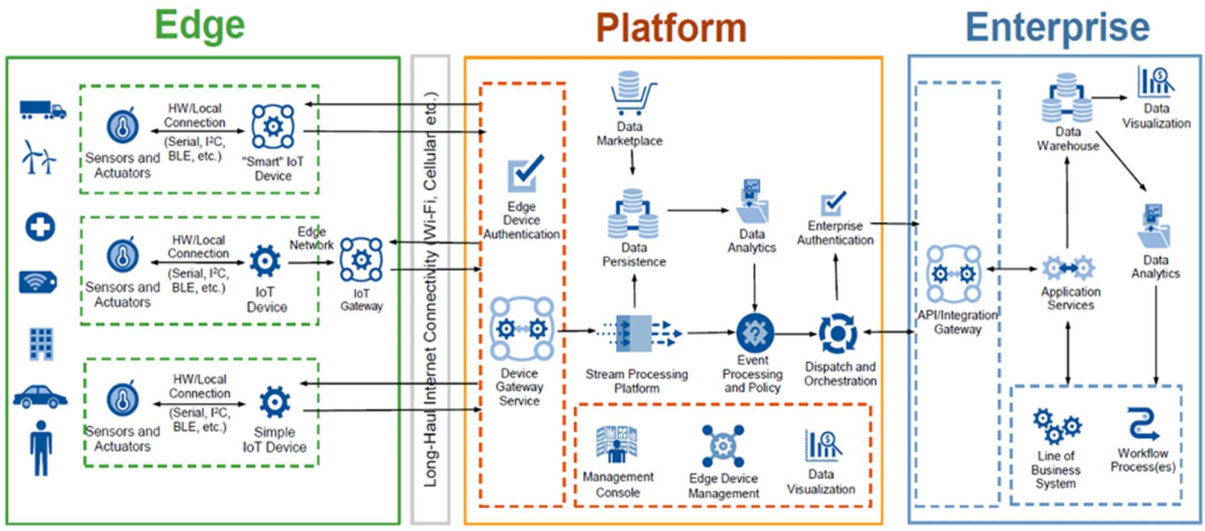


Fig 1: Typical IoT Architecture (Source: Gartner)

I Year – Semester II	Internet of Things (IoT)	L	T	P	Credits
		2	2	2	4

OBJECTIVE:
To make students understand IoT architecture and build IoT devices using sensing, communication, processing, and actuation**.**

COURSE OBJECTIVES (COs):
The student will be able to:

- Understand internet of Things and its hardware and software components
- Interface I/O devices, sensors & communication modules
- Remotely monitor data and control devices
- Develop real life IoT based projects.

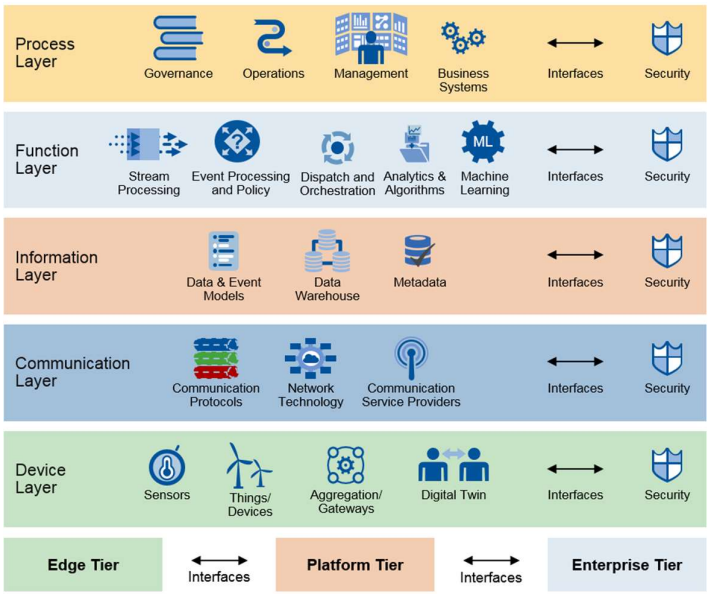


Fig 2: IoT Reference Model (Source: Gartner)

Module I

Unit – I

IoT Overview: Introduction to Internet of Things (IoT) - ***Sense, Communicate, Analyze and ACT***, IoT Reference architecture – Layers, Tiers, Interfaces, Examples.

Technology and business drivers, Trends, and implications

Unit – II

Sense & Processing

Fundamentals of Data Acquisition and digitalization, Analog and digital data acquisition, Sampling, Time averaging, Static and dynamic characteristics, placement of sensors, Calibration, and types of calibrations, Edge Processing – Data cleaning, Data normalization, Time stamping, storage handing and forwarding.

Control

Control systems – General actuators for on/off and 0-100% adjustable, Fail-Safe Actuators, feedback from actuators, command, and event processing.

Module II

Unit – I

IoT communication technologies and protocols: Data communication basics, short range and long range communication, communication devices, network topologies, communication at Edge, communication to platform, Internet and Web layering, Introduction to wired and wireless communication technologies for IoT, Physical and MAC layers, IP Versions, Edge connectivity and IoT protocols - MQTT, MQTT-SN, Constrained Application Protocol (CoAP), STOMP, AMQP, Comparison of protocols, Routing over low power and lossy networks, Wireless sensor networks.

Unit - II

Analyze: Structured vs Unstructured data and data in motion vs data in rest, Spectrum of Analytics, Databases for IoT – Relational Database, Timeseries Database (NOSQL), Data and Event models, Streaming Data processing, Batch Processing, Event Processing, Role of APIs, and TCP sockets for integration. Introduction to machine learning and the role of ML in decisions. Governance of IoT systems

Use cases: IoT application in Home – Appliance control, IoT application in Industry – Motor health monitoring, IoT application in Smart City – Air Quality Monitoring

TEXTBOOKS:

- Internet of Things Reference Architecture – Whitepaper – CISCO
- IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security– Perry Lea, Packt Publishing Limited.
- IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017
- Architect IoT using the Gartner Internet of Things Reference Model – Gartner Research

REFERENCE BOOKS

- Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015

- The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley
- "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier
- The Internet of Things, revised and updated edition (The MIT Press Essential Knowledge series)
- Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

I Year – Semester II	Advanced Microcontrollers – I	L	T	P	Credits
		2	2	2	4

OBJECTIVE:
To make student to acquire the knowledge on advanced microcontrollers such as ARM Cortex-M and work with its peripherals.

COURSE OBJECTIVES (COs):
The student will be able to:

- Understand and visualize embedded system
- Familiarize with IDE and tool chain and Familiarize with technical documents of microcontroller.
- Understand GPIO functionality and use port pins as input or output depending on the need with specific pin mode of operation
- Define GPIO interrupts and use them in programs
- Understand how to use timers for different purposes
- Generate PWM as required
- Understand and use RTC for time keeping and Time stamping
- Utilize WDT for program error handling

Module I

Unit – I

Introduction to embedded system and ARM architecture: Introduction to embedded system, block diagram view of embedded system, essential characteristics of embedded system.

The ARM architecture- features of ARM, Versions of ARM, Specific features of ARM cortex, Three stage pipeline, Registers - general purpose and special purpose, memory features, bit band region, Little Endian, Big Endian Architecture, the thumb-2 technology, Difference between ARM and Thumb instructions, Stack memory, Interrupts/Exceptions, Interrupt masking.

Instructions: Moving data, memory accesses, arithmetic operations, logic operations, shift and rotate operations, conversion (extend and reverse ordering) operations, bit field processing instructions, program flow control (branch, conditional branch, conditional execution, and function calls), multiply accumulate instructions, divide instructions, memory barrier instructions, exception-related instructions, sleep mode - related instructions etc.

Developing software on microcontroller: Introduction to Keil MDK ARM, Functional aspects of Keil IDE and toolchain- Downloading and installing Keil MDK ARM- Features testing of Keil MDK ARM- Creating a project with appropriate configurations- Downloading onto target board.

Unit – II
Understanding technical literature: Systematically follow datasheet, User Manual, Errata Sheet and Application notes - Block level diagram of LPC1769 ARM Cortex M3 controller

Memory Map, System Control, Clocking and Power Control, Flash Acceleration: Memory map

and peripheral addressing, Bus faults - System control - external interrupt flag, mode, and polarity registers, reset circuit, Reset source identification, System control and status, Brown-out detection.
- Clock generation for the LPC1769, Clock sources - internal RC, Main oscillator, RTC oscillator, Clock source selection, PLL settings, Clock dividers, Power control, Modes - sleep / deep sleep / power down / deep power down, Peripheral power control, Wakeup timer, external clock out - Flash Accelerator functionality.

Interrupts - Nested Vector Interrupt Controller (NVIC): Interrupt sources, Interrupt registers - Set enable, clear enable, set pending, clear pending, active bit, priority, Software triggered interrupt.

Pin Configuration, Pin connect block: Assign pins for specific functionality by locating and mapping them accordingly with required modes of operation.

General Purpose Input/Output (GPIO): Overview of ARM cortex-M GPIO module, Digital I/O ports, Interrupt generating digital ports, GPIO port direction, set & clear, read pin value, mask port pins.
- Coding: Developing the GPIO driver - Basic configuration using registers, Pin interrupts / pattern match engine, using Set& clear vs PIN with mask.

Module II

Unit – I
General Purpose Timer: Using as 32-bit timer with a programmable 32-bit prescaler, understand block diagram - Timer/Counter operation - Capture event, interrupt generation on match, stop or reset timer on match, external outputs set to low/high/toggle when match- Coding: Developing the program to configure timers for variety of purposes.

Repetitive Interrupt Timer: RI timer operation - Using RIT for generating interrupts at specified time intervals, without using standard timer - Coding: Configure RIT for continuous interrupt generation every 1msec.

Sys Tick Timer: Sys Tick Timer operation, configuring as needed, Coding: Program Sys Tick Timer running from CPU clock which is 100MHz, Program Sys Tick Timer running from the internal RC oscillator factory trimmed to 4MHz.

Unit - II

PWM, Motor Control PWM: PWM operation, configuring for single edge or double edge
- Coding: Program to generate PWM signals - single edge, double edged - Motor Control PWM operation.

Real Time Clock (RTC): RTC operation, Forward and Backward calibration, using 1PPS to calibrate RTC counters - Coding: Program to initialize and capture RTC values, Calibrate with external 1PPS signal or through set time.

Watch Dog Timer (WDT): Operation of Watchdog timer, Clock source selection, running under deep sleep mode to wakeup- Coding: Program to utilize watch dog to bring controller from erroneous state.

TEXTBOOKS:

- Embedded Systems Fundamentals with ARM cortex-M based microcontrollers: A practical approach, Alexander G. Dean
- A Beginner's guide to designing embedded system applications on ARM cortex-M microcontrollers, Ariel Lutenberg, Pablo Gomez, Eric Pernia
- LPC1769 Datasheet
- LPC1769 Reference Manual (User)
- LPC1769 Errata Sheet

REFERENCE BOOKS:

- Embedded System Design with ARM cortex-M microcontrollers – Applications with C, C++ and Micropython, Cem Ünsalan , Hüseyin Deniz Gürhan , Mehmet Erkin Yücel
- Embedded System Design with ARM by Prof. Indranil Sengupta, Prof. Kamalika Dutta, IIT Kharagpur (NPTEL)

I Year – Semester II	Measuring Principles and Sensors	L	T	P	Credits
		2	2	2	4

OBJECTIVE:

To make student to acquire the knowledge on types of sensors/transducers, working principles, selection procedure, applications of sensing systems

COURSE OBJECTIVES (COs):

The student will be able to:

- Understand measuring parameters, measuring systems, effects of environment, characteristics, and parameters to be considered for designing an instrument.
- Understand different types of sensors/transducers, working principles, selection procedure, applications of sensing systems.
- Understand Challenges and applications of sensors and sensor networks.
- Select a sensor/sensing system for a requirement.
- Test, install and collect the data from a group of sensors.
- Derive sensor-based solution for different applications.

Module I

UNIT – I

Introduction to Measurement: Measurement units, applications, elements, choosing appropriate measuring instruments. Instrument Types and Performance Characteristics: Review of instrument types, Static characteristics, dynamic characteristics

Error during measurement process: Sources of systematic error, reduction and quantification of systematic errors, random errors, aggregation of measurement system errors. Calibration: Calibration of measuring instruments, Primary calibration, secondary calibration, and field calibration. Calibration methods for different parameters (temperature, pressure, humidity,

flow...etc.). Automatic Calibration mechanisms.

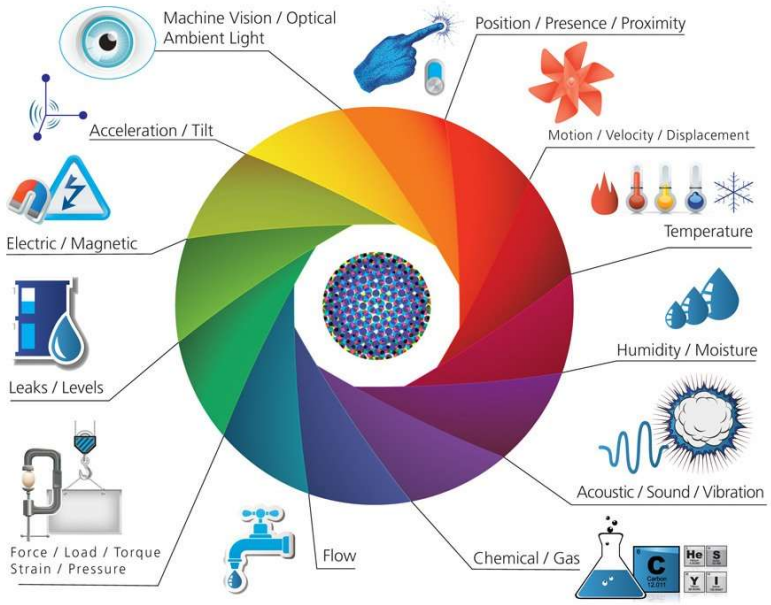


Fig 3: Sensor Categories

UNIT – II

Temperature, Humidity / Moisture Sensors: Thermo-resistive, Resistance Temperature Detectors, Silicon Resistive, Thermistors, Semiconductor, Optical, Acoustic, Piezoelectric Humidity and Moisture Sensors: Capacitive, Electrical Conductivity, Thermal Conductivity, Optical Hygrometer, Time Domain Reflectometer. Ex: PT100, PT1000 interfacing, SHT75 Sensor. Case Studies: Indoor and Outdoor environment monitoring

Occupancy and Motion Detectors: Ultrasonic, Microwave Motion, Capacitive Occupancy, Visible and Near-Infrared Light, Far-Infrared Motion, PIR Motion, Position, Displacement, and Level Sensors: Potentiometric, Gravitational, Capacitive, Inductive and Magnetic, Optical, Ultrasonic, Radar. Case Studies: Building Controls

Module II

UNIT – I

Velocity and Acceleration Sensors: Capacitive Accelerometers, Piezoresistive Accelerometers, Piezoelectric Accelerometers, Thermal Accelerometers, Heated-Plate Accelerometer, Heated-Gas Accelerometer, Gyroscopes, Piezoelectric Cables.

Pressure and Force Sensors: Mercury Pressure, Bellows, Membranes, and Thin Plates, Piezoresistive, Capacitive, Optoelectronic, Vacuum, Strain Gauges, Tactile, Piezoelectric Force Case studies in manufacturing industries, robotics, vibration sensing.

UNIT – II

Level and Flow Sensors: Pressure Gradient Technique, Thermal Transport, Ultrasonic, Electromagnetic, and Micro flow, Coriolis Mass Flow, Case Studies: Process Industry, Water Distribution Networks.

Sound, Acoustic and Light Sensors: Resistive Microphones, Fiber-Optic, Piezoelectric, Solid-State microphone, Light & Radiation Sensors: Photodiodes, Phototransistor, Photo resistors, diode dosimeters, digital dosimeters. Case Studies: Machine Monitoring, Ambient Controls, Environment monitoring.

Chemical Sensors: Metal-Oxide Chemical, ChemFET, Electro-chemical, Potentiometric, Conduct metric, Amperometric, Optical Chemical, Mass Detector. Ex: Gas Sensing. Case studies: Processing industries, oil and gas industries, water SCADA, pharmaceutical industries.

Machine Vision: Image sensor – physics of image formation, image analysis, binary image processing and filtering. Semiconductor charge-coupled devices (CCDs), active pixel CMOS sensors. Case studies: Object detection, Access control, Quality control in production.

TEXTBOOKS:

- Measurement and Instrumentation Principles - Morris, Alan S
- An Introduction to Error Analysis by John R. Taylor
- Sensor Technology Handbook, John S. Wilson
- Mechanical Measurements – Beckwith, Marangoni, Lienhard
- G.C.M. Meijer, Smart Sensor Systems, John Wiley and Sons

REFERENCE BOOKS

- Mechanical Measurements – Beckwith, Marangoni, Lienhard
- Measurement of Systems - Application and design - Earnest O. Doeblin
- Electronic Instrumentation and Measurement Technique - Albert D Helfrick
- E.O. Doebelin, D.N. Manik, Measurement systems, Tata McGraw Hill
- J.P.Bentley, Principles of Measurement systems, Pearson Education Ltd
- Alan S. Morris, R. Langari, Measurement and Instrumentation; Theory and Application, Academic Press

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

I Year – Semester II	Algorithms Design with Data structures	L	T	P	Credits
		2	2	2	4

Objective

Acquire knowledge on: Searching, sorting and various computational algorithms

Outcomes

1. Building Algorithms
2. Perform multithreaded computations

Prerequisites

Basics computer, number systems, C programming language

Module I

Unit-I

Role of Algorithms in Computing: Algorithms, Algorithms as a technology

Deriving Functions: Defining relationship between variables , formulating relationships

Digital Building Blocks: Combinational and Sequential Logics, Synthesis

Elementary Data Structures: Unions, structures, Stacks, queues, linked lists, pointers and objects.

Unit-II

Searching Techniques: Linear Search, Binary Search & applications

Sorting: Bubble Sort, Selection Sort, Insertion Sort, Quick Sort, Merge Sort, Heap sort, Sorting in Linear time

Module II

Unit-I

Dynamic Programming: Rod cutting, matrix-chain multiplication, elements of dynamic programming, longest common subsequence, optimal binary search trees

Greedy Algorithms: An activit-selection problem, Elements of the greedy strategy, Matroids and greedy methods

Unit-II

Elementary Graph Algorithms: Representations of graphs, Breadth-first search, Depth-first search, Topological sort

Minimum spanning trees: Growing a minimum spanning tree, The algorithms of Kruskal and Prim

Single-Source Shortest Paths: The Bellman-Ford algorithm, Single-source shortest paths in directed acyclic graphs, Dijkstra's algorithm"

Multithreaded algorithms: Basics, matrix multiplication, merge sort

Approximation Algorithms: The vertex-cover problem, The traveling-salesman problem, The set-covering problem, Randomization and linear programming

I Year – Semester II	Data communications and networks	L	T	P	Credits
		2	2	2	4

OBJECTIVE

To make student to acquire knowledge about transferring data using various Wired/Wireless communication technologies.

COURSE OBJECTIVES (COs):

- Able to design communication architecture.
- Able to work with various communication technologies (Wired/Wireless)
- Able to work with various protocols
- Configure and test communication technologies

Pre-Requisites

Basic knowledge on Digital numbering system; Micro Controller Peripheral Programming, Communication interfaces and protocols

Module I

Unit-I

Introduction to Communication and Networking: Communications, Signal Types and its characteristics (Analog/Digital), Data Transmission Types (Serial/Parallel), Communication Techniques (Asynchronous, Synchronous), Data Transmission Modes (Simplex, Half/Full Duplex), Network Topologies (Star, Ring, Mesh, Point to Point, Tree, Bus, Daisy chain, Multi drop) and its applications, Bandwidth utilization: multiplexing and spreading.

OSI Layers: Communication Layers and its applications, Communication media (Twisted Pair, Coaxial, Fiber Optics), Introduction to Errors (Error types, Detection, Correction) and Flow Control and its applications.

Unit-II

Wired Communication Protocols and standards: Ethernet (Types, Socket, MAC, IP, ARP, ICMP, TCP, UDP, DHCP), CAN, Modbus (RTU, ASCII), UART (RS485, RS232), OFC and Advantages, Disadvantages

and its applications, Introduction to Dial up Modems, Leased line modems.

Module II

Unit-I

Wireless Communication Protocols and Standards: Zigbee, Bluetooth, Wi-Fi, GPRS, GSM, NFC, IR, LoRa, NB-IoT, Satellite Communication. Advantages, Disadvantages and its applications.
IoT Protocols: MQTT, COAP, STOMP, AMQP

Unit-II

Network Types: Introduction to LAN, WAN, PAN, Internet and Intranet, sensor networks (wired/wireless) and its applications, Introduction to NAT, PAT, DNS, Network Routing algorithms, Introduction to Switch, Hub, Bridges and its working, Network Security and Introduction to Firewall and its applications.

TEXTBOOKS:

- Introduction to data communication and networking by Behrouz Forouzan
- Basics of data communications by William Stallings
- Designing and Deploying 802.11n Wireless Networks by Jim Geier

REFERENCE BOOKS:

- Introduction to data communication and networking by Wayne Tomasi
- Basics of computer networking by Thomas Robertazzi
- Wireless Networking Absolute Beginner's Guide by Michael Miller

I Year – Semester II	Cybersecurity in IoT	L	T	P	Credits
		2	2	2	4

OBJECTIVE

The purpose of this course is to provide students with an in-depth understanding of the challenges, issues, and solutions associated with implementing security for IoT systems. The knowledge gained will enable students to conceptualize, design, and implement secure IoT systems in various industry domains.

COURSE OBJECTIVES (COs):

- Understand Advanced IoT and Cybersecurity Concepts
- Identify and Analyze Threats and Vulnerabilities
- Implement Advanced IoT Security Technologies
- Comprehend IoT Security Standards, Frameworks, and Regulations
- Stay Abreast of Future Trends and Challenges

Module I

Unit-I

Introduction to IoT and Cybersecurity: Overview of cybersecurity, Role of Cybersecurity in IoT, IoT Architecture and security components, Basic security concepts and principles.

Understanding IoT Threats and Vulnerabilities: Threat landscape in IoT, Vulnerabilities in IoT devices, Network and Cloud security issues, Data privacy and security issues, Case studies of IoT attacks.

Unit-II

IoT Security Technologies and Tools: Basics of cryptography in IoT, Identity and Access Management (IAM) for IoT, Firewalls and IoT security tools, secure booting and firmware security, secure communication protocols in IoT, AI and ML for security.

Module II

Unit-I

IoT Security Standards and Frameworks: IoT Security Standards (ISO/IEC, NIST, etc.), IoT Security Frameworks, Security Compliance and Certification in IoT, Data Protection Regulations (GDPR, CCPA) and IoT, Ethical implications of IoT security.

Unit-II

Future Trends and Challenges in IoT security: Blockchain Technology and IoT Security, Quantum Computing and IoT Security, Advanced Penetration Testing for IoT, Privacy Enhancing Technologies (PETs) in IoT, Future Challenges and Opportunities in IoT Security.

TEXTBOOKS:

- "Introduction to Cybersecurity for Internet of Things" by Raj Samani, Gary Davis
- "The Dark Side of IoT" by Aniket Pingley, Vinod P, Pallapa Venkataram
- "IoT Security: Techniques for Protecting Connected Devices and Networks" by James J. (Jong Hyuk) Park, Shuai Han, Gangman Yi
- "IoT Security: Issues, Approaches, and Challenges" by Susmit Bagchi
- "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations" by Fei Hu

REFERENCE BOOKS:

- "The Internet of Things: Foundations and Applications" by Qusay H. Mahmoud
- "The Future of IoT: Leveraging the Shift to a Data Centric World" by Don DeLoach, W. David Stephenson, Emil Berthelsen
- "Practical Internet of Things Security" by Brian Russell, Drew Van Duren
- "Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry" by Maciej Kranz
- "Building Secure and Reliable Systems: Best Practices for Designing, Implementing and Maintaining Systems" by Heather Adkins, Betsy Beyer, Paul Blankinship, Piotr Lewandowski, Ana Oprea, Adam Stubblefield

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

I Year – Semester II	Business Systems	L	T	P	Credits
		2	2	2	4

OBJECTIVE

To provide students with a comprehensive understanding of the concept of business value and how it pertains to various stakeholders. It will guide students in recognizing, creating, and delivering value in a business context, with an emphasis on using analytics and data-driven decisions to identify and enhance value. The course will also explore the enterprise value equation, attribute analysis for product features, and techniques for evaluating business models, especially when considering entering new businesses.

COURSE OBJECTIVES (COs):

- **Understand Business Systems, Value and Product Development:** Gain a comprehensive understanding of business systems, the concept of business value, and the stages of the product development life cycle.
- **Identify and Create Business Value:** Learn techniques for identifying and creating business value within product development, and methods for delivering, scaling, and refining that value.
- **Apply Analytics for Value Identification and Decision-making:** Learn techniques for identifying and creating business value within product development, and methods for delivering, scaling, and refining that value.
- **Evaluate Business Models and New Business Opportunities:** Understand and apply the enterprise value equation and attribute analysis for product features. Develop skills to evaluate business models and opportunities for launching new products.

Module I

Unit-I

Understanding Business Value, Stakeholders, and Product Development: Introduction to Business Systems, Understanding Business Value and Stakeholders, Basics of Product Development Lifecycle, Role of Stakeholders in Product Development, Creating and Measuring Stakeholder Value in Product Development

Unit-II

Identifying, Creating, and Delivering Value in Product Development: Techniques to Identify Value in Product Development – Design thinking, Value Creation in the Product Development Process, Delivering Value through Effective Product Launch and Marketing, Scaling and Refining Value in Product Iterations, Case Studies on Value Creation in Product Development

Module II

Unit-I

Role of Analytics in Product Development and Business Value Identification: Introduction to Business Analytics in Product Development, Analytics in Business Value Identification and Product Metrics, Making Data-Driven Decisions in Product Development, Analytical Tools for Evaluating Product Performance and Value, Big Data and Predictive Analytics in Product Development.

Unit-II

Enterprise Value Equation, Attribute Analysis, and Business Model Evaluation in Product Development: Understanding the Enterprise Value Equation in Product Development, Attribute Analysis for Product Features, Business Model Evaluation Techniques for Product-centric Businesses, Evaluating Opportunities for Developing and Launching New Products, Case Studies on Enterprise Value and Business Model Evaluation in Product Development.

TEXTBOOKS:

- "Value Proposition Design: How to Create Products and Services Customers Want" by Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith
- "Product Design and Development" by Karl Ulrich, Steven Eppinger
- "Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days" by Jake Knapp, John Zeratsky, Braden Kowitz
- "The Lean Product Playbook: How to Innovate with Minimum Viable Products and Rapid Customer Feedback" by Dan Olsen
- "Design and Development of New Products (A McGraw-Hill series in marketing)" by Gerald M. Katz

REFERENCE BOOKS:

- "The Principles of Product Development Flow: Second Generation Lean Product Development" by Donald G. Reinertsen
- "The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail" by Clayton M. Christensen
- "Big Data at Work: Dispelling the Myths, Uncovering the Opportunities" by Thomas H. Davenport
- Gartner Enterprise Value Equation – Reference
- "The PDMA Handbook of New Product Development" by Kenneth B. Kahn

II Year – Semester I	Advanced Microcontrollers – II	L	T	P	Credits
		2	2	2	4

OBJECTIVE:

To make student to acquire the knowledge on advanced microcontrollers such as ARM Cortex-M and work with its peripherals.

COURSE OBJECTIVES (COs):

The student will be able to:

- Use ADC for sensor interfacing for AC/DC applications and use DAC for analog signal generation
-- Familiarize with different DMA transfer modes and use DMA in embedded applications
- Understand basics of communications and
- Use UART for serial communication with DTE or other communication devices
- Use I2C for communication with sensors and other peripherals
- Use SPI for communication with memories and other peripherals

- Understand GPRS technology, Module initialization and driver implementation for high speed communication
- Understand GPS/IRNSS operations, NMEA protocols and their implementation
- Understand ZigBee communication, modes of operation and their implementation
- Understand bluetooth communication, module operation and implementation

Module I

Unit – I

ADC: Successive Approximation ADC functioning, ADC block functioning in LPC1769, Hardware triggered conversion, Software triggered conversion, Interrupts, Accuracy, Error and Drift, Time averaging, RMS value- Coding: Program to use ADC via software triggered using timer interrupt and read value through ADC interrupt, Program to use ADC via hardware trigger, continuous and single step conversion.

DAC: DAC functioning - Resistor string architecture, Output buffering, Speed vs Power, Maximum update rate - Coding: Program to generate triangular wave or PWM using look up tables.

Unit – II

General Purpose DMA controller: Revisiting the multi AHB bus matrix and ARM cortex M Bus interfaces - MCU master and slave communication over bus matrix- DMA internals - channel mapping / streams / FIFO / Master ports / Arbiter etc.- DMA transfer modes: memory - to- memory, memory-to-peripheral, and peripheral-to-memory - DMA with peripherals like ADCm GPIO, UART_RX/TX- Triggering DMA by a timer match condition- DMA Channel Priority and DMA programming interface.

Internal Flash Memory: In-Application Programming, In-System Programming, Read/Write into internal flash memory, using flash accelerator- Coding: Program to erase, write into specific area of internal flash RAM by taking controller into IAP mode

Module II

Unit – I

Fundamentals of Communication: - Communication basics, synchronous and asynchronous, half duplex, full duplex, clock rate, baud rate, characteristics of serial communications, interfaces and protocols, data integrity checks (Checksum, CRC)

UART: UART in LPC1769, Receive and Transmit FIFO, Baud rate generation using fractional rate divider, Auto-baud capability, Software flow control and hardware flow control, using DMA.
- Coding: Program to transmit and receive data packets (defined protocol structure) in specified baud rate through specified UART port.

I2C: I2C operation, Master, Slave, Master/Slave mode, Clock adjustment, Fast mode plus operation, Slave address distinction, configuring as master receiver mode or transmitter mode, Slave receiver mode or slave transmitter mode, Arbitration and synchronization logic, data transfers, Status decoding- Coding: Program to interface temperature sensor and read value, multi-drop i2c connection.

SPI: SPI operation, SPI master or slave mode, SPI data transfers, Exception conditions

- Coding: Program to read and write data into Serial EEPROM / Flash.

Unit – II

GPRS: GPRS technology, 2G/3G/4G/LTE Cat1/Cat4, LTE module operation, Initialization, Using in-built protocols, High speed data communication and SMS
- Coding: Program for initializing GPRS module for use in specific protocol (TCP/UDP) web socket and achieve high speed bi-directional data transfer.

GPS: GPS/IRNSS functionality, NMEA protocol structure, $GP commands and interpretation of fields, 1PPS signal, Cold Start, Warm Start, Hot Start, Position Fix - Coding: Program to interface with GPS module and decode NMEA protocol commands.

ZigBee: ZigBee standard, Modes of operation - Coordinator, Router, End Device, CSMA/CA, Transparent Mode vs Application Mode, Addressing, Commands and their responses, Network formulation and Routing algorithms, XCTU tool usage - Coding: Program to configure device in coordinator, router, or end-device mode, implement for API mode of transfer.

Bluetooth: Understand Bluetooth standard, Bluetooth versions, BLE, BLE mesh, Gatt, Advertising, Pairing, data transfer- Coding: Program to implement BLE driver for ESP32 or NRF5x module and communicate with Bluetooth master

TEXTBOOKS:

- Embedded Systems Fundamentals with ARM cortex-M based microcontrollers: A practical approach, Alexander G. Dean
- A Beginner's guide to designing embedded system applications on ARM cortex-M microcontrollers, Ariel Lutenberg, Pablo Gomez, Eric Pernia
- "Wireless Communication Networks and Systems" by Cory Beard, William Stallings
- LPC1769 Datasheet
- LPC1769 Reference Manual (User)
- LPC1769 Errata Sheet

REFERENCE BOOKS:

- Embedded System Design with ARM cortex-M microcontrollers – Applications with C, C++ and Micropython, Cem Ünsalan , Hüseyin Deniz Gürhan , Mehmet Erkin Yücel
- "Next Generation Wireless LANs: Throughput, Robustness, and Reliability in 802.11n" by Eldad Perahia, Robert Stace
- Embedded System Design with ARM by Prof. Indranil Sengupta, Prof. Kamalika Dutta, IIT Kharagpur (NPTEL)

II Year – Semester I	Data Analytics	L	T	P	Credits
		2	2	2	4

OBJECTIVE:

To make students to extract insights from large volumes of data in various forms, by employing statistical mathematics techniques for drawing conclusions about that information.

COURSE OUTCOMES (COs):

The student will be able to

- Understand the essentials of data analytics and the corresponding terminologies.
- Determine the relevance of data to business.
- Be familiar with the steps involved in the analytics process.
- Understand and use statistical and graphical analysis to bring insights out from the data.
- Understand and use BI tools to present data in the form of Dashboards and reports.

Module I

UNIT – I

Essentials of Data analysis: Data Collection, Data Cleansing, Data Exploration, Statistical Analysis, Reporting, Decision.

Statistical Methods: Arithmetic mean, The Arithmetic mean of grouped Data, The Median, The mode; The variance and standard deviation, Interpretation of SD, Chebyshev's Lemma or Rule (for sample), Skewness and Kurtosis, Skewness and its measurement, Kurtosis and its measurements.

Probability Distribution & Statistical Inference: Elements of Probability, Random Variable, Probability distribution/density functions (Normal, Binomial, Poisson), Point Estimate, Interval Estimate, Testing of hypothesis

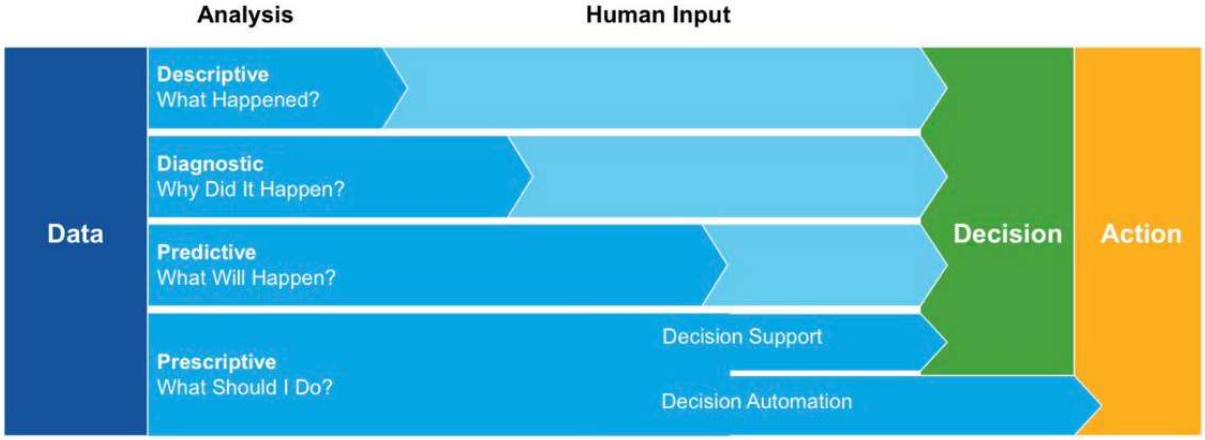


Fig 4: Spectrum of Analytics

UNIT – II

Visualization: Comparison, Distribution, Relationship, Composition, Visual Charts – Bar chart, Column chart, variable width column chart, Line chart, Column histogram, Line histogram, Scatter chart, stacked column chart, stacked 100% column chart, waterfall chart, pie chart, stacked area chart, 3D area chart, stacked 100% area chart, Bubble chart, Geometric Forms, Pictorial Diagrams, Pareto Diagrams.

Applications: Graphical representation of data from Battery health monitoring, Indoor Air Quality, CO2 emissions by country/region (Practice using MS-Excel & R/Python).

Time series Analysis: Characteristics Movements in a time series; Time series models; Measurement

of Trend; Secular Trend; Seasonal Movements; Cyclical Movements; Irregular Movements; Long Cycles, **Applications:** Analyze the trends of population growth, global temperatures, solar radiation, wind patterns. (Practice using MS-Excel & R/Python)

Module II

UNIT – I

Business Intelligence and Analytics: What is Business Intelligence and Analytics? The need for BI and analytics, how to determine requirements, Using the BI tools for extracting insights for data driven decisions

Microsoft Power BI - Part I: Understanding key concepts in business intelligence, data analysis, and data visualization. Getting Started with Power BI and Analytics - Creating account, Power BI Desktop, Working with Data - Connect, Import, Shape and Transform data, Creating Visualization, Author Reports and Schedule automated refresh of reports, Publishing Data to BI online, Using Quick Insights, Use natural language queries, Create real-time dashboards, Create custom visualizations which can be re-usable in reports and dashboards, Sharing dashboard effectively based on needs.

UNIT – II

Microsoft Power BI - Part II: Exploring live connections to data with Power BI, connecting directly to data bases, Introduction to Power BI Development API, Leveraging custom visuals in Power BI, Introduction to DAX

TEXTBOOKS:

- Statistics Concepts and applications, Nabendu pal & Sahadeb sarkar
- Effective Data Visualization: The Right Chart for the Right Data 1st Edition, Dr. Stephanie D. H. Evergreen
- Introducing Microsoft Power BI, Alberto Ferrari and Marco Russo, 2016

REFERENCE BOOKS:

- Applied Microsoft Power BI: Bring your data to life! Teo Lachev
- Microsoft PowerBI guided learning

II Year – Semester I	IoT Edge (Embedded System) Design - Aggregator	L	T	P	Credits
		2	2	2	4

OBJECTIVE:

To provide a comprehensive understanding of IoT edge sensor aggregator devices, their design, operation, and applications. By the end of this course, students will have a firm understanding of how edge sensor aggregator devices function, how they are integrated into larger IoT systems, and how they contribute to data collection and processing at the edge of the network.

COURSE OUTCOMES (COs):

- To understand the concept of edge computing in the context of IoT and its importance.
- To explore various types of sensors and their roles in IoT applications.

- To learn the design and operation of sensor aggregator devices.
- To understand data handling, processing, and communication protocols.
- To gain hands-on experience through projects that involve designing and deploying IoT edge sensor aggregator devices.

Module I

UNIT – I

Introduction to IoT and Edge Computing: Understanding IoT: Concept, Applications, and Architectures, Introduction to Edge Computing: Importance, Benefits, and Challenges, Difference between Cloud Computing and Edge Computing, Role of Edge Computing in IoT.

UNIT – II

Understanding Sensors and Their Roles in IoT: Sensor Types and Selection, Sensor Integration in IoT, Sensor Data Collection, Interpretation, and Management, Understanding Sensor Networks. Case Study: pH sensor interfacing, electro-chemical gas sensor interfacing – Measuring accurate value with offset correction, temperature compensation, and calibration.

Module II

UNIT – I

Sensor Aggregator Devices - Design and Operation: Introduction to Sensor Aggregator Devices, Design Principles for Sensor Aggregator Devices, Programming Sensor Aggregator Devices, Communication Protocols and Standards.

UNIT – II

Deploying IoT Edge Sensor Aggregator Devices: Data Handling and Processing at the Edge, Security Considerations for IoT Edge Devices, IoT Edge Device Management and Maintenance, Designing and Deploying an IoT Edge Sensor Aggregator Device.

TEXTBOOKS:

- "Edge Computing for the Internet of Things" by Dhananjay Singh, Pradeep Kumar Singh, Vivek Kumar Sehgal. This book provides a thorough understanding of edge computing and its role in IoT.
- "Internet of Things: Architectures, Protocols and Standards" by Simone Cirani, Gianluigi Ferrari. This text offers comprehensive coverage of IoT architectures and communication protocols.
- "Sensors and Actuators in IoT: A Practical Guide and System Approach for IoT Design" by Yasser Ismail

REFERENCE BOOKS:

- "IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition" by Perry Lea

II Year – Semester I	IoT Edge (Embedded System) Design – Edge processor / Gateway	L	T	P	Credits
		2	2	2	4

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

OBJECTIVE:

To offer in-depth knowledge about IoT edge processors and gateways, their role in IoT ecosystems, and how they manage communication between devices and the cloud/central server. The course aims to equip students with the necessary skills to design, program, and deploy edge processors and IoT gateways, considering the key aspects of data processing, security, and system performance.

COURSE OUTCOMES (COs):

- To understand the fundamental concepts of IoT and the role of edge computing.
- To learn about the design and operation of edge processors and IoT gateways.
- To explore data handling and processing at the edge, and the interaction with the cloud.
- To gain insights into the security and performance considerations of IoT edge processors and gateways.
- To develop practical skills through hands-on projects involving edge processors and IoT gateways.

Module I

UNIT – I

IoT Edge Processors: Overview of IoT Edge Processors, Role and Functionality, Designing Edge Processors: Hardware and Software Considerations, Programming Edge Processors, Edge Processing: Data Collection, Preprocessing, and Analysis.

UNIT – II

IoT Gateways: Understanding IoT Gateways: Role and Functionality, Designing IoT Gateways: Hardware and Software Considerations, Communication Protocols and Standards for IoT Gateways, Gateway Deployment and Management

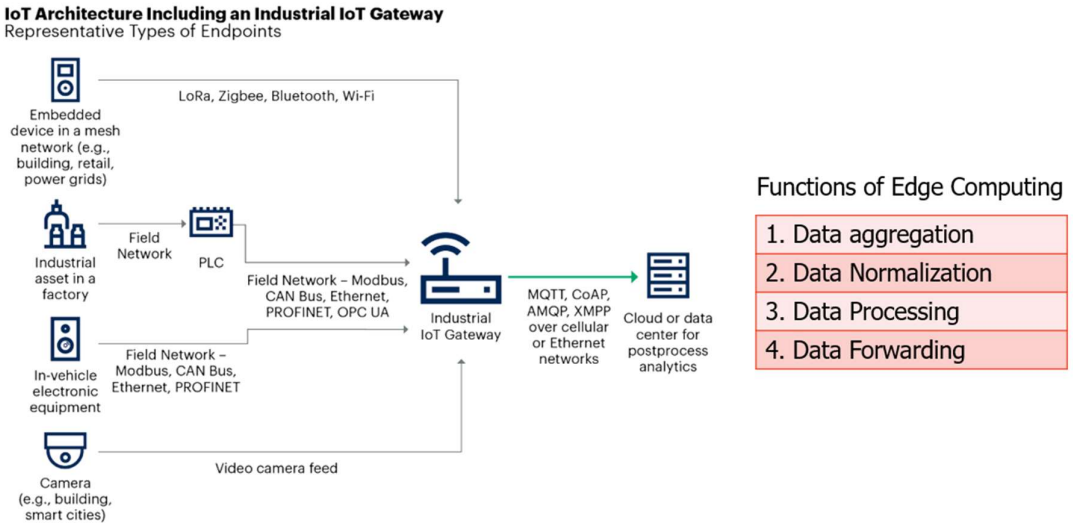


Fig 5: IoT Gateway

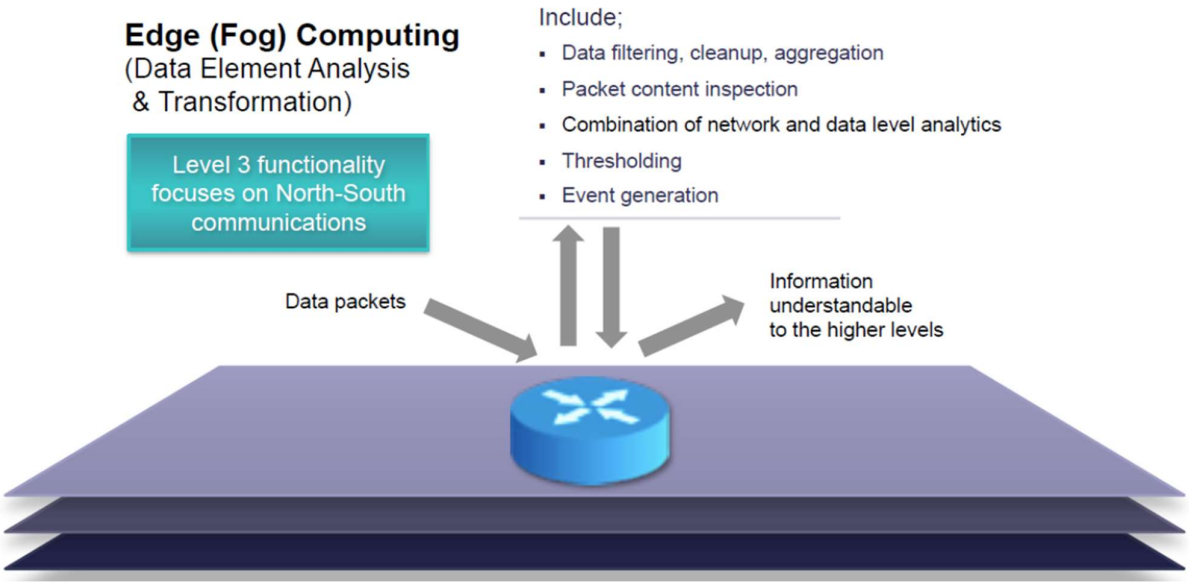


Fig 6: Edge Computing

Module II

UNIT – I

Key algorithms in Edge Systems: Data aggregation, data normalization, data processing, data routing. Event creation techniques, light weight protocol implementation, and time synchronization algorithms, protocol conversion.

UNIT – II

Performance, Security, and Deployment: Performance Optimization for IoT Edge Processors and Gateways, Security and Privacy Considerations in Edge Computing, Deployment Strategies and Challenges, Hands-on Project: Designing and Deploying an IoT Edge Processor and Gateway.

TEXTBOOKS:

- "Edge Computing for the Internet of Things" by Dhananjay Singh, Pradeep Kumar Singh, Vivek Kumar Sehgal. This book provides a thorough understanding of edge computing and its role in IoT.
- "Internet of Things: Architectures, Protocols and Standards" by Simone Cirani, Gianluigi Ferrari. This text offers comprehensive coverage of IoT architectures and communication protocols.
- "Sensors and Actuators in IoT: A Practical Guide and System Approach for IoT Design" by Yasser Ismail

REFERENCE BOOKS:

- "Edge Computing: A Primer" by Mahadev Satyanarayanan, Zhenyu Wen, Renyu Yang
- "IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition" by Perry Lea
- "IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition" by Perry Lea

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (ECE)

II Year – Semester I	IoT Edge (Embedded System) Design – Control System	L	T	P	Credits
		2	2	2	4

OBJECTIVE:
To provide students with a solid understanding of the design and operation of control systems within the Internet of Things (IoT) framework. This includes the principles of different types of actuators (on/off, adjustable), fail-safe controls, and the integration of these components within a broader IoT system.

COURSE OUTCOMES (COs):

- To understand the concept of IoT and the role of control systems within it.
- To learn about the different types of actuators used in IoT and their operation.
- To understand the principles of fail-safe controls and how they are applied in IoT.
- To gain experience in designing and implementing IoT control systems.
- To develop practical skills through hands-on projects and case studies.

Module I
UNIT – I
Introduction to Control Systems: Basics of control systems: Understanding what control systems are and their importance, types of control systems (open-loop and closed-loop systems), Role of Control Systems in IoT: Understanding how control systems fit into the IoT paradigm, examples of IoT control systems.

UNIT – II
Components of Control Systems: Sensors: Understanding different types of sensors used in IoT, how they collect data and interface with the rest of the control system, Actuators: Introduction to actuators, types of actuators (on/off, adjustable, failsafe) and their role in IoT control systems, control modules: understanding how they process sensor data and control actuators in response.

Control System Dynamics: Understanding the dynamic behavior of control systems, role of feedback, stability of control systems.

Module II

UNIT – I
Fail-Safe Controls in IoT: Understanding Fail-Safe Controls: Importance and Applications, Designing Fail-Safe Controls: Factors to Consider, Implementing Fail-Safe Controls in IoT, RAMS concepts, Safety integrity levels, and fail-safe standards.

UNIT – II
IoT Control System Design: Design Principles for IoT Control Systems, Case Study: Designing and Implementing IoT Control Systems, Hands-on Project: Developing an IoT Control System, Analysis of real-world examples where IoT control systems are implemented, discussing the design, components, and operation of these systems.

Future Trends and Challenges: Discussion of future trends in IoT control systems, challenges in designing and implementing these systems, the role of emerging technologies like AI and machine

learning in control systems.

TEXTBOOKS:

- "Internet of Things: Principles and Paradigms" edited by Rajkumar Buyya, Amir Vahid Dastjerdi
- "Control Systems Engineering" by Norman S. Nise
- "Sensors and Actuators in IoT: A Practical Guide and System Approach for IoT Design" by Yasser Ismail
- "Safety Critical Systems Handbook: A Straightforward Guide to Functional Safety: IEC 61508 and Related Standards" by David J. Smith, Kenneth G. L. Simpson

REFERENCE BOOKS:

- "Actuators: Basics and Applications" by Hartmut Janocha
- "RAMS Analysis Made Simple" by Mark Ayres
- "Practical Reliability Engineering" by Patrick D. T. O'Connor, Andre Kleyne