T.Y. Diploma : Sem. V
[ME/PG/PT/MH/MI]

Metrology and Quality Control

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 100**

Q.1(a) Attempt any THREE of the following: **[12]**

Q.1(a) (i) State the various needs of the inspection. **[4]**

Ans.: Needs of the inspection:

(1) To ensure that the part, material or a component confirms to the established standard.
(2) To meet the interchangeability of manufacturer.
(3) To maintain the customer relation by ensuring that no faulty product reaches the customer.
(4) Provide the means of finding out shortcomings in manufacture.
(5) It helps to purchase good quality of raw material, tools, equipment which governs the quality of the finished product.
(6) It helps to coordinate the functions of quality control, production, purchasing and other departments of the organization.
(7) To take decision on the defective parts.

Q.1(a) (ii) Define the following terms: **[4]**

(1) Tolerance (2) Allowance (3) Deviation (4) Limits

Ans.: (1) Tolerance: The difference between the maximum and minimum limits of size is called tolerance. The permissible variation in size or dimension is called tolerance

(2) Allowance: The difference between the maximum shaft and minimum hole is known as allowance. In clearance fit this is the minimum clearance and is positive allowance. In an interference fit, it is the maximum interference and is a negative allowance.

- It is the prescribed difference between the dimensions of two mating parts for any type of fit.
- It is the intentional difference between the lower limit of hole and higher limit of the shaft.
- Allowance may be positive or negative. The positive allowance is called clearance and negative allowance is called interference.

(3) Deviation: Deviation is the algebraic difference between the maximum or minimum size with basic size/zero line.

(4) Limits: These are maximum and minimum permissible sizes of the part.

Q.1(a) (iii) Explain various errors in gears. **[4]**

Ans.: (1) Runout: it is the total range of reading of a fixed indicator with the contact point applied to a surface rotated, without axial movement, about a fixed axis.

(2) Radial runout: it is the runout measured along a perpendicular to the axis of rotation.

(3) Axial runout: it is the runout measured parallel to the axis of rotation, at a specified distance from the axis.

(4) Periodic error: An error occurring at regular intervals not necessarily corresponding to one revolution of the component.

(5) Cyclic Error: It is the error occurring during each revolution of the element under consideration.

(6) Tooth thickness error: it is the value obtained by subtracting the design tooth thickness from the actual tooth thickness measured along the surface of the reference cylinder.

(7) Pitch error: pitch error is a source of gear noise and the character of noise will depend upon how pitch errors are produced and how they are distributed.
(i) Adjacent pitch error (ii) Cumulative pitch error

(8) Profile error: it is the maximum distance of any point on the tooth profile form and normal to the design profile when the two coincide at the reference circle.

Q.1(a) (iv) Explain the procedure for P-chart. **[4]**

Ans.: Procedure for p chart:

1. Record the data for each subgroup of number of articles inspected and number of defectives.
2. Compute P (fraction defective) for each subgroup,
   $$P = \frac{\text{Number of defective in subgroup}}{\text{number of articles inspected in subgroup}}$$
3. Compute $\bar{p}$ (Average| fraction defectives),
   $$\bar{p} = \frac{\text{Total no. of defectives}}{\text{Total Quantity inspected}}$$
4. Compute control limits,
   $$UCL_p = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$
   $$LCL_p = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$
5. Plot each point on the graph.

Q.1(b) Attempt any ONE of the following: **[6]**

Q.1(b) (i) State the various objectives of the quality control (any eight). **[6]**

Ans.: Objectives of quality control:

1. To improve the company's income
2. To reduce the production cost through reduction in losses due to defects, rework, scrap, customer return etc.
3. To achieve interchangeability in large scale production.
4. To produce optimum quality at minimum price.
5. To ensure customer satisfaction through quality level.
6. To make the inspection prompt to ensure production of non-defective products
7. To improve quality and productivity by process control experimentation and customer feedback.
8. Developing quality consciousness in the organization.

Q.1(b) (ii) Differentiate 'line standard', 'end standard' and 'wavelength standard'. (Give one application of each of them). **[6]**

Ans.:

Sr. No.	Line Standard	End Standard	Wavelength Standard
1	When the length is measured as the distance between centres of two engraved lines, is called line standard.	When the length is measured as the distance between two flat parallel faces, is called end standard.	When the wavelengths of monocromatic light is used as natural invariable unit of length, is called wavelength standard.

2	Line standard is not accurate and precise.	End standard is accurate and precise.	Wavelength standard is highly accurate and precise with reproducibility is 3 parts in 10^{11}.
3	Wear and tear is less as compared to end standard.	More wear and tear due surfaces is in always contact with work piece.	It is not material standard hence no wear and tear.
4	Preservation in safe custody is required.	Preservation in safe custody is required.	Preservation in safe custody is not required.
5	Cost of standard / replica is less.	Cost of standard/ replica is high.	Cost of standard is moderate.
6	These are influence by effects of variation of environmental condition like temperature, pressure, humidity, and aging etc.	These are influence by effects of variation of environmental condition like temperature, pressure, humidity, and aging etc.	These are not influence by effects of variation of environmental condition like temperature, pressure, humidity, and aging etc.
7	Application: Measurement of length using steel rule.	Application: Measurement of length using Slip gauges.	Application: The meter can be defined as equal to 1650763.73 wavelengths of the red orange radiation of Kripton isotope 86 gas

Q.2Attempt any FOUR the following : [16]

Q.2(a) Explain the Taylors principle of gauge design. [4]

Ans.: Taylors Principle of Gauge design:

It states that

(1) GO gauge should be designed to check the maximum material limit, while the NO-GO gauge should be designed to check the minimum material limit.

Plug gauges are used to check the hole, therefore the size of the GO plug gauge should correspond to the low limit of hole, while that of NO-GO plug gauge corresponds to the high limit of hole. Similarly, the GO snap gauge on the other hand corresponds to the high limit of shaft while NO-GO snap gauge corresponds to the low limit of shaft.

(2) GO gauges should check all the related dimensions (roundness, size, location etc.). Simultaneously whereas NO-GO gauge should check only one element of the dimension at a time.

For example the bush to be inspected has a curved axis and a short GO plug gauge is used to check it. The short plug gauge will pass through all the curves of the bent bushing. This will lead to wrong result that the workpiece (hole) is within the prescribed limits. Actually such a bushing with curved hole will not mate properly with its mating parts and thus defective. A go plug gauge with adequate length will not pass through a curved bushing and the error will be detected. A long plug gauge will thus check the cylindrical surface not in one direction but in a number of sections simultaneously.

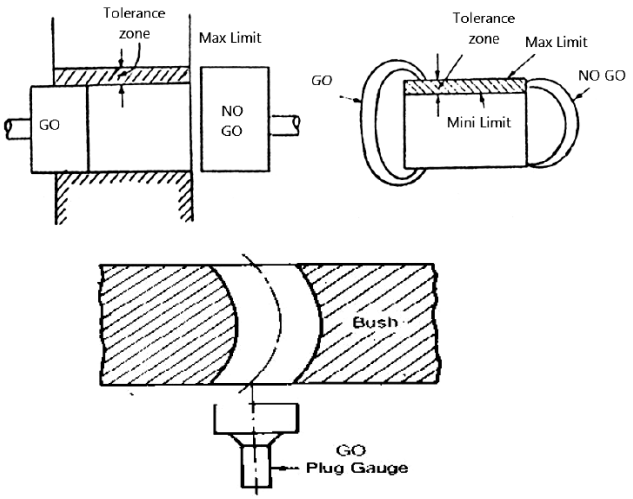


Fig.: Checking a bush with curved

Q.2(b) Give the name of measuring instrument/method for following parameter of screw threads: [4]

(i) Major diameter of external screw

(ii) Minor diameter of internal screw

(iii) Pitch of external screw

(iv) Effective diameter of external screw

Ans.: (i) Major diameter of External screw: Flat faced screw thread micrometer/bench micrometer/ Hand micrometer

(ii) Minor dia of Internal Screw: Taper parallels, roller and slip gauges. Floating carriage micrometer with v- anvils, profile projector, tool makers microscope.

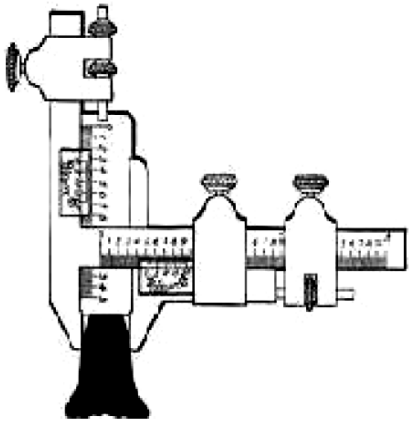
(iii) Pitch of external thread: Screw pitch gauge, pitch measuring machine, tool mackers microscope.

(iv) Effective dia Of External Thread: Tread Micrometer methods, one/two/three wire method.

Q.2(c) Explain the method of gear tooth thickness measurement by Gear tooth vernier with neat sketch. [4]

Ans.: Gear tooth thickness (chordal tooth thickness) measurement using Gear tooth vernier:

- Gear tooth vernier calliper consists of two perpendicular vernier arms with vernier scale on each arm.
- One of the arms is used to measure the thickness of gear teeth and other for measuring depth.
- The caliper is so set that it slides on the top of tooth of gear under test and the lower ends of the calliper jaws touch the slides of the tooth at the pitch line.
- The reading on the horizontal vernier scale gives the value of chordal thickness (W) and the reading on the vertical vernier scale gives the value of chordal addendum.
- Theoretical values of chordal tooth thickness may be calculated and compared with actual obtained values.



Q.2(d) Distinguish between the terms "Producer's risk" and "Consumers risk". [4]

Ans.:

Sr. No.	Producers risk	Consumers risk
1.	If the quality is good still from sampling plan some lots are rejected and producer has to suffer.	If the quality is bad still from the sampling plan some lots are accepted the consumer will suffer.
2.	The producers risk is the probability of rejecting a good lot which otherwise would have been accepted.	Consumers risk is the probability of defective lots being accepted which otherwise would have been rejected.
3.	Saying a producers risk α = 0.05 means that in the long run about 1 lot in 20 will be rejected provided that the lots are coming from a process controlled at AQL quality level.	Saying that $_{P0.10}$ = 2.5% means the consumer does not want a worse quality containing more that 2.5% defectives and he would at the most accept 10% of lots containing 2.5%
4.	It is acceptable quality level	It is objectionable quality level

Q.2(e) Compare acceptance sampling with 100% inspection. [4]

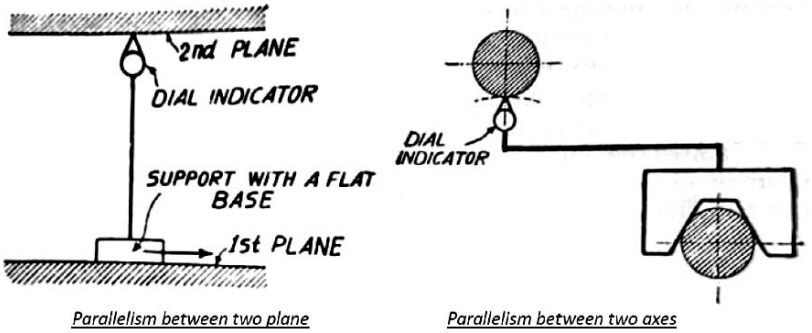
Ans.: Acceptance sampling with 100% inspection

- The cost required for sampling inspection is quite less as compare to 100% inspection.
- The time required for sampling inspection is less as compared to 100% inspection.
- In sampling inspection problem of inspection fatigue which occurs in 100% inspection is eliminated.
- Smaller inspection staff is necessary for sampling inspection as compare to 100% inspection.
- In sampling inspection less damage to product, because only few items are subjected to handling during inspection.
- The problem of monotony and inspector error introduced by 100% inspection is minimized.
- Sampling inspection exerts more effective pressure on quality improvement. Since the rejection of entire lot on the basis of sampling brings much stronger pressure on quality improvement than the rejection of individual articles.
- Sampling inspection provides less information about the product than 100% inspection.
- Some extra planning and documentation required in sampling inspection.

Q.3Attempt any FOUR of the following : [16]

Q.3(a) Explain how the parallelism between two planes and parallelism between two axes is checked with neat sketch. [4]

Ans.:



Parallelism between two plane Parallelism between two axes

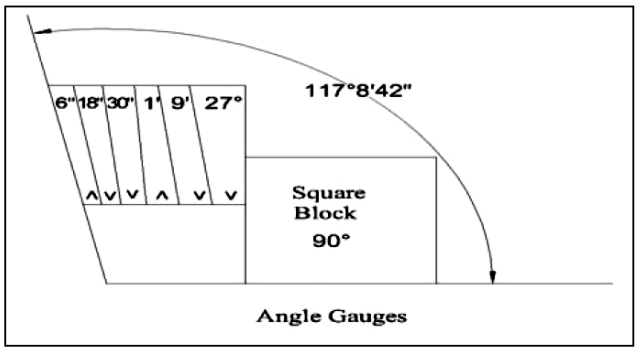
Parallelism between two planes: The test for parallelism of two planes is carried out in two directions (generally perpendicular to each other). The dial indicator, which is held on a support with a flat base, is moved in one plane over a given length, and the feeler is made to rest against the second plane; and the deviation is noted down.

Parallelism between two axes: In this test, the dial indicatoor is held on a support with a base of suitable shape, so that it slides along a cylinder representing one of the two axes; and the dial indicator is adjusted so that its feeler slides along the cylinder representing the second axis. The maximum deviation between the axes at any point may be determined by gently rocking the dial indicator in a direction perpendicular to the axes. In the same way the parallelism may be tested in the perpendicular plane.

Q.3(b) An angle of 117° 8′ 42″ is to be set and measured with the help of standard angle gauges and square block. Select the minimum number of pieces and sketch the arrangement. **[4]**

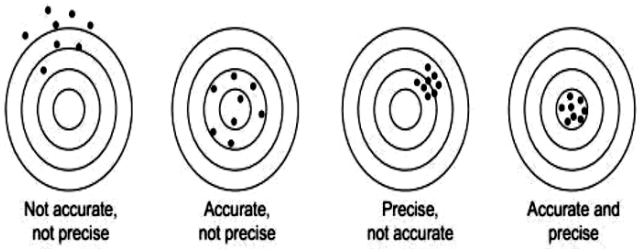
Ans.: 8′ = 9′ – 1′

42″ = 30″ + 18″ – 6″



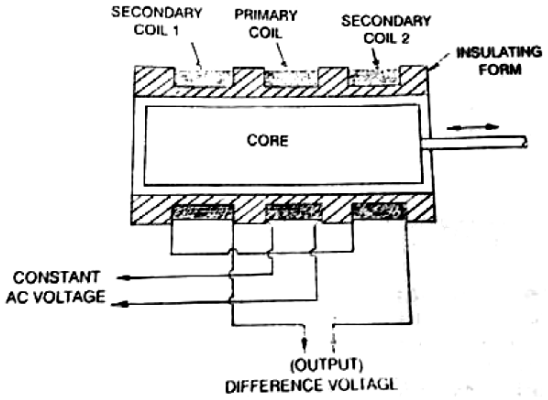
Q.3(c) Compare accuracy and precision. **[4]**

Ans.:

Sr. No.	Accuracy	Precision
1.	The closeness to the measured value with true value is called accuracy.	Repeatability of measuring process is called precision.
2.	It is related to true value	It is related to average value
3.	Costlier to achieve great accuracy	Easier and cheaper to achieve precision
4.	Example 	

Q.3(d) Explain the (LVDT) Electrical comparator with neat sketch. **[4]**

Ans.: LVDT Electrical comparator



Explanation: LVDT works on mutual inductance principle. It is a transformer consisting of three symmetrically spaced coils carefully wound on an insulated bobbin. It consists of a

primary coil wound on an insulated bobbin and two identical secondaries symmetrically spaced from the primary. AC carried excitation is applied to the primary and two secondaries are connected externally in a series opposition circuit. There is non-contacting magnetic core which moves in the center of these coils. Motion of this core varies the mutual inductance of each secondary to the primary, which determines the voltage induced from the primary to each secondary.

If the core is centered in the middle of the two secondary windings, then the voltage induced in each secondary winding will be identical and 1800 out of phase and the net output will be zero. If the core is moved off middle position, then the mutual inductance of the primary with secondary will be greater than the other, and a differential voltage will appear across the secondaries in series which can be directly calibrated in terms of linear movement of core.

Q.3(e) State any four characteristics of good comparator. [4]

Ans.: characteristics of good comparator:

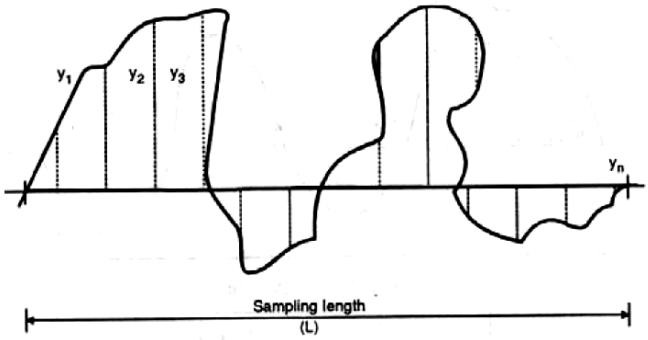
1. Robust in design and construction.
2. Linear characteristics of scale.
3. High magnification.
4. Quick response to input.
5. Minimum wear of contact point.
6. Free from oscillations.
7. Free from back lash.
8. Output must be easily readable and understandable.
9. Low in cost.
10. Less maintenance.

Q.4(a) Attempt any THREE of the following: [12]

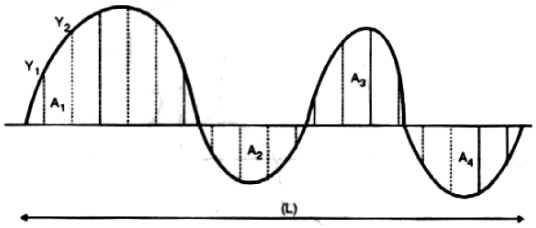
Q.4(a) (i) State methods of evaluation of surface roughness. Explain any one in detail. [4]

Ans.: Methods of Evaluation of surface roughness:

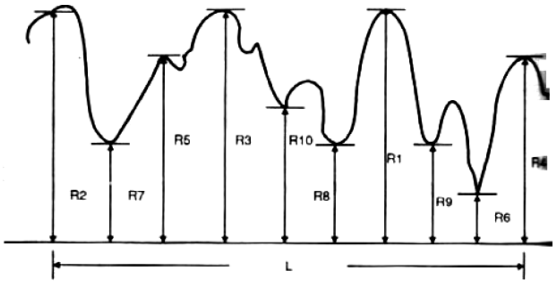
1. Root mean square value method (RMS Value)



2. Centre line average method (CLA Value)



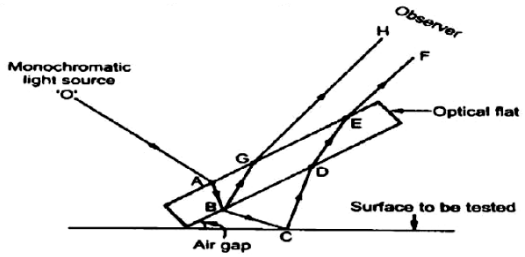
3. Ten point average method (Rz Value)



Q.4(a) (ii) By using optical flat and monochromatic light source, explain how will you determine whether the given surface is convex or concave or flat. [4]

Ans.:

- Following fig. Shows the optical ray diagram of optical flat and the checking can be started by keeping the optical flat on the surface to be tested and monochromatic light is incident on optical flat.
- The air gap between optical flat and surface to be tested and the phase difference between reflected ray will generate the dark and bright band which gives basis idea about flatness of surface



- From diagram it is observed that ray B-C-D-E-F is longer than B-G-H by an optical distance BCD and if, (i) BCD = n λ (1, 2, 3…), two rays come in phase and join together as a bright band and (ii) If BCD = n/λ9 (n=1,2,3…), two rays comes in phase and join together as a bright and gives dark band.
- When the surface is not flat, the band obtain will be curved and if the band curved around the line of contact the surface is convex as shown in following fig.a.
- If the bands curve in opposite direction the surface is concave as shown in fig. b.

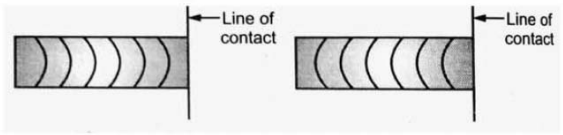


Fig.a Convex surface Fig.b Concave surface

Q.4(a) (iii) List the minimum number of slip gauges to be wrung together to produce an overall dimension of 63.875 mm using a set of 87 pieces. The set contain (Ref. Table No.1) [4]

Range (mm)	Step	Pieces
1.005	–	01
1.001 to 1.009	0.001	09
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 90	10	09

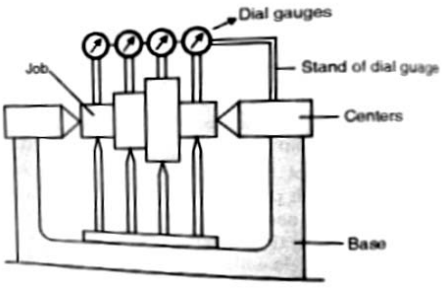
Ans.: To build dimension of 63.875 mm using a given set of 87 pieces select the following slip gauges:

1.005
+1.37
+1.5
+60.00
63.875

Minimum number of slip gauges required are 4

Q.4(a) (iv) Explain the multi-gauging machine with neat sketch. State it's any two advantages. [4]

Ans.: Multi Gauging Machine:



Explanation: Multi Gauging machines are useful for measurement of number of dimensions at a time. Part to be checked are compared with setting standards and the deviation is recorded.

First the setting standard is held between two centers than the dial indicators are adjusted to the zero position for different dimensions. Than setting standard is removed and the component to be tested is fixed between centers and the readings of dial indicators are recorded.

Advantages of Multi Gauging Machine :

1. Number of dimensions can be measured at a time.
2. Time for inspection is very less.
3. Cost of inspection is less.

Q.4(b) Attempt any ONE of the following: [6]

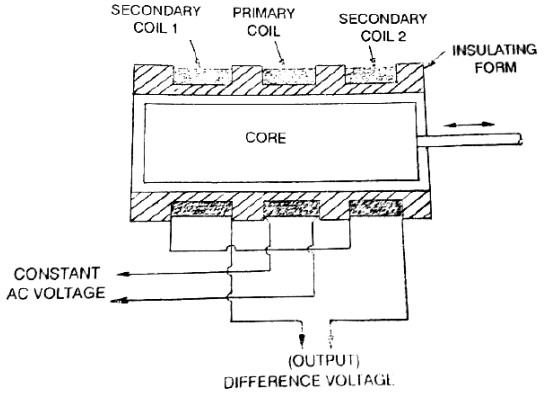
Q.4(b) (i) State the various factors controlling the quality of design. [6]

Ans.: Factors controlling quality of design are:

(i) Design does not reflect the customer's requirements,
(ii) The product which the producer offers would not probably satisfy the customer, even if it does sufficiently conform to the design.
(iii) Quality of design is usually indicated by completeness and correctness of specifications.
(iv) Drawings, catalogues, etc.

Q.4(b) (ii) What is LVDT? Explain its principle of working with neat sketch. [6]

Ans.: LVDT : LVDT is the inductive transducer used to translate linear motion into electrical signal. (displacement)



Explanation: LVDT works on mutual inductance principle. It is a transformer consisting of three symmetrically spaced coils carefully wound on an insulated bobbin. It consists of a primary coil wound on an insulated bobbin and two identical secondaries symmetrically spaced from the primary. AC carried excitation is applied to the primary and two secondaries are connected externally in a series opposition circuit. There is noncontacting

magnetic core which moves in the center of these coils. Motion of this core varies the mutual inductance of each secondary to the primary, which determines the voltage induced from the primary to each secondary.

If the core is centered in the middle of the two secondary windings, then the voltage induced in each secondary winding will be identical and 180° out of phase and the net output will be zero. If the core is moved off middle position, then the mutual inductance of the primary with secondary will be greater than the other, and a differential voltage will appear across the secondaries in series which can be directly calibrated in terms of linear movement of core.

Q.5Attempt any TWO of the following: [16]

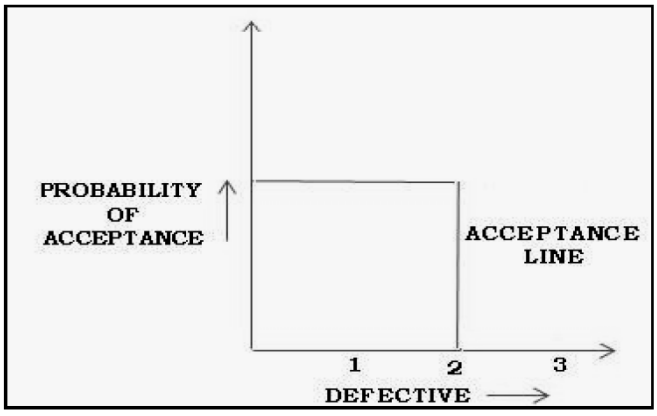
Q.5(a) State the various factors responsible for the variation due to assignable causes. [8]

Ans.: Various factors responsible for the variation due to assignable causes are:

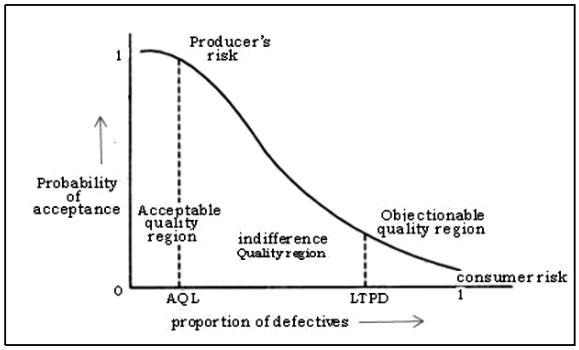
1. Tool wear
2. Poor quality of raw material.
3. Faulty jigs and fixtures.
4. Untrained operator.
5. Metrology errors.
6. Machine problems such as loose moving parts.
7. Incorrect machining parameters.
8. Careless attitude of operators.

Q.5(b) Draw a neat labelled sketch of O.C. curve. State the procedural steps of construction of O.C. curve. [8]

Ans.: 1. Ideal OC Curve:



2. Actual OC Curve:



OC CURVE Procedure

1. It is graph drawn with lot fraction defective 'P' on X axis verses the probability of acceptance on Y axis, as shown in figure.
2. The OC curve defines the actual characteristics of a given acceptance sampling plan.

3. An OC curve shows, for every possible fraction defectives 'P' on a given lot will be acceptance by the acceptance sampling plan that the OC curve represents.
4. An OC curve provides the means of evaluating the operation of an acceptance sampling plan.
5. This risk in a particular sampling plan can be determined by considering the results of samples drawn from a large number of lots of various quality levels using the mathematical theory of probability.
6. Every sampling plan has its own consumer and producer's risks as indicated by its OC curve.

Q.5(c) (i) What is six sigma statistical concept? Enlist its benefits. **[4]**

Ans.: Six sigma: Six sigma is defined as a disciplined, data drive approach for eliminating defects in any process of manufacturing or service industry.

Benefits of six sigma:

(1) Customer driven
(2) Continuous improvement process.
(3) It helps to increase customer satisfaction.
(4) Improve efiiciency and effectiveness in process

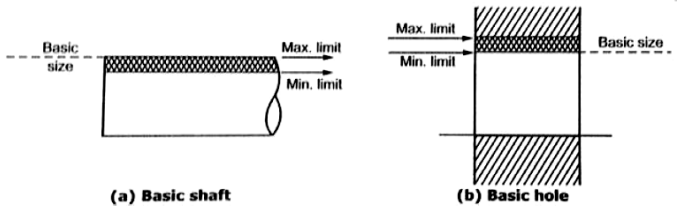
Q.5(c) (ii) Explain basic shaft and basic hole with neat sketch. **[4]**

Ans.: Basic Shaft: Basic shaft is the shaft whose upper deviation is zero.

- Thus the upper limit of the basic shaft is the same as the basic size.
- It is denoted by letter "h"

Basic Hole: Basic hole is the hole whose lower deviation is zero.

- Thus the lower limit of the basic hole is the same as the basic size.
- It is denoted by letter "H"



Q.6Attempt any TWO of the following: **[16]**

Q.6(a) The following table gives the numbers of missing rivets noted at aircraft final inspection: **[8]**

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

Find $\bar{C}$ compute trial control limits and plot control chart for C. What values of C' would you suggest for the subsequent period?

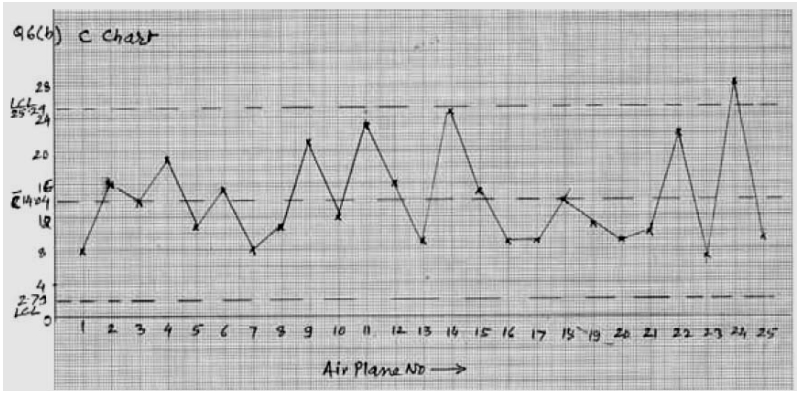
Ans.: Step I calculate $\bar{C}$ = Sum of total defects/ quantity inspected

$\bar{C}$ = 351/25 = 14.04

Step II Calculate statistical control limits for C chart

UCL $\bar{C}$ + 3($\sqrt{\bar{C}}$) = 25.29 LCL $\bar{C} - 3(\sqrt{\bar{C}})$ = 2.79

Step III Plot C chart



Step IV Comments on C chart

Q.6(b) Following are the inspection results of magnets for five observations. Draw appropriate control chart and conclude. [8]

Week No.	1	2	3	4	5
No. of magnets inspected	728	724	720	730	724
Defectives found	48	83	80	58	60

Ans.:

Sr. No.	Lot size	Defectives	Fraction Defectives	% defectives
1	728	48	0.0659	6.59
2	724	83	0.1146	11.46
3	720	80	0.1111	11.11
4	730	58	0.0794	7.94
5	724	60	0.0828	8.28

$$\bar{P} = \frac{\Sigma d}{\Sigma n} = \frac{329}{3626} = 0.0907 = 9.07\%$$

$$n = \frac{3626}{5} = 725.2$$

$$UCL = \bar{P} + 3\times\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

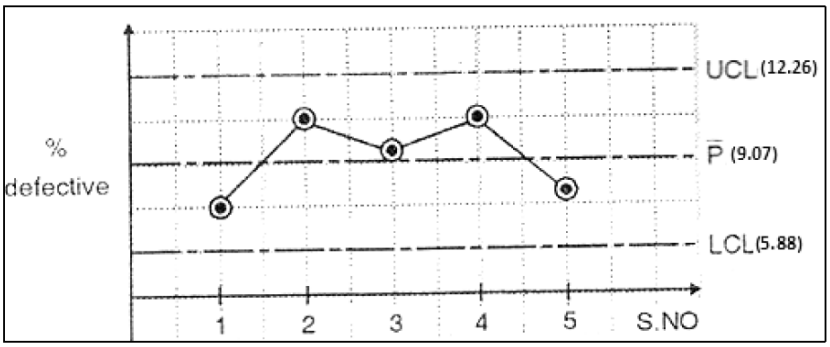
$$= 0.0907 + 3\times\sqrt{\frac{0.0907(1-0.0907)}{725.2}} = 0.1226$$

UCL = 12.26%

$$LCL = \bar{P} - 3\times\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

$$= 0.0907 - 3\times\sqrt{\frac{0.0907(1-0.0907)}{725.2}} = 0.058$$

LCL = 5.88%



Conclusion:
As all points are within control limits, hence given Process is in Control.

Q.6(c) Explain quality of conformance and quality of performance and state factors affecting quality of product. [8]

Ans.: **Quality of conformance** : It is concerned with how well the manufactured product confirms to the quality of design, means confirms to the specifications adopted for design of the product.

During designing, it is necessary to obtain high level of quality of conformity.

Quality of performance : it is related to the performance of the product i.e how well the product performs during its prescribed life time at customers end. Quality of performance is assessed at customer end. Quality of performance depends on quality of design, manufacturing, sales, services.

Factors affecting quality of product

1. Quality of incoming materials
2. Machines, tools, instruments
3. Men
4. Quality systems are not adopted
5. Poor design
6. Mistakes in manufacturing
7. Excess material handling
8. After sales services
9. Non adherence to specifications
10. Rework

❑ ❑ ❑ ❑ ❑