Maharashtra State Board of Technical Education (MSBTE)

I – Scheme
VI – Semester Course Curriculum

Course Title: Industrial Engineering and Quality Control (ME)
(Course Code: .....)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

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. Diploma mechanical engineer needs to determine the standardised 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 Qualty Control is an effective system of intergrating quality development, qualty 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 customers satifacation.Understanding of fundamental principles of industrial engineering and quality control helps a Diploma technician in maximizing efficiency within a company by finding the best use of people, equipment, and facilities.This course will give the students, the basic skills and knowledge of developing various industrial processes through the use of statistical analysis, and quality control which will make him employable in the various types of industry.

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 techniques and TQM principles 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 process.
b. Apply ergonomic concept to improve working conditions in various industrial environments.
c. Redesign simple mechanical control member for specific applications.
d. Prepare the detailed sequence of operation carried out for given component.
e. Analyze the data obtained from the different measurements processes.
f. Draw & Interpret control charts for variable and attribute data.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	**150**
4	**-**	**2**	**6**	**70**	**30***	**25**	**25**	

(*): 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.

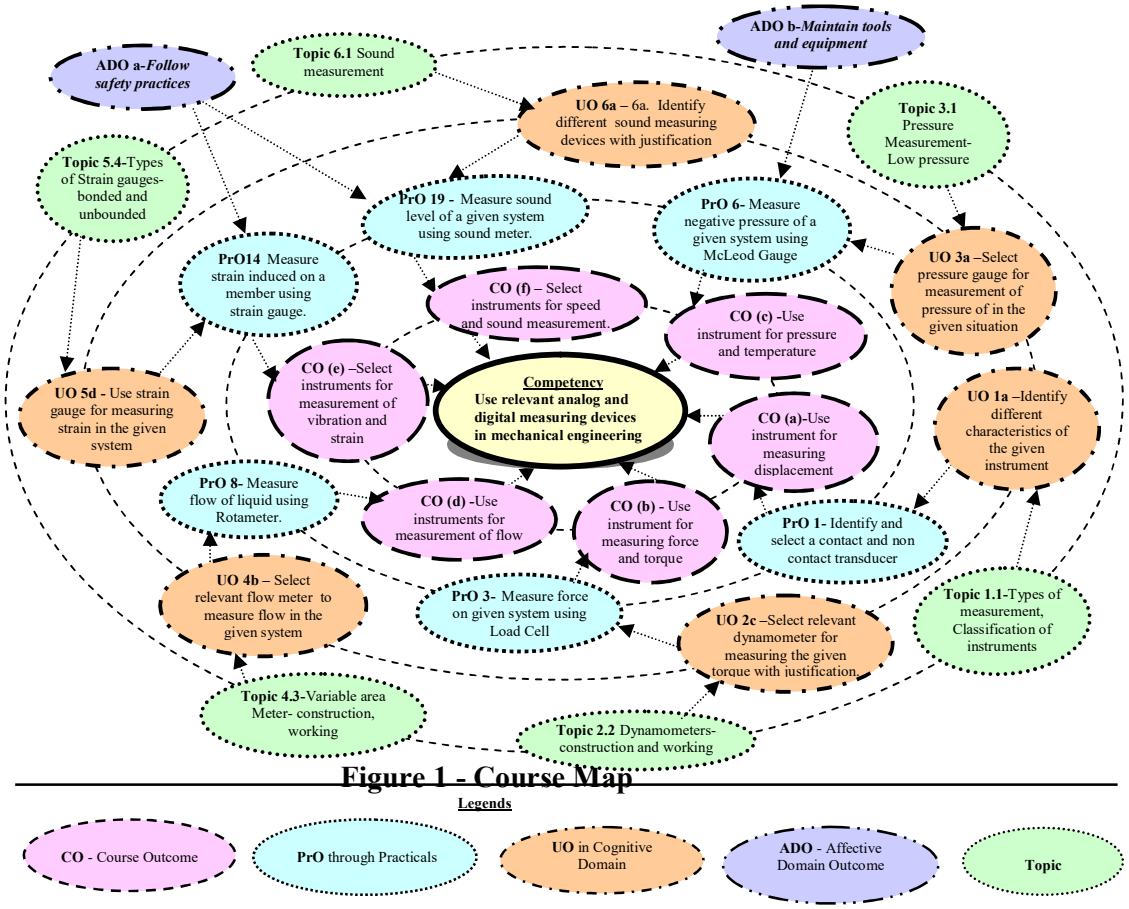

Figure 1 - Course Map

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 to the given job including step turning operation	I	02
2	Apply method study to the given job including plain turning & taper turning operation.	I	02*
3	Apply time study technique for the the given step turning operation using stop watch.	I	02
4	Apply time study technique for the the given drilling operation with multiple/radial hole stop watch.	I	02*
5	Calcutate standard time for all the operation carried out in step turning process.	I	02*
6	Prepare motion chart of given acitvty using standard symbols used in representing the therbligs (max 18).	I	02*
7	Prepare supply chain management technique in day- to-day situation like supply of Cold drink/tooth paste or any grocery item.	II	02*
8	Prepare supply chain management technique in for online purchase of goods /products.	II	02
9	Prepare Sequence of operation chart for manufacturing of simple job like manufacturing of hexagonal nut & bolt/ Manufaturing of V-Block on shaper machine.	II	02*
10	Line Balancing	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
11	Redesign the given simple levers for specific applications like gear shifting lever/brake/clutch lever/foot lever for best ergonomic aspect	III	02*
12	Redesign the given simple knob/push buttons for specific applications like motor starter,door bell for best ergonomic aspect.	III	02
13	Redesign the given simple crank for particular machine part.	III	02
14	Prepare and analyse steps to solve the given problem in institute/industry using quality circle concept.	IV	02*
15	Prepare TQM operation chart by using PDCA(Plan, Do, Check & Act) Technique	IV	02
16	Draw the frequency histogram, frequency polygon for the samples and calculate mean,mode and median for same.	V	02
17	Draw the normal distribution curve and curve and calculate deviation, Variance, range anddetermine the process capability.	V	02*
18	Draw and interpret the control charts (X&R-bar, P-chart and C-chart) for given data.	V	02*
19	Draw and interpret the control charts (P-chart and C-chart) for given data.	V	02
	Total		32

Note

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

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

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	10
2	Handling of measuring instruments carefully while performing the practical.	20
2	Setting and operation	30
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. 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.
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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		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit I- 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 different types of charts for given process using given recording techniques. 1e) Calculate standard time for given activity using work measurement.	1.1 Introduction to 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 application. 2b) Plan appropriate manufacturing proessesses for the given simple job/component. 2c) Sketch precedence diagram for the given simple manufacturing task using line balancing concept.	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: Herustic approach of line balancing

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit III : Ergonomics	3 a) Apply ergonomic concept to improve working conditions in the given industrial environment(s). 3 b) Redesign the given simple levers/knobs for specific applications. 3 c) Redesign the given simple crank or hand wheel for particular machine part.	3.1Ergonomics- Concept, need, man-machine relationship, anthropometric and functional anatomy data, ergonomic in design of control members – push button, knobs, levers, cranks, hand wheel. 3.2 Ergonomic considerations applied to types and location of display. Compatibility in the design of control members.
Unit–IV Quality Control	4a) Prepare quality characteristics chart which contributes to fitness for use of the given job/component 4b . Arrange sequence of activities for any quality characteristics for the given component. 4c) Prepare and analyse steps to solve the given problem in institute/industry using quality circle concept. 4b. Prepare cause & effect digram/ Pareto chart/Scatter diagram for solving the given problem for root cause analysis. Apply TQM principles for assuring quality of products and services in specific industrial application.	4.1Definitions, 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 Principles and concept of total quantity management. a) Quality Audit: Concept of audit practices, lead assessor certification. b) Six sigma: Statistical meaning, methodology of system Improvement c) Introduction of ISO 9000,ISO-14000. 4.3 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. 4.4 Various QC tools: Cause-and-effect diagram (fishbone or Ishikawa diagram),Check sheet,Histogram, Pareto chart and Scatter diagram.
Unit–V Statistical Qualty Control	5a) Draw the frequency histogram, frequency polygon for the given sample(s) and calculate mean, mode and median for same. 5b). Represent the the given data through normal distribution curve and calculate standard deviation (σ), variance, range and determine the process capability. 5c). Draw and interpret the control charts (XandR-bar, P-chart and C-chart) for measured data of the given sample(s). 5d) Prepare Single/Double sampling plan for the given Lot size (N), Sample size(n), acceptance number(c)	5.1 Basics of Statistical concepts, Meaning and importance of SQC,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, process capability of machine, C_p and C_{pk} calculations. 5.2 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve, Different types of sampling plans, sampling methods, 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	08	14
II	Process Engineering	12	02	04	08	14
III	Ergonomics	12	02	04	06	12
IV	Quality Control	12	02	04	06	12
V	Statistical Qualty Control	16	02	06	10	18
Total		64	10	22	38	70

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal based on practical performed in measurement laboratory. Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Measuring Tools and equipment in measurement laboratory.
   ii. Machineries in measurement laboratory
c. Undertake a market survey of local dealers for measuring equipments and prepare a report.
d. Visit to any Tool room and observe the working of inspection and testing department. also prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed.

C)Prepare Wall Chart of 3Sigma & Six Sigma Curves and Compare number of defectives/rejection in parts per million(PPM)
D) Prepare list of National/international industries working on principal of Six Sigma Technique

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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

a. Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
b. 'L' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About 15-20% of the topics/sub-topics which is relatively simpler or descriptive in nature is to be given to the students for self-directed learning and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
e. Guide student(s) in undertaking micro-projects.
f. 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. Prepare 50 jobs in workshop of diameter $32.25^{+}_{-}{}^{0.05}$ mm or equivalent dimension, Measure all dimensions of 50 jobs & prepare tally sheet showing frequency distribution,bar chart & frequency polygon.
b. Calculate arthimetic mean (X bar), median& mode by using data of Sr. No.(a).
c. Calculate Control limits and plot X Bar & R chart by using data of Sr. No.(a) & calculate process capability (for subgroup of 5 items, (d_2=2.326)
d. Collect 50 similar dimension workpieces from industry/workshop/market like steel balls/ razor blades/glass balls/bearings/ bushes etc. Measure all dimensions of 50 jobs & prepare tally sheet showing frequency distribution,bar chart & frequency polygon.
e. Calculate arthimetic mean (X bar), median& mode by using data of Sr. No.(d).
f. Calculate Control limits and plot X Bar & R chart by using data of Sr. No.(d) & calculate process capability (for subgroup of 5 items, (d_2=2.326)
g. The following data gives the number of missing rivets noted at aircraft final inspection.(OR student may use any other equivalent data from reference book, to plot control chart for C .)

Airplane No.	No.of missing rivets	Airplane No.	No.of missing rivets	Airplane No.	No.of missing rivets
1	8	10	12	19	11
2	16	11	23	20	9
3	14	12	16	21	10
4	19	13	9	22	22
5	11	14	25	23	7
6	15	15	15	24	28
7	8	16	9	25	9
8	11	17	9		
9	21	18	14		

Caclulate C bar & Plot Control chart for C.What values of C" would you suggest for subsequent period?

h. In a factory producing spark plug, number of defectives found in inspection of 20 lots of 100 each is given below. (OR student may use any other equivalent data from reference book)

Lot No.	No. of Defective	Lot No.	No. of Defective
1	5	11	4
2	10	12	7
3	12	13	8
4	8	14	3
5	6	15	3
6	4	16	4
7	6	17	5
8	3	18	8
9	3	19	6
10	5	20	10

(1)Construct appropriate control chart & State whether process is under control or not?

(2) Determine the sample size when a quality limit not worse than 9% is desirable& 10% Bad product will not be permited more than 3 time in thousand.

i. Prepare a wall chart by using the standard 18 therblings, state meaning of each symbol
j. Collect information of flow measuring devices.
k. Perfrom comparative study of different parameters of LVDT various contact sensors.
l. Perform comparative study of various non - contact sensors
m. Visit to automobile workshop and observe the various sensors used in car. also prepare report of the same i.e name ,use, location, function.
n. Visit the market and collect the sensor brochures with specifications of different manufactures.
o. Prepare a list of instruments used for vibration measurement and analysis.
p. Vist a power plant or manufacturing industry and identify situations where these sensors and instruments are used for predictive maintenance and condition monitoring.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Industrial Engineering and management	Dr. O.P.Khanna	Dhanapat Rai Publications(P) Ltd., New Delhi
2	Statistical Quality Control	M. Mahajan	2010 Dhanpat Rai and Sons
3	Statistical Quality Control	Douglas C. Montgomery	Sixth reprint 2011,Wiley India Pvt. Ltd.
4	Total Quality Management	Dale H. Besterfield	ThirdReprint 2012 Pearson
5	A Guide to the Ergonomics of Manufacturing :	Martin Heylander,	East West Press, Teylor and Fransis.
6	Ergonomics : Man in his Working Environment :		Chhapman and Hall Ltd., U.S.A.
7	Ergonomics at Work	David J.Oborn	John Wiley andSons, New York
8	Motion and Time Studies	Ralph M.Barnes	John Wiley and Sons.
9	Motion and Time Studies	Martin E. Muldel	
10	Hand Book of Industrial Engg	Gavriel Salvendy	John Wiley and Sons
11	Six Sigma: The Breakthrough Strategy Revolutionizing the World's Top Corporations.	Harry, M., & Schroeder, R.	New York: Currency Doubleday.
12	Process Management and the Future of Six Sigma	Hammer, M.	Winter. MIT Sloan Management Review.
13	October. "Six Sigma Black Belts: What Should They Know?"	Hoerl, R	Journal of Quality Technology.
14	Six Sigma Project Management: A Pocket Guide.	Lowenthal, J. N	Milwaukee, WI: ASQ Quality Press.
15	The Essential Six Sigma: How Successful Six Sigma Implementation Can Improve	Lucas, J. M.	January. "*Quality Progree*

S. No.	Title of Book	Author	Publication
	the Bottom Line."		
16	*The Six Sigma Handbook.*	Pyzdek, T	New York: McGraw-Hill.

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=I2Oz5cyr9qs (Line Balancing)

b. https://www.ifm.eng.cam.ac.uk/research/dstools/quality-function-deployment

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

MSBTE Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
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NITTTR Bhopal Resource Persons

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