Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Industrial Engineering and Quality Control**

Course Code : **22657**

1. RATIONALE

In any mechanical industry, industrial engineering integrates men, machines, materials, method of production, information, and energy to make a product and hence enhance productivity by eliminating wastefulness in production processes. Mechanical engineering technologists needs to determine the standardized process, time for its completion known as work and time study, measuring the output in terms of productivity, evaluation of jobs, workers and determining the wages and incentives, measurement of quality of product. Total Quality Control is an effective system of integrating quality development, quality maintenance and quality improvement efforts of the various groups in industry, so as to enable production and services at most economical level which tends towards full customer satisfaction. Understanding of fundamental principles of industrial engineering and quality control helps a technologists in maximizing efficiency within a company by finding the best use of people, equipment, and facilities..

2. COMPETENCY

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

- **Apply Industrial Engineering and Quality Control techniques for assuring quality of products and services.**

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) Apply work study techniques to optimize manufacturing processes.
b) Prepare the detailed sequence of operations for manufacturing of components.
c) Apply Ergonomic principle for designing simple mechanical component .
d) Interpret the data obtained from the different quality control processes.
e) Interpret control charts for variable and attribute data.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

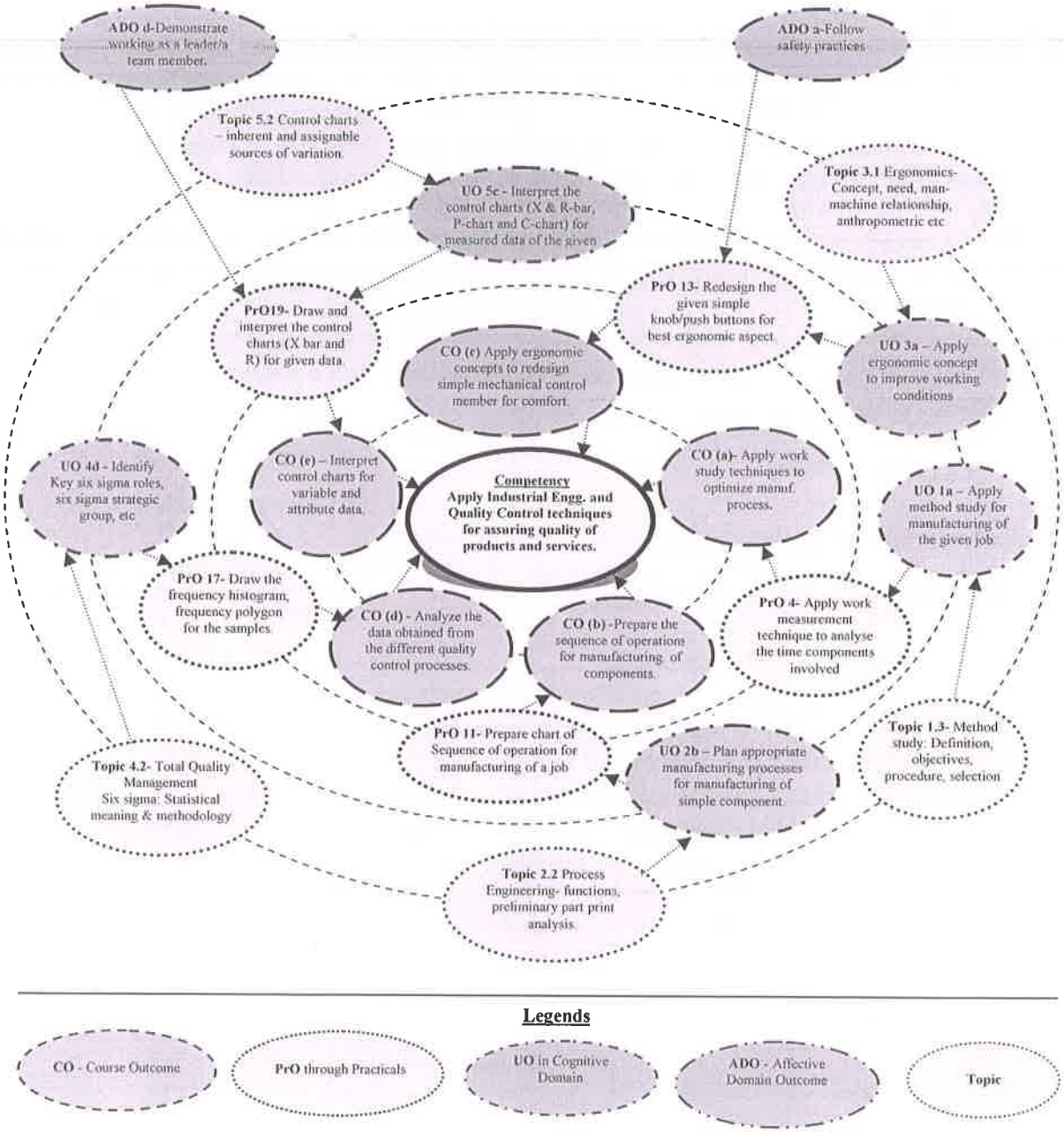

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Apply method study approach Analyze the motions involved in machining operation of the given job	I	02*
2	Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch.	I	02*
3	Calculate standard time for all the operations involved in step turning process.	I	02
4	Prepare motion chart of given activity using standard symbols of therbligs (max 18).	I	02
5	Prepare supply chain chart in day-to-day situation like supply of Cold drink/tooth paste/any grocery item.	II	02*
6	Prepare supply chain management chart for online purchase of goods/products.	II	02
7	Prepare detailed process plan for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.	II	02*
8	Prepare chart of Sequence of operation for manufacturing of simple job like manufacturing of hexagonal nut & bolt/ Manufacturing of V-Block on shaper machine.	II	02
9	Prepare Chart of sequence of operation for Single or Double riveted lap joint/Single riveted butt joint (single strap).	II	02*
10	Use Ergonomic principle for given component .	III	02*
11	Prepare and analyze steps to solve the given problem in institute/industry using quality circle concept.	IV	02*
12	Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.	V	02
13	Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.	V	02*
14	Draw and interpret the control charts (Xbar and R) for given data.	V	02
15	Draw and interpret the control charts (P-chart and C-chart) for given data.	V	02*
	Total		**30**

Note

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

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

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations 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) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical practices.

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

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Stop Watch Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1,2,3,4,5,6
2	Digital Video Camera for Micro Motion Analysis with following specification (i) ISO 100-12800 (ii) Focal length f = 3.5-5.6 (iii) 24.2 MP (iv) lenses 18-55mm.	1,2,3,4,5,6
3	Steel Rule for Length Measurement Range 0-5 feet	4,5,6 ,10,11.12
4	Digital/manual Vernier Caliper Range 0-150 mm, L.C. 0.02mm	10,11,12
5	Digital / manual Screw thread Micrometer, Range 0-25 mm, L.C. 0.01mm	10,11,
6	Digital / manual Screw Thread Micrometer Range 25-50mm, L.C. 0.01mm	10,11,
7	Display Wall chart showing X bar Chart and R CHART	13.14.15
8	Display Wall chart showing "C Chart"	13,14,15
9	Display Wall chart showing Therbilgs with minimum 18 symbols	7
10	Standard samples like steel balls, bearings, turning operation jobs, gear samples for sample measurement	13,14,15
11	Different types of Ergonomic Charts	7

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 Work Study (Method Study and Work Measurement)	1a. Apply method study for manufacturing of the given job. 1b. Apply time study for manufacturing of the given job. 1c. Select relevant recording techniques for the given process with justification. 1d. Prepare relevant types of charts for the given process using the given recording techniques. 1e. Calculate standard time for the given activity using work measurement.	1.1 Industrial Engineering: Definition, Need, Objectives and Scope 1.2 Work study: Method study(Motion Study) and Time study(Work Measurement) 1.3 Method study: Definition, objectives, procedure, selection of work 1.4 Recording Techniques: - Process Charts – Outline process chart, Flow process chart, Two Handed process chart/Simo Chart, multiple activity Chart, Flow diagram, String diagram, Therbligs, Travel chart. 1.5 Work Measurement – Objectives, procedure, Time Study, Time Study Equipment. Stop Watch Time Study, Allowances, Calculation of Standard Time.
Unit– II Process Engineering	2a. Apply principles of supply chain management in the given industrial/domestic application. 2b. Plan appropriate manufacturing processes for manufacturing of the given simple job/component. 2c. Sketch precedence diagram for the given simple manufacturing task using line balancing concept. 2d. Apply CPM for the given project of the specified industry. 2e. Prepare the detailed sequence of operations for manufacturing the given component.	2.1 Production: Concept, factors of production, Supply Chain Management, 2.2 Process Engineering- functions, preliminary part print analysis, Selecting and planning manufacturing process; determining manufacturing sequence 2.3 Line Balancing: Heuristic approach of line balancing 2.4 Critical Path Method (CPM) and its application related to Project completion.
Unit-III Ergonomics	3a. Apply ergonomic concept to improve working conditions in the given industrial environment(s). 3b. Apply ergonomics principle to given simple component. 3c. Use ergonomic principle for	3.1 Ergonomics- Concept, need, man-machine relationship, anthropometric and functional anatomy data, 3.2 Ergonomic in design of control members – push button, knobs, levers, cranks, hand wheel. 3.3 Ergonomic considerations applied to

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	designing different controls and displays	types and location of display. 3.4 Compatibility in the design of control members.
Unit –IV Quality Control and Inspection	4a. Prepare quality characteristics chart which contribute to fitness for use of the given job/ component. 4b. List steps to solve the given problem in the industry using quality circle concept with justification. 4c. Identify Key six sigma roles , six sigma strategic group, Master Black Belt and Black Belt as coaches for the given industrial situation. 4d. Prepare cause and effect diagram/ Pareto chart/Scatter diagram for solving the given problem for root cause analysis. 4e. Select the type of inspection to be carried out at various stages of process/ product layout for the given situation relevant to industry with justification. 4f. Interpret the data obtained from the given quality control processes.	4.1 Meaning of quality of produce and services, Quality characteristics, Quality of design, Quality of conformance, Quality of performance, Concept of reliability, Cost, Quality assurance, Cost of rework and repair, Quality and Inspection, Quality Circle 4.2 Total Quality Management; Six sigma: Statistical meaning and methodology, Six sigma Black Belt concept. 4.3 KAIZEN, POKA-YOKE, 5S Techniques. 4.4 Introduction of ISO 9000, ISO-14000. 4.5 Quality Economics: Cost of quality, Value of quality, Economics of quality confirmation, Cost of quality appraisal, prevention, external and internal failure cost. Quality function deployment: Basic concept and areas of application. 4.6 Various Q-C tools: Cause-and-effect diagram (fishbone or Ishikawa diagram),Check sheet, Histogram, Pareto chart and Scatter diagram. 4.7 Inspection Definition and meaning, Difference between Inspection and quality control, Classification of Inspection –(i) Process Inspection (ii) Final Inspection (iii) Raw Material (finished/semifinished) Inspection (iv) Tool and Gauge Inspection. Role of Quality Control Inspector/supervisor.
Unit-V Statistical Quality Control	5a. Calculate mean, mode and median for the given sample(s) including the frequency histogram, frequency polygon. 5b. Represent the given data through normal distribution curve after calculating the standard deviation (σ), variance, range to determine the process capability. 5c. Interpret the control charts (X and R-bar, P-chart and C-chart) for measured data of the given sample(s). 5d. Prepare Single/Double	5.1 Basics of Statistical concepts, Meaning and importance of SQC. 5.2 Variable and attribute Measurement. Control charts – inherent and assignable sources of variation. Control charts for variables – X and R charts, control charts for attributes p, np, C charts. 5.3 Process capability of machine (±3σ or ±6σ), Cp and Cpk calculations. 5.4 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve, 5.5 Different types of sampling plans, sampling methods.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	sampling plan for the given Lot size (N), Sample size(n), acceptance number(c) 5e. Interpret control charts for the given variable and attribute data.	5.6 Merits and demerits of acceptance sampling.

***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	Work Study (Method Study and Work Measurement)	12	02	04	06	12
II	Process Engineering	08	02	04	06	12
III	Ergonomics	06	02	04	06	12
IV	Quality Control and Inspection	10	02	04	10	16
V	Statistical Quality Control	12	02	04	12	18
Total		**48**	**10**	**20**	**40**	**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) Collect examples related to improvements which can be implanted in manufacturing using concepts of ergonomics.
b) Explain with suitable examples of your choice interaction between human and machine (any machine). Explain the procedure of evaluation of this interaction w.r.t. ergonomics.
c) Prepare Wall Chart of 3 Sigma and Six Sigma Curves and Compare number of defectives/rejection in parts per million (PPM).
d) Prepare list of National/international industries working on principle of Six Sigma Technique.
e) Visit any production industry. Collect the actual data from production and quality control department. Calculate mean, mode and median for the collected data.
f) Prepare a wall chart using standard 18 Therblings, state meaning of each symbol

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) Before starting practical, teacher should demonstrate the working of instrument.
g) Instructions to students regarding care and maintenance of measuring equipments.
h) Show video/animation films to explain functioning of various measuring Instruments
i) Teacher should ask the students to go through instruction and Technical manuals of instruments

12. SUGGESTED MICRO-PROJECTS

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

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

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

a) Calculate the predermine time and total time required for the delivery of food (pizza/Burger) from fast food centers available in your city or town. Prepare sequence of activity and represent with Therbligs.
b) Prepare the list on World class industries using Six sigma Technique at present. and write detail report on any one of industry.
c) Visit any manufacturing Industry and observe analyse actual Quality Control practices.
d) Visit any manufacturing local/nearby Industry and observe the working of type of inspection practices carried out and prepare a report.
e) Visit any manufacturing local/nearby Industry and observe the various statistical Quality controls techniques carried out. Prepare related chart.
f) Visit any manufacturing local/nearby Industry and observe the various sampling plan followed by the industry. Draw the same sampling plan.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Oil Hydraulic system-Principles and maintenance	Majumdar, S.R	Tata McGraw Hill, New Delhi, (2002), ISBN: 9780074637487
2	Industrial Engineering and management	Khanna, O.P.	Dhanapat Rai Publications(P) Ltd., New Delhi, (1980), ISBN-10: 818992835X
3	Statistical Quality Control	Mahajan, M.	Dhanpat Rai and Sons, New Delhi, (2006) ISBN-10: 817700039X
4	Statistical Quality Control	Montgomer,y Douglas C.	Wiley India Pvt. Ltd., New Delhi, (2009), ISBN:9781118146811
5	Total Quality Management	Besterfield, Dale, H.	Pearson New Delhi, (2011) ISBN-13: 9780130993069
6	A Guide to the Ergonomics of Manufacturing	Heylander, Martin	East West Press, Taylor and Fransis, UK, (1997) , ISBN 0748401229
7	Ergonomics : Man in his Working Environment :	Murrell, K. F.	Chhapman and Hall Ltd., U.S.A. (2012), ISBN 13: 9780412219900
8	Ergonomics at Work	Oborn, David J.	John Wiley and Sons, New York , (1982), ISBN-10: 0471909424
9	Motion and Time Studies	Ralph, M. Barnes	John Wiley and Sons, UK, (2009), ISBN-9788126522170
10	Hand Book of Industrial Engg	Gavriel, Salvendy	John Wiley and Sons, UK, (2001) ISBN-10: 0471502766
11	Six Sigma Project Management: APocket Guide	Lowenthal, J. N	Milwaukee, WI: ASQ Quality Press. (2001), Lowenthal, J. N ISBN: 087389-519-3
12	The Six Sigma Handbook.	Pyzdek, T.	McGraw-Hill, New York, (2018) ISBN-13: 978-0071372336

14. SOFTWARE/LEARNING WEBSITES

a) https://nptel.ac.in/courses/112107143/8
b) https://www.youtube.com/watch?v=SRV27U2LBf0
c) https://www.youtube.com/watch?v=I2Oz5cyr9qs
d) https://www.ifm.eng.cam.ac.uk/research/dstools/quality-function-deployment
e) https://www.pinterest.com/pin/342696471431684 77/
f) https://www.simplilearn.com/reasons-to-do-six-sigma-certification-article
g) https://www.youtube.com/watch?v=ZUZKtzhivQo
h) https://www.youtube.com/watch?v=4zrbfsAdEw0
i) https://www.youtube.com/watch?v=ENSb6BsM_q8
j) http://www.safetycare.com/en/shop/ergonomics-2/