Maharashtra State Board of Technical Education, Mumbai

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

Program Name : Diploma in Automation and Robotics

Program Code : AO — **With Effect From Academic Year: 2020 - 21**

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						
				L	T	P		Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
									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	Artificial Intelligence and Machine Learning in Robotics	AIM	22589	4	--	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
3	Embedded Systems	ESY	22590	4	--	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
	Elective-I (Any one)																				
4	Industrial Process Control	IPC	22591	3	--	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Industrial Robotics and Applications	IRA	22592																		
5	Industrial Training	ITR	22057	--	--	6	6	--	--	--	--	--	--	--	75#	30	75	30	150	60	150
6	Capstone Project Planning	CPP	22058	--	--	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20	50
			Total	14	--	18	32	--	280	--	120	--	400	--	225	--	225	--	450	--	850

Student Contact Hours Per Week: **32 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **850**

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/ Diploma in Automation and Robotics**

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/AO**

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					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					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

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

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 after the finalization 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?

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)							

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	i. Take care of more than three POs ii. Scope of problem/task very clear	02	
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest	02	
Second Progressive Assessment (at the end of 12th week)							
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)	02	
4	**Execution of Plan in fifth semester (please write by hand about students performance in appropriate column)**					02	
5	**Log Book**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week	03	
Third progressive Assessment at the end of 14th week							
6	Portfolio Preparation	Answer to only few of the 'questions from self' (prompts)	Answer to only about 50% of the 'questions from self'	Answer to most of the 'questions from self' (prompts) written. Some	Answer to nearly all the 'questions from self' (prompts) written in detail		

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
		written. Answers are not in much detail	(prompts) written. Answers are not in much detail	answers are not in much detail			
7	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions omitted, some details are wrong Nearly sufficient and correct details about methods, material, precautions and conclusion. but clarity is not there in presentation, not enough graphic description.	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables, charts and sketches	**04**	
8	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented	**03**	
9	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly	**04**	
					Total marks	**25**	

Any Other Comment:

.....

.....

Name and designation of the Faculty Member.....**Signature**.....

.....

Program Name : **Diploma in Automation and Robotics**

Program Code : **AO**

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						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					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.

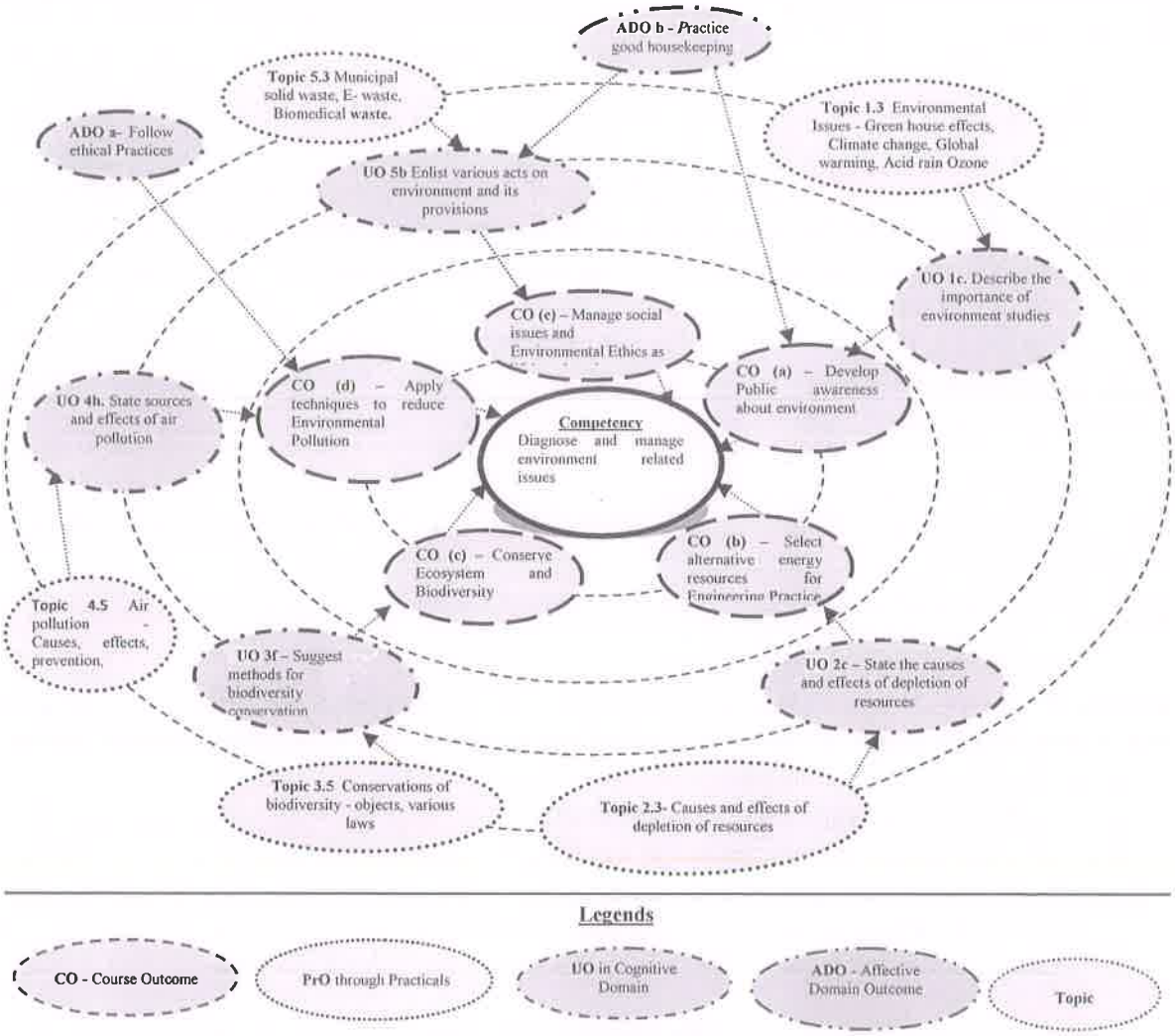


Figure 1 - Course Map

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
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)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		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. 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.	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 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.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	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.	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	4	16
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 .

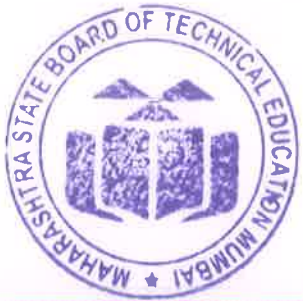
e. **Collection of Data from Hospital: Collect** everyday information on percentage of solid hazardous and toxic waste for two month
f. **Visit of Municipal Effluent Treatment Plant:** Visit effluent treatment plant and prepare report on waste management.
g. **Visit of Water Treatment Plant:** Visit 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


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : Diploma in Automation and Robotics
Program Code : AO
Semester : Fifth
Course Title : Artificial Intelligence and Machine Learning in Robotics
Course Code : 22589

1. RATIONALE

AI which stands for artificial intelligence refers to systems or machines that mimic human intelligence to perform tasks and can iteratively improve themselves based on the information they collect. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems. Machine learning is a subfield of artificial intelligence.. AI has played a very major role not only in increasing the comforts of humans but also by increasing industrial productivity which includes quantitative as well as qualitative production and cost-efficiency. AI gives robots a computer vision to navigate, sense and calculate their reaction accordingly. Robots learn to perform their tasks from humans through machine learning which is again a part of computer programming and AI. Students will be able to learn how AI and Machine Learning can improve Robotics.

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 Robotic systems through AI and ML.

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. Build AI intelligent agents for problem solving.
b. Choose relevant AI search strategies for problem solving.
c. Interpret the features and functions of predictive modeling in ML.
d. Apply supervised machine learning algorithms for solving problems.
e. Use unsupervised machine learning for solving practical problems.

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 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 center of this map..

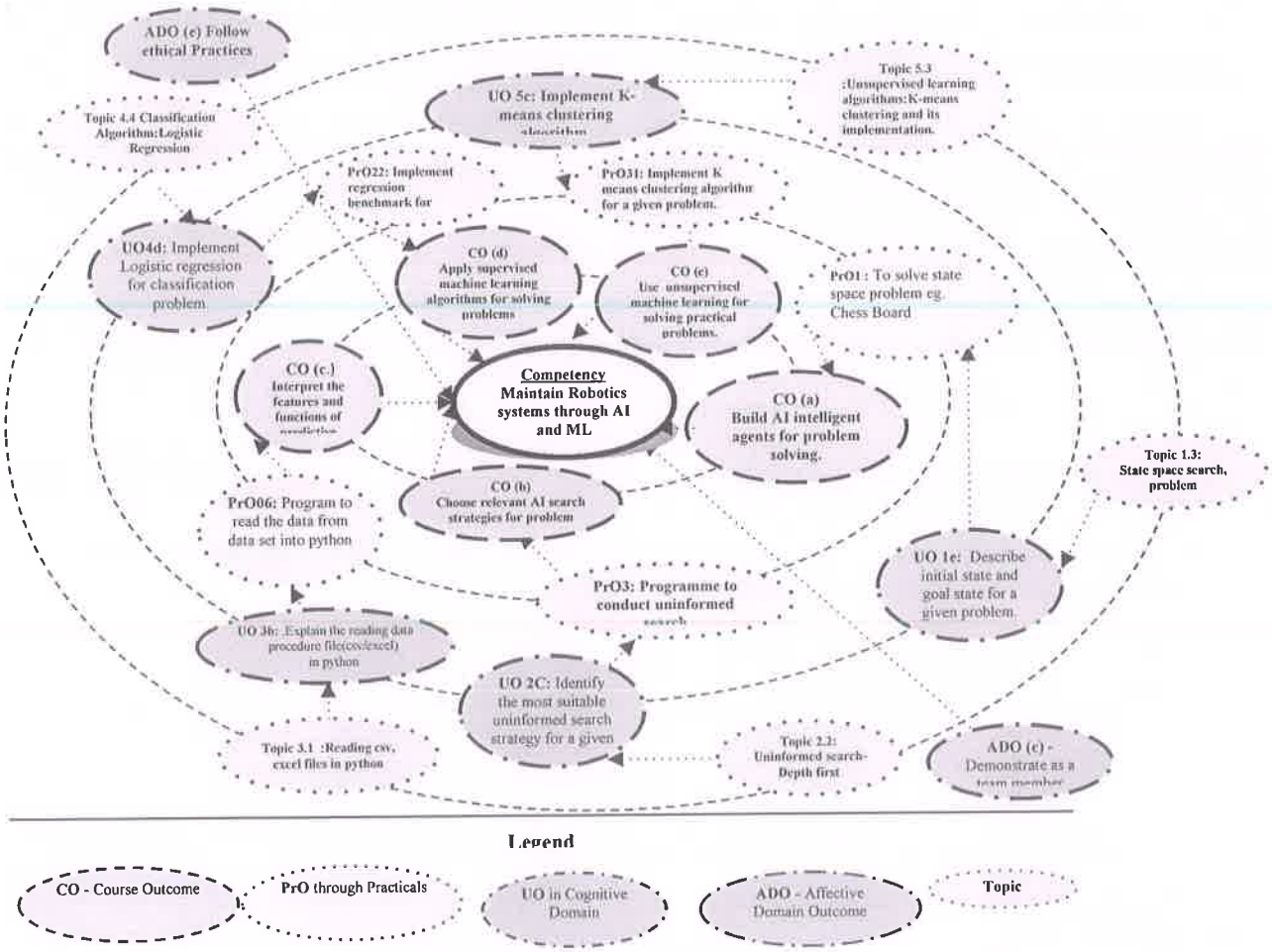
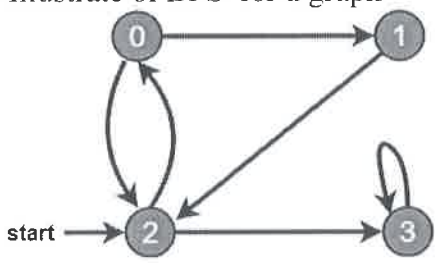
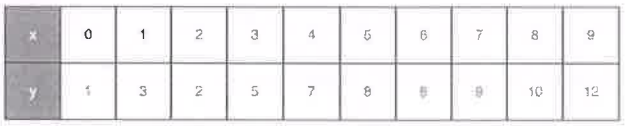


Figure 1 - Course Map

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	Solve the following problem as a state space problem- Pegs and Disks problem	I	2
2	Solve the following problem as a state space problem -The problem is to place 8 queens on a chessboard so that no two queens are in the same row. column or diagonal	I	2
3	Write a program to Illustrate of BFS for a graph 	II	2*
4	Install and configure Anaconda installer Python 3.9 version and 64-bit on Windows.	III	2*
5	Write a program to read the data from a given data set(titanic or iris or any other binary/multiclass) into python.	III	2*
6	Write a program to identify the variables from the dataset(titanic or iris or any other binary/multiclass) into python.	III	2*
7	Write a program for Data Exploration Univariate analysis of continuous variables from the data set (titanic or iris or any other binary/multiclass) in python.	III	2*
8	Write a program for Data Exploration Bivariate analysis of continuous variables from the dataset(titanic or iris or any other binary/multiclass) in python	III	2*
9	Write a program to treat missing values from the dataset(titanic or iris or any other binary/multiclass) in python	III	2*
10	Write a program to univariate and bivariate outlier treatment from the dataset(titanic or iris or any other binary/multiclass) in python	III	2
11	Write a program for variable transformation from the dataset(titanic or iris or any other binary/multiclass)in python	III	2*
12	Write a program to split available dataset into training and test set	III	2*
13	Write a program for Evaluation Metrics in ML for Classification Problems	III	2

14	Write a program to evaluate the confusion matrix.	III	2*
15	Write a program to evaluate accuracy, precision, sensitivity and specificity evaluation metrics	III	2*
16	Write a program to implement k-fold cross validation.	III	2*
17	Write a program to implement hold-out validation.	III	2
18	Implement Simple linear regression for predicting a response using a single feature.  	IV	2*
19	Implement regression benchmark for given predictive model	IV	2
20	Implement classification benchmark for given predictive model	IV	2
21	Implement logistic regression algorithm for any database (titanic or iris or any other binary/multiclass) ..	IV	2*
22	Write a program to implement multi class classification for iris data set	IV	2*
23	Implement support vector machine algorithms for any database (titanic or iris or any other binary/multiclass) .	IV	2*
24	Implement Decision tree algorithm for any database (titanic or iris or any other binary/multiclass) .	IV	2*
25	Write a program to tune hyperparameter in random forest classification problem,	IV	2*
26	Implement linear regression algorithm.	IV	2*
27	Implement KNN algorithm for classification problem for a given data set.(titanic or iris or any other binary/multiclass)	IV	2
28	Implement K means clustering algorithm for a given problem..	V	2
29	Study various applications of AI and ML in Robotics.	V	2*
		Total	**58**

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 %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	PrO. S. No.
1	Computer System (Any computer system with basic configuration)	1-29

2	Python Interpreter/ IDE	1-29
3	Anaconda-Jupyter notebook-Python 3.9 • 64-Bit Graphical Installer • 594 MB	1-29
4	Google colab-cloud service Supports libraries of PyTorch, Keras, TensorFlow, and OpenCV	1-29

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 Artificial Intelligence	1a. Describe the interaction between the given agent and environment. 1b. Describe the salient features of a given agent. 1c. Explain performance measures used to evaluate a given agent. 1d. Explain the environment in artificial intelligence. 1e. Describe initial state and goal state for a given problem.	1.1 Introduction– Definition of AI, AI history. 1.2 Introduction to Agents-Define agent, agent performance,Agent faculties. Examples of agents-Robots, Softbots, Expert systems, autonomous spacecraft, intelligent buildings 1.3 Intelligent Agents, Rationality, Environment- Observability, Determinism, Episodicity, Dynamism and Continuity.(Only definitions) 1.4 State space search- Goal directed agent, State Space Search Notations-Initial state, action or an operator, plan, path cost.
Unit II: AI Search Algorithms	2a. Explain key issues of search strategies. 2b. Explain various search strategies 2c. Illustrate Breadth First Search for a graph. 2d. List different uninformed search strategies. 2e. List different informed search strategies	2.1 Search Problem-Representation of search problems, Illustration of Search process 2.2 Basic search algorithm, Key issues, Evaluating various search strategies. 2.3 Uninformed search-Various types of Uninformed search, Breadth First Search-Algorithm, Illustration of BFS for a graph 2.4 Informed search-Various types of informed search

Unit III: Introduction to Machine Learning	3a.Explain the Installation process of Anaconda Jupyter Notebook 3b.Explain the reading data procedure file(csv/excel) in python 3c.Explain the machine learning workflow. 3d.Explain how to evaluate performance of model using evaluation metrics. 3e.Explain the significance of hyper parameter tuning to improve the accuracy of the model. 3f. List various cross validation methods in machine learning	3.1 Definition of Machine Learning. Reading csv, excel files in python, 3.2 Classification of Machine learning- Supervised and Unsupervised, and Reinforcement 3.3 Introduction to Predictive modeling. Stages of predictive modeling(Machine learning Pipeline)- Problem definition, Hypothesis generation, Data Extraction/collection, Data exploration and transformation, Splitting dataset into training and test set, Model selection, Model deployment / implementation. 3.4 Evaluation Metrics - Confusion matrix Accuracy, Precision and Recall, Sensitivity and Specificity. 3.5 Validation-k-fold cross validation, Hyperparameter tuning.
Unit IV: ML Supervised Learning	4a. Describe supervised learning. 4b. Explain the procedure of Implementation of Simple Linear Regression Algorithm 4c. Differentiate Binary, Multi class and Multi label 4d. List key points of Logistic regression for classification problems. 4e. List key points of the Decision tree for classification problems. 4f. List key points of Random forest for classification problems.	4.1 Supervised learning: Regression and Classification 4.2 Regression: Implementation of Simple Linear Regression Algorithm 4.3 Classification: Binary, Multi class and Multi label(Only definition) 4.4 Classification Algorithm: K-Nearest Neighbors, Logistic Regression, Support vector machine, Decision tree, Random forest(No mathematical derivation, only key points of each algorithm)
Unit V: ML Unsupervised Learning	5a. Explain an unsupervised algorithm. 5b.Compare clustering and association unsupervised algorithms.	5.1 Working of unsupervised learning algorithms 5.2 Types: Clustering and Association 5.3 Unsupervised learning algorithms: K-means clustering (Key points)

	5c. List key points of K-means clustering algorithm. 5d. List and explain the given applications of AI and ML in robotics.	5.4 Application of AI and ML in Robotics-Computer vision, AI enabled manipulation and grasping, AI enhanced navigation and motion control, Real world perception and natural language processing.

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'

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 Artificial Intelligence	06	04	04	02	**10**
II	AI Search Algorithms	06	04	04	02	**10**
III	Introduction to Machine Learning	18	04	10	08	**22**
IV	ML Supervised Learning	10	04	06	06	**16**
V	ML Unsupervised Learning	08	04	04	04	**12**
	Total	**48**	**20**	**28**	**22**	**70**

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 a chart displaying the various types of search algorithms.
b. Prepare a chart displaying the various types of machine learning
c. Prepare a chart displaying the various types regression type algorithm supervised learning
d. Prepare a chart displaying the various types of classification type algorithm supervised learning.
e. Prepare a chart displaying the various types unsupervised learning algorithms

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
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/subtopics*** which are 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. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab
i. Use proper equivalent analogy to explain different concepts.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student 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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a 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 a 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 a 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. Housing Prices Prediction Project
b. Stock Price Prediction using Machine Learning
c. Titanic Survival Project
d. Iris Flowers Classification Project
e. Fake News Detection Project
f. Credit Card Fraud Detection Project
g. Movie Recommendation System using Machine Learning

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Artificial Intelligence	Rich and Knight	Tata Mcgraw Hill Education Private

			Limited ISBN-13:978-0-07-067816-3
2	Artificial Intelligence-A modern approach	Stuart Russell, Peter Norvig. Russell /. Norvig	Pearson ISBN-13: 978-0-13-604259-4, ISBN: 0-13-604259-7
3	A Classical Approach to Artificial Intelligence	trivedi, M.C	Khanna Publishing House, Delhi.ISBN-13: 978-81-906988-9-4
4	Python machine learning by example	Yuxi Liu	Packt PublishingISBN-13: 978-1-78355-311-2
5	Machine learning	Tom M. Mitchell, Ryszard S.	Morgan Kaufmann Publishers ISBN-13: 978-0-08-051054-5
6	Practical Machine Learning with Python	Dipanjan Sarkar Raghav Bali Tushar Sharma	Apress-ISBN-13 (pbk): 978-1-4842-3206-4

14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

https://nptel.ac.in/courses/106105077
https://nptel.ac.in/courses/106106126
https://aima.cs.berkeley.edu
https://ai.berkeley,edu/project_overview.html (for Practicals)

Program Name : **Diploma in Automation and Robotics**

Program Code : **AO**

Semester : **Fifth**

Course Title : **Embedded Systems**

Course Code : **22590**

1. RATIONALE

Embedded systems play a vital role in Automation & Robotics engineering. It is dealing with the design, construction, and operation of robots. This course helps the Automation and Robotics diploma graduates to understand and apply the concepts and principles of sensors and actuators interfaced with different microcontrollers. Students will also be able to develop the hands on skills to design, develop and maintain different 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 microcontroller for various industrial applications.
b. Interpret the features and functions of AVR microcontrollers.
c. Use Embedded C programming language to maintain embedded systems.
d. Develop the basic applications using Arduino.
e. Interpret the communication standards of embedded 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	-	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 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 center of this map..

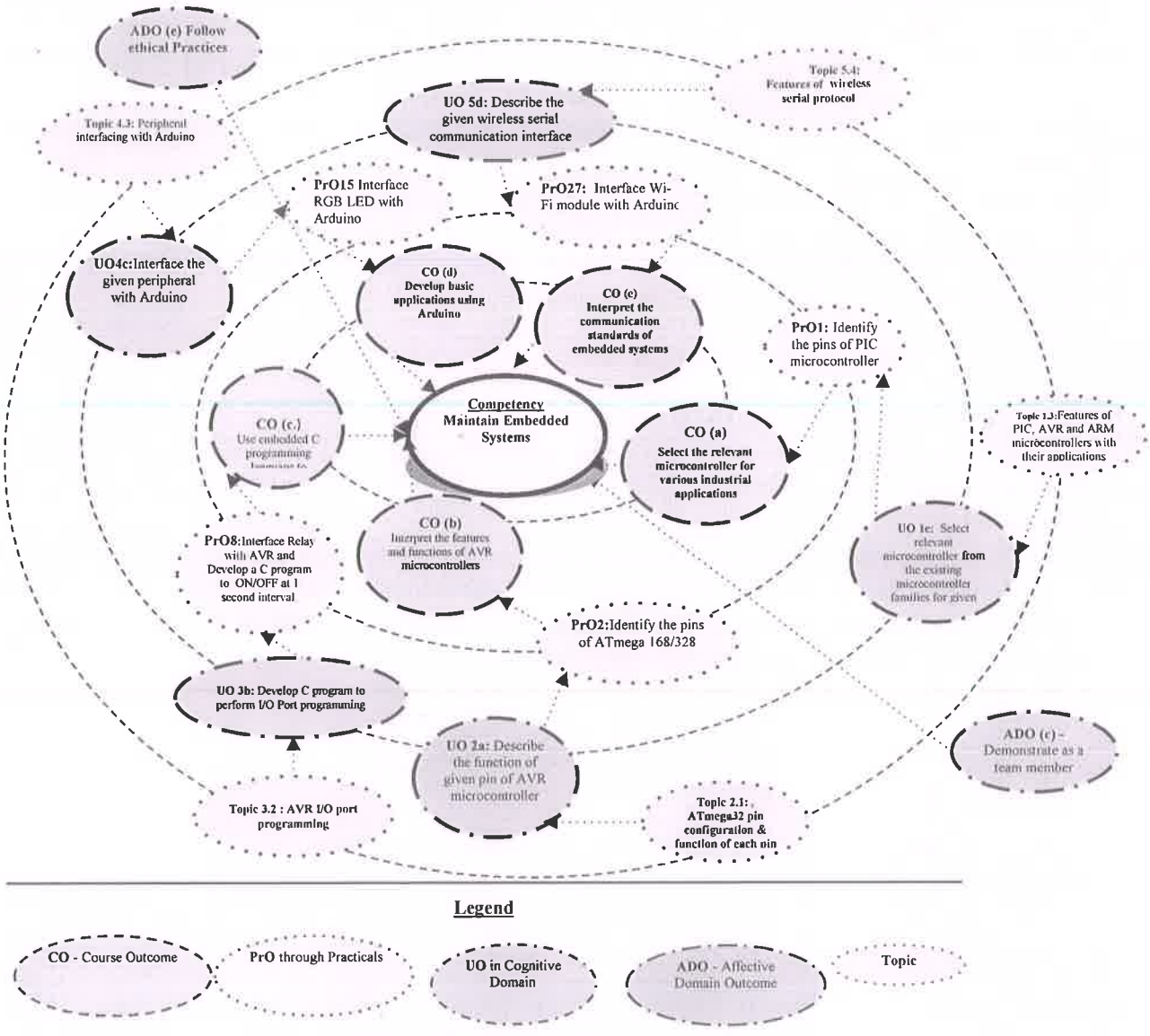


Figure 1 - Course Map

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 PIC microcontroller	1	2*
2	Identify the pins of AVR ATmega 168/328 and its functions.	2	2*
3	Use an integrated development environment tool for developing 'C' programmes for ATmega 168/328.	3	2*
4	Develop AVR C program to perform AND, OR, XOR operations on two constant data and outputs the result to Port B with 5 seconds delay between each result.	3	2*
5	Develop AVR C program to perform addition, subtraction and multiplication operations on two constant data and outputs the result to Port B with sufficient delay between each.	3	2*
6	Interface 4X4 LED matrix with AVR and Develop C program to display various patterns	3	2
7	Interface key(s) and LED (s) with AVR and Develop a C program to control LED(s) through the key(s).	3	2*
8	Interface Relay with AVR and Develop a C program to ON/OFF at 1 second interval.	3	2*
9	Interface multiplexed seven segment display with AVR and Develop a C program to display 1234	3	2
10	Develop AVR C program to toggle a port pin after the timer 0 overflows 6 times.	3	2*
11	Interface temperature sensor LM35 to AD0 pin of AVR and develop a C program to read analog input and display the digital values on Ports	3	2
12	Develop a C program to generate PWM square wave using AVR to control LED light intensity.	3	2
13	Interface Stepper Motor with AVR and develop a C program to rotate it..	3	2*
14	Identify the pins of Arduino board & install Arduino IDE Software in PC.	4	2*
15	Interface RGB LED with Arduino board and develop a program to glow it alternately with a delay	4	2*

16	Interface 4 switches and 4 LEDs to Arduino board and write program to control the LEDs as per switch position	4	2*
17	Develop Arduino based program to perform arithmetic operations using Math Functions : constrain(),max(),min(),Pow(),sq(),sqrt()	4	2*
18	Interface 16x2 LCD module with Arduino board.and write program to display MSBTE on it	4	2*
19	Interface Single digit Seven segment display with Arduino for displaying numbers with specified delay from 0 to 9.	4	2*
20	Interface the keypad with Arduino and display the keycode on the LCD module.	4	2*
21	Interface Stepper motor with Arduino and develop a program to rotate it clockwise and anticlockwise.	4	2*
22	Develop Program to Read the value from the temperature sensor through Arduino and display it on LCD.	4	2*
23	Interface DC motor with Arduino and write program to control its speed	4	2*
24	Develop a program to read the value from the Ultrasonic sensor through Arduino and use this input to control the direction of the DC motor..	4	2
25	Interface Bluetooth module with Arduino and write a program to turn ON/OFF the bulb / fan.	5	2
26	Interface two 16x2 LCD modules with Arduino using I2C serial communication protocol.	5	2*
27	Interface Wi-Fi module with Arduino and develop a program to control output device(s).	5	2*
28	Interface the digital Potentiometer MCP4131 to the Arduino with SPI and develop program to vary its resistance.	5	2
		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 %
1.	Preparation of experimental setup.	20
2.	Setting and operation.	20
3.	Safety measures.	10
4.	Observation and recording.	10
5.	Interpretation of result and conclusion.	20
6.	Answer to sample questions.	10
7.	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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	PrO. Sr. No.
1	Microcontroller kit (AVR ATmega 168/328 board and PIC): Single board systems with minimum 8K RAM, ROM memory with battery backup, 16x4 LCD display, Seven segment display, PC keyboard interfacing	1,3,4,5,6,7,8 9,10,11,12,

	facility, cross 'C' compiler, USB, Interfacing facility with built in power supply.	
2	Arduino board UNO or MINI	14,15,16,17, 18,19,20,21, 22,23,24,25, 26,27,28
3	Computers for software - Arduino Software / Keil / MicroPro C RAM - 4GB Windows OS	All
4	4X4 LED matrix	6
5	Relay Board	8
6	DC motor, Stepper motor 50/100 RPM	13,21,23,24
7	CRO 20MHz	12
8	Power Supply (Single and Dual)-0-30v,0-10A	All
9	Digital Multimeter	All
10	LCD 16x2 Modules, Keypad	18,20,22,26
11	Single digit and Multiplexed Seven Segment display	9,19
12	Bluetooth module	25
13	Ultrasonic and Temperature sensors	12 & 13
14	Wi-Fi Module (ESP 8266 or relevant)	27
15	Digital Potentiometer MCP4131	29

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 components of the given embedded system. 1b. Describe with the help of a block diagram, the architecture of the given processor. 1c. Describe the given characteristics of the specified embedded systems.	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 PIC, AVR and ARM microcontrollers with their

	1d. Identify with the justification the type of embedded systems used for the given application. 1e. Justify the selection of the relevant microcontroller from the existing microcontroller families for the given application.	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 AVR microcontrollers	2a. Describe the function of given pin of AVR microcontroller 2b. Describe with sketches the given memory and I/O block of AVR microcontroller 2c. Describe with sketches the given peripheral block of AVR microcontroller 2d. Identify the features of given Arduino specific microcontroller	2.1 Introduction to AVR microcontroller: Overview of AVR family, ATmega32 pin configuration & function of each pin 2.2 AVR Microcontroller architecture: Internal Memory, Registers, Digital I/O ports, Serial I/O 2.3 AVR Microcontroller architecture: Timers/Counters, Analog Comparator, ADC,, Interrupts. 2.4 Features of Arduino specific AVR microcontroller ATmega 168/328.
Unit– III Programming AVR using Embedded C	3a. Develop the algorithm, flowchart and C program for AVR to perform the Arithmetic/Logical operations 3b. Develop the algorithm, flowchart and C program for AVR to perform the I/O port programming for the given application. 3c. Develop the algorithm, flowchart and C program for the given delay using a timer with AVR microcontroller 3d. Develop the algorithm, flowchart and C program to read analog input with AVR microcontroller	3.1 Comparison of Embedded C and assembly language programming, AVR programming in C, AVR Data types., Arithmetic and Logic Operations programming 3.2 I/O port programming. 3.3 Timer programming, PWM programming. 3.4 ADC programming
Unit– IV	4a. Identify the Arduino Board to be used for a given application	4.1 Introduction of Arduino board Layout with pin function & Detail

I/O interfacing with Arduino	4b. Describe the use of given Arduino Function 4c. Interface the given peripheral with Arduino 4d. Interface the given sensor with Arduino	of IDE of Arduino Software. Compare different Arduino boards: Arduino UNO, NANO, MINI, and MEGA. 4.2 Functions used in Arduino: Math, Analog I/O, Digital I/O, Timer. 4.3 Peripheral interfacing with Arduino : Keypad, LCD, Seven segment LED, Relay, Stepper Motor, DC Motor, (connection diagram, working & programming). . 4.4 Sensor Interfacing with Arduino: LM35 Temperature sensor and Ultrasonic sensor (connection diagram, working & programming.)
Unit-V Communication Standards and Protocols	5a. Describe the given modes of communication. 5b. Describe the functions of the given pin(s) of RS232 and MAX232 with suitable sketches. 5c. Describe the given communication protocol(s) with relevant sketches. 5d. Describe the given wireless serial communication interface.	5.1 Modes of data communication: serial, parallel, synchronous and Asynchronous communication. 5.2 Serial communication standards: RS232, MAX232 as a bidirectional level converter. 5.3 Communication protocols & its types, Serial Communication: I2C, CAN, USB, SPI 5.4 Features of **wireless** serial protocol IrDA, bluetooth, zigbee, WiFi.

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	AVR Microcontrollers	14	04	08	04	**16**
III	Programming AVR using Embedded C	16	04	04	06	**14**

IV	I/O interfacing with Arduino	16	04	04	08	**16**
V	Communications Standards and Protocols	10	02	04	06	**12**
	Total	**64**	**18**	**24**	**28**	**70**

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 a chart displaying the various types of microcontrollers.
b. Prepare a chart displaying the various types of communication protocols.
c. Prepare a chart displaying the various types of sensors.
d. Visit nearby automation industries and prepare a report.
e. Market survey of various AVR microcontrollers used in robotic industries.
f. Market survey of various Arduino Boards used for different applications.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
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/subtopics*** which are 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. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab
i. Use proper equivalent analogy to explain different concepts.
j. Use Flash/Animations to explain various Robotic actions

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student 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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a 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 a 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 a 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. Arduino based simple line following Robot
b. Arduino based Quiz Buzzer
c. Arduino interface with LCD module 16x2 with Two line message displaying.
d. Arduino based traffic light signal
e. Arduino interface with GSM based security system for alarm/alert and calling.
f. Arduino interface with RFID for door lock system.
g. Arduino interface with DC motor with variable speed adjustment using switch or potentiometer.
h. Interface IR sensor with Arduino and write a program and use this input to control LED.
i. Arduino interface with GPRS based tracking system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Microcontroller Architecture Programming, Interfacing and System Design	Raj Kamal	Pearson Education India, Delhi, 2012, ISBN:9788131759905
2	Arduino A Technical Reference	J. M. Hughes	O' REILLY,2016, .ISBN - 978-1-491-92176-0
3	The Embedded Software Primer	David E. Simon	Addison- Wesley, Delhi, ISBN - 978-0780201615692
4	AVR Microcontroller and Embedded Systems: Using Assembly and C, January 2013	Muhamed Ali Mazidi,Sarmad Naimi, Sepehr Naimi	Pearson Education India; 1st edition (1 January 2013), ISBN - 978-9332518407
5	Serial Communication Protocols and Standards: RS232/485, UART/USART, SPI, USB, INSTEON, Wi-Fi	Professor Dawoud Shenouda Dawoud (Author), Peter Dawoud	River Publishers, 31 July 2020, ISBN - 978-8770221542

	and WiMAX	(Author)	

14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

a. Simulation Software: www.keil.com
b. https://www.arduino.cc/en/main/arduinoBoardUno
c. https://onlinecourses.swayam2.ac.in/aic20_sp04/
d. https://microcontrollerslab.com/avr-microcontroller-tutorials/
e. https://www.engineersgarage.com/avr-microcontroller-all-you-need-to-know-part-1-46


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Diploma in Automation and Robotics**

Program Code : **AO**

Semester : **Fifth**

Course Title : **Industrial Process Control**

Course Code : **22591**

1. RATIONALE

In the industry environment, Automation and Robotics diploma graduates are expected to handle various Industrial processes where parameters involved are required to be transmitted for efficient functioning of process operations. Also, selection of proper control schemes like feedback, feed forward and cascade for various unit operations such as heat exchanger, boiler etc. is important. Use of appropriate safety methods and Fuzzy logic are other important aspects in Industrial processes. This course helps the Automation and Robotics diploma graduates to understand and apply the concepts and principles of process control system

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 Process Control 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. Describe the operation of a given process field instrument.
b. Compare the given process control actions
c. Apply the suitable process control action to the given unit operation.
d. Use appropriate safety method in process automation industries
e. Describe the concepts of Fuzzy Logic

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*	12	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 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 center of this map..

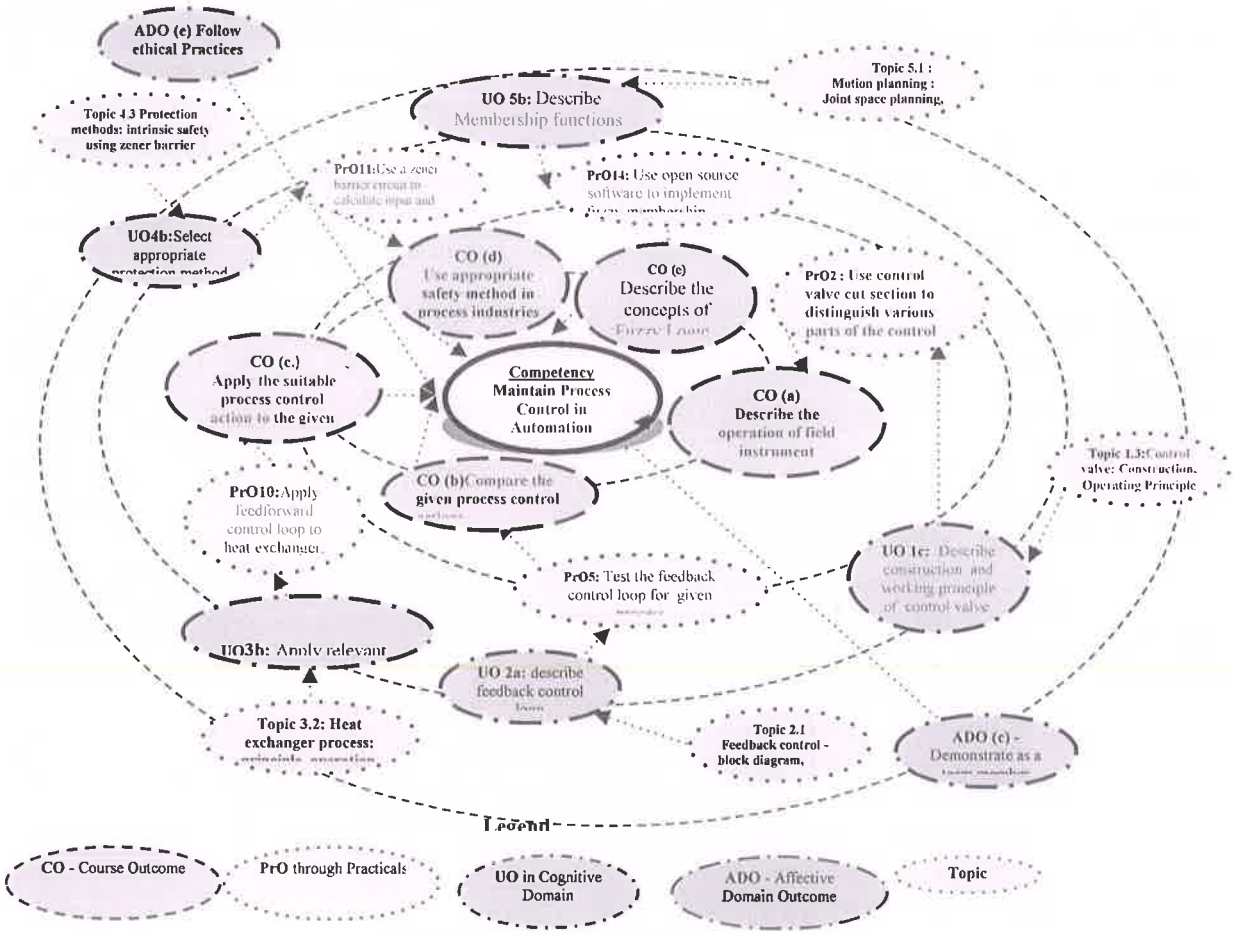


Figure 1 - Course Map

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	Draw P&ID of the given Process Field Instruments	I	2*

2	Use control valve cut section to distinguish various parts of the given control valve.	I	2*
3	Use control valve trainer setup to plot flow characteristics of different types of valves.	I	2
4	Use SMART to demonstrate the features	I	2
5	Test the feedback control loop for given process using set up or simulator	II	2*
6	Test the cascade control loop for given process using set up or simulator	II	2
7	Test the feedforward control loop for given process using set up or simulator	II	2
8	Apply feedback control loop to heat exchanger or boiler using set up or simulator	III	2*
9	Apply cascade control loop to heat exchanger or boiler using set up or simulator	III	2*
10	Apply feedforward control loop to heat exchanger or boiler using set up or simulator	III	2
11	Use a zener barrier circuit to calculate input / output current and voltage.	IV	2*
12	Use open source software to create a SIL Verification Harness for a Controller	IV	2
13	Use open source software to control the speed of a DC motor using fuzzy logic	V	2*
14	Use open source software to implement fuzzy member-ship	V	2*
15	Use open source software to implement defuzzification	V	2*
16	Use open source software to implement fuzzy logic operators	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 24 or more practical need to be performed, out of which, the practical 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.	Preparation of experimental setup.	20
2.	Setting and operation.	20
3.	Safety measures.	10
4.	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	PrO. S. No.
1	Cut sections of control valve	1,2
2	Control valve characteristics trainer setup	3
3	SMART transmitter	4
4	Heat exchanger/ boiler setup or simulator	5-10

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: Process Field Instruments	1a. Describe with sketch the given type of process control 1b. Draw the P&ID symbol for given process instrument 1c. Describe constructional features and working principle of a given control valve. 1d. Differentiate between the given transmission system. 1e. Describe the working principle of the given type of transmitter(s).	1.1 Process Control: Principle, Block diagram of process control system, Identification of elements, Examples 1.2 P & ID symbols: basic field instruments in process loop 1.3 Control valve: Construction, Operating Principle, Flow characteristics, Construction and working of Globe valve (single seated) and Solenoid valve 1.4 Pneumatic transmission system: Standard signal 3-15 psi, Live zero 1.5 Electronic transmission system: Standard signal 4-20 mA, Live zero 1.6 SMART transmitters: Block diagram, explanation, Salient features.
Unit II: Process Control Actions	2a. Describe feedback control loop with example. 2b. Compare the given control strategies. 2c. Apply cascade control to a given process. 2d. Explain concept of Selective control	2.1 Feedback Control-Block/schematic diagrams, Concept and Examples. 2.2 Feed Forward Control-Block/schematic diagrams, Concept and Examples, Comparison with feedback control. 2.3 Cascade Control-Block/schematic diagrams, Concept and Examples. 2.4 Selective control-Concept and Examples
Unit III: Unit Operations in Process	3a. Explain with sketches the working of the given heat exchanger process. 3b. Apply relevant control strategy to the given heat exchanger process. 3c. Select relevant control strategy for given boiler process.	3.1 Unit Operations: definition and types 3.2 Heat Exchanger Process-Principle, Operation, Type of Heat Exchanger- Shell & tube and Plate type 3.3 Boiler Process -Principle, Operation, Safety interlocks 3.4 Application of heat exchanger and boiler 3.5 Application of feedback, feed forward and cascade control

	3d. Explain with sketches the working of the boiler process.	action to Heat exchanger and Boiler
Unit IV: Safety in process automation industries	4a. Select the appropriate material for the given hazardous location 4b. Select appropriate protection method for the given application with justification 4c. Identify the enclosures for the given hazardous location with justification. 4d. Explain the concept and importance of SIS and SIL	4.1 Hazardous area: classification according to the materials as per NEC and IEC 4.2 Protection methods - Explosion proof, Intrinsic safety using zener barrier, oil immersion and purging 4.3 Enclosures: IP classification, NEMA types 4.4 Safety Instrumented System and Safety Integrity Levels (SIL) - concept, Layer of Protection Analysis (LOPA)
Unit V: Introduction to Fuzzy Logic	5a. Differentiate between the given Fuzzy set 5b. Describe the given type of Membership function 5c. Explain the basic Fuzzy set operations 5d. Describe Fuzzy control logic	5.1 Introduction to Fuzzy Logic: Fuzzy set theory , Crisp set Vs Fuzzy Set 5.2 Membership functions: Triangular, Trapezoidal, Gaussian, Generalized bell, Sigmoid. 5.3 Basic Fuzzy set operations: Union, Intersection, Complement, Equality, Difference, Disjunctive Sum, Properties of Fuzzy set 5.4 Fuzzy control logic: Block Diagram, Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences, Defuzzification Techniques 5.5 Case Study: Fuzzy Air Conditioner control, Fuzzy Cruise controller

***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	Process Field Instruments	10	04	04	04	**12**
II	Process Control Actions	06	02	04	04	**10**
III	Unit operations in Process	10	04	06	06	**16**
IV	Safety in Process Automation Industries	10	04	06	06	**16**
V	Introduction to Fuzzy Logic	12	04	06	06	**16**
	Total	**48**	**18**	**26**	**26**	**70**

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 a chart displaying the various types of transmitters
b. Prepare a chart displaying the various types of control valve
c. Prepare a chart displaying the various types of P&ID symbols
d. Prepare a report on the market survey for availability of different unit operations.
e. Visit nearby process industries and prepare a report on control systems used.
f. Prepare a chart on comparison of different Process control actions.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
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/subtopics*** which are 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. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.

g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab
i. Use proper equivalent analogy to explain different concepts.
j. Use Flash/Animations to explain various Process Control systems

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student 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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a 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 a dated work diary consisting of individual contributions 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 a 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. Compare technical specifications of various valves
b. Develop a process control loop for any parameter
c. Develop a model of control valve
d. Use control valve for flow control in pipeline
e. Use control valve for level control application
f. Use Feedback control for temperature control in the classroom
g. Set a cascade loop for any given application
h. Develop P&ID for boiler process
i. Develop P&ID for heat exchanger
j. Calculate the number of I/Os from given P&I diagram
k. Prepare a chart on functional safety in any industry
l. Prepare a prototype for basic fuzzy logic controlled robot for various applications

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Process Control Instrumentation Technology	Johnson, C. D.	Prentice hall of India, NewDelhi,2015 ISBN: 978-9332549456
2	Instrumentation Engineers Handbook-Process Control	Liptak, B. G	Chilton Book Company, New York, 2016, ISBN:

3	Chemical Process Control	Stephanopoulos, G	Pearson India ISBN: 9789332549463
4	"Functional Safety: A Straightforward Guide to IEC61508 and Related Standards"	Smith, D.J. & Simpson, K.G.L.	-Butterworth-Heinemann Publications. ISBN:9780750652704
5	Fuzzy Logic with Engineering Applications	Timothy, J, R	Wiley, Third Edition, 2010 ISBN 978-0-470-74376-8
6	Understanding Neural Network and Fuzzy Logic:Basic Concepts and Applications	Kartalopolous, S.V	Wiley-IEEE Press, 1995 ISBN: 978-0-780-31128-2
7	Neural Networks,Fuzzy Logic and Genetic Algorithms	Rajasekaran,S & Pai, V.G.A	PHI Pvt Ltd ISBN:9788120321861

14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

a. https://www.youtube.com/watch?v=XAItnsUcES0
b. https://www.controleng.com/single-article/fundamentals-of-cascade-control/f25b1cb6548975a2adab1645fl1d20d8.htm1
c. https://www.slideshare.net/haki517/industrial-process-control
d. https://www.youtube.com/watch?v=02p5AKP6 W0Q.
e. https://instrumentationapplication.com/2021/10/12/what-is-sis-sil-and-sif/
f. https://www.youtube.com/watch?v=rln_kZbYaWc
g. https://www.youtube.com/watch?v=c2eZ_2fsqfk


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : Diploma in Automation and Robotics
Program Code : AO
Semester : Fifth
Course Title : Industrial Robotics and Applications
Course Code : 22592

1. RATIONALE

Industrial robots are widely used in many manufacturing industries. They can assist manufacturing to make it more competitive and efficient. The most obvious impact of industrial robots is that they eliminate many dirty, repetitive and dangerous tasks with hazardous materials and in challenging environments. The purpose of industrial robotics course is to respond the demands of manufacturing industries and to meet 21st century workforce needs. It is therefore need of the time for students to learn industrial robotics principles to work in industry like welding, automobile, medical, handling materials etc. This course therefore attempts to build required skills of this field in diploma students.

2. COMPETENCY

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

- Operate various Industrial Robots.

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:

After completion of this course, the students will be able to:

a. Select sensors for different robotics application.
b. Understand Robot vision system.
c. Program robot for basic applications
d. Maintain robot for basic applications.
e. Identify future robot technologies.

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*	12	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 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 center of this map..

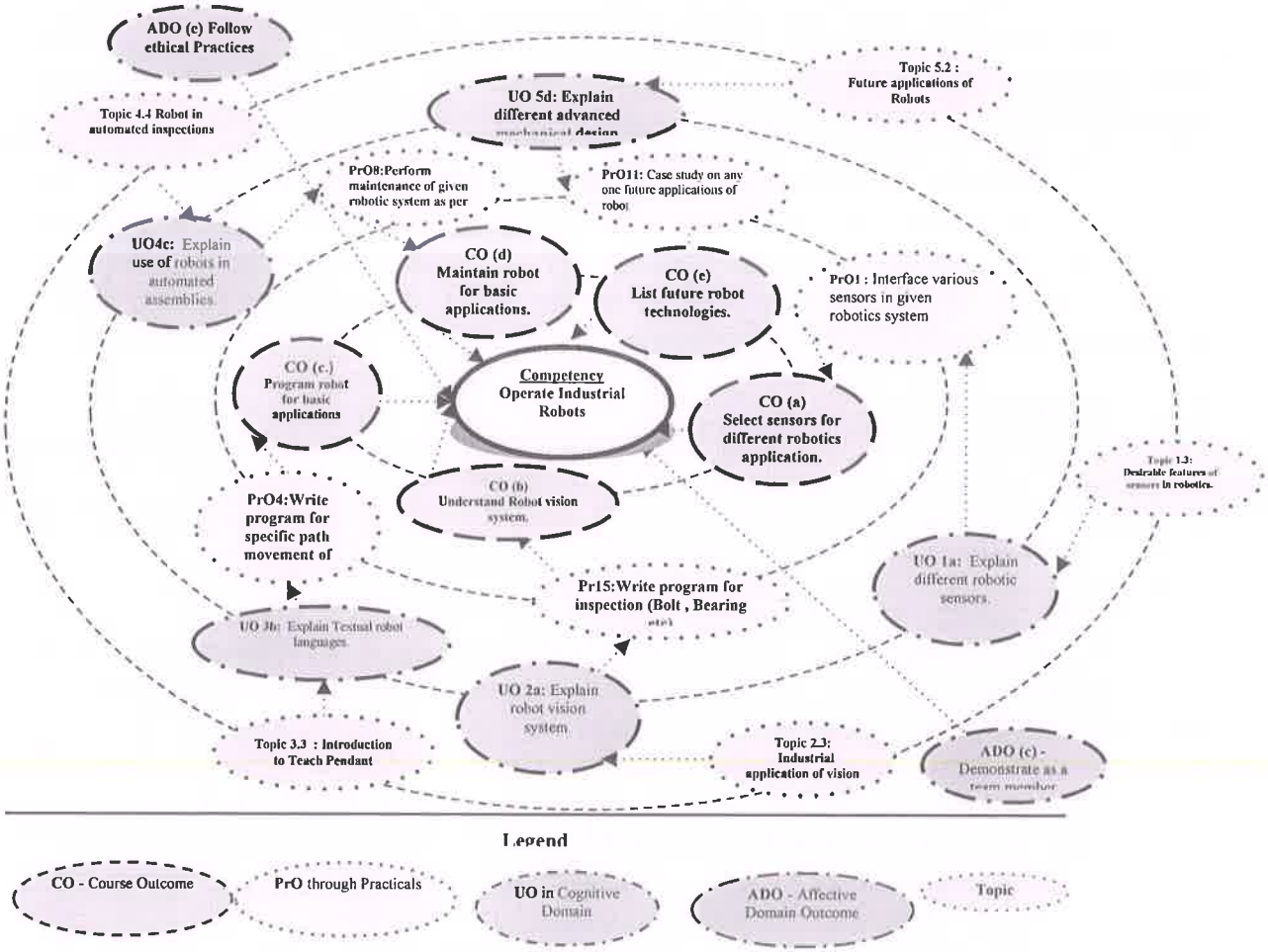


Figure 1 - Course Map

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	Interface various sensors in given robotics system	1	2
2	Simulate different motion commands for given systems	1	2

3	Simulate different end effector command for given systems	I	2
4	Overview of Industrial Machine vision: Components (industrial camera, lens, light source, etc.)	II	2
5	Study and Implementation of Machine vision basics: Edge/shape/location/color detection.	II	2*
6	Robot Operation with Machine Vision: Bridging of vision and robot programming codes.	II	2*
7	Use of open source computer vision programming tool openCV and Image Processing using openCV.	II	2*
8	Write program for inspection (Bolt , Bearing etc)	II	2
9	Write program for specific path movement of robot	III	2
10	Write program palletizing the object	III	2
11	Sensing strategy and robot path creation for interrupted welding lines at car underbody	III	2*
12	Write program for painting operation	III	2
13	Interface PLC and prepare ladder diagram for any simple application	III	2*
14	Write program for spot welding operation	III	2
15	Perform maintenance of given robotic system as per standard procedure	IV	2*
16	Case study on any one future applications of robot (e.g. Military Operations, Fire -fighting operations, under sea operations, Space operations, Industry 4.0 etc.)	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:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20

2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	PrO. S. No.
1	4 axis Robotic Arm Workcell - (Qty = 1) **Specifications:** MANIPULATOR General Specifications: - Number of Axes = 4 - Payload = 500 g - Max. Reach = 320 mm - Position Repeatability (Control) = 0.2 mm - Communication = USB/ Wifi/ Bluetooth - Power Supply = 100 V – 240 V, 50/60 Hz - Power in = 12V/ 7A DC - Consumption = 100W Max	6, 9, 10, 18-32

- Working Temperature = 4°C to 40°C
- Controller = Dobot Integrated Controller

AXIS MOVEMENT @250 g workload
- Joint 1 base: Range = -90° to +90°, Max speed = 320°/s
- Joint 2 rear arm: Range = 0° to +85°, Max speed = 320°/s
- Joint 3 forearm: Range = -10° to 95°, Max speed = 320°/s
- Joint 4 rotation servo: Range = +90° to -90°, Max speed = 480°/s

APPLICATION SOFTWARE:
- MATLAB, DobotStudio, Repetier Host, Dobot Blockly (Visual Programing editor), Python Editor, Sample codes for ROS, C#, Java, VB, Lab View, etc.

SDK (Software Develop Kit): Communication Protocol, Dobot Program Library
Extensible I/O Interfaces:
- 1. Arm: I/O × 10 (Configurable)
  2.Controllable 12V Power output × 4
  3. Communication Interface = (UART, Reset, Stop, 12V, 5V and two I/O included)
  4. Stepper × 2 Nema17
- 2. 5V/2A | 12V/1A | 24V/2A for peripherals
- 3. 2- Channel high speed isolation card for PWM
- 4. 4- Channel isolated SSR

END-EFFECTORS:
1. 3D Printer Kit:
- Maximum Print Size (L×W× H) = D80 mm ×150 mm x (MAX); Leveling table
- Material = PLA
- Resolution = 0.1mm
2. Laser*
- Power = 500mW
- Type = 405nm (Blue laser)
- Power = 12V, TTL trigger with PWM Driver
3. Pen Holder
- Pen Diameter = 10mm
4. Vacuum Suction Cup
- Cup Diameter = 20mm
- Pressure = -35KPa
5. Gripper
- Range = 27.5mm
- Drive Type = Pneumatic
- Force = 8N

CONVEYOR:
- Payload = 500g
- Effective delivering distance = 600mm

	- Maximum speed = 120mm/s - Maximum acceleration = 1100mm/s² PHOTOELECTRIC SWITCH SENSOR: - Measurable range = 20~150mm - Signal = Analog Output - Input = 4.5 – 5.5V COLOUR SENSOR: - Input = 20~150mm - Detectable = non-glowing object - Embedded controllable white LED VISION CAMERA: - Effective Pixel = 3 million - Hue = Colour - Frame Rate/ Resolution =12 @2048x1536 LIGHT SOURCE: - Luminous Colour = White - Illumination = 40,000 lux - Brightness = Continuously Adjustable, (Range:0~100%), Colour Temperature Constant FOCUS LENS: - Focal length = 16mm - Aperture = F1.4-F16C - Focus Point = 0.3m-Inf OVERALL PHYSICAL: - Installation Weight = 70kg - Gross Transport Weight = 100kg - Transport Package Size = 1000mm x 1000mm x 1000mm (approx.) Bundled Applications • Handling: Pick-and-Place, Palletizing, Conveyor operations • Path Following: Writing, Laser Engraving • Additive Manufacturing: 3D Printing • Machine Vision: Edge/shape/location/colour detection • Second Development: (optional) IoT operations (Arduino), PLC operations	
2	Power Supply(Single and Dual)-0-30v,0-10A	6, 9, 10, 18-32
3	Digital Multimeter	6-

4	Computers for software - Dobot software suite RAM - 4GB Windows OS	1-32
5	Parallel link Gripper kit	8
6	Mechanism Display board	3

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
1.Robotic Sensors	1a. Explain different robotic sensors. 1b. List uses of sensors in Robotics. 1c. List desirable features of sensors in robotics.	1.1 **Robotic sensors-** Introduction to Sensors. 1.2 **Types of sensors in robotics -** Tactile Sensors - Touch sensors, Force sensors, Force sensing wrist, Joint sensing, Tactile array sensors, Proximity and range sensors, Miscellaneous sensors and sensor-based systems, uses of sensors in robotics. 1.3 Desirable features of sensors in robotics.
2.Robotic Vision	2a. Explain robot vision system. 2b. List industrial applications of vision controlled robotic system	2.1 **Robot Vision - Introduction**, Sensing and Digitizing function - Image devices, Lighting techniques, analog to digital signal conversions (Sampling, Encoding, Image storage) 2.2 **Image processing and analysis -** Image data reduction, segmentation, thresholding, region drawing, edge detecting, feature extraction, Object Recognition 2.3 Industrial application of vision controlled robotic systems.
3.Introduction to Robot Languages and Programming	3a. List different robot languages and their generations. 3b. List various generations of programming languages. 3c. State capabilities and limitations of lead through programming method.	3.1 **Introduction to Robot languages:** The textual robot languages , generations of robot programming languages , robot language structure, constant , Variables and other data objects, Motion commands, End effector and sensor commands, Computations and Operations.

	3d. Write simple programs to perform simple operations. 3e. State capabilities and limitations of lead through programming method.	Program Control and Sub- routines. Communications and Data processing. Monitor Mode Commands. 3.2 **Introduction to Robot Programming:** Methods of programming a Robot. Lead through Programming Methods, Robot Programme as a Path in Space , Motion Interpolation , WAIT , SIGNAL and DELAY Commands, Branching , Capabilities and Limitations of Lead through Methods. 3.3 Introduction to Teach Pendant. 3.4 Simple Program for Pick and Place activity. 3.5 Simple Program to Palletize the Object. 3.6 Simple Program for Inspection(Bolt. Bearing etc)
4.Robot Applications and Maintenance	4a. Explain use of robot in material handling. 4b. Explain use of robots in automated assemblies. 4c. Explain procedure of robot maintenance. 4d.List different safety rules in robot handling	**Robot Applications:-** 4.1 **Robot in Material Handling** - Pick and place robot, robot in palletizing and related operations. 4.2 **Robot in processing operations** - Spot welding, Continuous Arc Welding , Spray Coating, Die-casting, Plastic molding, Forging operation 4.3 Robot in automated assemblies 4.4 Robot in automated inspections 4.5 **Robot maintenance** - Need and types of maintenance. 4.6 Common troubles and remedies in robot operation. 4.7 General safety norms, aspects and precautions in robot handling. 4.8 Introduction on interlocking of robot.
5. Robot Technology of the Future	5a. Explain robot intelligence. 5b. Explain Telepresence and related technologies. 5c. Explain system integration and network. 5d. Explain future use of robots in various applications like military operations, fire-	5.1 Introduction, Robot intelligence, Advanced sensor capabilities (3D Vision), Telepresence and related technologies, Mechanical design features (Direct Drive robot, Multiple arm coordinate robot), Mobility, locomotion and navigation, Universal hand, System integration and network. 5.2 Future applications of Robots -

	fighting operations, space operations etc.	Military operations, Fire-fighting operations, under sea operations, Space operations, Industry 4.0, etc

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	Robotic Sensors	06	04	06	02	12
II	Robotic Vision	12	06	06	04	16
III	Introduction to Robot Languages and Programming	10	04	06	04	14
IV	Robot Applications and Maintenance	12	04	06	06	16
V	Robot Technology of the future	08	04	04	04	12
	Total	**48**	**22**	**28**	**20**	**70**

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. List various Robot controlling parameters and its effect on the performance of Robots.
b. List different types of robots and their applications.
c. Visit Industries having robots and prepare specification list, understand operational and maintenance practices.
d. Case study on various robot manufacturing companies and gripper manufacturing companies.
e. Download videos of robotic applications.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
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/subtopics*** which are 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. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab
i. Use proper equivalent analogy to explain different concepts.
j. Use Flash/Animations to explain various Robotic actions

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student 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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a 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 a 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 a 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. Visit industries having robots and prepare a detail report on operational and maintenance practices.
b. Develop robot programs for performing various industrial operations.
c. Case study on robotics systems used in the automobile/ manufacturing industry.
d. Case study on future robot technologies.
e. Case study on various future applications of robotic systems.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Introduction To Robotics	Saha,S.K	Mcgraw Hill Education Pvt. Ltd. Isbn: 9780070140011
2	Robotics Technology and Flexible Automation	Deb,S.R	Mcgraw Hill Education Pvt. Ltd. New Delhi, Isbn:0071331298

3	Introduction To Robotics (Mechanics And Control)	Craig, J J	Pearson Education Ltd. Isbn-10 : 0201543613
4	Robotics-Fundamental Concepts And Analysis	Ghosal,Ashitava	Oxford University Press 2006 Isbn-10: 61956729133
5	Industrial Robotics	Mikell P. Grover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey	TATA Mcgraw Hill Education Pvt. Ltd. New Delhi, 2010 ISBN - 978-0-07-026509-7

14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

a. https://youtube.com/c/LEARNWITHNIKHIL1
b. http://www.roboanalyzer.com/virtual-experiments.html.
c. http://www.roboanalyzer.com/mechanalyzer.html
d. http://vlabs.iitkgp.ac.in/mr/
e. https://www.robotshop.com/community/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