I

Name_____

Roll No._____Year20__20_____

Exam Seat No._____

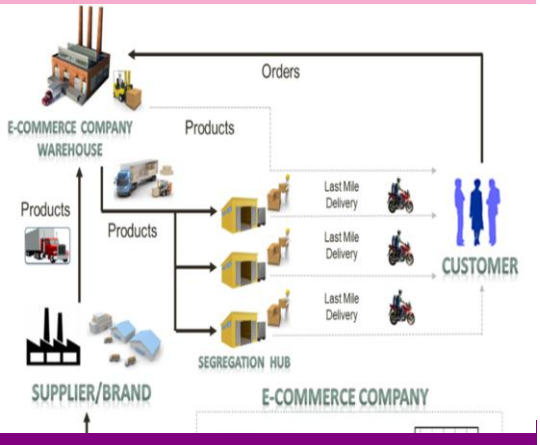
MECHANICAL GROUP| SEMISTER VI | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

Industrial Engineering And Quality Control (22657)

(ME)



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

A Laboratory Manual for

Industrial Engineering and Quality Control

(22657)

Semester – VI

(Diploma in Mechanical Engineering)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)

Maharashtra State
Board of Technical Education, Mumbai

(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)

4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai -400051.
(Printed on November 2019)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms …….

Roll No…….of Fourth Semester of Diploma in …….of Institute ……... (Code……..) has completed the term work satisfactorily in course **Industrial Engineering and Quality Control (22657)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……

Date:…..... Exam Seat No. …….....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

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 technologists in maximizing efficiency within a company by finding the best use of people, equipment, and facilities.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Based mechanical engineering related problems.

PO 1. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO 2. **Engineering tools:** Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 3. **The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of mechanical engineering.

PO 4. **Environment and sustainability:** Apply mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO 5. **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of mechanical engineering

PO 6. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 7. **Communication:** Communicate effectively in oral and written form.

PO 8. **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the mechanical engineering and allied industry.

Program Specific Outcomes (PSOs)

PSO 1: Modern Software Usage: Use latest mechanical related software for simple design, drafting, manufacturing, maintenance and documentation of mechanical components and processes.

PSO 2: Maintenance and selection of machines, equipment, instruments: Maintain and select appropriate machine, equipment and instrument in field of Mechanical Engineering.

PSO 3: Manage Mechanical Process: Manage the mechanical process by selection and scheduling right type of machinery, equipment, substrates, quality control techniques, operational parameters and software for a particular mechanical process or job for economy of operations.

List of Industry Relevant Skills-

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. Prepare the detailed sequence of operations carried out for manufacturing of components.

c. Apply ergonomic concepts to redesign simple mechanical control member for comfort conditions in various industrial environments.

d. Analyze the data obtained from the different quality control processes.

e. Interpret control charts for variable and attribute data.

Practical- Course Outcome matrix

Sr. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Apply method study approach to analyze the motions involved in machining operation of the given job	√	-	-	-	-
2.	Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch.	√	-	-	-	-
3.	Calculate standard time for all the operations involved in step turning process.	√	-	-	-	-
4.	Prepare motion chart of given activity using standard symbols of therbligs (max 18).	√	-	-	-	-
5.	Prepare supply chain chart in day-to-day situation like supply of Cold drink/tooth paste/any grocery item.	-	√	-	-	-
6.	Prepare supply chain management chart for online purchase of goods/products.	-	√	-	-	-
7.	Prepare detailed process plan for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.	-	√	-	-	-
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.	-	√	-	-	-
9.	Prepare Chart of sequence of operation for Single or Double riveted lap joint/Single riveted butt joint (single strap).	-	√	-	-	-
10.	Redesign the given simple lever(s) like gear shifting lever/brake/clutch lever/foot lever for best ergonomic aspect.	-	-	√	-	-
11.	Prepare and analyse steps to solve the given problem in institute/industry using quality circle concept.	-	-	-	√	-
12.	Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.	-	-		-	√
13.	Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.	-	-		-	√
14.	Draw and interpret the control charts ($\bar{X}$ and R) for given data.	-	-		-	√
15.	Draw and interpret the control charts (P-chart and C-chart) for given data.	-	-		-	√

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which She/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters(if any), which is not mentioned in the printed practical.
3. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

10.	Redesign the given simple lever(s) like gear shifting lever/brake/clutch lever/foot lever for best ergonomic aspect.	64					
11.	Prepare and analyse steps to solve the given problem in institute/industry using quality circle concept.	72					
12.	Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.	80					
13.	Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.	88					
14.	Draw and interpret the control charts (Xbar and R) for given data.	95					
15.	Draw and interpret the control charts (P-chart and C-chart) for given data.	103					
Total							

Note: To be transferred to Proforma of CIAAN-2017.

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 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.

Practical No.1 : Analyze the motions involved in machining operation of the given job

I Practical Significance

Method study enables the industrial engineer to lead each operation to systematic analysis. The main purpose of method study is to eliminate the unnecessary operations and to achieve the best method of performing the operation. Method study is also called as method engineering or work design. Method engineering is used to describe collection of analysis techniques which focus on improving the effectiveness of men and machines.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.
PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

- 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.**

IV Relevant Course Outcome(s)

a. Apply work study techniques to optimize manufacturing process.

V Practical Outcome

Apply method study approach to analyze the motions involved in machining operation of the given job.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical practices.

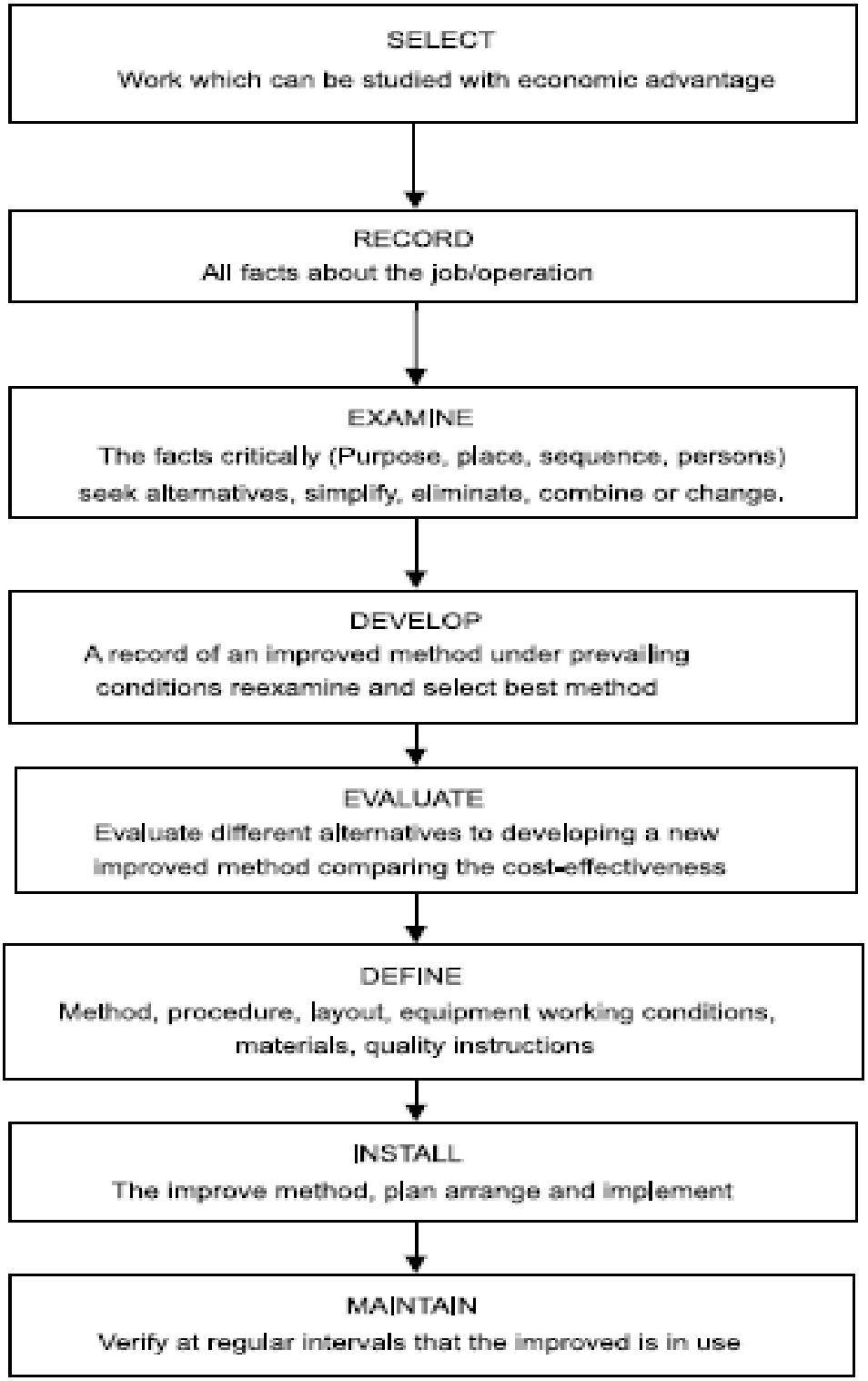
VII Minimum Theoretical Background

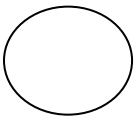
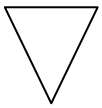
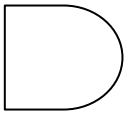
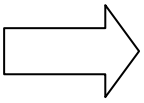
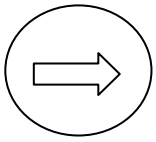
Steps of Method Study:

Following steps are used in Method Study

1. **Select** a concern area (work to be studied).
2. **Record** all the relevant facts about the present method.

3. **Examine** the facts critically and in ordered sequences, using the techniques best suited to the purpose.
4. **Develop** the most practical, economical and effective method having due regard to all contingent circumstances.
5. **Define** the new method so that it can always be identified.
6. **Install** the method as standard practice.
7. **Maintain** the method by regular routine checks.



Event	Symbol	Description
Operation		It represents an action. It indicates a main step in the process. Ex .pressing, grinding, polishing.
Storage		Representing stage when material awaits an action. Ex. Holding, storing, stocking, or retaining.
Delay or temporary storage		Indicates delay or a temporary hurdle in the sequence of operations. Ex. waiting for transport or operation etc.,
Transport		Indicates movement of men, materials from one place to another. Eg: movement, travelling etc.,
Inspection		Represents an action of inspection or checking for quality and quantity. Verification or checking
Operation and transportation		It refers to operation during transportation.

Meaning of different symbols used in Process chart

VIII Experimental setup

Fig.1 Recording devices

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Digital Video Camera	Available in the market or even student can use mobile camera.	1

X Precautions to be Followed

1. Avoid abrupt movements..
2. Keep safe distance from the machine.

XI Procedure

Steps involved in Motion Analysis are:

a) Select the operation to be studied.
b) List and chart various motions performed by the operator.
c) Identify the productive and idle motions.
d) Eliminate the unnecessary and non-productive motions.
e) Redesign the present operating procedure by employing minimum number of motions in the most appropriate sequence and in accordance with the principles of motion economy. Develop final set of operations & their sequence.
f) Impart necessary instructions to the worker so that he develops proper habit cycle.
g) Check once again the procedure in the light of step (e) above.

XII Resources used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

Process flow chart

Method : Existing/Proposed
Operation :
Operator :
Start of Activity :
Department :

Machine No. :
Operation No. :
Charted by :
End of Activity :
Date :

Distance	Symbol	Description
	○ ⇨ ▽ D □ ○ ⇨ ▽ D □ ○ ⇨ ▽ D □ ○ ⇨ ▽ D □	

Figure 1

Summary -

Sr. No.	Observed motions	Essential motions	Excess motions
1			
2			
3			
4			
5			
6			
7			
8			

XVI Results

.....
.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw Process chart for
   a. Toasting of Bread
   b. Orange Juice Making
   c. Book Binding
   d. Kite Making

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=XUs5xkJF0vs
2. https://slideplayer.com/slide/8053948/
3. https://www.youtube.com/watch?v=cxz_QKHmbMw
4. https://www.youtube.com/watch?v=K-t5bTLU6rc

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(40%)**
1	Recording of motions	20%
2	Identifying motions	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.2 : Apply work measurement technique to analyze the time components involved in machining operation of given job using stop watch.

I Practical Significance

Work measurement is the systematic determination of how long a task should take to complete. One of the most common types of work measurement is time study.Time studies determine how long a qualified worker under stated conditions can reasonably be expected to complete a task.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

- 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 techniquesfor assuring quality of products and services.**

IV Relevant Course Outcome(s)

b. Apply work study techniques to optimize manufacturing process.

V Practical Outcome

Apply work measurement technique to analyse the time components involved in machining of given job using stop watch.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Work Measurement

Work measurement refers to the estimation of standard time for an activity, that is the time allowed for completing one piece of job by using the prescribed method.

Time study is conducted for measuring work in process. Before making this time study each operation is broken into definite number of elements, which are not large or too short in time. Then select average cooperative operator(s). The stopwatch time study

is used to analyze a specific process by qualified workers in an effort to find the most efficient ways in terms of time. Moreover, this method measures the time necessary for a work process to be completed using the best ways. The time was measured using snapback stopwatch equipment because it is easier and faster in data recording. Moreover, this type of stopwatch is suitable for this research because it can develop accurate data. This allows the element times to be entered directly on the time study sheet without the need for subtractions.

Rating: Rating is the assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to standard pace. The society of Advancement of Management National Committee defines rating as that process during which the time study engineer compares the performance of the operator under observations with the observer's concept of proper (normal) or standard performance.

$$Basic\ time = Observed\ time \times \frac{Rating\ of\ worker}{Standard\ Rating}$$

So, **Actual Rating or Rating factor** of a worker can be found as follows:

$$Actual\ Rating = \frac{Basic\ time}{Observed\ time} \times 100$$

VIII Experimental setup

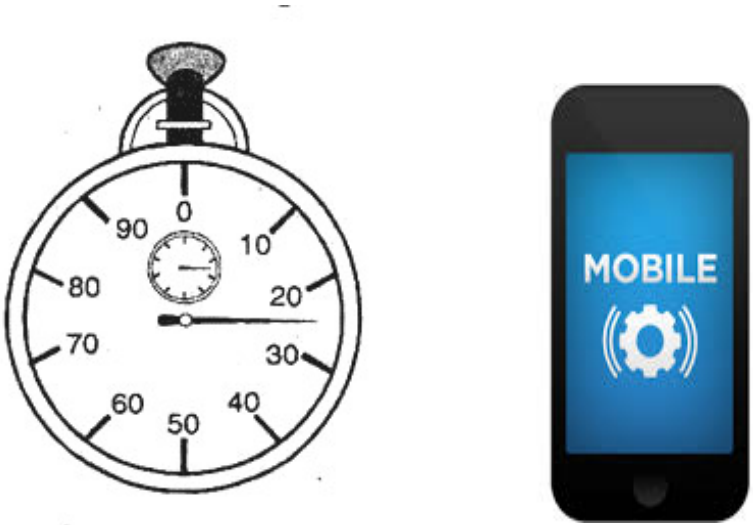


Fig 1 Recording devices

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Stop Watch	Timing capacity:23hrs, 59mins and 59.99secs,Accuracy: ±3 seconds/day	1
2.	Digital Video Camera for Micro Motion Analysis	Available in the market or even student can use mobile camera.	1
3.	Steel Rule for Length Measurement	Range 0-5 feet	1

X Precautions to be Followed

1. Avoid improper handling of stop watch
2. Keep safe distance from machine .

XI Procedure

i. Observe operators performing a task. i.e drilling operation.
ii. Record time taken for each element of operation, over several cycles.
iii. Record the time taken to perform an activity and to give the ratings of that activity.
iv. Determine the total time for the activity
v. Find the unnecessary element and associated time /excess time in the activity
vi. Find percentage saving in time.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

Performance Rating -

Basic time –

Department					Operator						Analyst				Total Time	No. of Obs.	Avg. Time	Most frequently reading	Minimum reading	Rating	Normal Time
Operation					Foreman						Date										
No.	Element	Unit Produced	1	2	3	4	5	6	7	8	9	10	11	12							

XVI Results

.....
.....
.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....
.....
.....
.....

XVIII Conclusions

.....

.....

.....

.....

.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Differentiate between work measurement and Time Study
2. Define 'Basic Time '

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

i. https://slideplayer.com/slide/7439691/
ii. https://www.youtube.com/watch?v=0ufrez3JMIQ
iii. https://www.youtube.com/watch?v=jDaa1HZQQZg
iv. https://www.youtube.com/watch?v=Ewy7ps51FZI

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identification of elements for one cycle	20%
2	Recording of time elements for multiple cycles	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.3 : Calculate standard time for all the operations involved in step turning process.

I Practical Significance

Work measurement involves finding out the time taken for doing each element. The time taken for each element is totaled. Time study with the help of a stopwatch is the most commonly used work measurement method. Time study is best suited for short-cycle repetitive jobs Most of the production jobs can be easily timed by a time-study. The technique helps to determine performance rating of workers and their wage rates.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

- 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 techniquesfor assuring quality of products and services.**

IV Relevant Course Outcome(s)

c. Apply work study techniques to optimize manufacturing process.

V Practical Outcome

Calculate standard time for all the operations involved in step turning process.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Stop Watch Time Study:

Stop Watch is one of the equipment used for Time Study. It is employed for measuring the time taken by an operator to complete the work. Stop watch used for time study purpose should be very accurate and preferably be graduated in decimals so that it can recover even up to 0.01 minute.

A large hand in the stop watch is revolved at a speed of one revolution per minute. The dial of the stop watch is divided into 100 equal divisions. The small hand inside the stop watch revolves at a speed of one revolution in 30 minutes.

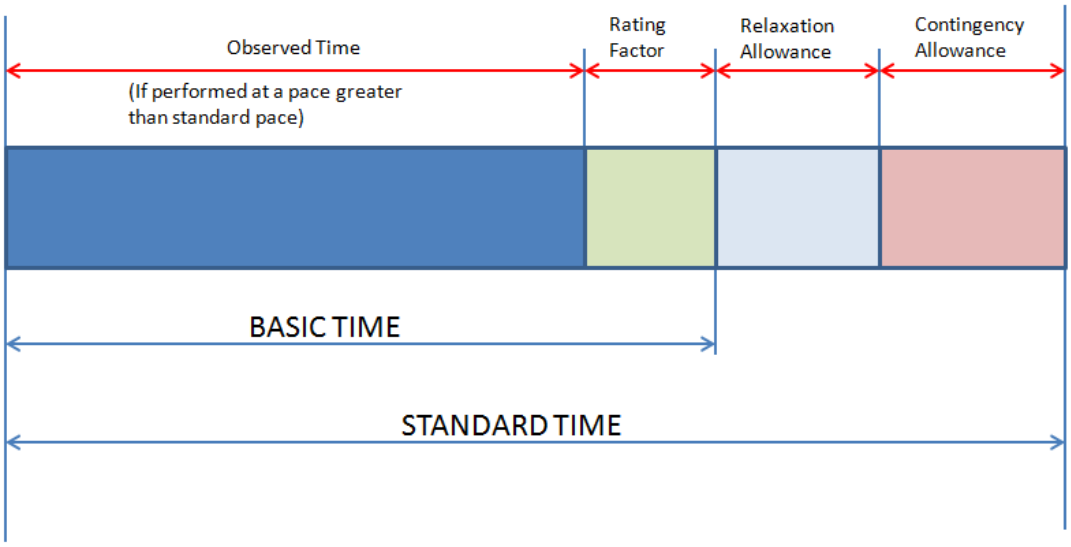


Figure 1 This shows how standard time is made up

Rating: Rating is the assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to standard pace. The society of Advancement of Management National Committee defines rating as that process during which the time study engineer compares the performance of the operator under observations with the observer's concept of proper (normal) or standard performance.

$$Basic\ time = Observed\ time \times \frac{Rating\ of\ worker}{Standard\ Rating}$$

So, **Actual Rating or Rating factor** of a worker can be found as follows:

$$Actual\ Rating = \frac{Basic\ time}{Observed\ time} \times 100$$

Standard time= Basic time + Allowances

VIII Experimental setup

Figure 2 stop watch

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Stop Watch	Timing capacity:23hrs, 59mins and 59.99secs,Accuracy: ±3 seconds/day	1
2.	Digital Video Camera for Micro Motion Analysis	Available in the market or even student can use mobile cmera.	1
3.	Steel Rule for Length Measurement	Range 0-5 feet	1

X Precautions to be Followed

1. Avoid improper handling of stop watch
2. Maintain safe distance from the machine

XI Procedure

a. Understand the job to establish the quality to be achieved in the job.
b. Identify key operations to be timed in the job.
c. Get improved procedure from the method study department. (Refer to Expt. 1)
d. Organize resources and explain the objectives of time study to the worker and supervisor.
e. Explain details to worker about improved working procedure.
f. Break operation into elements to separate the constant elements from variable elements.
g. Observe and record the time taken by an operator.
h. Determine for number cycles to be timed and then the average time or representative time can be found out.
i. Rate the performance of the worker during observation.
j. Calculate normal time from observed time by using performance rating factor.

k. Add process allowance rest and personal allowance and special allowances to the normal time in order to obtain standard time or allowed time.

l. Standard time determination by adding normal time and allowances.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....

.....

.....

.....

.....

XIV Precautions Followed

.....

.....

.....

.....

.....

XV Observations and Calculations

Performance rating -

Basic time –

Allowances –

Standard Time -

Time Study Form :

Date	:	Description	:
Time Study Engineer	:	No. of Cycles	:
Product	:	Standard time found	:
Operation	:		

Element Description	Observed Time (Stop Watch Reading)					Average time	Rating factor	Normal time	Allowance	Standard time
	1	2	3	4	5					

XVI Results

.....

.....

.....

.....

.....

.....

XVII Interpretation of Results

.....

.....

.....

.....

.....

.....

XVIII Conclusions

.....

.....

.....

.....

.....

.....

.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Problem 1:

Naresh, a marketing surveyor, takes an average of 10 minutes to complete a particular questionnaire. His performance rating (pace) is 110% and there is an allowance of 10%.

1. Calculate the Normal time for completing questionnaire.
2. Calculate the Standard time for completing questionnaire.

Problem 2:

Krishna, Rama, Govinda, and Shreekumar, takes 3 hours and 25 minutes to write an end of month report. Krishna is rated at 95% (work pace is 95%) and the office has a personal time allowance of 8%. There is no delay time or fatigue time.

1. Calculate the Normal time for writing an end of month report.
2. Calculate the Standard time for writing an end of month report.

Problem 3:

The two steps in preparing chocolate candy bars are molding and packaging. Personal fatigue and delay allowances are set at 15%. The molding machine operator is rated at 110% and the packer is rated at 80%. Observed times per batch are given below.

	Observed Time in Minutes			
Task	1	2	3	4
Molding	26	30	29	31
Packing	45	50	35	30

Determine the Normal and standard times for both tasks.

Problem 4:

A work-study sample of a manufacturing activity conducted over a 40-hour period shows that a worker with an 85% rating produced 12 parts. The worker's idle time was 10% and the allowance factor was 12%

Find the Normal and Standard time for this activity.

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

i. https://slideplayer.com/slide/7439691/
ii. https://www.youtube.com/watch?v=0ufrez3JMIQ
iii. https://www.youtube.com/watch?v=jDaa1HZQQZg
iv. https://www.youtube.com/watch?v=Ewy7ps51FZI

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Observing and Identifying elements in cycle	20%
2	Recording of time for multiple cycles	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.4 : Prepare motion chart of given activity using standard symbols of therbligs

I Practical Significance

Micro motion study technique is best suited for those operations or activities which are of short duration and which are repeated hundreds of time. These are the operations or motions which require very small time and it is quite difficult to measure time for these motions accurately and the time required by these motions cannot be neglected due to repetitive operations.

In such activities it is interesting to go into greater details in order to find out which movement and effort can be avoided. All this is done to develop the best possible pattern of movement so that the operator can perform the operations repeatedly with a minimum effort and fatigue.

II. Relevant Program Outcomes (POs)

PO1- Basic knowledge: Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

d. Apply work study techniques to optimize manufacturing process.

V Practical Outcome

Prepare motion chart of given activity using standard symbols of therbligs

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Micromotion study is a set of techniques intended to divide human activity into group of movements or micromotions and the study of such movements helps to find for an operator one best pattern of movements that consumes less time and requires less effort to accomplish the task.

Short cycle operations require to be studied for microscopic motions e.g., operation of picking up a nut from bin and its fixing consists of three hand motions namely reach for the nut, grasp nut and move hand back to assembly position. Such detailed analysis help to develop the best possible pattern of movements and hence enabling the operator to perform various operations repeatedly with minimum effort and fatigue.

Micro motion study is one of the most accurate techniques of work analysis used for work improvement. It makes use of motion pictures of the different activities or movement, so with the help of camera. Very small time upto 0.0005 minute can be measured and recorded by this system. When picture camera is utilized, the procedure is known as "MICR-MOTION STUDY". The motion time data from the film is transferred to simo chart. The simo chart data can be further analyzed for the purpose of work place layout or method improvement.

This technique was developed by Fran Gilbreth who considered that an operation consists of minute elements which may be repetitive or non repetitive. He termed these elements THERBLIG (after his name Gilbreth if spelt back word is Therblig).

Therbligs primarily refer to motion of human body at the workplace and to the mental activities associated with it. They permit much more precise and detailed description of the work than any other recording techniques.Therbligs were suggested by Frank B. Gilberth the founder of motion study who differentiated 17 fundamental hand or hand and eye motions to which an eighteenth has been added.Each therblig has a specific color, symbol and letter for recording purposes.

Therbligs are used for the following:

1. In studying the activities of two or more persons on a group work.
2. In studying the relationship of the activities of the operator and the machine as a means of timing operations.
3. In obtaining motion time data for time standards.
4. Acts as a permanent record of the method and time of activities of the operator and the machine.

VIII Experimental setup

Sr. No.	Therblig	Symbol		Colour	Definition
1.	Assemble		A	Violet	Putting objects together.
2.	Disassemble		DA	Light violet	Separating different parts of an assembled unit.
3.	Avoidable delay		AD	Lemon yellow	A delay within operator's control.
4.	Unavoidable delay		UD	Yellow	A delay on which operator has no control.
5.	Transport loaded		TL	Green	Moving an article from one place to another.
6.	Transport empty		TE	Olive green	Moving (a body member, say hand) empty.
7.	Search		SH	Black	Hunting for an object.
8.	Plan		PN	Brown	Mental reaction before action.
9.	Rest		R	Orange	An allowance, idleness or pause to overcome fatigue incurred during previous work.
10.	Position		P	Blue	Turning to line up, orient or change position.
11.	Find		F	Gray	Mental reaction at end of search.
12.	Inspect		I	Burnt ochre	Examining an object for its quality.
13.	Preposition		PP	Pale blue	Locating an article in predetermined position so that it is ready for use.
14.	Grasp		G	Red	Taking hold of something.
15.	Use		U	Purple	Manipulating or causing a tool to do its function.
16.	Hold		H	Gold ochre	Retention (after grasp).
17.	Select		ST	Light gray	Choosing one object from amongst many.
18.	Release load		RL	Carmine red	Releasing an object.

Figure no 1 Therbligs

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Stop Watch	Timing capacity:23hrs, 59mins and 59.99secs,Accuracy: ±3 seconds/day	1
2.	Digital Video Camera for Micro Motion Analysis	Available in the market or even student can use mobile camera.	1
3.	Steel Rule for Length Measurement	Range 0-5 feet	1

X Precautions to be Followed

1. Avoid improper handling of camera / recording devices
2. Keep safe distance from the machine.

XI Procedure

i. Select a job for step turning operation for method study.
ii. Observe and record movements /motions in the operation.
iii. Chart the recorded motions with the help of symbols.
iv. Analyze the motions with respect to man, machine and materials.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....
.....
.....

XV Observations and Calculations

Operation : Operator : Part Name : Method : Present / Proposed				Film No. : Operator No. : Date : Charted by :		
Left hand	**Symbol**	**Time (Wink)**	**Total**	**Time (Wink)**	**Symbol**	**Right hand**

XVI Results

.....

.....

.....

.....

.....

XVII Interpretation of Results

.....

.....

.....

.....

.....

XVIII Conclusions

.....

.....

.....

.....

.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Differentiate Cycle graph v/s Chrono cycle graph.
2. Discuss the comparison of various techniques of work measurements**.**

[Space for Answer]

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=XUs5xkJF0vs
2. https://slideplayer.com/slide/8053948/
3. https://www.youtube.com/watch?v=cxz_QKHmbMw
4. https://www.youtube.com/watch?v=K-t5bTLU6rc

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Observing and Identifying the motions	20%
2	Recording of motions	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.5 : Prepare supply chain chart in day-to-day situation like supply of cold drink/tooth paste/any grocery item.

I Practical Significance

Supply chain plays important role in ensuring right time delivery of goods & services to the customer economically. For various functions like planning, purchasing, production, transportation, distribution & customer service , supply chain people play important role. Supply chain management increases competitiveness in market and achieves customer satisfaction.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO 8.**Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Prepare the detailed sequence of operations carried out for manufacturing of components.

V Practical Outcome

Use technique of Supply Chain Management in production of goods & services.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Supply Chain consists of all the parties, vendors, manufacturers, suppliers involved directly or indirectly in fulfilling all the customer needs and changing demands. The flow of materials, products, money, information not only between the manufacturer

and suppliers but also with transport, logistics, warehouses and retailers in the entire value chain.

Cold drink production – Raw material needed is sugar, fresh juices, flavors, & concentrate. Water treatment is necessary to for bacteria, salts etc. Simple syrup prepared with sugar & water. Then concentrate is mixed to get final syrup. A flash pasteurization ensures more shelf life. Treated & cooled water is them mixed with syrup with carbon dioxide. Drinks are then hermetically sealed, labeled, coded and tested in automatic plants. Non returnable glass bottles, PET bottles, cans are used for packaging. Then packaged bottles are supplied to wholesalers. Further they are transferred to retailers before they reach final customers.

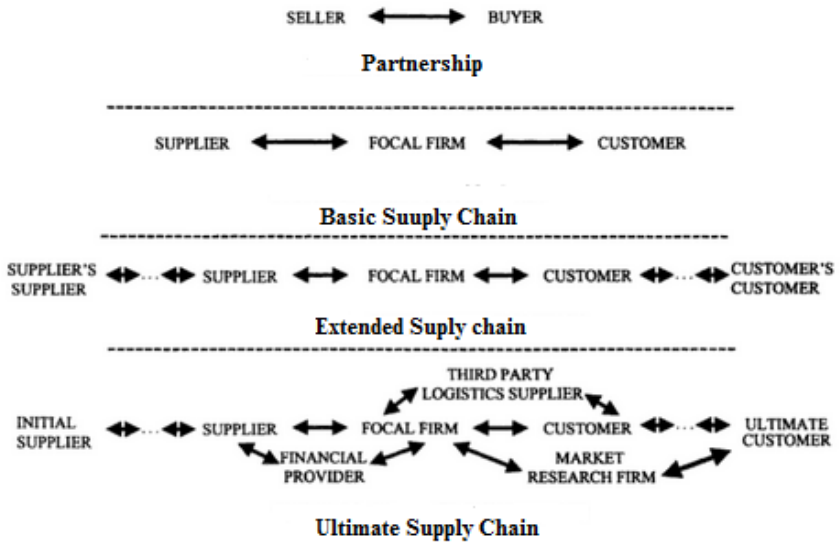


Figure 1. Types of channel Relationships

VIII Experimental setup

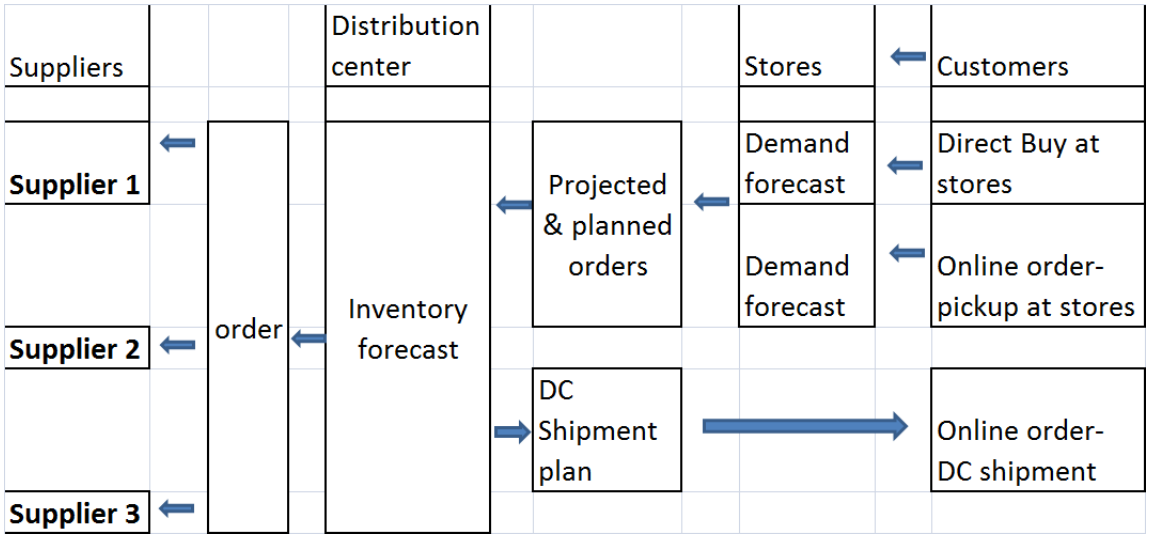


Figure 2. SCM chart for a typical consumer store

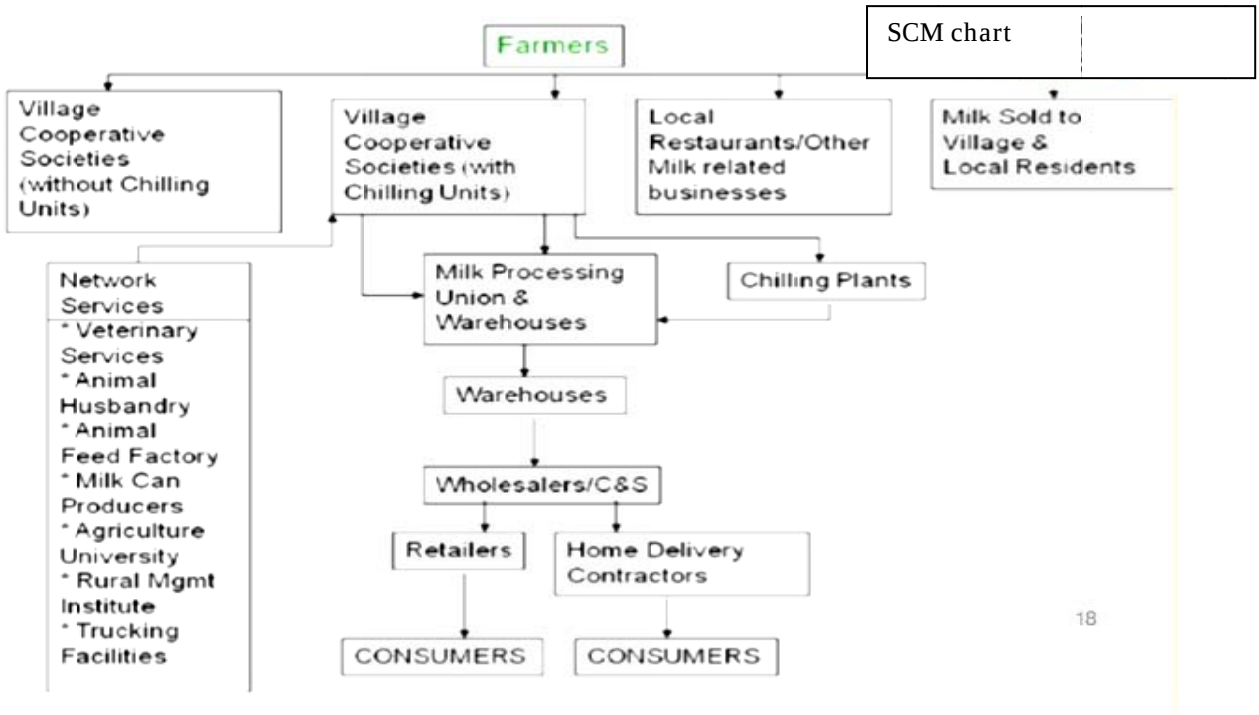


Figure 3. SCM chart for a Amul products

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Websites, relevant books, manufacturing company websites	NA	NA

X Precautions to be Followed

1. Use standard terminology
2. Consider all processes involved from supplier to distributor ends.

XI Procedure

i. Know demands & necessities of customers
ii. Identify suppliers for raw material.
iii. Determine methods of shipping, delivery and payment.
iv. Construct delivery & payment processes.
v. Set facility for receiving & examining materials.
vi. Transfer raw materials to manufacturing.
vii. Determine & schedule activities for manufacturing, testing, packaging and synchronize for delivery.
viii. Deliver product to customer destination.
ix. Establish network for warehouses.
x. Establish network for return of damaged / defective products.
xi. Prepare performance assessment / control metrics.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

(Students are expected to draw SCM chart of any suitable day-to-day product.)

XVI Results

.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Define SKU in supply chain management

Q2. List key elements of supply chain management?

Q3. Define inbound & outbound transportation in SCM.

Q4. State purpose of control metrics in SCM? Draw a typical one

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

XX References / Suggestions for Further Reading

1. https://www.scribd.com/document/347303313/Supply-Chain-Management-of-Coca-Cola-pdf (COCA COLA SCM)
2. https://www.slideshare.net/chandan9211/presentation-on-supply-chain-management-of-amul (AMUL SCM)
3. https://www.mhlnews.com/global-supply-chain/how-measure-supply-chain-performance (performance measurement for SCM)

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identify elements of supply chain	20%
2	Preparation of SCM chart	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.6 : Prepare Supply Chain Management Chart For Online Purchase Of Goods/Products.

I Practical Significance

It is expected that in 2020 India will have US$120 billion dollar revenue from e-commerce and by 2026 it will touch US$200 billion dollars. (Source – India Brand Equity Foundation) The product portfolio has also increased to multifold times within a very short span of time. Supply chain management is important in online trading. Not only manufacturers but customers are largely benefitted due to online shopping. It has brought customers & online seller under one roof along multiple brands of multiple products. Online trading has resulted in reduced costs to customers as well as overheads of manufacturers & sellers drastically. SCM for online trading has it's own challenges**.**

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO 8.**Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Prepare the detailed sequence of operations carried out for manufacturing of components.

V Practical Outcome

Use technique of Supply Chain Management in online trading.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Supply chain management is also defined as central organization of company's all resources and materials required to rationalize production process with reduction in costs.

Major components of online trading of goods are

1. Web server
2. Stock database
3. Bank systems for payments
4. Warehouse & dispatch
5. Transportation arrangements for goods.

Online traders have their delivery centers at various locations. Once order is received from customer it is checked in delivery center stock. If it is available then it is delivered. If no, order is placed with company. Depending on locations different logistic bodies are identified. Like DHL etc.

In inventory management online trader, wholesaler / distributor, supplier / manufacturer can have their own system. Online trader carries inventory of high demand items where as purchases low demand items from distributor in response to customer order.

Some concepts -

- **Product sourcing** is locating a source of products to sell that you do not manufacture yourself.
- **Drop shipping** involves transferring customer orders to another company, who fulfills the orders by shipping the items directly to the customer on your behalf.
- **Wholesale suppliers** are simply providing you items at wholesale prices from the manufacturers.

Important points to be thought of while designing SCM chart for e-commerce

Before preparing SCM charts ascertain following points

- Will you manufacture or resell items?
- Will you keep an inventory or not?
- How much control do you want over the packaging and shipping?
- How critical is price control to your business model at this stage?
- What volumes will you be dealing in?
- Contact Trade Magazines and Associations to Develop Suppliers
- Evaluate Local Retailers as a Source
- Sourcing Directly From Manufacturers.

VIII Experimental setup

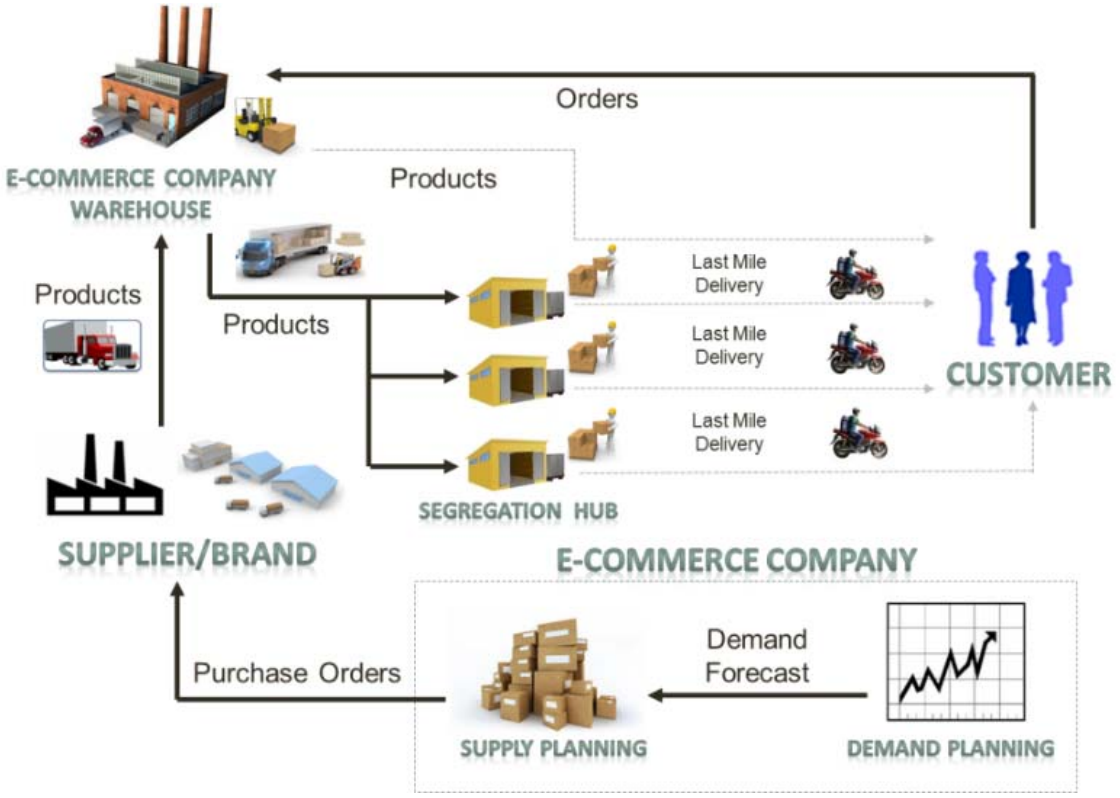


Figure 1 Typical SCM chart for online goods

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Websites, relevant books, manufacturing company websites	NA	NA
2.			

X Precautions to be Followed

1. Use standard terminology
2. Consider all processes involved from supplier to distributor ends.

XI Procedure

i. Identify demands & necessities of customers
ii. Identify products suitable for online selling
iii. Identify suppliers for raw material / final products.
iv. Design mobile / personal computer interface for online booking, online payments & online tracking as well as online cancellation.
v. Decide delivery period for different products based on inventory availability.
vi. Tie-ups with distributors & courier companies.

vii. Determine methods of shipping, delivery and cash on delivery payment.
viii. Set facility for receiving & examining materials.
ix. Issue supplier payments
x. Deliver product to customer destination.
xi. Establish network for warehouses.
xii. Establish network for return of damaged / defective / cancelled products.
xiii. Prepare performance assessment / control metrics.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

(Students are expected to draw SCM chart of any of the e-commerce business)

XVI Results

.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Define 'Reverse logistics'

Q2.State pros& cons of online shopping.

Q3.Elaborate multiple tier inventory model used by amazon.

Q4. Explain term ' logistic outsourcing'

Q5. State benefits & risks of drop shipping.

Q6. State elements / activities involved in Demand Planning, supply planning & demand fulfillment.

Q7. Give examples of B2B, B2C & C2C trading via ecommerce.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....

XX References / Suggestions for Further Reading

1. https://www.thebalancesmb.com/supply-chain-strategy-1141735 (drop shipping etc.)
2. https://www.webretailer.com/lean-commerce/ecommerce-supply-chain/
3. https://slideplayer.com/slide/5378700/ (Ecommerce supply chain)

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying supply chain elements	20%
2	Preparation of SCM chart	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 7 : Prepare detailed process plan for manufacturing of simple job.

I Practical Significance

Once the product is designed, one of the primary aims of mechanical group branch student is to plan manufacturing processes in best possible ways. Develop & use tools, processes, machines & equipment used for carrying out specific job. Integrate all necessary facilities to produce quality & economic product. In short process planning can be defined as systematic determination of methods by which a product can be manufactured economically & competitively. It consists of devising & specifying process, machine tools and other equipment to convert raw materials in to finished / assembled product. The aim of process planning is to develop best process for each job.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO6 - **Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

III Competency and Skills

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.

IV Relevant Course Outcome(s)

Prepare the detailed sequence of operations carried out for manufacturing of components.

V Practical Outcome

Prepare detailed process plan for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Contents of process plan - A process plan should contain

1. Identification of purpose of process including name and number of components to be produced, lot size, material, assembly in which this part will fit, number of components per assembly.
2. List of operations making up the processes and place where they will happen.
3. Specifications for interchangeability. Locating surfaces, clamping surfaces, dimensions, tolerances, surface quality etc.
4. Specifications of methods, machines, tools &equipments to produce required quality & quantity in lowest cost. Include information on what is to be done in each operation, kind of machine, m/c location, accessories and attachments, special tools, jigs & fixtures, set up, feed speed and so on.
5. Specifications of performance expected from each operation, standard time of each operation, setup time, output expected per unit time etc.

After this one need to understand various process operation required. Depending on nature of operations one has to decide which operation shall be done before other operations. Operation include basic operations, principal operations, major operations (critical operations, secondary operations, qualifying operations, re-qualifying operations)

VIII Experimental setup

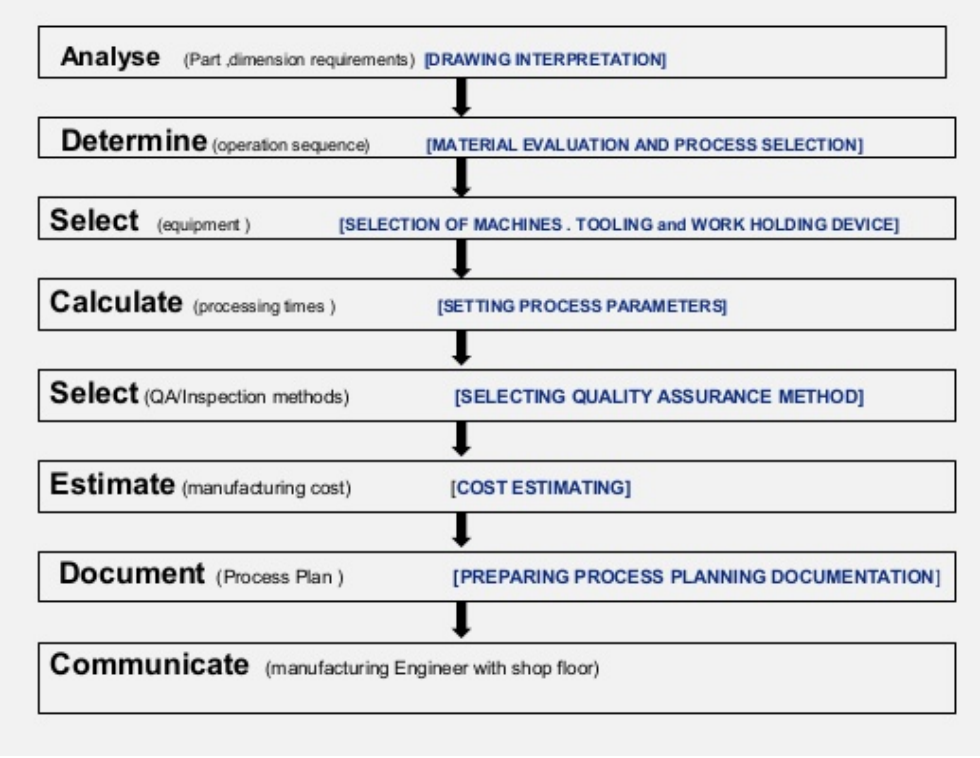


Figure 1. Steps in preparation of process plan

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Websites, relevant books, manufacturing company websites	NA	NA

X Precautions to be Followed

1. Use standard terminology
2. Consider all possible alternative options available.

XI Procedure – (to prepare process plan)

i. Requirements and conditions of process – specifications of finished product, raw material conditions, quantity to be produced. Various requirements of product should be studied.

ii. Improvement of specifications – Investigate part design to economize production. Suggest changes.

iii. List basic operations – Without any particular sequence list down all necessary operations.

iv. Determine most practical & economical manufacturing method – Consider economic materials, tooling, labor costs, overheads. Calculate & compare these costs. Principal operations are decided by method by which work piece is originated like forging, sheet metal etc.

v. Selection of equipment – They are long term investments. Consider size and shape of material, work material, accuracy & surface finish required, quantity, lot sizes, personal preferences are some considerations in selection of equipments. This step will consider use of general or special purpose machines.

vi. Combine operations and put them in proper sequence – Put operations in best sequence. Operations are combined in two ways: simulation & Integration.

vii. Specify gauging required for the process – Gauging requirements must be specified to maintain quality & functionality of the parts.

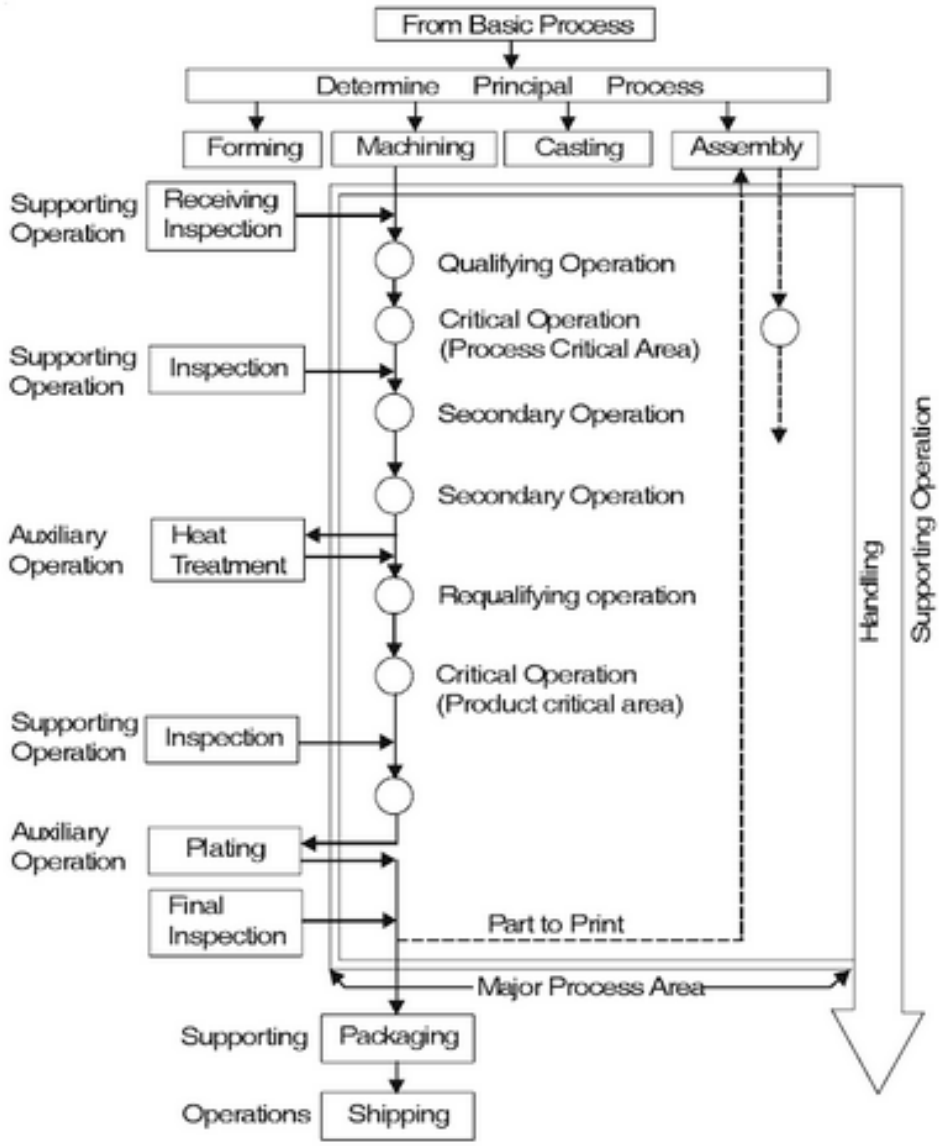


Figure 2. Typical Process Plan

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....

.....

.....

.....

.....

XIV Precautions Followed

.....

.....

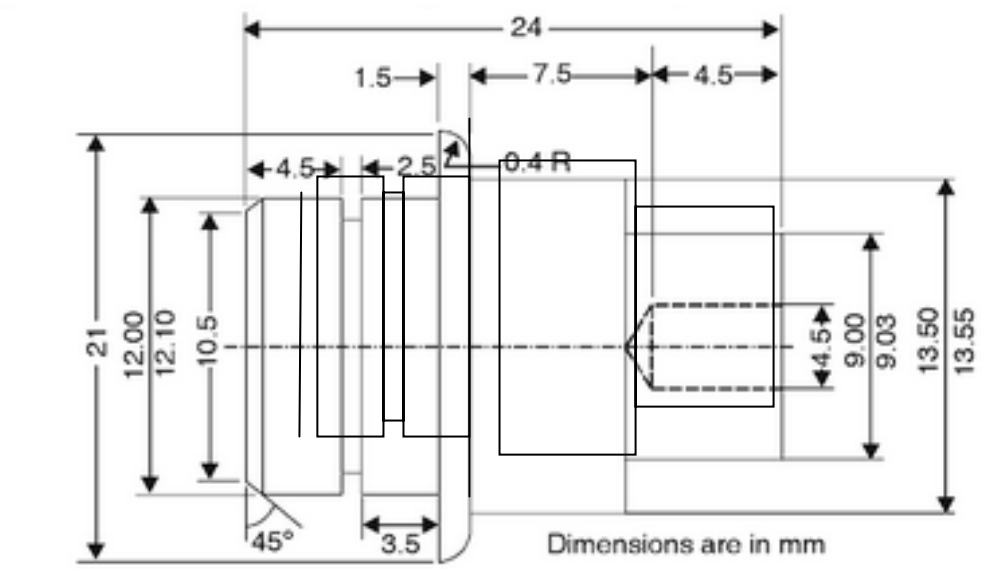
.....

.....

.....

XV Observations and Calculations

(Students are expected to prepare process plan of a simple job.)



1. **Analyze print – Largest diameter -**
   Assume tolerance –
   Bar size needed
2. **List basic operations –**
   Stop drill
   Drill ……. mm
   Turn …… mm dia
   Turn …… mm dia
   Form …….. mmdia
   Face ……
   Radius ……
   Cutoff
3. **Machine tool selected –**
4. **Combine operations and put in sequence –**

5. Specify gauging

6. Prepare operations sheet

Operation Sheet

	Part Name - **Part Number -**		**Material -**
Operation No.	**Operation**	**Machine**	**Tools, gauge**
1			
2			
3			
4			
5			
6			
7			

XVI Results

.....
.....
.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. List processes involved in manufacturing of hexagonal nut / V-block. Prepare process plan for the same.
Q2. Define 1. Principal operations 2.Qualifying operations 3.Re-qualifying operations.
Q3. Describe product & process critical areas.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://books.google.co.in/books?id=GRSbGhQ-ywwC&printsec=frontcover&dq=production+engineering&hl=en&sa=X&ved=0ahUKEwji3N2fwtfjAhVK4nMBHaDvDekQ6AEIKDAA#v=onepage&q=production%20engineering&f=true (book on production Engineering)
2. https://www.slideshare.net/MuruganantanK/unit-1-introduction-to-process-planning (process planning)

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying elements of process plan	20%
2	Preparation of process plan	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 8: Prepare chart of sequence of operations of a simple job.

I Practical Significance

Operation process chart is one of the tools useful in method study. It shows all the operations that occur from reception of raw material to packaging of finished product. Hexag onal nut & bolt are very common components required in almost all machines used for production purpose. As well as in very common appliances that we use in our day to day life these components are frequently used. Preparation of operation sheets for such small components enables students to prepare complex operation sheets. A typical gear can have as many as 30 operations. And similarly more complex parts can have more number of operations.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Prepare the detailed sequence of operations carried out for manufacturing of components.

V Practical Outcome

Prepare chart of Sequence of operations for manufacturing of simple job like manufacturing of hexagonal nut & bolt/ manufacturing of V-Block on shaper machine.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

In method study information recording is important task. One of techniques used for the same is process charts. Process charts can be operation process chart / flow process chart / operator chart. Operation process chart provides sequence of all operations and all inspections that occur during manufacturing / business process. It also shows materials used and and time taken by operator for different elements of work.

In preparation of these charts symbols of operation ( ) and inspection ( ) are necessary.

Operation indicates main steps, usually a material / product is modified, adding or subtracting during assembly / disassembly. Inspection is done to check quality and / or quantity. e. g. measuring dimensions, counting number of components.

Advantages of OPC

(i) To improve shop/plant layout

(ii) Helps in specifying the basic manufacturing system.

(iii) Helps in determining sequence of assembly and the scheduling activities regarding dates of purchased material and completion dates for fabricated parts.

(iv) To introduce the new technical personal with the manufacturing system.

VIII Experimental setup

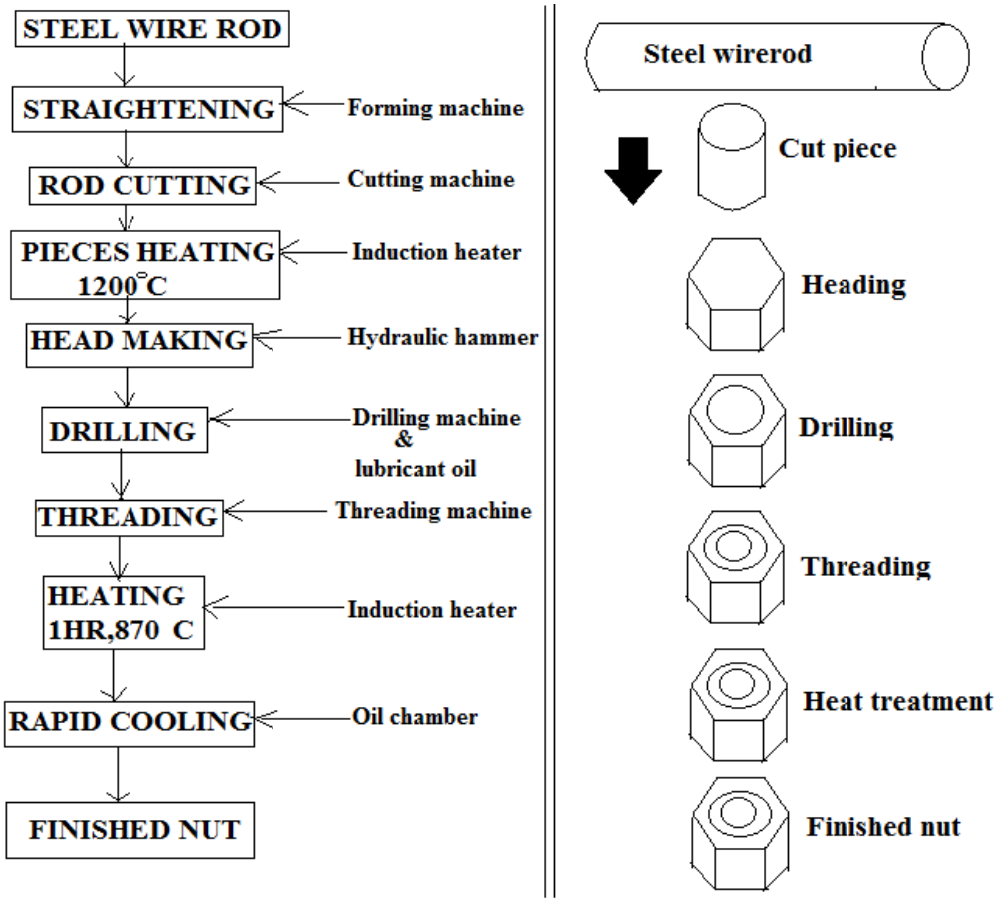


Figure 1 Typical hexagonal nut manufacturing

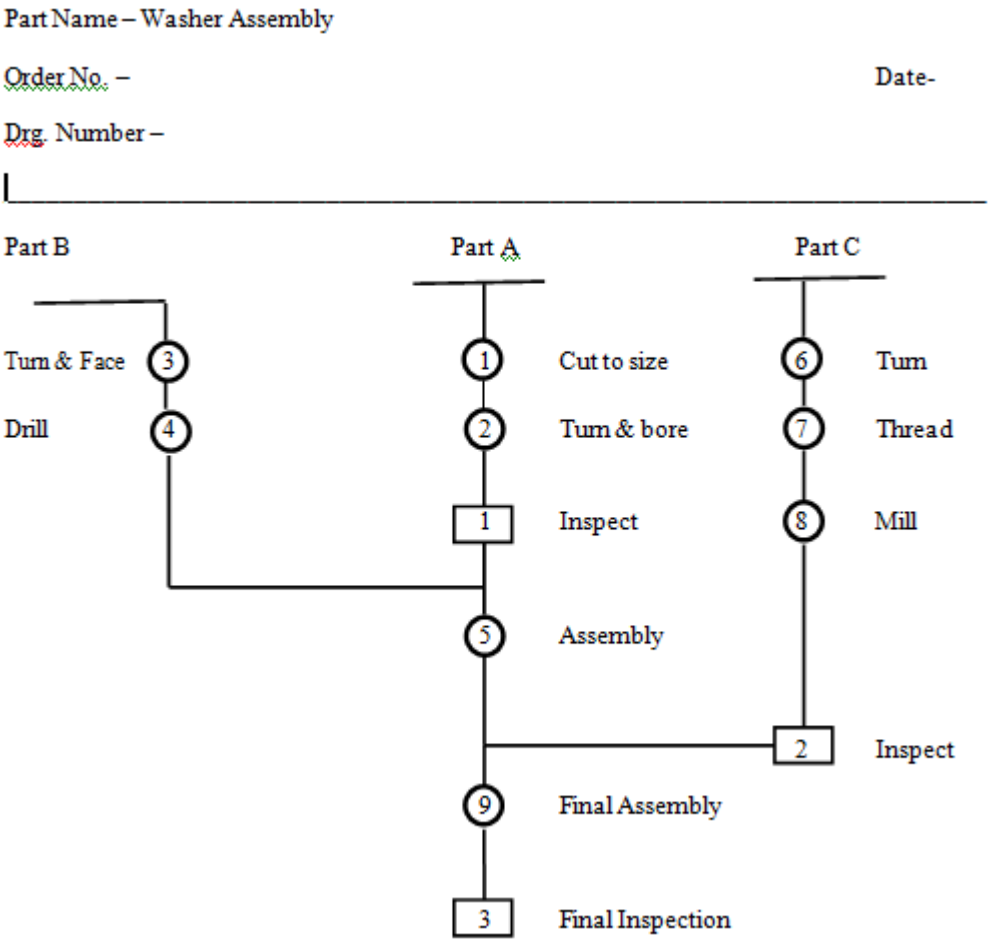


Figure 2 Typical operation process chart

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Simple job drawing	NA	NA
2.			

X Precautions to be Followed

1. Use standard terminology
2. Best possible method of doing job must be used.

XI Procedure – (to prepare process plan)

i. Prepare list of operations to be carried out for a given part.
ii. Arrange all these operations in a sequence in which they must be manufactured.
iii. Identify operations which must follow inspection.
iv. Identify parameters for inspection.
v. Prepare a chart in standard format indicating all operations and inspections.
vi. Represent all operations & inspections along with symbols.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

(Students are expected to prepare operation sheet of a simple job using suitable method.)

S. No.	Operation	S. No.	Inspection

XVI Results

.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. List alternative methods for hexagonal nut manufacturing.

Q2. State advantages of cold forming.

Q3. List heat treatment methods required in manufacturing of hexagonal nut / v block.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://books.google.co.in/books?id=ecJWJZjuC-cC&pg=PR5&source=gbs_selected_pages&cad=2#v=onepage&q&f=true
2. https://www.wuerth-industrie.com/web/media/en/pictures/wuerthindustrie/technikportal/dinokapitel/Kapitel_04_DINO_techn_Teil.pdf

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying operations and inspections	20%
2	Preparation of Operation sheet	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 9 : Prepare chart of sequence of operations of a riveted joint.

I Practical Significance

Permanent joints cannot be dissembled without damaging the components. These joints can be of two kinds depending upon the nature of force that holds the two parts. The force can be of mechanical origin, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by applying mechanical force. The components can also be joined by molecular force, for example, welded joints, brazed joints, joints with adhesives etc. Not until long ago riveted joints were very often used to join structural members permanently. However, significant improvement in welding and bolted joints has reduced the use of these joints. Even then, rivets are used in structures, ship body, bridge, tanks and shells, where high joint strength is required.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Prepare the detailed sequence of operations carried out for manufacturing of components.

V Practical Outcome

Prepare Chart of sequence of operation for Single or Double riveted lap joint / Single riveted butt joint (single strap).

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

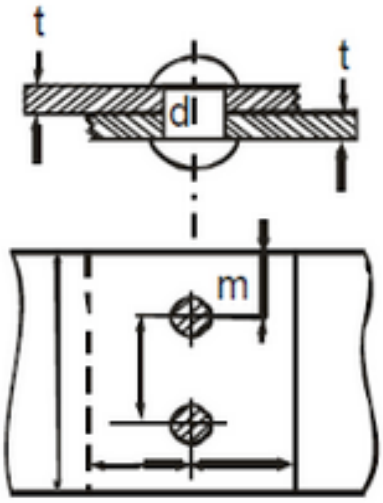
VII Minimum Theoretical Background

A Rivet is a short cylindrical rod having a head and a tapered tail. The main body of the rivet is called shank.

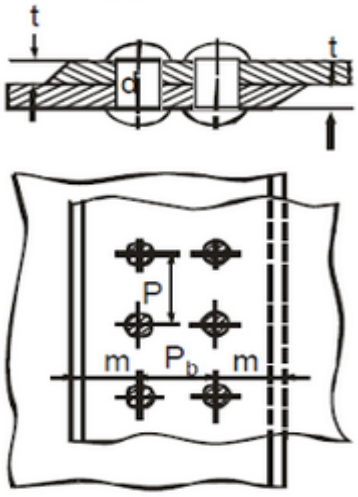
The plates that are to be joined are brought face to face such that an overlap exists. Rivets are inserted on the overlapping portion. Single or multiple rows of rivets can be used to give necessary strength to the joint. Based on the number of rows the riveted joints can be classified as single riveted lap joint, double or triple riveted lap joint etc. While multiple joints are used, the arrangement of rivets between two adjacent rows can be of two kinds. In chain type of riveting the adjacent rows have rivets in the same transverse line. In zig-zag riveting, on the other hand, the adjacent rows of rivets are staggered.

Riveting includes preparation of sheet metals plates, drilling / punching, using rivet tool & die, heating rivet area, deform tail section manually or using machine.

VIII Experimental setup



Single riveted lap joint



Double riveted lap joint

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Internet, actual operation.	NA	NA
2.			

X Precautions to be Followed

1. List operations by observing the process.
2. Best possible method of doing job must be used.

XI Procedure –

i. Prepare list of operations to be carried out for an application need riveting.
ii. Arrange all these operations in a sequence in which they must be manufactured.
iii. Identify operations which must follow inspections.
iv. Identify parameters for inspection.
v. Prepare a chart in standard format indication all operations and inspections.
vi. Represent all operations & inspections along with symbols.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

(Students are expected to prepare operation sheet of a riveting job using suitable method.)

Chart of sequence of operations

Name of part – **Drg. Number -**

S. No.	Operation	S. No.	Inspection

XVI Results

.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Define Pitch, diagonal pitch, transverse pitch, marginal pitch.

Q2. State essential qualities of rivet and it's materials.

Q3. Compare hot riveting & cold riveting

Q4. State applications of riveted joints.
Q5. Comment on chain type & zigzag type riveted joints.
Q6. State relation between diameter of rivet & thickness of plate.

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=tIgZi1duP3E
2. https://www.youtube.com/watch?v=H137Yb8TGvI
3. https://www.youtube.com/watch?v=IDbTUt3OG9s

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying operations and inspections	20%
2	Preparation of Operation sheet	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.10 : Redesign the given simple lever(s) for best ergonomic aspect.

I Practical Significance

A system is a set of elements, the relations between these elements and the boundary around them. Most systems consist of people and machines and perform a function to produce some form of output. Inputs are received in the form of material, energy and information. In ergonomics, *the human is part of the system* and must be fully integrated into it at the design stage. Human requirements are therefore system requirements, rather than secondary considerations and can be stated in general terms as requirements for:

• Equipment that is usable and safe
• Tasks those are compatible with people's expectations, limitations and training
• An environment that is comfortable and appropriate for the task
• A system of work organization that recognize people's social and economic needs.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

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.**

.

IV Relevant Course Outcome(s)

- Apply ergonomic concepts to redesign simple mechanical control member for comfort conditions in various industrial environments.

IV Practical Outcome

Redesign the given simple lever(s) like gear shifting lever /brake / clutch lever / foot lever for best ergonomic aspect.

V Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI Minimum Theoretical Background

The focus is on the interaction between the person and the machine and the design of the interface between the two. Every time we use a tool or a machine we interact with it via an interface (a handle, a steering wheel, a computer keyboard and mouse, etc.). We get feedback via an interface (the dashboard instrumentation in a car, the computer screen, etc.) The way this interface is designed, determines how easily and safely we can use the machine.

VII Experimental setup

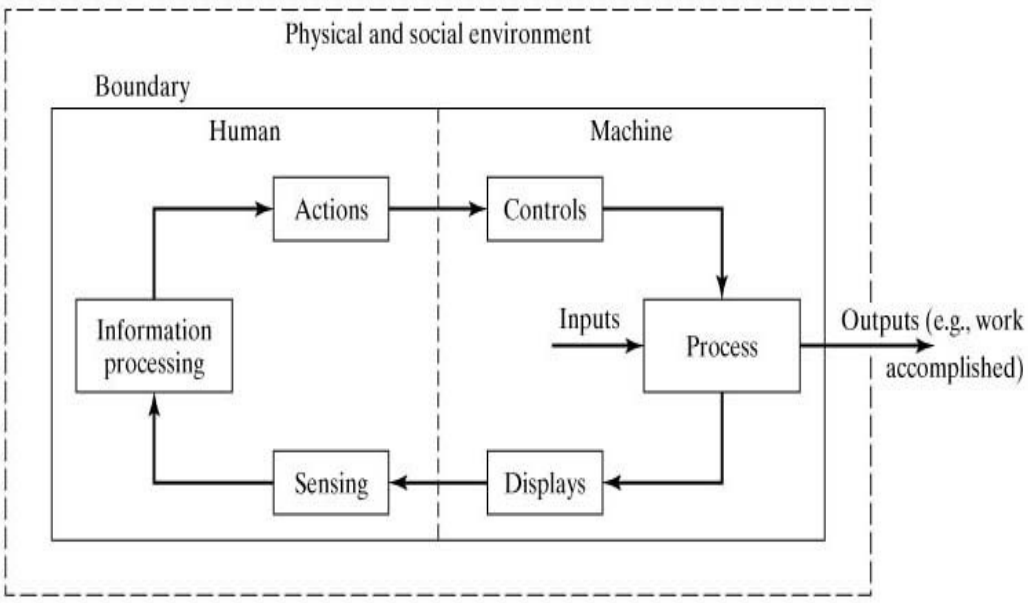
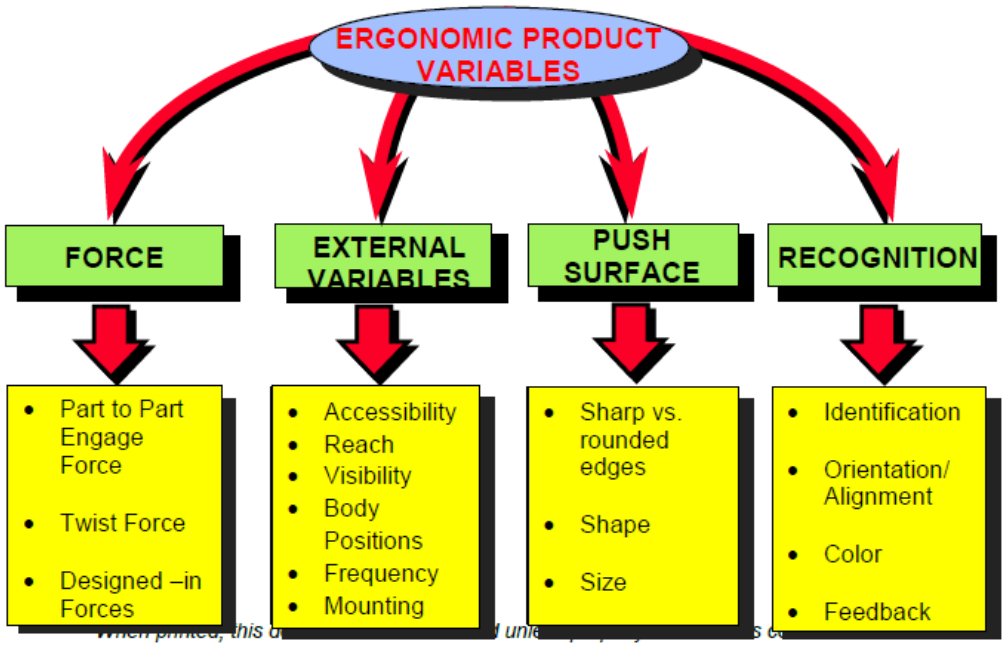


Figure 1. Ergonomic chart for a typical setup

Figure 2. Ergonomics at BMW



General ergonomic variables

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Websites, relevant books, manufacturing company websites	NA	NA
2.	Charts		

IX Precautions to be Followed

1. Redesign shall be economic
2. Aesthetic & ease of use shall be priority.

X Procedure

To increase efficiency many industries are using the concept of "Ergonomics". Example of Office is studied in following example

i. **Chair** – Should offer pneumatic seat-pan height adjustment, a backrest that tilts backward and forward, backrest tension control and lumbar support.

ii. **Adjustable workstation** – Should offer height adjustability of work surface and have a large surface with ample room to perform tasks.

iii. **Keyboard/keyboard tray** – Should lie flat and offer slope adjustability to achieve up to ± 15° slope and have a low profile (approximately 1" or 30 mm).

iv. **Input device** – Features should include a long cord for proper placement or wireless, should move easily and be usable by left- and right-handed users.

v. **Monitor** – Adjustable brightness and contrast, free from flicker and adjustable tilt.
vi. **Monitor arm/stand** – Should be height-adjustable 27" (69 cm) to 34" (86 cm) above the seat pan and the weight of monitor should match the weight of the stand or arm.
vii. **Wrist rest** – Should be constructed of compressible or soft material to reduce external pressure on the wrist and offer a non-friction surface.
viii. **Headset** – Should be digital, rather than analog, and offer a quick-disconnect capability.
ix. **Footrest** – Needs to be height adjustable from 11" (28 cm) to 18" (46 cm).
x. **Task lighting** – Should offer 75 to 140-foot candles of adjustable lighting and be asymmetrical to reduce shadows and glare spots.
xi. **Laptops** – Use an external mouse and keyboard for extended periods of computer use and take regular breaks and change your posture when working for long periods of time.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

.....
.....
.....
.....
.....

XIII Precautions Followed

.....
.....
.....
.....
.....

XIV Observations and Calculations

Name of component selected – (Say Gear shifting level /students may use their own chart if needed for other applications he / she has selected)

Parameter	Existing situations	Redesign suggested	Justification
Location Near to dashboard / Away from dash board / steering mounted			
Level with respect to driver seat Below / Upwards			
Readability During day/ during night			
Posture while shifting Awkward / relaxed			
Mechanical stress Present / absent			
Grip Pinch / power			
Activation pressure			
Push / pull force			
Seat up / down adjustments			
Lay out (gear positions on knob)			
Reach from body (inches / cm)			
Knob / push button type / touch button			
Knob Material			

XV Results

.....

.....

.....

.....

.....

.....

.....

.....

XVI Interpretation of Results

.....
.....
.....
.....
.....

XVII Conclusions

.....
.....
.....
.....
.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Define Ergonomics.

Q2. State brief history of Ergonomics.

Q3. Write short note on Modern Ergonomics.

Q4. In brief explain design procedure for standing.

Q5. Explain design procedure for Sitting. Draw a typical one

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

XIX References / Suggestions for Further Reading

1. https://en.wikipedia.org/wiki/Gear_stick
2. https://delphi.portal.covisint.com/.../Design-InErgonomicGuidelines.pdf/d9af2c23-38...
3. http://www.allsteeloffice.com/SynergyDocuments/ErgonomicsAndDesignReferenceGuideWhitePaper.pdf

XX. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Listing parameters for design of existing component	20%
2	Listing parameters of redesign suggested.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.11: Prepare and Analyze Steps To Solve The Given Problem In Institute/Industry Using Quality Circle Concept

I Practical Significance

Quality Circle is a small group of employees in the same work-area or doing a similar type of work who voluntarily meet regularly for about an hour every week to identify, analyses and resolve work-related problems, leading to improvement in their total performance, and enrichment of their work life

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

e. Analyze the data obtained from the different quality control processes.

V Practical Outcome

Prepare and analyse steps to solve the given problem in institute/industry using quality circle concept.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

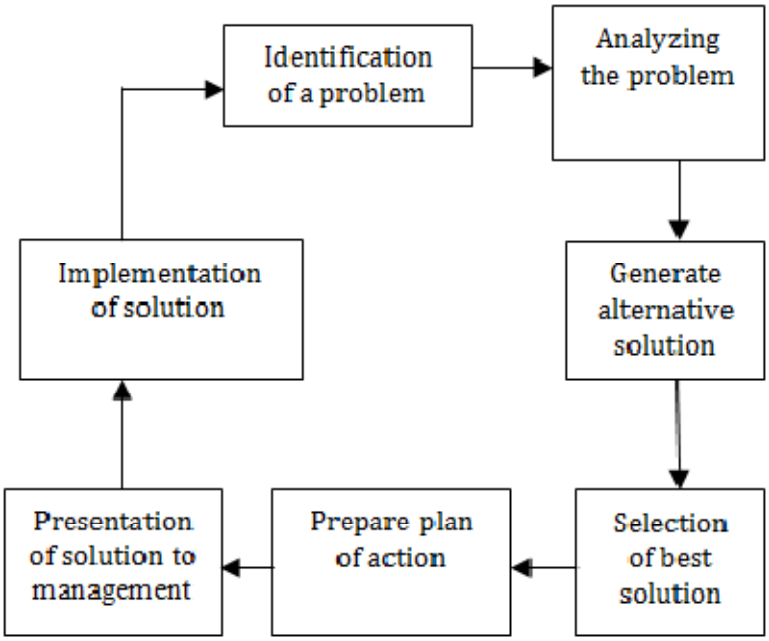
VII Minimum Theoretical Background

Quality circle is a management tool which is implemented in many organizations to improve effectiveness of equipment in an organization. Quality circle is a tool which gives a number of benefits like organizational performance improvement, product quality improvement and improvement in the relationship within the organization which motivate workers and improve team work among them. Implementation of

quality circle contains brief study of all factors which affect it. The main objective of this practical is to study the factors which help in implementation of quality circle for the success of organization.

VIII Experimental setup

Steps in quality circle problem solving



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			1
2.			1
3.			1
4.			1
5.			1
6.			1
7.			1
8.			1

X Precautions to be Followed

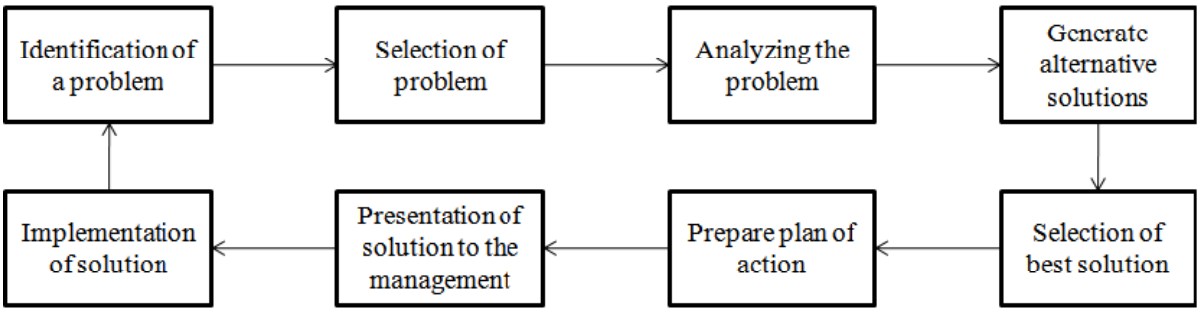
1. Avoid improper handling of Transducer
2. Don't apply excessive pressure on tips of Transducer .

XI Procedure

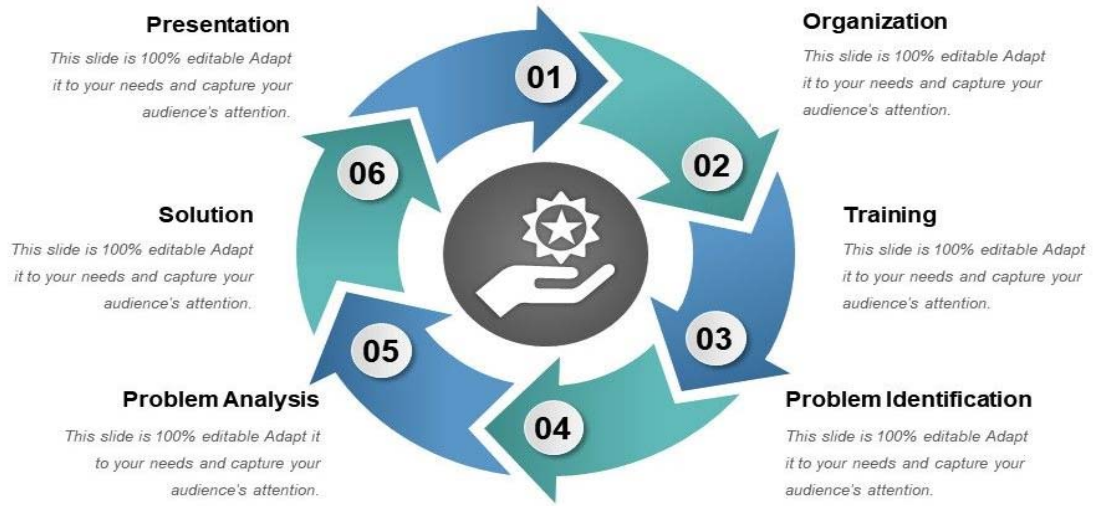
The steps involved in the implementation process of Quality Circle are following:

1) Identification of problem: First of all the problem is identified by the Quality Circle members which is to be solved.

2) Analysis of the problem: The selected problem is then analyzed by basic problem solving techniques.
3) Generate alternative solution: On the basis of various causes the alternative solutions are generated.
4) Selection of best solution: The best and the most suitable solutions is selected from the alternative solutions.
5) Prepare action plan: The members prepare plan for the area of implementation, date, time etc.
6) Presentation of solution to management: The solution is then presented before the management for the approval.
7) Implementation of solution: The management evaluates the solution and implements it for a small run to check its reliability.



Working model of quality circle



Quality Circle Process

Student quality circle Traditional teaching methods are lacking in effective knowledge transfer due to one way communication from teachers. But enhancement of course quality and quality of teaching depends to the greater extent on a system to assess its effectiveness at the receivers end and seeking important suggestions to overcome lacuna. Student involvement is the most important condition for promotion of excellence in education. The more students are involved in education, more intensely they engage in their education to make learning happen.

The use of quality circles in classroom is one way of increasing student involvement. Classroom quality circle is small voluntary group of students enrolled from the same class who meet regularly to provide continuous student generated feedback to the teaching team in order to improve course content, structure and environment in the class. Student quality circles are formed one for each class, with 5-10 student members in each circle. The quality circle is structured as one of the members is selected as leader and the concerned staff member as facilitator. The selection of the members is based on voluntary participation part of it. Apart from this, selection can be done with a view to form diver;:; e committee in terms of gender, class rank etc. In the beginning of every semester, concept and purposes of quality circle along with its background and operation, needs to be explained to the member to ensure appropriate results in the end. The QC members conduct the meeting at regular intervals during the semester to collect and process data using appropriate quality citcle tools and techniques. The QC members are required to take a proactive approach in soliciting feedback from class members and should see that whole process is carried out in anonymous fashion The feedback obtained is to be shared by QC members with teaching team and discussion is expected regarding incorporating suggestions accrued and their implementation. Here, what is important is teaching needs to be more flexible, open and responsive to student observations, their opinion and suggestions to strengthen the objective with which quality circles are setup. The classroom quality circles are beneficial for the reason that there is positive interaction between staff and students. Some of the inputs, which the classroom quality circle team receives for ensuring better teaching learning process, are;

- Frequency of written assignments,
- Content of lectures, • Assessment methods to be used,
- Frequency, duration and period of class tests during semester,
- Need to conduct extra evening sessions on 'How to Study',
- Extra lecture series for slow learners and those for those with backlog subjects,
- Providing lecture outlines and lecture material in the beginning of semester,
- Utilization of lecture hours more for discussion.

Finally, the gains expected to be achieved due to effective implementation of student quality circles as above are;

- Improvement in students learning of course material,
- Enhancement in student's involvement,
- Increased students morale and satisfaction
- Enhancement in course quality and structure,
- Better way of utilizing student's input for restructuring course content and pedagogical methodology,
- Improvement in climate of learning by open communication between students and faculty members,
- Opportunity for students to share their inputs in a confidential manner.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....
.....

XV Observations and Calculations

XVI Results

.....
.....
.....
.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Enlist the advantages of Non-Contact type measuring Instruments
2. Compare between contact and Non-contact type Measuring Instruments

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

XX References / Suggestions for Further Reading

1. http://www.academia.edu/12409229/A_study_of_the_quality_circles_concept_in_Indian_industry_a_case_study_on_Bharat_Electronics_Limited_Ghaziabad_
2. https://www.jstor.org/stable/20712775
3. https://www.youtube.com/watch?v=sOU5FN7aD0Y
4. https://study.com/academy/lesson/quality-circle-definition-process.html
5. https://slideplayer.com/slide/217764/

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Preparing the steps in quality circle	20%
2	Analyzing the steps in Quality circle	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 12: Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.

I Practical Significance

Histograms or bar charts are quality improvement tools that are instantly recognizable but are often neglected. They can offer a powerful analysis of problems. Continuous process improvement requires that we collect data through simple quality tools such as tally charts, but then people need to be able to analyze this data. One of the simplest tools to do this with is a histogram or bar chart, a quality tool that many of us will be familiar with from school. Histograms and other quality tools are key to achieving continual process improvement of your business

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4 - **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Interpret control charts for variable and attribute data.

V Practical Outcome

Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

A histogram is a graphical representation of data. The data is represented by columns on a graph which vary in height depending on the frequency (how many times) the specific range of data occur.

Why use a histogram as a quality tool?

1. Displays data in an easy-to-interpret graphical manner
2. Shows frequency of occurrence of data values
3. Reveals the centering, variation and shape of the data
4. Illustrates the underlying distribution of the data
5. Enables future prediction of process performance
6. Enables identification in changes in processes parameters
7. Allows one to answer the question: "Is the process capable of meeting the customer requirements?"

The **frequency polygon** is a **polygon** - a closed two-dimensional figure of straight line segments - joining the mid points of the top of the bars of a histogram.

Histogram tells us -

- C**entering of the process data:** The centering of the data provides information on the process about some mean.
- **Spread of the data:** Histogram width defines the variability of the process about the mean
- **Shape of the histogram:** Bell or normal shaped histogram is expected. Other than normal or bell shape means something wrong with the process responsible for poor quality.

VIII Experimental setup

1. From the given data in the table find out mean and standard deviation.

Class	0-4	5-9	10-14	15-19	20-24	25-29	30-34
Frequency	5	10	15	20	14	11	6

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Relevant inspection data for a typical process	NA	NA
2.			

X Precautions to be Followed

1. Use standard terminology
2. Adequate sampling data shall be collected.

XI Procedure – (Histogram)

1. Define Categories for Data
2. Collect Data, sort them into the categories
3. Count the Data for each category
4. Draw the Diagram. Each category finds its place on the x-Axis.
5. The bars will be as high as the value for the category

1. **MeanorAverage:**Meanoraverageisameasureofcentraltendencyorlocation.Thenotation x□(x bar) is used to denote mean or average. Thus if there are "n" number of observations valued
x1, x2, x3……xn, then

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 \ldots\ldots + x_n}{n}$$

The mean for grouped data i.e. data having frequency can be find using

$$\bar{x} = \frac{\sum f_i x_i}{n}$$

Where

$$\sum f_i x_i = f_1 x_1 + f_2 x_2 + f_3 x_3 + \cdots \ldots + f_n x_n$$

$$n = \sum f = f_1 + f_2 + f_3 + \cdots \ldots + f_n$$

2. **Mode:** Mode is the value that occurs most frequently. But the most important one used in statistical quality control is half the mean oraverage.
For grouped data where frequency is given: Mode will be the value with the largest frequency. If class or cell is given: The mode can be found out by using the formula

$$\text{mode} = L + \left[\frac{f_1}{f_1 + f_2}\right] * i$$

Where, L= Lower Boundary of the class having maximumfrequency
f_1=Frequency of the class before the class having maximumfrequency
f_2=Frequency of the class after the class having maximumfrequency

3. **Median:**Medianisthemagnitudeofmiddleclass,i.e,thevaluethathastheobservationabove its half and half below it. Therefore, median can be said as middle observation, dimension or figure.
For simple data: First arrange the data in ascending order and then find the middle value. If the observation is even, then adding the two middle values and divide it by 2.
For grouped data having frequency: The median can be find using the following formula:

First divide the frequency by 2, we will get the class by answer of the division then using the formula

$$\text{median} = L_m + \left[\frac{\frac{N}{2}+Cf_m}{f_m}\right] * \text{i}$$

Where, L= Lower Boundary of the median class
N= number of observations
f_m=Frequency of the median class
Cf_m= Sum of Frequencies of all classes below median class
i = class interval

Spread or dispersion: The manner in which the observation is spreader between minimum and maximum is called spread or dispersion. They are of twotypes:

1. **Range:**Itisameasureofdispersionanditisthedifferencebetweenthelargestobservedvalue and the smallest observed value of a set of observations. It is represented by the symbol'R'.
2. **Standard Deviation:** It is defined as the root mean square deviation of the observed value from their arithmetic mean. It is denoted as σ (sigma)

So,

$$\sigma = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + \cdots .. + (x_n - \bar{x})^2}{n}}$$

Variance: The square of standard deviation is called variance.

Normalized deviation of Z-value: For measuring the areas under normal distributioncurve, the normal deviation is used. It is also calledZ-value

$$Z = \frac{x_i - \bar{x}}{\sigma}$$

x_i = The value up to which area is tobe found
$\bar{x}$ = Mean Value
σ = Standard Deviation

XII. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII. Actual Procedure Followed

.....
.....
.....
.....

XIV. Precautions Followed

.....
.....
.....
.....

XV. Observations and Calculations

(Students are expected to find mean, median standard deviation and draw normal distribution curve for a suitable data / data given by teacher .)

XVI. Results

.....
.....
.....
.....
.....

XVII. Interpretation of Results

.....
.....
.....
.....
.....

XVIII. Conclusions

.....
.....
.....
.....

XIX. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Draw Histogram, Frequency Bar Chart, Frequency Polygon and Frequency Distribution Curve from the followingdata:
75, 80, 63, 65, 70, 12, 18, 22, 31, 33, 34, 35, 38, 40, 52, 55, 57, 60, 41, 45, 47, 49

Q2. Calculate mean, median, mode and range for the following data: 2, 4, 5, 4, 9, 6, 4, 6

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://toughnickel.com/business/Histograms-Bar-Charts-Quality-Tools
2. https://www.researchoptimus.com/article/x-bar-and-r-chart-difference.php
3. https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/X-bar_and_R_Charts.pdf

XX. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Drawing of frequency Histogram, frequency polygon	20%
2	Calculation of mean, mode and median	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 13 : Draw the normal distribution curve, calculate deviation, variance, range and determine the process capability for $\pm 3\sigma$ Or $\pm 6\sigma$.

I Practical Significance

In day to day routine, the event in which the normal distribution curve can applied are figures for age of students studying in a class, eligible voters' data, and rainfall figures at a place during tenyears. Standard deviation is widely used to obtain important findings in the subjects like sociology, psychology andstatistics. Standard deviation is useful in controlling quality inindustries. It is also useful to estimate the quality of whole lot, only by drawing & checking a small sample from that lot. It helps to indicate the process that is stable, but not able to produce items withintolerances. Also it helps to indicate that the process is stable, producing item within tolerances. If this is pulled to one side, then it shows that either there are more number of larger or smaller products than the normalsize..

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4 - **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Interpret control charts for variable and attribute data.

V Practical Outcome

Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.

- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Normal Distribution Curve: Normal distribution curve shows the simplest pattern of distribution upon the type of thing being measured. There is generally a pattern of distribution that indicates the way in which a dimension can vary. If the dimensional variability in products of a system is by chance, then it will follow approximately 'Normal Distribution Curve'

In a normal distribution curve, there are two statistical controls, average and standard deviation. It has been calculated that two times the standard deviation covers about 68% of the total area. Four times the standard deviation covers 95.5% and six times the standard deviation covers 99.73% of the total area.

VIII Experimental setup

1. From the given data in the table find out mean and standarddeviation.

Class	0-4	5-9	10-14	15-19	20-24	25-29	30-34
Frequency	5	10	15	20	14	11	6

2. Draw Normal Distribution curve from the followingdata:

Upper & lower specification limits of shaft diameter are 30.20 and 30.00mm respectively. Mean diameter of shaft is 30.05mm and standard deviation is 0.05mm. Find out how many parts out of 400 will be accepted.

Z-value	**Area**
3	0.4987
-1	0.3413

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Relevant inspection data for a typical process	NA	NA

X Precautions to be Followed

1. Use standard terminology
2. Adequate sampling data shall be collected.

XI Procedure –

1. **MeanorAverage:**Meanoraverageisameasureofcentraltendencyorlocation.Thenotation

$\bar{x}$ (x bar) is used to denote mean or average. Thus if there are "n" number of observations valued
x1, x2, x3……xn, then

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 \ldots\ldots + x_n}{n}$$

The mean for grouped data i.e. data having frequency can be find using

$$\bar{x} = \frac{\sum f_i x_i}{n}$$

Where

$$\sum f_i x_i = f_1 x_1 + f_2 x_2 + f_3 x_3 + \cdots \ldots\ldots + f_n x_n$$

$$n = \sum f = f_1 + f_2 + f_3 + \cdots \ldots\ldots + f_n$$

2. **Mode:** Mode is the value that occurs most frequently. But the most important one used in statistical quality control is half the mean oraverage.
For grouped data where frequency is given: Mode will be the value with the largest frequency. If class or cell is given: The mode can be found out by using the formula

$$\text{mode} = L + \left[\frac{f_1}{f_1 + f_2}\right] * i$$

Where, L= Lower Boundary of the class having maximumfrequency

f_1=Frequency of the class before the class having maximumfrequency

f_2=Frequency of the class after the class having maximumfrequency

3. **Median:**Medianisthemagnitudeofmiddleclass,i.e,thevaluethathastheobservationabove its half and half below it. Therefore, median can be said as middle observation, dimension or figure.
For simple data: First arrange the data in ascending order and then find the middle value. If the observation is even, then adding the two middle values and divide it by 2.
For grouped data having frequency: The median can be find using the following formula:
First divide the frequency by 2, we will get the class by answer of the division then using the formula

$$\text{median} = L_m + \left[\frac{\frac{N}{2} + C f_m}{f_m}\right] * i$$

Where, L= Lower Boundary of the median class
N= number of observations
f_m=Frequency of the median class
Cf_m= Sum of Frequencies of all classes below median class
i = class interval

Spread or dispersion: The manner in which the observation is spreader between minimum and maximum is called spread or dispersion. They are of twotypes:

3. **Range:**Itisameasureofdispersionanditisthedifferencebetweenthelargestobservedvalue and the smallest observed value of a set of observations. It is represented by the symbol'R'.
4. **Standard Deviation:** It is defined as the root mean square deviation of the observed value from their arithmetic mean. It is denoted as σ (sigma)

So,

$$\sigma = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + \cdots..+(x_n - \bar{x})^2}{n}}$$

Variance: The square of standard deviation is called variance.

Normalized deviation of Z-value: For measuring the areas under normal distributioncurve, the normal deviation is used. It is also calledZ-value

$$Z = \frac{x_i - \bar{x}}{\sigma}$$

x_i =

Thevalueuptowhichareaistobefound

$\bar{x}$ = Mean Value
σ = Standard Deviation

XXI. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XXII. Actual Procedure Followed

.....
.....
.....
.....
.....

XXIII. Precautions Followed

.....

.....

.....

.....

.....

XXIV. Observations and Calculations

(Students are expected to find mean, median standard deviation and draw normal distribution curve for a suitable data / data given by teacher.)

XXV. Results

.....

.....

.....

.....

.....

.....

.....

XXVI. Interpretation of Results

.....

.....

.....

.....

.....

.....

XXVII. Conclusions

.....
.....
.....
.....
.....

XXVIII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Draw Histogram, Frequency Bar Chart, Frequency Polygon and Frequency Distribution Curve from the followingdata:

75, 80, 63, 65, 70, 12, 18, 22, 31, 33, 34, 35, 38, 40, 52, 55, 57, 60, 41, 45, 47, 49

Q2. Calculate mean, median, mode and range for the following data: 2, 4, 5, 4, 9, 6, 4, 6

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.pqsystems.com/qualityadvisor/DataAnalysisTools/x_bar_range.php
2. https://www.researchoptimus.com/article/x-bar-and-r-chart-difference.php
3. https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/X-bar_and_R_Charts.pdf

XXIX. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Drawing normal distribution curve	20%
2	Calculation of various parameters	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 14 : Draw and interpret the control charts ($\bar{x}$ − R chart).

I Practical Significance

Control charts like the X-Bar and R-Chart are often used in business applications like manufacturing, to measure equipment part sizes; in service, industries to evaluate customer support call handle times, or in healthcare for uses like measuring blood pressure over time. These are variable control charts. Variable data include things we can measure. Example includes length, weight, time, temperature, diameter, etc. Variable Quality is one that can be measured like . Diameter of shaft, length of bolt, radius of pulley, hardness of materials, strength, density, weight and temperatures are the examples of variablequality. X-bar and R charts are used to monitor the mean and variation of a process based on samples taken from the process at given times (hours, shifts, days, weeks, months, etc.). The measurements of the samples at a given time constitute a subgroup. Typically, an initial series of subgroups is used to estimate the mean and standard deviation of a process. The mean and standard deviation are then used to produce control limits for the mean and range of each subgroup.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3 - **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO4 - **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Interpret control charts for variable and attribute data.

V Practical Outcome

Draw and interpret the control charts ($\bar{x}$ − Rchart) for given data.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

x□ − R charts - This type of control charts is used for manufactured parts which the inspector checks by measurement and not by gauging. This method of control is more expensive. It reveals much more about the behavior of the process. The x□ − R charts supply a basis on which to judge the stability of the pattern of variation. To found out whether the process is in the state of control or not, control limits are setup. The control chartisusually maintained for averages and not for individual components. The distribution for individual may or may not be normal but the distribution for averages follow normal distribution. In any manufacturing process there is some variation from piece to piece. Two kinds of variation exist in manufacturing. The variation due to chance causes & assignable causes. The chance causes are inevitable in any process. This inherent process variation is a characteristic of the process and is the result of random causes. These random fluctuations cause the process to deviate either side of the average.

VIII Experimental setup

Construct$x$□ -R Chart and show calculations for the following:

1. From the given data find out control limits for X-bar & R chart. Calculate standard deviation and process capability.

Observation No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
x □	26.00	34.00	28.50	32.75	29.25	26.00	27.25	30.25
R	30	17	18	23	30	15	19	18

A2=0.73, D4=2.28, d2=2.059

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Product samples with defects	NA	NA

X Precautions to be Followed

1. Use standard terminology
2. Adequate sampling data shall be collected.

XI Procedure –

I. Take random sample from production process, and measure its important quality such as length, diameter. Indicate this dimension as x□ -variable for all such sub-groups it is necessary to take 4 or 5 observations. For inspection take such 25sub-groups.

II. Calculate$x$□andRforallsubgroups.Risthedifferencebetweenthemaximumandminimum value of individual subgroup.

III. The values of-and R follows the principle of standard deviation. Calculate the mean of□ and R asunder:

$$x = \frac{x}{n} \quad and \quad R = \frac{R}{n}$$

'Where x□ = mean of or mean of average of subgroup

R□ = mean of Spread-R

x□ = Average or mean of thesubgroup

R=spread

N=No. of random sample

x□ is the central or middle line of x□ chart.

R□ is the central or middle line of R chart.

IV. Calculate the upper control limit- UCL. This line is at a distance of 3σ from the central line of **chart**, above the line.

$$UCL = x\square + 3\sigma$$

$$OR$$

$$UCL = x\square + A_2 R\square$$

The is constant which depends upon size of subgroup and can be found from the table of constants.

V. Calculate lower control limit-LCL. This line is at a distance of 3σ from the central line of chart, below the line.

$$LCL = x\square - 3\sigma \qquad OR \qquad LCL = x\square - A_2 R\square$$

VI. To draw control lines for R-chart. Calculate as mean of R observations & then find upper control limit (UCL **)** lower control limit(LCL)**,**

$$UCL = d_4 R\square \qquad \& \qquad LCL = d_3 R\square$$

Where $d_3 \& d_4$ are constants which are obtained from the table of constants

VII. To draw each chart mark, the value of x□ and R & obtain corresponding points. Joint these points by straight lines.

VIII. Calculate standard deviation using formula as given below:

$$\sigma = \frac{R\square}{d_2}$$

IX. Calculate Process capability, $\acute{\sigma} = 6 \cdot \sigma$

Where $\boldsymbol{d}$, is the constant for standard deviation which is given in table of constants.

Following is table of constants

Sample Size	**Constant for -chart**	**Constants for R-chart**		**Constant for Standard Deviation**
$\boldsymbol{n}$	A_2	D_3	D_4	d_2
2	1.880	0	3.268	1.128
3	1.023	0	2.574	1.693
4	0.729	0	2.282	2.059
5	0.577	0	2.114	2.326
6	0.483	0	2.004	2.534
7	0.419	0.076	1.924	2.704
8	0.373	0.136	1.864	2.847
9	0.337	0.184	1.816	2.970
10	0.308	0.223	1.777	3.078

X. Resources Used

S. No.	**Name of Resource**	**Broad Specifications**		**Quantity**	**Remarks (If any)**
		Make	**Details**		
1.					
2.					
3.					

XII. Actual Procedure Followed

.....

.....

.....

.....

.....

XIII. Precautions Followed

.....

.....

.....

.....

.....

XIV. Observations and Calculations

(Students are expected to prepare $x\square - R$ chart on a sheet separately.)

XV. Results

.....
.....
.....
.....
.....

XVI. Interpretation of Results

.....
.....
.....
.....
.....

XVII. Conclusions

.....
.....
.....
.....
.....

XVIII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

Q1. Amachineisworkingtoaspecificationof12.58±0.05mm.Astudyof50

consecutive pieces shows the following measurements for 10 groups of sample:
Construct x□ − **R** chart and show the calculations. Find process capability

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
12.54	12.58	12.61	12.57	12.57	12.58	12.6	12.65	12.6	12.65
12.58	12.57	12.6	12.61	12.60	12.59	12.62	12.57	12.59	12.61
12.62	12.6	12.64	12.56	12.62	12.59	12.61	12.57	12.6	12.6
12.56	12.6	12.58	12.59	12.61	12.56	12.67	12.56	12.63	12.62
12.59	12.61	12.64	12.59	12.58	12.57	12.6	12.61	12.56	12.62

Q2. Define process capability.

[Space for Answer]

XIX. References / Suggestions for Further Reading

1. https://www.pqsystems.com/qualityadvisor/DataAnalysisTools/x_bar_range.php
2. https://www.researchoptimus.com/article/x-bar-and-r-chart-difference.php
3. https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/X-bar_and_R_Charts.pdf

XX. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	20%
2	Recording of motions	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 15 : Draw and interpret the control charts (p-chart and c-chart).

I Practical Significance

These are attribute control charts. It can not have fractions or decimals. These control charts deals with attributes like presence or absence of something, success or failure, accept or reject, correct or not correct. P chart informs number of defective items as a percentage of whole. For e.g number of broken eggs in a cartoon, number of leaking tubes in a box of 48. C chart are used for discrete defects where there can be more than one defects per unit. For e.g. number of flaws in a carpet, number of complaints per customer of a hotel.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3 - **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO4 - **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

III Competency and Skills

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.**

IV Relevant Course Outcome(s)

Interpret control charts for variable and attribute data.

V Practical Outcome

Draw and interpret the control charts (P-chart and C-chart) for given data.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

Statistical control charts are graphs used to monitor a production process. Samples are taken from the process periodically and observations are plotted on the graph. Upper and lower control limits are determined. If any observation is outside the limit it indicates that some thing is wrong with the process. Attribute of a product can be color, surface texture, cleanliness, smell, taste etc. If quality specifications are complex attribute test can be useful for determining product acceptance.

VIII Experimental setup

1. Construct P-chart using data given

There are 10 samples of shaft taken for inspection. Draw P-chart and state whether the process is under control or not, from the data given asunder:

Number of Products	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Defective Products	12	4	8	3	7	6	0	8	5	9

2. Construct C-chart using data given below

During the production of Nano Car, 10 cars were inspected and defects in each car were as under. Draw C-chart, control limits and comment about theprocess:

Nano Car No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Defects in Nano Car	1	3	13	4	2	5	3	3	4	5

IX Resources Required

S. No.	**Name of Resource**	**Suggested Broad Specification**	**Quantity**
1.	Product samples with defects	NA	NA
2.			

X Precautions to be Followed

1. Use standard terminology
2. Adequate sampling data shall be collected.

XI Procedure – (for p-chart)

i. Samples are taken from manufactured product and number of faults or defects in it are counted.

ii. The size of the defect is not measured. For example, say 100 pins are inspected out of which 12 are found defective then it is rejected.

iii. Note that the size, location or shapeof the defects is not important and notmeasured.

iv. Fraction defective, **P** is defined as the ratio of number of defective units in each lot

v. inspected to the number of units in thelot.

Suppose we have taken a lot of 'n' number of products from the process, out of which 'd' number of products found defective, then fraction defective of that lot can be found out as under:

fraction defective = p = d / n

i. Find out standard deviation = ρ_p = SQRT $\left(\frac{\bar{p}\,(1-\bar{p})}{n} \right)$

Where p-bar is Average fraction defective = Σp / N

Where Σp = number of defective products in all samples

N = Number of samples taken

Control Limits for p-chart can be calculated as

1. Upper control limit (UCL) = $\bar{p}$ + 3 * SQRT $\left(\frac{\bar{p}\,(1-\bar{p})}{n} \right)$
2. Lower control limit (LCL) = $\bar{p}$ - 3 * SQRT $\left(\frac{\bar{p}\,(1-\bar{p})}{n} \right)$

For R chart –

The control limit of C-Chart is based on Poisson's distribution. So the center line of C-chart can be found out using the following

Average defect $\bar{C}$ = Total number of defects / numbers of assembly inspected.

Control limits of C-chart can be calculated as

1. Upper control limit (UCL) = $\bar{C}$ + 3 * SQRT ($\bar{C}$)
2. Lower control limit (LCL) = $\bar{C}$ - 3 * SQRT ($\bar{C}$

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Actual Procedure Followed

.....

.....

.....

.....

.....

XIV Precautions Followed

.....

.....

.....

.....

.....

XV Observations and Calculations

(Students are expected to draw p-chart & c-chart for suitable data / data given by teacher)

Calculate UCL & LCL for both charts

Use separate sheets to prepare charts and attach them.

XVI Results

.....
.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questionsso as to ensure the achievement of identified CO.

Q1. State importance of capability analysis?

Q2. A hospital manager receives complaints as per following table in 15 days. What are control limits one will construct a control chart using three sigma limits.

Days	No. of complaints	Days	No. of complaints	Days	No. of complaints	Days	No. of complaints
1	4	5	4	9	5	13	4
2	6	6	8	10	3	14	6
3	4	7	6	11	5	15	4
4	5	8	7	12	4		

Q3. In a car manufacturing company, 10 assembly of a car was inspected and the defects were found as under. Draw C-chart, control limits and comment about the process:

Car Assembly No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Number of defects	5	4	4	10	5	9	7	3	2	1

Q4. No. of defectives Spark plugs for ten samples are 4,3,4,5,3,4,5,3,5,4 in a sample size of 100. Selecting suitable control chart, find upper control limit and lower control limit. Also give your comment either the process is under control ornot.

[Space for Answer]

XX References / Suggestions for Further Reading

1. https://www.pqsystems.com/qualityadvisor/DataAnalysisTools/c_chart.php
2. https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/C_Charts.pdf
3. https://www.spcforexcel.com/knowledge/attribute-control-charts/c-control-charts

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Handling of the measuring Instruments	20%
2	Recording of motions	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	