Maharashtra State Board Of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Electronics & Tele-Communication, Diploma in Electronics, Diploma in Communication Technology, Diploma in Communication Engineering,Diploma in Electronics Engineering

Program Code : EJ/EN/EQ/ET/EX — **With Effect From Academic Year: 2017 - 18**

Duration of Program : 6 Semesters — **Duration : 16 Weeks**

Semester : Fifth — **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme														Grand Total
									Theory								Practical					
									ESE		PA		Total		ESE		PA		Total			
				L	T	P		Exam Duration in Hrs.	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks		
1	Environmental Studies	EST	22447	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Control Systems and PLC	CSP	22531	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Embedded Systems	ESY	22532	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Mobile and Wireless Communication	MWC	22533	4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
	Elective (Any One)																					
5	Industrial Automation	IAU	22534	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Microwave and RADAR	MAR	22535	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Industrial Training	ITR	22057	-	-	6	6	--	--	--	--	--	--	--	75#	30	75	30	150	60	150
7	Capstone Project Planning	CPP	22058	-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20	50
			Total	**17**	**-**	**18**	**35**	--	**350**	--	**150**	--	**500**	--	**225**	--	**225**	--	**450**	--	**950**

Student Contact Hours Per Week: **35 Hrs.** — Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. — Total Marks : **950**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment

* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks. Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **Evalution of Industrial Training and its reports is to done after completion of Industrial Training. Credits of Industrial Training will not affect the framing of time table.**

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : **CE/CR/CS/CH/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/ MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**

Semester : **Fifth**

Course Title : **Capstone Project – Planning**

Course Code : **22058**

1. RATIONALE

According to the requirement of National Board of Accreditation (NBA), 'learning to learn' is an important Graduate Attribute (GA No.11). It is required to develop this skill in the students so that they continue to acquire on their own new knowledge and skills from different 'on the job experiences' during their career in industry. An educational 'project' just does that and may be defined as ***'a purposeful student activity, planned, designed and performed by a student or group of students to solve/ complete the identified problem/task, which require students to integrate the various skills acquired over a period to accomplish higher level cognitive and affective domain outcomes and sometimes the psychomotor domain outcomes as well'***. Projects mainly serve this purpose of developing learning-to-learn skills with an aim to develop the following attributes in the students:

a) Initiative, confidence and ability to tackle new problems
b) Spirit of enquiry
c) Creativity and innovativeness
d) Planning and decision making skills
e) Ability to work in a team and to lead a team
f) Ability of self directed learning which is required for lifelong learning
g) Persistence (habit of not giving up quickly and trying different solutions in case of momentary failures, till success is achieved)
h) Resourcefulness
i) Habit of keeping proper records of events and to present a formal comprehensive report of their work.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the required course outcomes (COs) so that students will acquire following competency needed by the industry:

- **Plan innovative/creative solutions independently and/or collaboratively to integrate various competencies acquired during the semesters to solve/complete the identified problems/task/shortcomings faced by industry/user related to the concerned occupation.**

3. COURSE OUTCOMES (COs)

The following could be some of the major course outcomes depending upon the nature of the projects undertaken. However, in case of some projects few of the following course outcomes may not be applicable.

a) Write the problem/task specification in existing systems related to the occupation.
b) Select, collect and use required information/knowledge to solve the problem/complete the task.
c) Logically choose relevant possible solution(s).
d) Consider the ethical issues related to the project (if there are any).
e) Assess the impact of the project on society (if there is any).
f) Prepare 'project proposals' with action plan and time duration scientifically before beginning of project.

g) Communicate effectively and confidently as a member and leader of team.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. Capstones Project

One of the dictionary meaning is the 'crown' or the stone placed on top of the building structure like 'kalash on top of Temples and Mosques' or 'Cross on top of churches'. Capstone projects are culminating experiences in which students synthesize the competencies acquired over whole programme. In some cases they also integrate cross-disciplinary knowledge. Thus Capstone projects prepare students for entry into a career and can be described as a 'rite of passage' or 'minimal threshold' through which participants change their status from student to graduate. A capstone project therefore should serve as a synthesis — reflection and integration— to bridge the real-world preparatory experience to real life. Thus capstone project should have emphasis on integration, experiential learning, and real-world problem solving and hence these projects are very important for students. To develop the highly essential industry oriented skills and competencies in the students, the capstone projects are offered in the last two semesters to serve for following purposes:

a) Integrate the competencies acquired by the students in the previous and current semesters.
b) Provide opportunities for interdisciplinary work in tackling problems likely to be faced by them in industry which are exciting and challenging.

6. Capstone Project Planning

Students are supposed to find out a suitable project and prepare a detailed plan in fifth semester so that it can be executed smoothly in sixth semester. The main characteristic of any project whether small or big is that it requires simultaneous application of various types of skills in the different domains of learning. Moreover, project normally do not have a predefined single solution, in other words for the same problem different students may come up with different but acceptable solutions. Further, in the process of arriving at a particular solution, the student must be required to make a number of decisions after scrutiny of the information s/he has accumulated from experiments, analysis, survey and other sources.

The projects will have a detailed project proposal, which must be executed or implemented within the time allocated, simultaneously maintaining a logbook periodically monitored by the teacher. A detailed project report is to be prepared as project progresses, which has to be submitted after the project is over. For self assessment and reflection students have to also prepare a portfolio of learning.

During the guidance and supervision of the project work, teachers' should ensure that students acquire following ***learning outcomes*** (depending upon the nature of the project work some of these learning outcomes may not be applicable):

a) Show the attitude of enquiry.
b) Identify the problems in the area related to their programme.
c) Identify the information suggesting the cause of the problem and possible solutions.
d) Assess the feasibility of different solutions and the financial implications.

e) Collect relevant data from different sources (books/internet/market/suppliers/experts etc. through surveys/interviews).
f) Prepare required drawings and detailed plan for execution of the work.
g) Work persistently and participate effectively in group work to achieve the targets.
h) Work independently for the individual responsibility undertaken.
i) Ask for help from others including guide, when required.
j) Prepare portfolio to reflect *(chintan-manan)* on experiences during project work.
k) Prepare seminar presentations to present findings/features of the project.
l) Confidently answer the questions asked about the project.
m) Acknowledge the help rendered by others in success of the project.

If students are able to acquire these *learning outcomes*, then they would be able to acquire the COs as discussed in section 3.

7. Scopes of Projects

Scope of the project work should be decided based on following criteria:

a) Relation to diploma programme curriculum: When students intend to select topics for the project work they need to choose a project which relates well to their curriculum (It may be beyond curriculum, but it should relate to it) and requires implementation of theories already learnt and skills already possessed by them from the previous semesters.

b) Abilities possessed by the group of students: Projects should be chosen so that it can be completed mainly using students' problem solving capabilities and depth of learning. It is natural that highly motivated students or high achievers may come out with projects which are more complex and challenging. Teachers should guide students to choose challenging projects according to the students' ability.

c) Resources Available: Students and Guides should keep in mind the availability of resources while deciding the topic and the scope of the project. Some of the important resources which need consideration are:

i. Time available
ii. Raw Material/Components required
iii. Manufacturing/Fabrication equipment and tools required
iv. Testing/Measuring equipment and instruments required
v. Access to Journals (Library/Digital)
vi. Expertise for theoretical guidance (available in polytechnic, nearby institutes or nearby industries)
vii. Expertise and technology required for fabrication (if required)
viii. Software required.

An important aspect to be considered is to decide who will choose a project. The best practice is that teacher should guide students about the above factors to be considered for choosing the project and based on these factors students should do the ground work and identify the possible projects and teachers should work as only facilitator and Guide in final selection of the project title and its scope.

d) Suggested Type of Capstone Projects

In general, the projects that the students can take up could be of the following types;

i. Feasibility studies.
ii. Design projects
iii. Market surveys about raw material, components or finished products.
iv. Prototype (design, make, test and evaluate).
v. Advanced experimental work requiring the development of existing equipment to be used and developed.
vi. Field works: This could include surveys, using equipment, charting data and information from visual observation.

vii. Comparative Studies: Theoretical study of two systems/mechanisms/ processes in detail and comparing them on the basis of cost/energy conservation/impact on environment/technology used etc.
viii. Application of Emerging technology: Theoretical study of some emerging technology and feasibility of its application in some real life situation in detail.
ix. Fabrication of some equipment/machine etc.
x. Construction of some structure.
xi. Development of software or use of software for solving some broad-based problem.

8. GUIDELINES FOR UNDERTAKING A PROJECT

The selection of the *Capstone Project title* must have emphasis to the Elective courses/ Elective Group taken for the study and exam for 5th and 6th semester. The students will then work on the identified problem/task through a rigorous process of understanding and analyzing the problem, conducting a literature search, deriving, discussing (monitored by the guide every fortnight) and designing the ***Semester V 'Project Proposal'*** with the following ***sub-titles***:

a) Rationale (one page)
b) Introduction
c) Literature Survey
d) Problem Definition
e) Proposed Methodology of solving Identified problem
f) In-case some prototype has to be fabricated then its tentative design and procedure for making it should be part of the proposal.
g) Resources and consumables required.
h) Action Plan (sequential list of activities with probable dates of completion)

As soon as the 'Project Proposal' is approved by the teacher, the student will begin to maintain a dated ***'Project Logbook'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This *'project logbook'* should be got signed by the teacher at regular intervals for progressive assessment to match the project proposal. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the 'Project Report' at the end of the semester by him/her.

9. PORTFOLIO FOR SELF-DIRECTED LEARNING

To ensure that students acquire these outcomes, students should also be guided to prepare a **'Portfolio'**, so that they may reflect on their weaknesses/mistakes and learn from them. ***Students should also be encouraged to discuss with their guide and record not only technical problems but also problems related to group work, planning, execution, leadership in the team etc., so that students can also identify their weaknesses in affective domain and take remedial actions to overcome the same.*** If they wish, the students can also show their portfolio to their teachers (whom they trust) for obtaining teachers' comments on their reflection for pointing out their mistakes so that they can improve their performance.

'Portfolio' is the record of the reflection (thinking or *chintan-manan*) on experiences to which students undergo during the different stages of the project. In a portfolio, students record their critical experiences and reflect (think or do *chintan-manan*) on them in writing. This process of reflecting on the experiences make them learn from their mistakes and build on their strengths. To help students in reflection, a Portfolio format with reflective prompts (simple thought provoking questions) for different stages of the project is given as annexure B.

12.1 Purposes of Portfolio Preparation

Reflection by self is important since group work is so complex that it is difficult for teachers to appreciate the real problems amongst the students. In a portfolio, prompts (simple thought provoking questions) are given to trigger reflection on different aspects of project work. Prompts help the students to ask questions from themselves regarding different aspects of the project work and interpersonal relationships. Process of answering these questions forces students to think about behavioral problems and possible remedies/solution to deal with those problems. Portfolio preparation therefore helps in reflection on building the strengths and elimination of the weaknesses of the students pertaining to following qualities which the industry also need.

a) Plan properly for execution of given work.
b) Take appropriate decisions.
c) Arrange resources.
d) Work as member and leader of team.
e) Communicate properly.
f) Resolve the conflicts.
g) Manage the time well.
h) Have concern for ethical, societal and environmental issues.
i) Learn-to-learn from experiences.

It may be seen that these qualities are not directly related with the theoretical subject knowledge and can be developed only through real life experiences. Project work is one such type of experience where opportunity is available to develop all these qualities.

However, even during project work, emphasis of most of the students and teachers remains on development of the technical knowledge and skills while development of above qualities is neglected. Students can develop these qualities if they reflect (do thinking or *Chintan-Manan*) on their experiences from the point of view of these qualities and find out their own weaknesses and strengths. Because if somebody wants to improve his/her abilities then first step for that person is to have self awareness about his/her weaknesses and strengths.

Though portfolio preparation requires considerable time, it is essential, if we want to learn from the experiences and develop these qualities. Writing down reflections helps in better reflection as it is well known that when a person starts writing something he/she becomes more cautious about his/her view and evaluate those views before writing. Thus process of writing improves the quality of reflection or thinking. Moreover, if reflections on different stages of work are written down, over a period of time a large amount of reflection can be generated, and if this reflection is looked back, it may help in identifying some pattern of behaviour in individual which may be improved or rectified latter on as per requirement.

12.2 Guidelines for Portfolio Preparation and assessment

The main purpose of portfolio preparation is learning based on self-assessment and ***portfolio is not to be used for assessment in traditional sense.***

a) Each student has to prepare his/her portfolio separately. However, he/she can discuss with the group members about certain issues on which he/she wants to write in the portfolio.
b) For fifth semester and sixth semester, there will be only one portfolio but it will have two separate parts, first part for project planning (having two sections A and B) second part for project execution. (having two sections C and D)
c) Whatever is written inside the ***portfolio is never to be used for assessment***, because if teachers start giving marks based on whatever is written in the portfolio, then students would hesitate in true self-assessment and would not openly describe their own mistakes or shortcomings.

d) Some marks are allocated for portfolio, these marks are to be given based on how sincerely portfolio has been prepared and not based on what strengths and weaknesses of the students are mentioned in the portfolio.
e) Portfolio has to be returned back to the students after assessing it (assessment is only to see that whether portfolio is completed properly or not) by teachers. Because student is the real owner of the portfolio.
f) Students mainly learn during portfolio preparation, but they can further learn if they read it after a gap. And hence they are supposed to keep the portfolios with them even after completion of the diploma because it is record of their own experiences (it is like diary some people write about their personal experiences), because they can read it again after some time and can revise their learning (about their own qualities)

Even after completion of Diploma programme, students can continue to prepare portfolio related to different experiences in their professional and personal life and by refereeing back to old portfolios after a gap of some years, they can learn that how their personality has evolved over the years. They can also see a pattern of behaviour in their own personality which may be source of their weaknesses or strengths and they can take remedial measures based on this study of their portfolios.

Note

Since some sections of the portfolio are related with interpersonal relationships and student may find it difficult to write these experiences in English. Language should not be the barrier in reflection and hence students should be allowed to prepare the portfolio in their preferred language such as *Marathi* or *Hindi if they find it difficult to write in English.*

The amount and type of mistakes identified by students would not affect the marks received by the students. The total 7 Marks allocated for portfolio (4 marks for PA and 3 for ESE) are only for proper completion of the portfolio.

10. PROJECT REPORT

At the end of fifth Semester, the student will prepare a Semester V 'Project Report' with the following sub-titles:

- Certificate (in the Format given in this document as annexure A)
- Acknowledgements
- Abstract (in one paragraph not more than 150 words)
- Content Page
- Chapter-1 Introduction and background of the Industry or User based Problem
- Chapter-2 Literature Survey for Problem Identification and Specification,
- Chapter-3 Proposed Detailed Methodology of solving the identified problem with action plan
- References and Bibliography

Note: The report should contain relevant diagrams and figures, charts.

11. ASSESSMENT OF CAPSTONE PROJECT – PLANNING

Like other courses, assessment of Project work also has two components, first is progressive assessment, while another is end of the term assessment. The mentor faculty will undertake the progressive assessment to develop the COs in the students. They can give oral informal feedback about their performance and their interpersonal behaviour while guiding them on their project work every week. The following characteristics/ qualities informally or formally should be considered during different phases of the project work which will be assessed thrice as discussed in sub-section.

(A) Initial Phase

i. **Definition of the Problem**

a) Accuracy or specificity

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b) Appropriateness with reference to desired course outcomes.

ii. **Methodology of Conduction the Project**
   a) Appropriateness
   b) Flexibility
   c) Clarity

iii. **General Behaviour**
   a) Initiative
   b) Resourcefulness
   c) Reasoning ability
   d) Imagination/creativity
   e) Self-reliance

(B) Intermediate Phase

i. **Performance of Student**
   a) Ability to follow correct procedure
   b) Manipulative skills
   c) Ability to collect relevant information
   d) Ability to observe, record & interpret
   e) Ingenuity in the use of material and equipment
   f) Target achievement

ii. **General Behaviour**
   a) Persistence
   b) Interest
   c) Commitment
   d) Confidence
   e) Problem solving ability
   f) Decision making ability
   g) Initiative to act
   h) Team spirit.
   i) Sharing of material etc.
   j) Participation in discussion
   k) Completion of individual responsibilities

(C) Final Phase

i. **Quality of Product**
   a) Dimensions
   b) Shape
   c) Tolerance limits
   d) Cost effectiveness
   e) Marketability
   f) Modernity

ii. **Quality of Report**
   a) Clarity in presentation and organization
   b) Styles and language
   c) Quality of diagrams, drawings and graphs
   d) Accuracy of conclusion drawn
   e) Citing of cross references
   f) Suggestion for further research/project work

iii. **Quality of presentation**
   a) Understanding of concepts, design, methodology, results, implications etc
   b) Communication skills
   c) Ability to draw conclusions and generalization

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12. PROGRESSIVE ASSESSMENT (PA) GUIDELINES

15 Marks are allocated for the formal progressive assessment. However, following points need consideration during the three times of formal progressive assessment of the students at the end of 4th, 12th and 14th week.

a) ***Fortnightly monitoring*** by the mentoring teachers is necessary and marks given progressively (even the gradual chapter preparation) so that that students will not copy earlier reports or get things done or reports from the market. The ***students should not be awarded marks*** if they have not done on their own.

b) For progressive assessment at the end of 14th week, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the capstone project work they have to carry out in future).

c) Although marks for *portfolio preparation* is to be given at the end of 14th week, students should be asked to bring their partly prepared portfolio (relevant sections prepared) also during their assessment at the end of 4th week and 12th week.

d) Marks for portfolio preparation should be based only on proper preparation of portfolio by writing answers to most of the prompts (self-questions to students) in the portfolio. These marks should not be based on the mistakes indicated by students in their working (while answering the prompts) and corrective actions taken by them.

e) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)

f) ***Originality of the report*** (written in own words) would be given more importance rather than use of glossy paper or multi-colour printing.

12.1 Progressive Assessment (PA) Criteria

Allocation Criteria of the ***25 marks*** are for the Progressive Assessment (PA).

S. No.	Criteria	Marks
	First Progressive Assessment at the end of 4th week	
1	**Problem Identification/Project Title** (Innovation /Utility of the Project for industry/ User/Academia) marks to be also given based on (i) Accuracy or specificity of the scope and (ii) Appropriateness of the work with reference to desired course outcomes.	02
2	**Industrial Survey and Literature Review**: marks to be given based on extent/volume and quality of the survey of Industry / Society / Institutes/Literature/Internet for Problem Identification and possible solutions	02
3	**General Behaviour**: initiative, resourcefulness, reasoning ability, imagination/creativity, self-reliance to be assessed **Note:** Oral feedback on general behaviour may also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back/suggestions**	**00**
	Second Progressive Assessment at the end of 12th week	
4	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester	**03**

S. No.	Criteria	Marks
5	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	02
6	**Log book** (for work done in fifth semester, detailed and regular entry would be basis of marks)	02
7	**General Behaviour** (persistence, interest, confidence, problem solving ability, decision making ability, initiative to act, team spirit, sharing of material etc., participation in discussions, completion of individual responsibilities, leadership) **Note:** Oral feedback on general behaviour should also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back./suggestions**	00
	Third Progressive Assessment at the end of 14th week	
8	**Portfolio for Self learning and reflection** (marks based on amount of reflection and completion of the portfolio for work done in fifth semester)	**04**
9	**Final Report writing including documentation**. (marks based on: clarity in presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work) Report has to be prepared for work done in fifth semester and planning for sixth semester work.	**06**
10	**Presentation** (presentation skills including communication skills to be assessed by observing quality of presentations and asking questions during presentation and viva/voce) Report has to be prepared for work done in fifth semester and plan for sixth semester.	**02**
11	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**02**
	Total	**25**

13. END-SEMESTER-EXAMINATION (ESE) ASSESSENT GUIDELINES

The ***remaining 25 marks*** are for the end-semester-examination (ESE). And marks would be given according to following criteria. Moreover, the suggested evaluation scheme can be changed slightly by the external faculty according to nature of problem / project following University guidelines..

a) For each project, the one or two students from the concerned group of students should be asked to present the power point presentation before the external and internal (for about 10 minutes) and then external should ask the questions from each member of the group separately to ascertain the contribution made by each student.

b) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks commensurate with their efforts.)

c) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).

d) Originality of the report (written in own words, even if there are grammatical and spelling mistakes) would be given more importance rather than quality of printing and use of glossy paper (and preparing report by copy pasting from other reports).

Note: It is very common that people are not able to complete the project in time despite best of their efforts. (Please recall that how many times people are able to complete in time, personal projects such as building own house or professional projects such as developing the lab in the institute). So if students have put in enough genuine efforts but could not complete the project in time then we should consider it sympathetically and they should be given marks based on their efforts and they should get more marks as compared to students who have got their projects completed by taking major help from others/market.

13.1 End-Semester-Examination (ESE) Assessment Criteria.

Allocation Criteria of the ***25 marks*** are for the end-semester-examination (ESE)

S. No.	Description	Marks
1	**Problem Identification/Project Title** (innovation /utility of the project for industry/ user/academia) marks to be also given based on (i) accuracy or specificity of the scope and (ii) appropriateness of the work with reference to desired course outcomes.	**02**
2	**Industrial Survey and Literature Review** (marks to be given based on extent/volume and quality of the survey of industry / society / institutes/literature/internet for problem identification and possible solutions)	**02**
3	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester.	**02**
4	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	**02**
5	**Log book** (for work during fifth semester, marks to be given based on detailed and regular entry	**03**
6	**Portfolio for Self learning and reflection** (for work during fifth semester) Marks based on amount of reflection and completion of portfolio.	**03**
7	**Project Report including Documentation** (for work during fifth semester and planning for sixth semester) (marks based on: clarity in	**04**

S. No.	Description	Marks
	presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work)	
8	**Presentation** (presentation skills including communication skills to be assessed by observing the quality of presentations and asking questions during presentation and viva/voce) Presentation should be based on work done in fifth semester and planning for sixth semester.	**03**
9	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**04**
	Total	**25**

14. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and even first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should guide students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

d) Teachers should motivate students to maintain log book and prepare portfolio. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

e) Teachers should also encourage students to openly discuss their weaknesses and shortcomings in portfolio and teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them and their marks would not be affected by revealing their mistakes. Marks related to portfolio are awarded based only on the sincerity with which it is prepared and not based on strengths and weaknesses of students.

f) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

g) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Annexure A

CERTIFICATE

This is to certify that Mr./Ms.....

From .....College having Enrolment No: .....

has completed ***Report on the Problem Definition/ Semester V Project Report/ Final Project Report*** having title .....

individually/ in a group consisting of..... persons under the guidance of the Faculty Guide.

.....
The mentor from the industry for the project
Name: .....
Telephone:.....

Annexure B

Portfolio for Self Directed Learning for Major Project Work

Name of Student:.....

Semester:.....**Programme/Branch:**.....

Roll Number:.....

Title of the Project:.....

Name and Designation of Project Guide:.....

Name of Polytechnic:.....

Part A: Selecting the Project and Team (Answers to the following questions to be included in 'Portfolio' as Reflection related to formation of group and finalization of project topic).

Note: This section has to be prepared just <u>after the finalization</u> of the Project topic and formation of the Project Team .

1. How many alternatives we thought before finalizing the project topic?
2. Did we consider all the technical fields related to branch of our diploma programme?
3. Why we found present project topic as most appropriate?
4. Whether all the group members agreed on the present project topic? If not? What were the reasons of their disagreements?
5. Whether the procedure followed in assessing alternatives and finalizing the project topic was correct? If not, discuss the reasons.
6. What were the limitations in other alternatives of project topic?
7. How we formed our team?
8. Whether we faced any problem in forming the team? If yes, then what was the problem and how was it resolved?

9. Am I the leader of our project team? If yes, then why was I chosen? If not, why I could not become the project team leader?
10. Do I feel that present team leader is the best choice available in the group? If yes, then why? If not, then why?
11. According to me who should be the leader of the team and why?
12. Can we achieve the targets set in the project work within the time and cost limits?
13. What are my significant good/ bad sharable experiences while working with my team which provoked me to think? What I learned from these experiences?
14. Any other reflection which I would like to write about formation of team and finalization of project title, if any?

Part B: Reflection related to project planning (Answers to the following questions to be included in 'Portfolio' as reflection on planning)

Note: This section has to be prepared just after the finalization of the 'Project Proposal'.

1. Which activities are having maximum risk and uncertainty in our project plan?
2. What are most important activities in our project plan?
3. Is work distribution is equal for all project group members? If not? What are the reasons? How we can improve work distribution?
4. Is it possible to complete the project in given time? If not what are the reasons for it? How can we ensure that project is completed within time.
5. What extra precaution and care should be taken in executing the activities of high risk and uncertainty? If possible, how such risks and uncertainties can be reduced?
6. Can we reduce the total cost associated with the project? If yes, then describe the ways?
7. For which activities of our project plan, arrangement of resources is not easy and convenient?
8. Did we make enough provisions of extra time/expenditure etc. to carry out such activities?
9. Did we make enough provisions for time delays in our project activity? In which activities there are more chances of delay?
10. In our project schedule, which are the days of more expenditure? What provisions we have made for availability and management of cash?
11. Any other reflection which I would like to write about project planning?

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Teacher Evaluation Sheet (ESE)
for
Capstone Project Planning

Name of Student: .....

Name of Programme..... **Semester:** .....

Course Title and Code:.....

Title of the Capstone Project: .....

A. POs addressed by the Capstone Project (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

B. COs addressed by the Capstone Project (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

C. OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT

a) **Unit Outcomes (Cognitive Domain)**

i. .....
ii. .....
iii. .....
iv. .....

b) **Practical Outcomes (in Psychomotor Domain)**

i. .....
ii. .....
iii. .....
iv. .....

c) **Affective Domain Outcomes**

i. .....
ii. .....
iii. .....
iv. .....

D. SUGGESTED RUBRIC FOR ASSESSMENT OF CAPSTONE PROJECT

(please tick below the appropriate rating i.e. poor, average etc., for each characteristic to be assessed and give marks in the respective cell according to performance of student)

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
First Progressive Assessment (at the end of 4th week)							

Program Name : **Diploma in Civil Engineering/ Computer Engineering / Information Technology /Automobile Engineering/ Fashion & Clothing Technology / Electrical Engineering Group / Electronics Engineering Group**

Program Code : **CE/CR/CS/CO/CM/CW/IF/AE/DC/EE/EP/EU/DE/EJ/ET/EN/ EX/EQ/IE/IS/IC**

Semester : **Fifth**

Course Title : **Environmental Studies**

Course Code : **22447**

1. RATIONALE

The world today is facing the biggest challenge of survival. Degradation of ecosystem, depletion of natural resources, increasing levels of pollution pose major threat to the survival of mankind. The need of the hour, therefore, is to concentrate on the area of environmental aspects, which shall provide an insight into various environment related issues. Environmental studies are an interdisciplinary academic field that integrates physical, chemical and biological sciences, with the study of the environment. It provides an integrated, quantitative, and interdisciplinary approach to the study of environmental system & gives an insight into solutions of environmental problems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Diagnose and manage environment related issues**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Develop Public awareness about environment
b. Select alternative energy resources for Engineering Practice
c. Conserve Ecosystem and Biodiversity
d. Apply techniques to reduce Environmental Pollution
e. Manage social issues and Environmental Ethics as lifelong learning

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(#) Online Theory Examination.

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

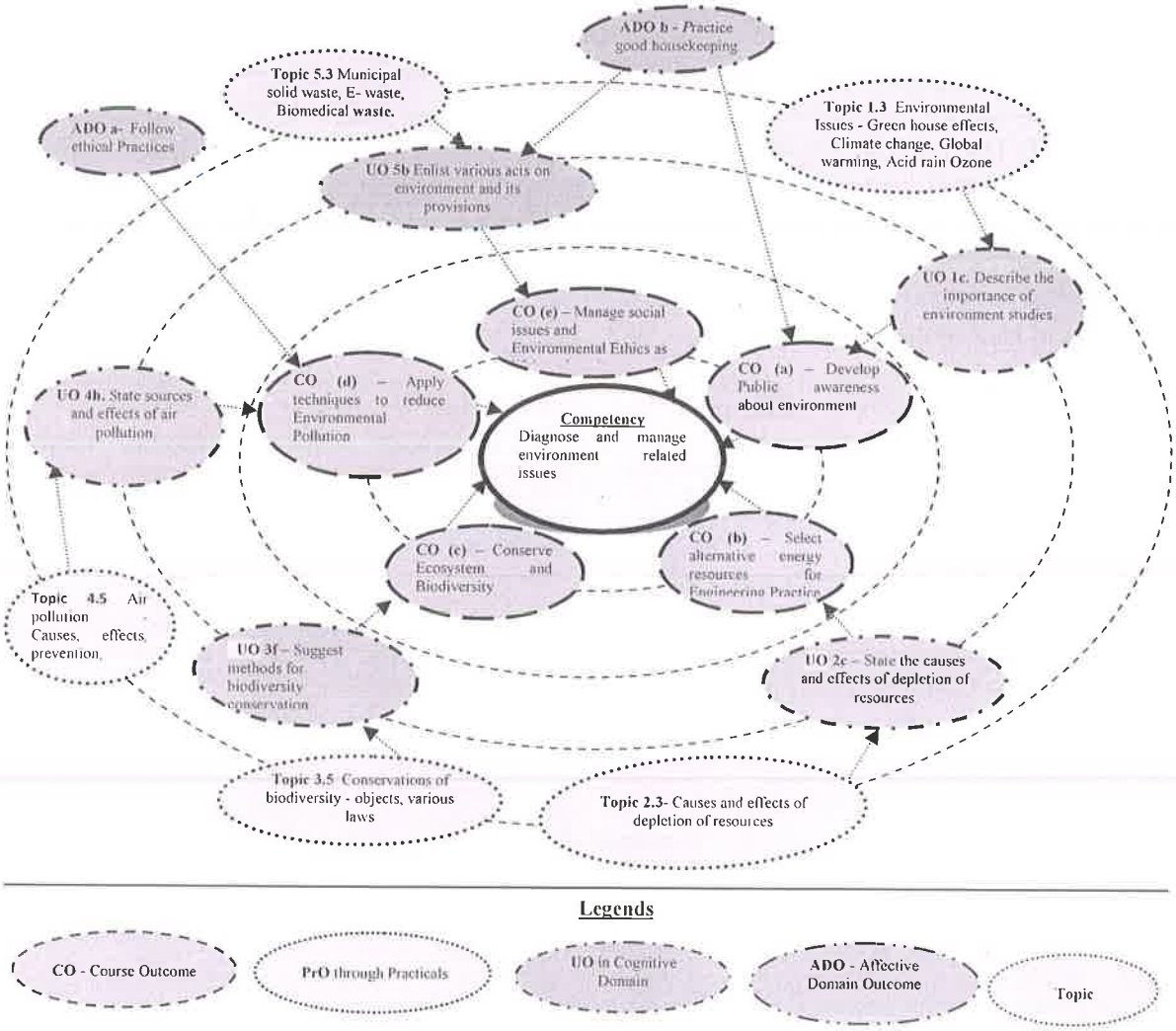

Figure 1 - Course Map

6. SUGGESTED EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	NIL		
	Total		

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	NIL	
	Total	

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	NIL	-

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Environment	1a. Discuss the scope of Environment. 1b. Describe various types of environment 1c. Describe the importance of environment studies. 1d. Discuss about the need of public awareness about environment. 1e. Describe various environmental issues.	1.1 Definitions, need of environmental studies. 1.2 Segments of environment- Atmosphere, Hydrosphere Lithosphere, Biosphere. 1.3 Environmental Issues - Green house effects, Climate change, Global warming, Acid rain Ozone layer depletion, Nuclear accidents. 1.4 Concept of 4R (Reduce, Reuse, Recycle and Recover), 1.5 Public awareness about environment.
Unit– II Energy Resources	2a. List various natural resources. 2b. Describe Renewable, Nonrenewable and Cyclic resources. 2c. State the causes and effects of depletion of resources. 2d. State advantages and disadvantages of forms of energy. 2e. Select appropriate solutions of efficient use of energy. 2f. State the impacts of overuse of natural resources.	2.1 Natural Resources - Forest Resources, Water Resources, Energy Resources, Land resources, Mineral resources. 2.2 Renewable, Non-renewable and Cyclic Resources. 2.3 Causes and effects of depletion of resources. 2.4 Energy forms (Conventional and non-conventional). 2.5 Present global energy use and future demands. 2.6 Energy conservation. 2.7 Over use of natural resources and its impacts on environment.
Unit- III Ecosystem and Biodiversity	3a. State the aspects and division of ecosystem. 3b. State the general characteristics and function of ecosystem. 3c. List levels of biodiversity. 3d. Enlist the endangered species. 3e. Describe value of biodiversity. 3f. Suggest methods for biodiversity conservation.	3.1 Ecosystem - Definition , Aspects of ecosystem, Division of ecosystem, General characteristics of ecosystem, Functions of ecosystem. 3.2 Biodiversity - Definitions, Levels, Value and loss of biodiversity. 3.3 Biodiversity assessment initiatives in India. 3.4 Threats and Hotspots of biodiversity. 3.5 Conservations of biodiversity - objects, various laws.
Unit– IV Environmental Pollution	4a. Define pollution. 4b. State the sources of pollution. 4c. State the effects of land pollution on environment and lives. 4d. State various units and their functions of water treatment plant. 4e. State the needs of water conservation.	4.1 Definition of pollution, types- Natural & Artificial (Man- made). 4.2 Soil / Land Pollution – Causes and effects on environment and lives , preventive measures. 4.3 Water Pollution - Sources of water (surface and sub surface), sources of water pollution, effects on environment and lives, preventive measures, BIS water quality

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	4f. State the impacts of sewage. 4g. State various units and their functions of sewage treatment plant. 4h. State sources and effects of air pollution. 4i. Describe various methods to prevent air pollution. 4j. State sources and effects of noise pollution. 4k. Describe preventive measures for noise pollution. 4l. State characteristics of solid waste. 4m. State the impacts of solid waste. 4n. Describe incineration, RDF and sanitary landfilling. 4o. State the standards limiting/controlling values of various types of pollution.	standards, flow diagram of water treatment plant, Water conservation. 4.4 Wastewater - Generation(domestic and industrial), Impacts, flow diagram of sewage treatment plant, CPCB norms of sewage discharge. 4.5 Air pollution - Causes, effects, prevention, Ambient air quality standards. 4.6 Noise pollution - Sources, effects, prevention, noise levels at various zones of the city. 4.7 Municipal Solid Waste, Bio-medical waste and E-waste - Sources, generation, characteristics, effects, and methods to manage.
Unit-V Social Issues and Environmental Education	5a. Elaborate article (48-A) and (51-A (g)) 5b. Enlist various acts on environment and its provisions. 5c. State the roles and responsibilities of CPCB. 5d. Define sustainable development, and EIA. 5e. Describe rain water harvesting and groundwater recharge. 5f. Differentiate between formal and non formal education.	5.1 Article (48-A) and (51-A (g)) of Indian Constitution regarding environment, Environmental protection and prevention acts, CPCB and MPCB norms and responsibilities, The role of NGOs. 5.2 Concept of sustainable development, EIA and environmental morality. 5.3 Management Measures - Rain Water harvesting, Ground water recharge, Green Belt Development, Use of Renewable energy, water shed management, interlinking of rivers. 5.4 Role of information technology in environment and human health.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Environment	06	4	6		10
II	Energy Resources	10	4	8		16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	Ecosystem and Biodiversity	08	4	4	4	12
IV	Environmental Pollution	16	8	8	4	20
V	Social Issues and Environmental Education	08	4	4	4	12
	Total	**48**	**24**	**30**	**16**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Plant and adopt a tree in your nearby locality/Polytechnic campus and prepare report about its growth and survival after six months with photos.
b. Organize seminar on air pollutants of relevant MIDC area/vehicle
c. Organize poster exhibition about global warming and ozone depletion.
d. Visit a nearest water purification/effluent treatment plant.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain various topics.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a report on visit to PUC Center.
b. Visit a near by RO plant and prepare detail technical report.
c. Prepare report on Household water filtration unit
d. Prepare a list of polluted natural resources which are responsible for pollution and collect information on how to manage them .
e. **Collection of Data from Hospital: Collect** everyday information on percentage of solid hazardous and toxic waste for two month
f. **Visit of Municipal Effluent Treatment Plant:** Visit effluent treatment plant and prepare report on waste management.
g. **Visit of Water Treatment Plant:** Visit water treatment plant and prepare report on various units of water treatment and its management.
h. **Preparation of report**: Prepare the chart of solid waste management showing effects on environment.
i. **And any other relevant topic related to course**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Basic Environmental Sciences	Michael Allaby	Routledge Publication, 2nd Edition, 2000, ISBN: 0-415-21176-X
2	Environmental Science	Y. K. Singh	New Age International Publishers, 2006, ISBN: 81-224-2330-2
3	Environmental Studies	Erach Bharucha	University Grants Commission, New Delhi
4	Environmental Studies	Rajagopalan	Third Edition, Oxford University Press, USA, ISBN: 9780199459759, 0199459754
5	A text book of Environmental Science	Arvind Kumar	APH Publishing New Delhi
6	A text book of Environmental Studies	Shashi Chawla	Tata Mc Graw-Hill New Delhi

14. SOFTWARE/LEARNING WEBSITES

a. www.eco-prayer.org
b. www.teriin.org
c. www.cpcb.nic.in

d. www.indiaenvironmentportal.org.in
e. www.whatis.techtarget.com
f. www.sustainabledevelopment.un.org
g. www.conserve-energy-future.com

Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ**

Semester : **Fifth**

Course Title : **Control Systems and PLC**

Course Code : **22531**

1. RATIONALE

A control system is a discipline that applies automatic control theory to design systems in such a way as to achieve a desired control of operation of the system. Control engineering has an essential role in a wide range of control systems. It seeks to understand physical systems, using mathematical modeling, in terms of inputs, outputs and various components with different behaviors. This course will facilitate students to use the different control systems used in various range of applications from simple home heating controller using a thermostat to a large Industrial control systems which are used for controlling processes or machines. The course introduces Control system and PLC which is adapted for the control of manufacturing processes.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain electronic automated systems in process and manufacturing industries.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify different types of control systems.
b. Determine the stability of the control system.
c. Test the performance of various types of controllers.
d. Maintain various components of PLC based process control system.
e. Maintain PLC based process control systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *- Credit*
ESE *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels

of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

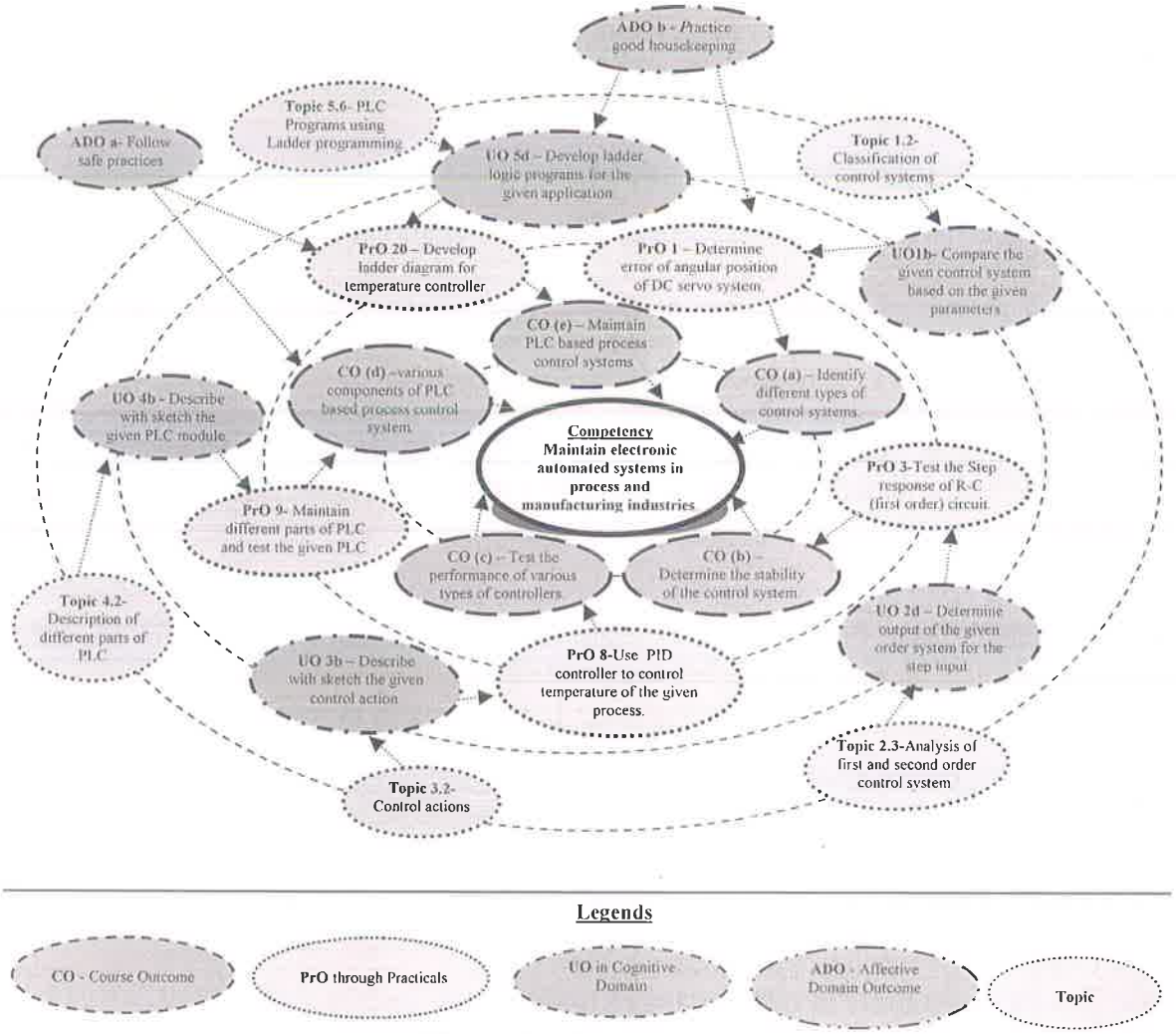

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use potentiometer as error detector.	I	02*
2	Determine error of angular position of DC servo system.	I	02
3	Test the Step response of R-C (first order) circuit.	II	02*
4	Test the Step response of R-L-C (second order) circuit.	II	02
5	Test the functionality of temperature control with on-off controller.	III	02*
6	Use PI controller to control temperature of the given process.	III	02
7	Use PD controller to control temperature of the given process.	III	02
8	Use PID controller to control temperature of the given process.	III	02*
9	Identify and test different parts of PLC .	IV	02*
10	Develop ladder diagram to test the functionality of the logic gates.	V	02
11	Develop ladder diagram to test Demorgan's theorem.	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
12	Develop the ladder diagram for Adder and Subtractor by using PLC.	V	02
13	Develop ladder diagram for ON and OFF control of lamp using timer and counter.	V	02
14	Develop ladder diagram for traffic light Control system.	V	02
15	Develop ladder diagram for stepper motor control.	V	02*
16	Develop ladder diagram for temperature controller.	V	02*
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Cathode ray oscilloscope: Dual trace 50Mhz	03,04
2	Multimeter 3 1/2: AC/DC,0-200V	01 ,02,06 to 08
3	DC position trainer kit	02
4	Potentiometer trainer kit	01
5	RC kit	03
6	RLC kit	04
7	ON-OFF controller kit	05
8	PID controller trainer kit	06 to 08
9	PLC trainer kit (20 digital I/O points and 2 analog I/O channels)	09 to 16
10	Desktop PC	10 to 16
11	Simulation Software: Picosoft,Scilab, Matlab, Prosim, PSpice, LabVIEW, Electronics Workbench, Win pro ladder	01 to 16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basics of control system	1a. Explain with sketches the working of the given type of control systems. 1b. Compare the given control systems based on the given parameters. 1c. Derive transfer function of the given electrical circuits. 1d. Use block diagram reduction rules to determine optimize transfer function of the given system.	1.1 **Control system:** Basics of control system block diagram and practical examples 1.2 **Classification of control systems:** Open loop and closed loop systems- block diagram, practical example and comparison, Linear and non -linear systems, Time varying and Time In-varying systems- practical example and comparison servo system - 1.3 **Transfer function:** Close loop and open loop system RC, LC and RLC circuits-Differential equations and transfer functions and analysis using Laplace transform 1.4 **Block diagram reduction technique:** Need, reduction rules,
Unit– II Time domain stability analysis	2a. Compare the parameter of given standard test inputs. 2b. Identify poles, zeros, type and order for the given transfer function. 2c. Sketch pole zero plot for the given transfer function. 2d. Determine output of the given order system for the step input.	2.1 **Time Response:** Transient and steady state response. 2.2 **Standard test inputs:** Step, ramp, parabolic, impulse and their corresponding Laplace transform 2.3 **Analysis of first and second order control system:** i. **Poles and zeros** - S-plane representation, Order of system (0, 1, 2)- standard equations, examples and numerical problems ii. **First order system**-Analysis for unit step input, concept of time constant

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2e. Calculate time response specifications of the given transfer function. 2f. Calculate error constants of the given type of control system. 2g. Determine stability of the given control system using Routh's stability criteria.	iii. **Second order system-** Analysis for unit step input (no derivation), concept, definition and effect of damping iv. **Time response specifications** (no derivations) - Tp, Ts, Tr, Td, Mp, Ess, numerical problems 2.4 **Steady state analysis**: Type 0, 1, 2 systems- steady state error and error constants, numerical problems 2.5 **Stability: C**oncept of stability, root locations in S-plane and analysis- stable system, unstable system, critically stable systems, conditionally stable system, relative stability 2.6 **Routh's stability criterion:** Steps and procedures to find stability by Routh's stability criteria,
Unit –III Process controllers	3a. Explain with sketch the given process control system. 3b. Describe with sketch the given control action. 3c. Compare different electronic controllers on the basis of the given parameters. 3d. Sketch the response of the given controller with respect to error.	3.1 **Process Control System**: Block diagram, functions of each block 3.2 **Control actions:** i **Discontinuous mode-** ON-OFF controllers- equation, neutral zone ii **Continuous modes:** Proportional Controller - offset, proportional band. Proportional, Integral and Derivative controllers -o/p equation, response, characteristics, 3.3 **Composite controllers**: PI, PD, PID controllers- o/p equation,response
Unit-IV Fundamentals of PLC	4a. Explain with sketch PLC based automation system. 4b. Describe with sketch the given PLC module. 4c. Identify different devices interfaced with PLC. 4d. Explain the steps for PLC installation.	4.1 **PLC**-Block diagram, classification, (fixed and modular PLCs), need and benefits of PLC in automation 4.2 **Description of different parts of PLC**: CPU –function, scanning cycle, speed of execution, Power supply- block diagram and function of each block Memory – function and organization of ROM and RAM Input and output modules- function, different input and output devices of PLC (only name and their uses). 4.3 **PLC Installation**
Unit-V PLC hardware and programming	5a. Identify and describe the given module of PLC. 5b. Describe the given addressing of PLC. 5c. Use instruction set to perform the given operation. 5d. Develop ladder logic programs for the given	5.1 **Discrete input modules:** Block diagram, specifications of AC input modules and DC input module. Sinking and sourcing concept in DC input modules 5.2 **Discrete output modules:** Block diagram description, specifications of AC output module and DC output modules 5.3 **Analog input and output modules:** Block diagram, specifications

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	application.	5.4 **I/O addressing of PLC**: Addressing data files, format of logical address, different addressing types 5.5 **PLC Instruction set**: Relay instructions, timer and counter instructions, data movement instructions, logical and comparison instructions 5.6 **PLC Programs** using Ladder programming language.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Control System	10	02	04	06	12
II	Time domain stability analysis	16	04	04	08	16
III	Process Controllers	08	02	04	04	10
IV	Fundamentals of PLC	12	04	04	06	14
V	PLC Hardware and Programming	18	04	06	08	18
Total		64	**16**	**22**	**32**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare manuals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Give seminar on relevant topic.
d. Library / Internet survey regarding different data books and manuals.
e. Prepare power point presentation on PLC.
f. Undertake a market survey of different manufacturer of PLC.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use Flash/Animations to explain working of control system.
g. Use open source simulation software modules to perform different applications using PLC.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Simulate and test the performance of 1st order RC and 2nd order RLC Circuit using simulation software.
b. Prepare a chart to show the error constants of type 0, 1 and 2 systems for different standard test inputs.
c. Simulate and test the performance of PI, PD, and PID-control action using simulation software.
d. Prepare a chart to show characteristics of control actions with respect to error.
e. Prepare a report on the basis of PLC data sheets of various manufacturers.
f. Develop/Test a ladder diagram for controlling washing machine operations.(Wash cycle-inlet valve should open for 10 sec. Motor starts running after 10sec. Running time for motor is 20sec. After that motors stops. Then outlet valve opens and water is drained out. Same operations are repeated for rinse cycle. Spin cycle- Motor runs at high speed for 20 sec and outlet valve remains open for the whole period of spin cycle.)
g. Develop/Test a ladder diagram for automatic cold drink bottle filling system.(When sensor senses a bottle, after 3 sec outlet valve of the container containing cold drink will open . It will be open for 10 sec and then the valve will be closed. The bottle will be moved forward automatically. The process should stop after filling of 25 bottles.)
h. Develop/Test a ladder diagram for Interlock Control circuit. (The entry/exit of the parking lot is a single lane passage. By controlling the indicators only one car should pass through the entry/exit so as to prevent car accidents between entering and leaving cars.)

i. Develop/Test a ladder diagram for product mass packaging. (When the photoelectric sensor detects specified number of products, robotic arm will begin to pack up. When the action is completed, robotic arm and counter will be reset.)
j. Develop/Test a ladder diagram for 24 hour clock operated by 3 counters.
k. Develop/Test a ladder diagram for sequential delay output i.e starting 3 motors sequentially. (Example- Start the oil pump motor when the start button is pressed. Main motor will be started after 10 sec delay and then the auxiliary motor after 5 sec delay. Also stop all the motors immediately when stop button is pressed.)
l. Develop/Test a ladder diagram for performing Pulse-Width modulation by changing the set value in the timer.
m. Develop/Test a ladder diagram for Artificial Fish pond water level monitoring system. (Feeding /Draining water immediately when the water level of the artificial fish pond is not at the normal level. Also enabling the alarm and alarm lamp when the water is above or below the normal level.)
n. Develop/Test a ladder diagram for Automatic Door Control system. (When someone enters the door should open automatically and if no one enters for about 10sec, door should close automatically. Also if someone enters the sensing field during door closing process, closing action should stop immediately.)
o. Develop/Test a ladder diagram for Automatic Coffee Making system. (When a coin is inserted paper cup should come out from the outlet. At the same time coffee pours in the mixing container. After 2 sec hot water pours in. After 60 sec readymade coffee will come out from coffee outlet.)
p. Develop/Test a ladder diagram for automatic control of a machine which is required to direct 6 objects along one path for packaging in a box and then 12 objects along another path for packaging in another box. A deflector plate might be controlled by a photocell sensor gives an output every time an object passes it.

13. SUGGESTED LEARNING RESOURCES

S. No.	Author	Title of Book	Publication
1	Process control instrumentation Technology	Johnson, C. D.	Prentice Hall, 8th edition, United States of America,2014 ISBN: 978-0131194571
2	Intro. To Programmable logic control	Dunning, Gary	Cenage Learning, United States of America,2005 ISBN: 9781401884260
3	Control System Engineering	Nagrath, J.J. ; Gopal, M.	Anshan Publishers (2008) ISBN: 9781848290037
4	Modern control Engineering	Ogata, K.	PHI , 5th Edition, NEW DELHI,2010 ISBN: 978812034010
5	Programmable logic controllers and industrial automation an introduction	Mitra, Madhuchhanda ; Gupta, Samarjit Sen	Penram,1st Edition, Mumbai, 2007 ISBN: 9788187972174
6	Programmable logic controllers	Petruzella, F.D.	Tata- McGraw Hill, 3rd Edition, 2010 ISBN: 9780071067386

14. SOFTWARE/LEARNING WEBSITES

a. www.scilab.org

b. www.openplc.fossee.in
c. www.github.com/FOSSEE/OpenPLC
d. www.youtube.com /plc
e. www.dreamtechpress.com /ebooks
f. www.nptelvideos.com/control_systems/
g. www.in.mathworks.com/solutions/control-systems.html?s_tid=srchtitle
h. www.edx.org/course?subject=Engineering&course=all&language=English
i. www.plcs.net
j. www.ab.rockwellautomation.com › Allen-Bradley
k. www.plc-training-rslogix-simulator.soft32.com/free-download/

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IS/IC**

Semester : **Fifth**

Course Title : **Embedded Systems (Elective for IS/IC)**

Course Code : **22532**

1. RATIONALE

In the rapidly growing digital world, role of embedded systems is increasingly vital in various domains such as industrial and home automation, entertainment systems, medical equipments and many more. The core of all such system is powered by electronic hardware and associated software. It is therefore evident to impart the knowledge of the related technology and hands on skills to develop and maintain electronics hardware based embedded systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain Embedded Systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select the relevant microcontrollers for various industrial applications.
b. Use 'Embedded C' programming language to maintain embedded systems.
c. Interpret the communication standards of embedded systems.
d. Develop basic applications using embedded systems.
e. Interpret features of Real Time Operating System.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

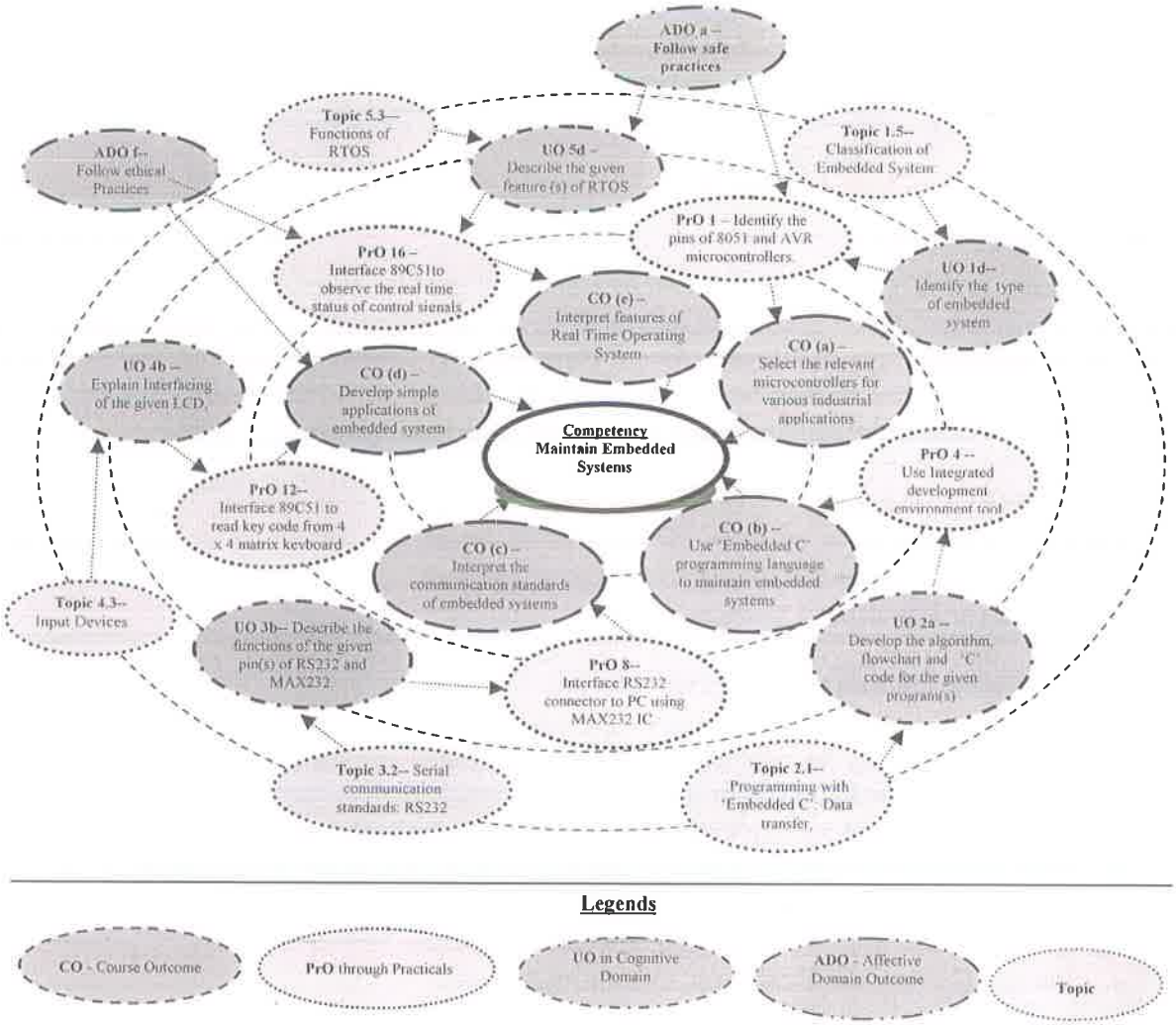

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the pins of 8051 and AVR microcontrollers.	I	2*
2	Identify the pins and features of PIC microcontrollers.	I	2
3	Identify the features of ARM microcontroller on the basis of IC number.	I	2
4	Use Integrated development environment tool for developing embedded 'C' programs (Using MicroProC/ Keil).	II	2*
5	Execute the 'C' program to perform following arithmetic operations on 8-bit data: addition, subtraction, multiplication and division.	II	2*
6	Develop and Test the 'C' program to perform following arithmetic operations on 16-bit data: addition, subtraction.	II	2

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Develop and Test the 'C' program to perform data transfer from source to destination (Use internal data memory locations).	II	2*
8	Interface RS232 connector to PC using MAX232 IC.	III	2
9	Develop and test the 'C' program to turn on LED (S) with key (S) press.	IV	2*
10	Interface 89C51/AVR microcontroller and write the 'C' program to display numbers from 0 to 9 on 7-segment display with specified delay.	IV	2
11	Interface 89C51/AVR microcontroller and write C program to display string on given 16 x 2 LCD.	IV	2*
12	Interface 89C51/AVR microcontroller and write 'C' language program to read key code from 4 x 4 matrix keyboard and LCD display .	IV	2*
13	Interface 89C51/AVR microcontroller and write C program to convert analog signal into digital form using given 8 bit ADC and store the converted digital data in memory.	IV	2*
14	Interface 89C51 and write C program to generate square and sawtooth waveforms using given 8 bit DAC.	IV	2*
15	Interface 89C51 /AVR microcontroller and write C program to rotate stepper motor with different speeds in clockwise and counter clockwise direction.	IV	2*
16	Interface 89C51 and write C program to observe the real time status of the triangular waveform generated using DAC (Use IDE tool MicroProC / Keil).	V	2
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

Sr. No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisitions of the ADOs take place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Microcontroller kit (8051,AVR/PIC/ARM): Single board systems with minimum 8K RAM,ROM memory with battery back up,16X4, LCD display,7-segment Display, PC keyboard interfacing facility, 4X4 matrix keyboard, cross c-compiler, USB, interfacing facility with built in power supply.	All
2	Arduino Board with AVR microcontroller	All
3	Desktop PC with Integrated Development Environment (MicroPro C/ Keil / Proteus).	All
4	Stepper Motor- 50/100 RPM (or any relevant).	15
5	CRO- Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe.	13,14,
6	ADC (0808) trainer board.	13
7	DAC (0808) trainer board.	14
8	Add on cards.	9
9	Digital Multimeter : 3 1/2 digit display, 9999 counts digital multimeter measures: V_{ac}, V_{dc} (1000V max) , A_{dc}, A_{ac} (10 amp max) , Resistance (0 - 100 MΩ) , Capacitance and Temperature measurement	13,14, 15,16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (In cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Embedded systems	1a. Describe the given component (s) of the given embedded system. 1b. Describe with the help of block diagram, the architecture of the given processor. 1c. Describe the given characteristic (s) of the specified embedded systems. 1d. Identify with justification the type of embedded systems used for the given application. 1e. Select with justification the relevant microcontroller from the existing microcontroller families for the given application.	1.1 Block diagram of embedded system with hardware components 1.2 Harvard and Von-Neumann architecture, RISC and CISC processors 1.3 Features of 89C51, PIC, AVR and ARM microcontrollers with their applications 1.4 Characteristics of embedded system: Processor power, memory, operating system, reliability, performance, power consumption, NRE cost, unit cost, size, flexibility, time-to-prototype, time-to-market, maintainability, correctness and safety 1.5 Classification of embedded system: small scale, medium scale, sophisticated, stand-alone, reactive/real time (soft and hard real time).
Unit– II Programming using Embedded C	2a. Develop the algorithm, flowchart and 'C' program (s) for the given microcontroller to perform the given operation. (data transfer, arithmetic /logical, decision control and looping operations). 2b. Develop the algorithm, flowchart and 'C' code for the given delay using timer/counter with microcontroller. 2c. Develop the algorithm, flowchart and 'C' code for the given data transfer through serial communication port. 2d. Develop the algorithm, flowchart and 'C' code to control the given interrupt.	2.1 Programming with 'Embedded C': arithmetic and logical operations, data transfer with memory and port, decision control & looping 2.2 Timer/Counter program using 'embedded C' for given microcontroller 2.3 Serial communication program using 'embedded C' for given microcontroller 2.4 Interrupt control program with 'embedded C' for given microcontroller
Unit-III Communication standards and protocols.	3a. Describe the given mode (s) of communication. 3b. Describe the functions of the given pin(s) of RS232 and MAX232 with suitable sketch. 3c. Describe the given communication protocol (s) with relevant sketch. 3d. Describe the given advanced serial communication interface.	3.1 Modes of data communication: serial parallel, synchronous and synchronous communication 3.2 Serial communication standards: RS232 3.3 MAX232 as a bidirectional level converter 3.4 Communication protocols i. Serial communication protocols: I^2C, CAN, USB, serial peripheral

Unit	Unit Outcomes (UOs) (In cognitive domain)	Topics and Sub-topics
		interface (SPI), synchronous serial protocol (SSP) ii. Parallel communication protocols: PCI, PCI-X 3.5 Features of advanced serial protocol: IrDA, bluetooth, zigbee
Unit –IV Interfacing Input and Output devices	4a. Explain the steps for interfacing of the given basic input/output device (s) to the given microcontroller with embedded 'C' 'program. 4b. Explain the steps for interfacing of the given LCD, matrix key board, multiplexed 7-segment display, sensor to the given microcontroller with embedded 'C' program. 4c. Explain interfacing of DC motor to the given microcontroller to rotate in the given direction using embedded 'C'program. 4d. Explain the steps for interfacing of given stepper motor with the microcontroller to rotate in given direction, angle of rotation, with half step/full step with embedded 'C'program. 4e. Explain interfacing steps of the given ADC/DAC to convert data with the given microcontroller with embedded C program.	4.1 Interface the various input, output and special devices to the microcontroller 89C51/AVR 4.2 Output Devices : LED, LCD, relays, 7-segment displays, multiplex 7-Segment display 4.3 Input Devices : key, matrix keyboard 4.4 Motor : stepper motor, DC motor 4.5 ADC/DAC: 8 bit ADC/DAC (0808/09) 4.6 Sensor :Temperature sensor (LM35)
Unit-V Real Time Operating Systems	5a. Describe the given functions of the specified operating system with suitable sketch. 5b. Compare the given characteristics of RTOS and General OS. 5c. Explain deadlock condition in RTOS with suitable sketch. 5d. Explain the given features of RTOS with suitable sketch.	5.1 Operating system: general and real time operating system 5.2 Characteristics of real time operating system: consistency, reliability, scalability, performance, predictability 5.3 Functions of RTOS: i. Task management: inter task communication and multitasking ii. Scheduling: scheduling algorithms. iii. Resource allocation and interrupt handling 5.4 Features of RTOS: watchdog timer, semaphore 5.5 Deadlock: i. Reason of occurrence ii. Handling of deadlock: detection, prevention, ignoring

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to embedded systems	08	04	04	04	12
II	Programming using embedded 'C'	12	02	06	08	16
III	Communication standards and protocols	08	02	04	06	12
IV	Interfacing input and output devices	12	04	06	08	18
V	Real Time Operating Systems	08	02	04	06	12
Total		**48**	**14**	**24**	**32**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Download the data sheets of all the components used in the practical.
b. Prepare a documentation of all the components and devices along with their specifications.
c. Deliver seminar on relevant topic.
d. Library / Web survey regarding different data books and manuals.
e. Prepare power point presentation on applications of microcontroller.
f. Undertake a market survey of different microcontrollers.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a chart of various features using data sheets of 8051, PIC, AVR, ARM microcontroller and its derivatives.
b. Prepare a chart of various features and operations of temperature sensors, devices using data sheets.
c. Prepare a chart of various types of LCDs to display its features, pin functions and steps of operations using data sheets.
d. Interface potentiometer with development board (Arduino) and write a program to generate LED pattern on it.
e. Programming of an Arduino (Arduino ISP) Interfacing Motor through L293D Driver with Arduino
f. Interfacing Accelerometer with Arduino Interfacing of Relay Driver ULN2803 with Arduino
g. Build a flashing display to flash advertisement of Mobile shop.
h. Build a system to display department name using rolling display.
i. Build a buzzer system for rapid fire quiz competition.
j. Build a two digit counter.
k. Build a class period bell as per the given time table which includes 7 teaching periods and lunch hour.
l. Build a temperature monitoring system to maintain temperature in given range.
m. Build a pollution monitoring system to observe the level of CO_2.
n. Build automated door control system to open and close the door.
o. Build traffic light controller for traffic signals as per specified delay.
p. Build a water level controller for given water levels.

Note: Use appropriate software for programming. Build the circuit on PCB or use development board such as Arduino.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	8051 Microcontroller Architecture, Programming and Application	Ayala, Kenneth	Cenage learning, 3rd edition, New Delhi,2007, ISBN: 978-8131502006
2	The 8051 Microcontroller and Embedded system	Mazidi, Mohmad Ali; Janice, Gelispe and Mckinlay, Roline D.	Pearson, 2nd edition, Delhi, 2008, ISBN: 9788177589030
3	Microcontroller Principle and Application	Pal, Ajit	PHI, New Delhi,2014, ISBN: 9788120343924
4	Microcontroller Theory and Application	Deshmukh, Ajay	McGraw Hill Education, New Delhi, 2011, ISBN: 9780070585959
5	Microcontroller Architecture Programming, Interfacing and System Design	Rajkamal	Pearson Education India, Delhi, 2012, ISBN: 9788131759905
6	The Embedded Software Primer	David E. Simon	Addison-Wesley,Delhi ISBN: 9780201615692

14. SOFTWARE/LEARNING WEBSITES

a. Simulation Software :-www.keil.com
b. https://www.arduino.cc
c. https://scilab-arduino.fossee.in
d. www.nptel.ac.in/courses/Webcourse-contents/IITKANPUR/microcontrollers/micro/ui/Course_home2_5.html
e. www.nptelvideos.in/2012/11/real-time-systems.html
f. RTOS:- https://www.youtube.com/watch?v=rpdygqOI9mM
g. www.intorobotics.com/8051-microcontroller-programming-tutorials- simulators-compilers-and-programmers
h. www.electrofriends.com/articles/electronics/microcontroller-electronics-articles/8051-8951/80518951-microcontroller-instruction-set
i. www.ikalogic.com/part-1-introduction-to-8051-microcontrollers
j. www.binaryupdates.com/switch-with-8051-microcontroller
k. www.mikroe.com/chapters/view/64/chapter-1-introduction-to-microcontrollers
l. www.8051projects.net/download-c4-8051-projects.html
m. https://www.elprocus.com/difference-between-avr-arm-8051-and-pic-microcontroller

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ**

Semester : **Fifth**

Course Title : **Mobile and Wireless Communication**

Course Code : **22533**

1. RATIONALE

In this world of connectivity and collaborative work environment, it is necessary to connect to the network from anywhere, with anybody, at anytime. Wireless communication provides connectivity with mobility, flexibility and convenience. Wireless devices are used across the various industries like Healthcare, Education, Automation, Renewable energy sector, Automobile etc. Effective use of Social networking has become possible due to high end wireless devices. This course will help the students to develop skills to handle wireless and mobile communication systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain mobile communication systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above-mentioned competency:

a. Troubleshoot mobile handsets.
b. Assess cellular systems capacity.
c. Assess performance of standards of different cellular mobile systems.
d. Select relevant wireless technology suitable for various applications.
e. Test the performance of various wireless protocols.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

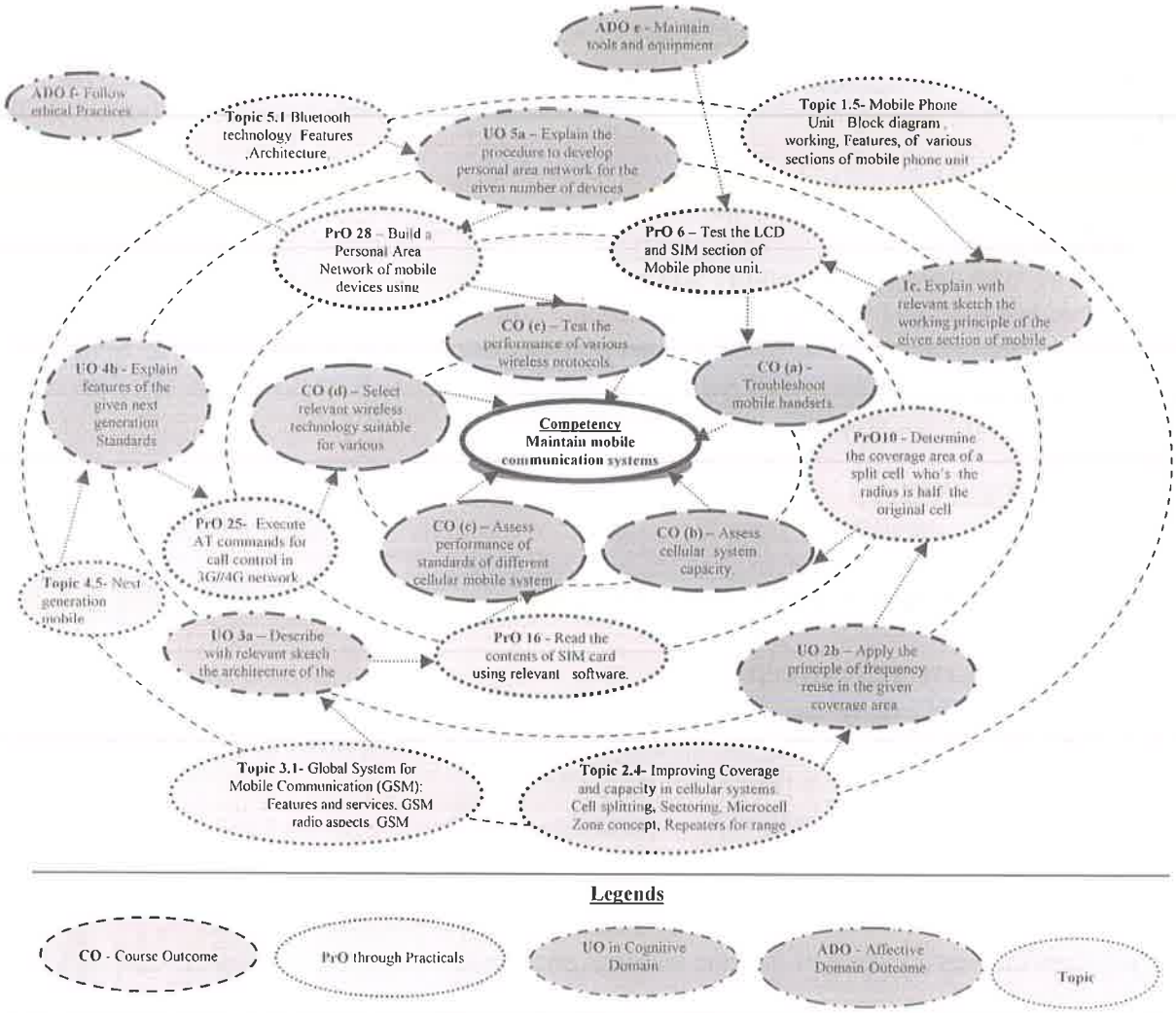

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify different sections and components of mobile phone such as ringer section, dialer section, receiver section and transmitter section, camera, microphone, speaker, flash light.	I	02*
2	Identify the inbuilt sensors of mobile handset and test their performance.	I	02
3	Perform cold test of different sections of mobile phone unit.	I	02*
4	Test the supply of the Transmitter /Receiver section of mobile phone unit.	I	02*
5	Test the Battery charger section and power management unit of	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	mobile phone unit.		
6	Test the LCD and SIM section of mobile phone unit.	I	02
7	Test the user Interface section (Keyboard Buzzer, Vibrator, LED, Mic, and Speaker) of Mobile phone unit.	I	02*
8	Troubleshoot the Battery charger section, LCD section and SIM card section of the mobile handset.	I	02*
9	Troubleshoot the speaker problem, Ringer problem, Microphone problem, vibrator problem (User Interface section).	I	02
10	Determine the coverage area of a split cell which has radius half the radius of original cell.	II	02*
11	Determine the channel capacity of a cellular system service area comprised of 4/7/12 microcells with 8/12/16 channels per microcell.	II	02*
12	Determine the channel capacity if each microcell in the above lab exercise split into 4 minicells and each minicell is further split into 4 microcells.	II	02
13	For the 7- cell cluster and 168-voice channels cellular system, determine the assignment of voice channel to each cell if Omni-directional antenna is used at the cell site.	II	02*
14	For the 7- cell cluster, 168-voice channels cellular system, determine the assignment of voice channel to each sector if 3-sector 120^0 and 6 -sector 60^0 directional antenna are used at the cell site.	II	02*
15	Perform installation, registration, activation and authentication of mobile applications on mobile handset.	III,IV	02
16	Read/Retrieve the contents of SIM card using relevant software.	III,IV	02*
17	Execute call control commands using relevant software.	III,IV	02*
18	Execute Network service commands using relevant software.	III,IV	02
19	Execute Security commands using relevant software.	III,IV	02
20	Execute Phone book commands using relevant software.	III,IV	02*
21	Execute Short message commands using relevant software.	III,IV	02*
22	Execute Data commands using relevant software.	III,IV	02
23	Execute Specific AT commands using relevant software.	III,IV	02
24	Execute AT commands for call control in 3G/4G network.	IV	02*
25	Execute AT commands for Video call and Phone camera related commands in 3G/4G network.	IV	02
26	Execute AT commands for Microphone and Loudspeaker volume control related commands in 3G/4G network.	IV	02
27	Build a Personal Area Network of mobile devices using Bluetooth.	V	02*
28	Test the hard reset function, hotspot and other networking functions of the given smart phone.	V	02
	Total		**56**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student*

reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Mobile Phone Trainer kit: Cellular System : EGSM/GSM 900/ 1800 MHz (3GDualband),Rx frequency band (Downlink): EGSM 900 : 925-960 MHz GSM 900 : 935- 960 MHz GSM 1800 : 1805-1880MHz Tx frequency band (Uplink) : EGSM 900 : 880- 890MHz GSM 900 : 890- 915 MHz GSM 1800 : 1710-1785MHz Output power : +5 ,+33 dBm / 3.2 mW , Channel spacing : 200 KHz Display : TFT, 256 K colours,128X 160 Pixels, 2.0", SIM support : Smart Dual SIM, Dual stand by (both GSM),Battery type : Li-Ion 1000m AH CPU : 208 MHz,Sound : Speaker and Earphone Jack (3.5 mm) On board sections : Keypad, Dual SIM, Charging.Circuit, Clock, User interface such as Buzzer,Vibrator, LEDs. Test points: 50 nos. (Gold plated)	1,2 to 8,

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Features that can be set :Screen savers, Ring tones, Logos, SMS	
2	3G GSM Mobile Phone trainer: GSM capability: GSM 900 /1800, E-GSM GSM data services: Asynchronous, Transparent & Non Transparent modes. 14.4 K bits/s, SIM Interface : 3 V RF , Transmitter : Maximum output power : 33 dBm +/- 236dB,(EGSM) Maximum output power : 30 dBm +/- 2 dB (DCS) Minimum output power : 5 dBm +/- 5 dB (EGSM) Minimum output power : 0 dBm +/- 5 dB (DCS1800)	2,4,5,6
3	Spectrum Analyzer: 9Khz to 1.5 GHz frequency range, Typical 135dBm Displayed average noise level(DANL) 80dBc/Hz @ 10KHz offset, phase noise Total amplitude Uncertainty <`1.5dB, 100Hz Minimum Resolution Bandwidth (RBW), Frequency Resolution 1Hz, Frequency span range 0 Hz, 100 Hz to maximum Frequency of instrument, Video bandwidth (-3db) 1Hz to 3 MHz in 1-3-10 sequence	2 to 08
4	Digital Multimeter (¾ Digital Multimeter): 4000 counts large LCD display with auto/manual range, No Power OFF under natural operation ,Data Hold, Max/Min value Hold Capacitance, Frequency/Duty Cycle	2 to 8
5	CRO: Bandwidth : DC-30 MHz (-3 dB)] Rise time : 12 ns approx Accuracy : ± 3 % Input Impedance : 1 MΩ 30 pF approx Sensitivity : Internal 5 mm, Ext 0.8 V approx Deflection coefficients : Micro-controller based 12 calibrated steps 5mV/Div – 20V/Div 1-2-5 sequence X-Y mode : Component Testing	2to 8
6	Digital Storage Oscilloscope : 100 MHz with 64K color TFT, 16kbps memory, FFT function, alternate triggering, Roll Mode, Math Function, digital filter, waveform recorder,20 automatic measurements, Standard USB host, USB device with waveform analysis software	2to 12
7	SIM Card Reader: Trainer for SIM card reader, USB SIM card reader, store, read and save the SIM card data	2 to 09
8	Fast Battery charger: 5 to 20 V,100W,1Amp or 2 Amp.	8 to 09
9	Mobile handset Tools:- **Tools** to repair any smart phone or **mobile phone** include - soldering iron, soldering station, solder wire, solder paste, liquid flux, paste flux, jumper wire, tweezers, screwdriver, multimeter, dc power supply, ESD-Safe antistatic wrist strap, mat, apron, hand gloves, LCD tester, Battery tester, PCB holder, PCB Cleaner	2 to 09
10	Computer system with 3G/4G modem	14 to 27

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (Uos) (in cognitive domain)	Topics and Sub-topics
Unit– I Wireless Communication System	1a. Explain the features of the given mobile radio standards. 1b. Describe with relevant sketch the working of the specified application of the mobile/ fixed wireless communication system. 1c. Explain with relevant sketch the working principle of the given section of mobile handset unit. 1d. Describe with relevant sketch the working of the given fixed wireless network system. 1e. Describe step-by-step trouble shooting procedure for the given section of mobile phone.	1.1 Wireless network generations 1.2 Mobile Radio standards- AMPS, N-AMPS, IS -95, GSM, UMTS, CDMA 2000 1.3 Mobile wireless systems : Cordless Telephone system and Cellular telephone system 1.4 Fixed wireless networks : Wireless Local Loop (WLL) & Local Multipoint Distribution System (LMDS) 1.5 Mobile Phone Unit : Block diagram , working, features, of transmitter, and receiver section, Frequency Synthesizer, Control unit and Logic Unit of Mobile phone, sensors: speakers, camera, touch screen, motion sensors and other common sensors
Unit– II Fundamentals of Cellular System	2a. Explain the given terms, with respect to Cellular systems. 2b. Apply the principle of frequency reuse for the given coverage area. 2c. Choose the handoff mechanism for the given situation with justification. 2d. Explain the effect of the given interference on cellular system performance. 2e. Select the relevant method to improve coverage and system capacity of the given cellular system with justification. 2f. Calculate number of traffic channels and control channels for the given frequency spectrum and the given frequency reuse ratio.	2.1 Cellular concept fundamentals: Cell, cell structure, Cluster, Reuse factor, minimum reuse distance, basic cellular system : mobile station, base station, Traffic channel (Forward and Reverse) , Control channel (Forward and Reverse), Frequency reuse, channel assignment strategies 2.2 Handoff strategies: Concept of handoff, Types of Handoffs: Hard, Soft, Queued, delayed, MAHO (Mobile Assisted Handoff) , Proper and Improper Handoff, Umbrella cell approach 2.3 Interference and system capacity: Co-Channel interference, Adjacent Channel Interference, Channel Planning for wireless systems 2.4 Improving Coverage and capacity in cellular systems: Cell splitting, Sectoring, Microcell Zone concept, Repeaters for range extension
Unit-III Digital Cellular Mobile Standards	3a. Describe with relevant sketch the architecture of the given 3G cellular standard. 3b. Explain features, of the given mobile communication standard. 3c. Describe with relevant sketch call	3.1 Global System for Mobile Communication (GSM): Features and services, GSM radio aspects, GSM architecture, GSM channel types, Security aspects 3.2 GSM call routing : Mobile terminated call and mobile

Unit	Unit Outcomes (Uos) (in cognitive domain)	Topics and Sub-topics
	processing stages in the given cellular standard. 3d. Describe with relevant sketch the layered architecture of the given SS7 protocol. 3e. Explain the features of the services and performance of the given type of signaling system.	originated call sequence , stages of call processing in GSM 3.3 IS-95/CDMA One: features, Radio aspects, comparison with GSM standards 3.4 Signaling System No.7 (SS7): Network services part(NSP) , Message transfer Part (MTP), Signaling Correction Control part (SCCP), Services and performance of SS7
Unit –IV Advance Wireless Standards	4a. Explain compatibility requirements of the given wireless standard. 4b. Explain features of the given next generation wireless standard. 4c. Describe with relevant sketch the functions of the given section of UMTS network architecture. 4d. Compare features of two given next generation mobile communication standards. 4e. Select the relevant wireless technology for the given application.	4.1 Need for 3G and 4G technology 4.2 IMT-2000 global standards: Vision, Compatibility, service and spectrum requirements 4.3 UMTS /W-CDMA standard: Features, architecture, UMTS Air-interface specification, security procedure 4.4 CDMA 2000, features and advanced versions, advantages of CDMA 2000 over 3G- GSM standards 4.5 Next generation mobile standards: Features of 4G & 4G LTE, VoLTE, 4.5G, 5G
Unit-V Wireless Network Technologies	5a. Explain the procedure to develop personal area network for the given number of devices using Bluetooth. 5b. Describe with relevant sketch given IEEE protocol standard for wireless communication networks 5c. Classify RFID tags on the basis of the given type of parameters. 5d. Compare the performance of given wireless network technologies based on given parameters. 5e. Describe with relevant sketch the given type of wireless networking technologies applications.	5.1 Bluetooth technology: Features, architecture, frequency band , IEEE 802.15.1 and other wireless protocol, applications , personal area network(PAN) 5.2 RFID: Concept, frequency band, classification of RFID tags, applications 5.3 WLAN technology: IEEE 802.11, WLAN system architecture, radio spectrum 5.4 WMAN /Wi-max/ :IEEE 802.16 WMAN and IEEE 802.16a Wimax 5.5 Mobile Ad-hoc networks (MANET's): MANET topologies, applications.

***Note**: To attain the Cos and competency, above listed Uos need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Wireless Communication System	10	04	04	04	12
II	Fundamental of Cellular System	12	04	04	04	12
III	Digital Cellular Mobile Standards	12	04	06	06	16
IV	Advance Wireless Standards	18	04	04	10	18
V	Wireless Network Technologies	12	02	04	06	12
Total		64	**18**	**22**	**30**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of Uos. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Visit nearby MTNL/BSNL exchange and prepare detail report of entire setup of their cellular system.
b. Visit nearby CDMA based cellular switching center and prepare details of the entire setup of their cellular system
c. Demonstrate the general steps to repair Mobile handset.
d. Prepare a detail list of equipment and software required to troubleshoot the mobile handset.
e. Interpret the IS code 15040:2010 CISPR 25:2008. (Radio Disturbance Characteristics for Protection of receivers Used on Board Vehicles, Boats and Internal Combustion Engines – Limits and Methods of Measurement)

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the Cos through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with Electronics communication and Digital communication(like: modulation ,wave propagation, Frequency modulation, multiplexing) .

g. Use proper equivalent analogy to explain different concepts.
h. Use Flash /Animations to explain functions of mobile handset.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more Cos which are in fact, an integration of PrOs, Uos and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented Cos.

A suggestive list of micro-projects is given here. The concerned faculty could add similar micro-projects:

a. Compare the specifications/ features / technology of different types of mobile phones available in the market (Min 12 specifications).
b. Collect the information regarding the special services provided by various mobile service providers (Min 4) in your area.
c. Prepare a report on TRAI regulations related to mobile communication.(spectrum allocation)
d. Prepare a report on FCC regulations for spectrum allocation/interference/ Qos for mobile communication.
e. Prepare a brief report on how radiations from BTS and handsets affect Human beings.
f. Market survey on various wireless devices available in the market.(wireless hands free, wireless speaker, wireless charger)
g. Prepare a short report on Li-Fi (light fidelity) technology.
h. Collect detailed information on various wireless technologies based on IEEE standard, frequency band, speed, range, advantages and disadvantages and submit the brief report of it.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mobile Cellular Telecommunications System	Lee, C. Y. William	Mcgraw Hill Education, New Delhi, 2017 ISBN-13: 978-0070635999
2	Wireless communication-Principles and practice	Rappaport, S.Theodore	Pearson publication New Delhi, 2005 ISBN: 978-81-317-3186-4
3	Wireless Communication	Singal, T. L.	McGraw Hill Education Private Limited, New Delhi, 2010, ISBN: 978-0-07-068178-1
4	Wireless and mobile network Architectures	Lin Yi-Bang Clamtac Imrich	John Wiley& sons, New Delhi,2001 ISBN : 978-81-265-1560-8

14. SOFTWARE/LEARNING WEBSITES

a. eBook:- www.philadelphia.edu.jo/newlibrary/.../file101fc6e5c77f4675b2958dc10a8c99c9.pdf
b. Mobile network standards:- https://gallucci.net/blog/gsm-cdma-and-lte-a-guide-to-mobile-network.../3/4
c. Mobile phone repairing tools and equipments : - www.mobilecellphonerepairing.com › Mobile Phone Repairing Tools
d. Bluetooth technology:- www.radio- electronics.com/info/wireless/Bluetooth /bluetooth_overview.php
e. VoLTE:- /www.gsma.com/futurenetworks/wp-content/uploads/2014/.../FCM.01-v1.1.pdf
f. The Evolution of mobile technologies: - https://www.qualcomm.com/.../the-evolution-of-mobile-technologies-1g-to-2g-to-3g-.
g. Wireless tutorials:- https://www.octoscope.com/English/.../octoScope_WirelessTutorial_20090209.pdf
h. 5G Wireless Technology:- https://www.qualcomm.com/invention/5g/technologies
i. Wireless Networks : NPTEL Video lectures :- https://www.youtube.com/watch?v=Eu_mTZxPofI
j. TRAI official website: www.trai.gov.in/

Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IS/IC**

Semester : **Fifth**

Course Title : **Industrial Automation (Elective for DE/EJ/ET/EN/EX/EQ)**

Course Code : **22534**

1. RATIONALE

In the present global scenario of manufacturing, industries are moving towards complete automation. Small and medium scale industries are in the phase of switching to PLC and SCADA technology for the data acquisition and control. Therefore, it is necessary for Electronics/Instrumentation engineers to have knowledge of both PLC and SCADA technology. This course attempts to provide basic knowledge of these technologies to develop operational competency. Hence this course is foundation for the engineers who want to further specialize in the Industrial automation field.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain Industrial Automation systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify different components of an automation system.
b. Interface the given I/O device with appropriate PLC module.
c. Prepare a PLC ladder program for the given application.
d. Select the suitable motor drives for the specified application.
e. Prepare a simple SCADA application.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs. ***Legends: L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

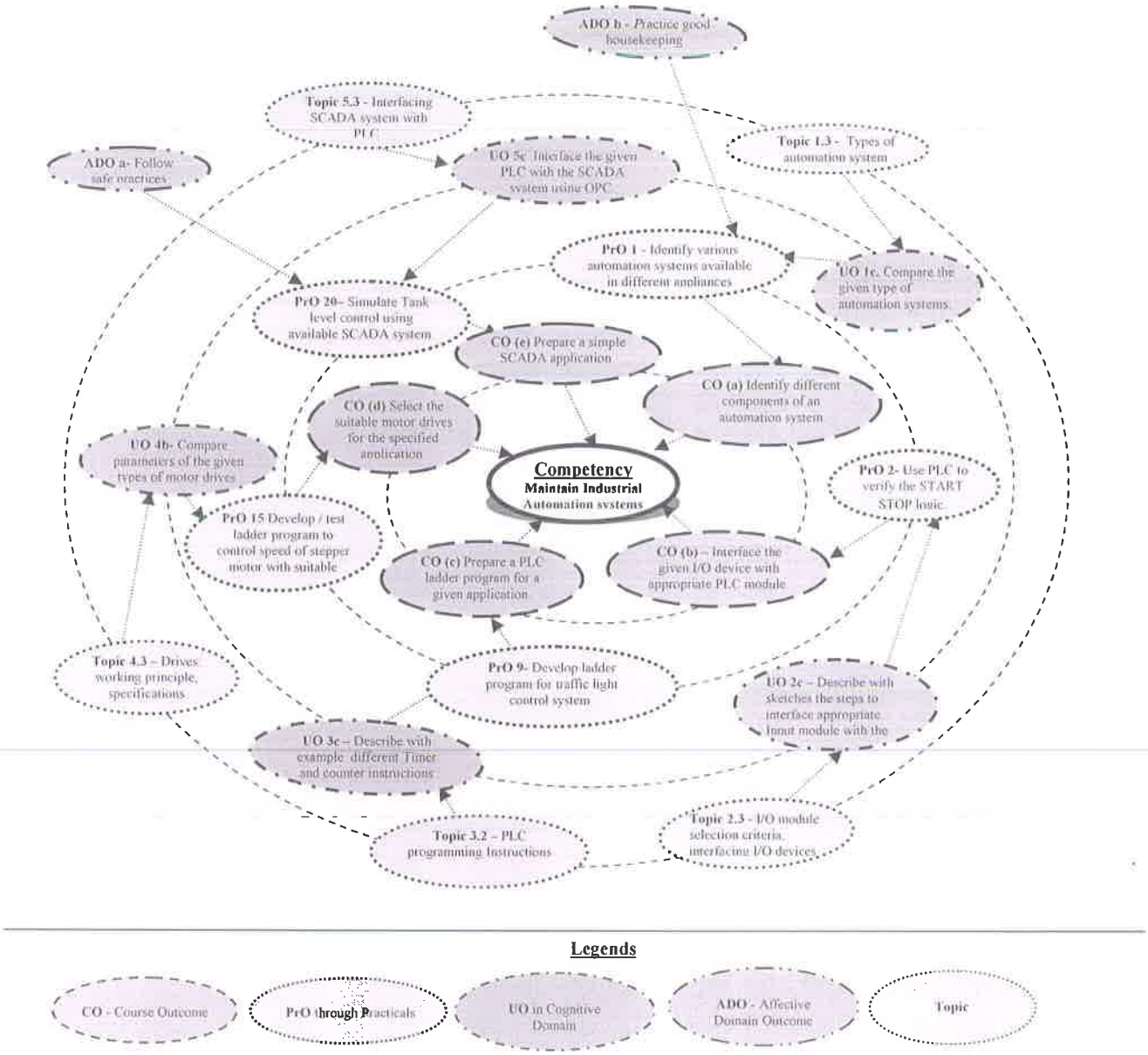

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify various automation systems available in different appliances/devices/machines in day-to-day use.	I	02
2	Identify various parts and front panel status indicators of the given PLC.	II	02
3	Use PLC to test the START STOP logic for two inputs and one	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	output system.		
4	Develop/Execute a ladder program for the given application using following:- timer, counter, comparison, logical, arithmetic instructions.	II,III	02
5	Use PLC to control the following devices : lamp, motor, push button switches, proximity sensor	II,III	02
6	Measure temperature of the given liquid using RTD or Thermocouple and PLC.	II,III	02
7	Develop/test ladder program to blink LED/lamp.	III	02
8	Develop and test the Ladder program for sequential control application of lamps/ DC motors.	III	02
9	Develop and test ladder program for traffic light control system.	III	02
10	Develop and test ladder program for pulse counting using limit switch /Proximity sensor.	III	02
11	Develop /test ladder program for automated car parking system.	III	02
12	Develop / test ladder program for automated elevator control.	III	02
13	Develop / test ladder program for rotating stepper motor in forward and reverse direction at constant speed.	III	02
14	Develop /test ladder program for tank water level control.	III	02
15	Develop / test ladder program to control speed of stepper motor with suitable drivers.	IV	02
16	a. Identify various front panel controls of Variable Frequency Drive (VFD) (smart drive). b. Control speed of AC/DC motor using VFD.	IV	02
17	Use various functions of SCADA simulation editors to develop simple project.	V	02
18	Develop a SCADA mimic diagram for Tank level control.	V	02
19	Develop SCADA mimic diagram for Flow control of the given system.	V	02
20	Simulate Tank level control using available SCADA system.	V	02
	Total		**40**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10

S.No.	Performance Indicators	Weightage in %
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	IEC 1131-3 compatible PLC with programming Software and interfacing hardware, user manual, (complete PLC Trainer system)	1
2	Input and Output devices for PLC: like Lamp, DC Motor, Proximity sensors, Thermocouple/RTD, Red, green, yellow LEDs, Stepper Motor, limit switches, push button	2,3,6
3	Nano PLC, Mini PLC, Micro PLC with analog and Digital I/O, memory, peripheral interfaces	1-16
4	Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools(open source)	1-13
5	Servomotor, DC motor, AC motor, steeper motor	14,15,16
6	Motor drives, drivers for special motors (VFD)	14,15,16
7	SCADA software: like Ellipse/FTVSE/Wonderware	14-16
8	Digital Multimeter (¾ Digital Multimeter): 4000 counts large LCD display with auto/manual range, No Power OFF under natural operation ,Data Hold, Max/Min value Hold Capacitance, Frequency/Duty Cycle	3 to 6

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Industrial Automation	1a. Describe the benefits of the given Industrial automation system. 1b. Describe functions of the given components of automation system. 1c. Compare the characteristics of the given type of automation systems. 1d. Describe applications of the given automation system.	1.1 Need and benefits of Industrial Automation 1.2 Automation Hierarchy, Basic components of automation system, description of each component 1.3 Types of automation system:- Fixed, programmable, flexible 1.4 Different systems for Industrial automation: PLC, HMI, SCADA, DCS, Drives
Unit– II PLC Fundamentals	2a. Explain with sketches the redundancy concept for the given PLC. 2b. Identify the specified parts of the given PLC along with its function. 2c. Describe with sketches the steps to interface appropriate Input module of the given PLC with the given input device. 2d. Explain the criteria to select appropriate module for the given I/O devices. 2e. Describe with sketches the steps to interface appropriate output device with the given output module of the given PLC.	2.1 Building blocks of PLC: CPU, Memory organization, Input-output modules (discrete and analog), Special I/O Modules, Power supply 2.2 Fixed and Modular PLC and their types, Redundancy in PLC module 2.3 I/O module selection criteria Interfacing different I/O devices with appropriate I/O modules
Unit-III PLC Programming and Applications	3a. Specify the proper I/O addressing format of the given PLC. 3b. Explain the use of different relay type instructions for the given operation. 3c. Use timer and counter instructions to write a program to perform the given operation. 3d. Use Logical and Comparison instruction to write a program to perform the given operation. 3e. Describe with example the given type of data handling instructions. 3f. Describe the given elements of different programming languages used to program PLC. 3g. Develop PLC ladder program for the given simple application. 3h. Describe a PLC ladder program	3.1 PLC I/O addressing 3.2 PLC programming Instructions : Relay type instructions, timer instructions: On delay, off delay, retentive, Counter instructions, Up, Down, High speed, Logical instructions, Comparison Instructions, Data handling Instructions, Arithmetic instructions 3.3 PLC programming language– Functional Block Diagram (FBD), Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming 3.4 Simple Programming examples using ladder logic: Language based on relay, timer counter,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	for the given industrial application.	logical, comparison, arithmetic and data handling instructions 3.5 PLC based applications: Motor sequence control, Traffic light control, elevator control, Tank level control, conveyor system, Stepper motor control, reactor control
Unit – IV Electric Drives and Special Machines	4a. Describe with sketches the working of the given type of drive(s). 4b. State the functions of the given type of V/F converter. 4c. Compare given parameters of the specified type of motor drives. 4d. Describe the application of the given type of drive(s).	4.1 Electric drives: Types, functions, characteristics, four quadrant operation 4.2 DC and AC drive controls: V/F control, Parameters, direct torque control 4.3 Drives: working principle, specifications, parameters, types and applications 4.4 Applications- Speed control of AC motor /DC Motor
Unit-V Supervisory Control and Data Acquisition System	5a. Describe the function of the given element of SCADA. 5b. Describe the steps to develop a simple SCADA screen for the given application. 5c. Interface the given PLC with the SCADA system using OPC. 5d. Describe the steps to develop SCADA system for the given industrial application.	5.1 Introduction to SCADA, typical SCADA architecture/block diagram, benefits of SCADA 5.2 Various editors of SCADA 5.3 Interfacing SCADA system with PLC: Typical connection diagram, Object linking and embedding for Process Control(OPC) architecture, Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and items) with PLC ladder program using OPC 5.4 Applications of SCADA: Traffic light control, water distribution, pipeline control

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Industrial Automation	04	02	04	-	06
II	PLC Fundamentals	12	04	06	08	18

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	PLC Programming and Applications	16	04	06	12	22
IV	Electric Drives and Special Machines	08	02	04	06	12
V	Supervisory Control and Data Acquisition System	08	02	04	06	12
Total		**48**	**14**	**24**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Do the internet survey and make a list of leading manufactures of the PLC, SCADA, DCS, HMI and other industrial automation tools with their brand name.
b. Refer operating manual of the PLCs of reputed Manufactures and prepare a step by step procedure to use PLC for the specified application.
c. Prepare a Power point presentation on the troubleshooting techniques of PLC.
d. Prepare the safety precautions list to be followed for installation of PLC system.
e. Download animated videos from the internet for any theory topic and make presentation on it.
f. Prepare a list of available analog input /output devices, digital input /output devices available in the market.
g. Guide the students for steps to be followed to configure available SCADA software.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Students can participate in the online industrial automation forums.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. **Automatic street light controller:** Prepare a PLC based system to control the street light as per the intensity of natural light.
b. **Automatic agriculture irrigation system:** Prepare a PLC based system to control drip irrigation.
c. **Railway gate automation:** Prepare a PLC and SCADA based system to open or close the proto type railway gate automatically.
d. **Home automation:** Implement the versatile automation system for home that can automate any three home appliances.
e. **Bottle filling station:** Prepare a PLC and SCADA based system for proto type bottle filling station.
f. **Troubleshoot the Faulty Equipment/Kit available in automation Laboratory.**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN : 9788174092281
2	Programmable logic controllers	Petruzella, F.D.	Tata – McGraw Hill India, New Delhi, Fourth edition,2010, ISBN: 9780071067386
3	Programmable logic controllers and Industrial automation An introduction	Mitra, Madhuchandra; Sengupta, Samarjit	Penram International Publication, New Delhi, 2015, Fifth reprint, ISBN: 9788187972174
4	Introduction to Programmable logic controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN 13 : 9781401884260
5	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication New Dxelhi (4th edition) ISBN: 978-1936007097
6	Programmable logic controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003 ISBN : 9780130607188

S. No.	Title of Book	Author	Publication
7	Industrial automation and Process control	Stenerson, Jon	PHI Learning, New Delhi, ISBN : 9780130618900
8	Practical SCADA for Industry	Bailey, David ; Wright, Edwin	Newnes (an imprint of Elsevier)international edition, 2003 ISBN: 0750658053

14. SOFTWARE/LEARNING WEBSITES

a. Software:- www.fossee.com
b. Software:- www.logixpro.com
c. Software:- www.plctutor.com
d. Software;-www.ellipse.com
e. PLC lecture:- https://www.youtube.com/watch?v=pPiXEfBO2qo
f. PLC tutorial:-http://users.isr.ist.utl.pt/~jag/aulas/api13/docs/API_I_C3_3_ST.pdf

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Diploma in Digital Electronics /Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ**

Semester : **Fifth**

Course Title : **Microwave and RADAR**

Course Code : **22535**

1. RATIONALE

Microwave communication is the back bone of terrestrial communication and also the sole of mobile communication. To provide communication at difficult geographical locations and for specific task microwave links and RADAR are the established telecommunication solution. This course has been designed to develop skills in the diploma engineers to maintain microwave and RADAR based telecommunication systems.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain microwave and RADAR based communication systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use specified waveguides in microwave communication system.
b. Maintain passive microwave components and devices.
c. Maintain active microwave components and devices.
d. Interpret RADAR based systems for range detection.
e. Maintain various types of RADAR system for the specified application.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

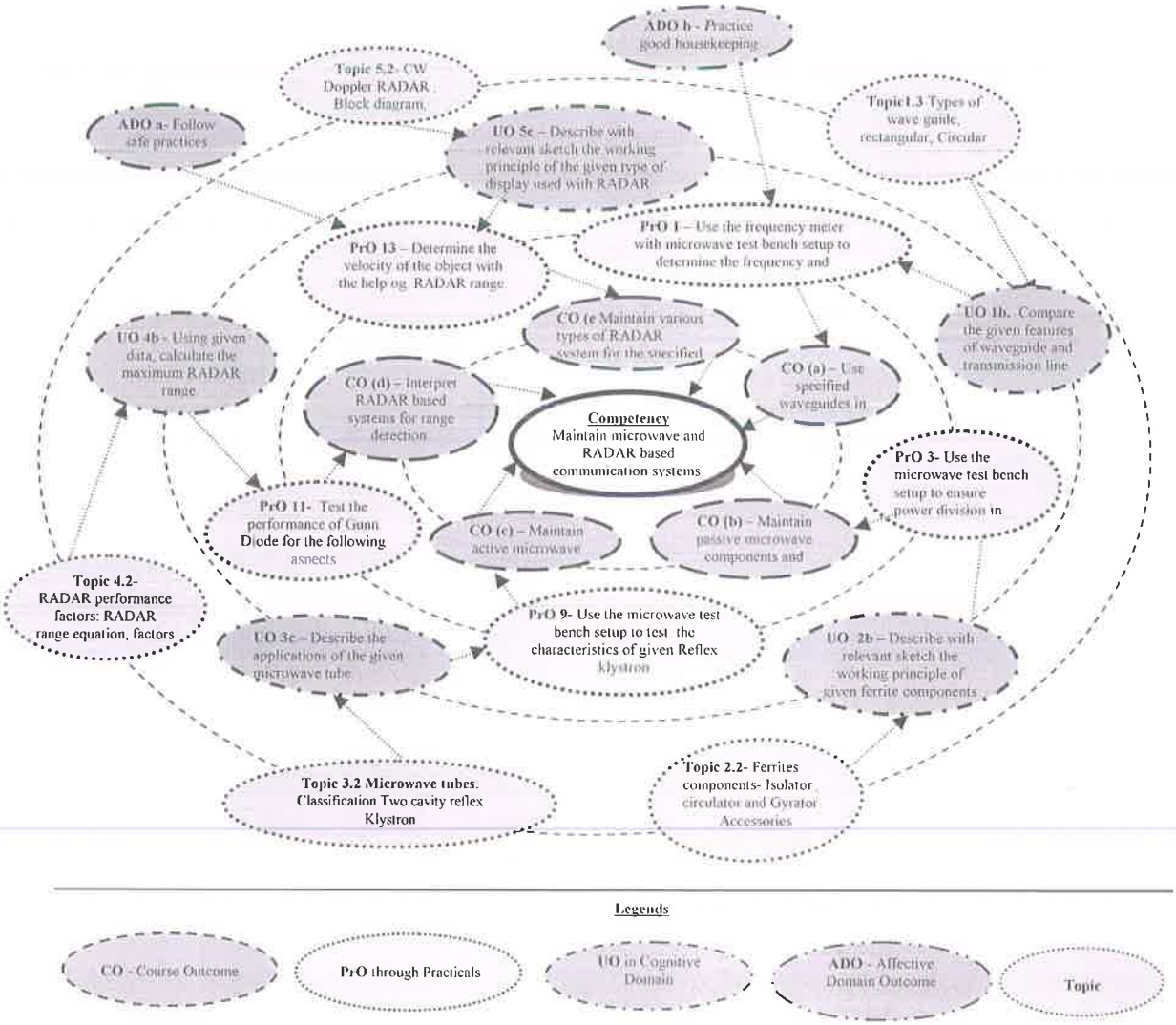

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use the frequency meter with microwave test bench setup to determine the frequency and wavelength of waveguide for TE10 mode.	I	02*
2	Use freeware/open source simulation tools to perform Practicals related to microwave waveguide .	I	02
3	Use the microwave test bench setup to ensure power division in microwave tees E-plane, H-plane and E-H plane.	II	02*
4	Determine coupling factor and insertion loss for the given circulator.	II	02
5	Measure VSWR for the given Microwave load.	II	02*
6	Measure attenuation of the given attenuator.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Determine the directivity, insertion loss and coupling factor for the given Multi- Hole Directional Coupler.	II	02
8	Use given microwave test bench setup to measure the gain of the horn antenna.	II	02
9	Use the microwave test bench setup to test the performance of the given Reflex Klystron tube.	III	02*
10	Test the performance parameter of the given type of microwave active components on freeware/open source simulation tools.	IV	02
11	Test the performance of Gunn Diode for the following aspects i. V-I characteristics ii. Output power and frequency as a function of voltage	IV	02*
12	Use Doppler RADAR to detect the maximum range .	V	02*
13	Determine the velocity of the moving object with the help of RADAR range.	V	02
14	Use RADAR system to measure the distance traveled by any object.	V	02
15	Use freeware/open source simulation tools to performance Practical related to RADAR communication.	V	02
	Total		**30**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Microwave Test Bench –X Band (Klystron based)** / or any other equivalent, Klystron Power Supply, Klystron tube with Klystron mounts, Frequency meter, Variable attenuator, Detector mount, Wave guide stand, SWR meter and oscilloscope, E Plane Tee, H Plane Tee and Magic Tee Isolator and Circulator, Directional Coupler, Horn Antenna proto type	1 To 10
2	Microwave test bench –X Band (GUNN Diode based)/ or any other equivalent, Gunn oscillator, Gun power supply, PIN modulator, Isolator, Frequency meter, Variable attenuator, Detector mount, Wave guide stands, SWR Meter, Cables and accessories	11
3	RADAR Trainer (X Band)/or any other equivalent Technical Specifications: Transmitting Frequency : 10 GHz, Output Power : 10 to 15mW, Operating Voltage : 8.6V or adjustable, Antenna : Horn and parabolic dish with LNA and mounting IF Output : Audio range, Power Supply : 230V ± 10%, 50Hz	12,13, 14
4	**List of Software/Learning Websites** List of software RF Tool box: MATLAB and SIMULINK or any other open source software. EZNEC, HFSS-CST, VSim, Microwave office	15

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Fundamentals of Microwave communication and Waveguides	1a. Summarize the range and applications of the given microwave frequency bands. 1b. Compare the given parameters of waveguide and transmission line. 1c. Explain the properties of the given parameters for the circular waveguide with example. 1d. Calculate the cut off wavelength, cut off frequency, group and phase velocity of the given rectangular waveguide. 1e. Describe with relevant sketch the field pattern of the given mode of rectangular waveguide. 1f. Compare the features of circular and rectangular waveguide for the given parameters.	1.1 Microwave frequency spectrum , band designations and applications of microwave in various fields 1.2 Comparison of wave guide with Transmission line 1.3 Types of Waveguides: Rectangular ,Circular , Propagation of waves in rectangular waveguides Reflection of waves from a conducting plane, dominant mode, The parallel plane waveguide, cut off wavelength, cut off frequency, group and phase velocity (Simple numerical) 1.4 Rectangular waveguide modes: TE ,TM TEM, field patterns of TE1,0,TE2,0,TE1,1 modes 1.5 Circular waveguide: Advantages, disadvantages and applications of circular waveguide
Unit– II Microwave Passive Components	2a. Describe with relevant sketch operation of the given microwave passive component. 2b. Describe with relevant sketch the working principle of given ferrite components. 2c. Describe the procedure to built/prepare the microwave test bench setup with the help of given microwave accessories and components 2d. Explain functions of the given parameters for a directional coupler.	2.1 Multiple Junctions : Working principle and applications of - E plane, H- plane , Magic Tee and Rat race ring 2.2 Ferrites components- Isolator , circulator and Gyrator Accessories: Flanges, Rotating coupling, Bends and corners, Taper and Twist 2.3 Directional couplers : Two hole directional coupler- Working principle and applications , directivity, coupling factor and isolation 2.4 Basic microwave antenna (Horn and Dish)
Unit-III Microwave Active Components	3a. Describe with relevant sketch the concept of velocity modulation and bunching effect for the given microwave tube. 3b. Prepare/Draw the apple gate diagram for the given parameters of the microwave tube. 3c. Describe the applications of the given microwave tube. 3d. Compare the performance of	3.1 Microwave tubes Classification Two cavity ,Reflex klystron i. Construction ii. Modulation iii. Bunching process iv. Principle of operation v. Magnetron: construction , operating principle and applications 3.2 Slow wave devices: Helix TWT construction and principle of operation and applications

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Klystron, Magnetron and TWT on the given parameters. 3e. Describe with relevant sketch the transfer electron effect for the given energy level diagram of Gunn Diode. 3f. Describe with relevant sketch the operation of the given active microwave component.	3.3 Compare the performance of Klystron, Magnetron and TWT. 3.4 TED (Transferred Electron Devices): Gunn diode – construction, operation principle, modes and application of Gunn diode as an oscillator Avalanche transient time device: 3.5 IMPATT diode - construction, operation and applications 3.6 PIN diode-. construction, operation and applications Esaki diode: Tunnel diode –V-I Characteristics, equivalent circuit, application as an oscillator and as an amplifier
Unit-IV RADAR Fundamentals	4a. Describe with relevant sketch functions of the given component of the RADAR system. 4b. Calculate the maximum RADAR range for the given data. 4c. State the affect on the RADAR range for the given the parameters. 4d. Explain with relevant sketch the given type of scanning and tracking methods used for RADAR communication. 4e. Describe with relevant sketch the construction and working of the given microwave antenna.	4.1 Basic block diagram of RADAR system 4.2 RADAR performance factors: RADAR range equation, factors influencing range, effect of noise 4.3 Basic pulse RADAR system: Block diagram and description, applications 4.4 Antenna Scanning (types and principle): Horizontal, vertical, helical and spiral. Antenna Tracking (types and principle): Sequential, conical and mono pulse 4.5 Antenna feed Mechanism: horn and cassegrain feed antenna
Unit –V RADAR Systems	5a. Explain with relevant sketch working principle of the given type of RADAR. 5b. Describe the applications of the given type of RADAR. 5c. Describe with relevant sketch the working principle of the given type of display used with RADAR system. 5d. Compare CW and Pulsed RADAR for the given parameters. 5e. Describe with relevant sketch	5.1 Doppler effect 5.2 CW Doppler RADAR : Block diagram, operation and application FM CW RADAR: Block diagram, operation and application 5.3 MTI: Block diagram, operation concept of blind speed, application, Automatic target detection RADAR 5.4 Display Methods: A-Scope: PPI, Beacons 5.5 SONAR system :working principle and applications

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the applications of the given SONAR system.	

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Microwave communication and Waveguides	08	04	04	06	14
II	Microwave Passive Components	08	04	04	04	12
III	Microwave Active components	16	06	08	06	20
IV	RADAR Fundamentals	08	04	04	04	12
V	RADAR Systems	08	04	04	04	12
Total		**48**	**22**	**24**	**24**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare chart showing various microwave components.
b. Prepare /download an animation and share with the class to illustrate the working principle of the following
   i. Microwave Tubes
   ii. EM wave propagation.
c. Visit a place where waveguides are used for microwave communication (such as earth Station, Radio station, telephone exchange, airport, TV broadcast, navigation center) and prepare the report.
d. Conduct a Library / Internet based survey of microwave components.
e. Interpret the various BIS Code for microwave communication.
f. Compare specifications of at least two different types of RADAR system.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain various microwave components, tubes and RADAR systems.
h. Use open source /MATLAB models to explain different concepts of microwave devices.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Market survey of consumer microwave equipments with respect to working principle, manufacturer, technical specification and submit the detail report of it.
b. Prepare survey report on mobile van used for live telecast of any event.
c. Prepare a report on the applications of RADAR for Defense and Air navigation.
d. Prepare power point presentation to explain working of various microwave components and Microwave tubes.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	RADAR systems and radio aids to navigation	Sen, A. K. and Bhattacharya, A. B.	Mercury Learning & Information, PVT.LTD. New Delhi, 2017,ISBN: 978-1683921189
2	Microwave Engineering	Das, Annapurna and Das, S. K.	Mc Graw Hill, New Delhi(3rd edition 2017, ISBN: 978-9332902879
3	Microwave Engineering	Gupta, Sanjeev	Khanna Publication, Nai sadak Delhi (3rd edition,2015, ISBN: 9788174090878
4	Microwave and RADAR Engineering	Gautam, A. K.	S K Kataria Publications, New Delhi 2012, ISBN: 978-9350141519
5	Fundamentals of	Sharma, K.K.	S.Chand and Company PVT. LTD.

S. No.	Title of Book	Author	Publication
	Microwave and RADAR Engineering		New Delhi,2011, ISBN:9788121935371
6	Electronics Communication System	Kennedy, George; Davis, Brendan ; Prasanna, Srm	Mc Graw Hill, New Delhi,5th edition,2011,ISBN: 978-0071077828
7	Microwave devices and circuits	Liao Samuel Y	PHI Learning ,New Delhi,(Latest Edition), ISBN: 978-8131762288
8	Microwave and RADAR Engineering	Kulkarni, M.	Umesh Publications, New Delhi,2009,ISBN978-8188114009

14. SOFTWARE/LEARNING WEBSITES

a. Microwave components:-www.youtube.com /microwave components and devices
b. RADAR:-www.youtube.com /RADARs
c. Microwave fundamentals:-www.nptelvideos.in/microwave engineering
d. Microwave:-www.learnerstv.com/free-engineering
e. Rectangular Waveguides:- www.ece.uprm.edu/ppt/rectangularwave
f. Waveguide:- www.academia.edu/waveguide
g. Microwave engineering Book:- monitor.westernfriend.org/microwave-engineering-by-sanjeev-gupta.pdf

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