SUMMER – 13 EXAMINATION

Subject Code: **12157** **Model Answer**

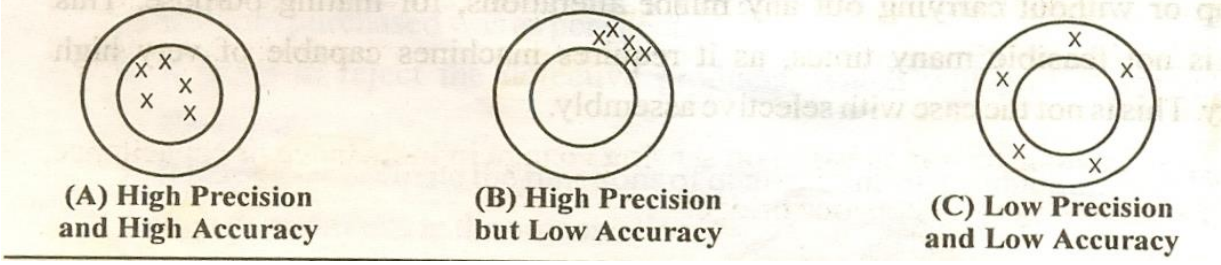
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q1.A. Attempt any **Three.**

a) Difference between Accuracy and Precision **(4 mark for ANY 4 point)**

Sr.no.	**Accuracy**	**Precision**
1	It is the closeness to the true value.	It is repeatability of various reading given by instrument.
2	Single reading can be taken to comment about accuracy.	Group of readings are required to make any comment about precision.
3	It is difficult and expensive to have good accuracy.	It is much easier and cheaper to achieve precision than to achieve great accuracy
4	During the act of measurement accuracy is less important than precision	During the act of measurement precision is more important.



b) Distinguish between Unilateral and bilateral tolerance system. (04 Marks)

Unilateral		Bilateral	
1.	The variation is made in only one direction from the nominal or basic dimension.	1.	The variation is both over &under the nominal dimension.
2.	It is possible to change tolerances for same allowance or type of fit, without changing the nominal size of shaft or hole.	2.	For maintaining the same allowance, changing the tolerances is possible only by changing the nominal sizes of shaft, if nominal size of shaft is maintain. Sometimes the nominal dimension of both of the mating parts may have to be changed
3.	It is used in mass production where mating parts must be interchangeable	3.	It cannot use for mass production where mating parts must be interchangeable.
4.	GO gauges for holes & NO-Go gauges for shafts can be standardized	4.	GO gauges for holes & NO-Go gauges for shafts cannot be standardized
5.	Example: $30^{+0.00}_{+0.02}$	5.	Example: $30.01^{+0.01}_{-0.01}$

C) Distinguish between Line standard and End standard?(4 marks FOR ANY 4 point)

SR.NO	Line Standard	End Standard
1	When length is expressed distance between two lines called line standard.	When length is expressed as a distance between to flat parallel Faces is called end standard.
2	Measurement is quick and easy.	Measurement is complicated and time Consuming
3	It is not used for precision measurement	It is used for precision measurement
4	It is subjected to Parallax error	It is not subjected to Parallax error.
5	It is simple in construction	It is complicated in construction.
6	No skill required	High skill workers are required
7	e.g Scale, Yard, Meter tape etc	e.g. Slip gauges, Micrometer,

d) Set of <u>M45</u> as follows

RANGE	STEP	PIECES
1.001 TO 1.009	0.001	9
1.01 TO 10.9	0.01	9
1.1 TO 1.9	0.1	9
1 TO 9	1	9
10 TO 90	10	9
TOTAL		45

34.468

- 1.008 --------5

33.460

-1.06 ----------4

32.40

-1.40 ----------3

31.00

-1.00 -----------2

30.00

-30.00 ---------1

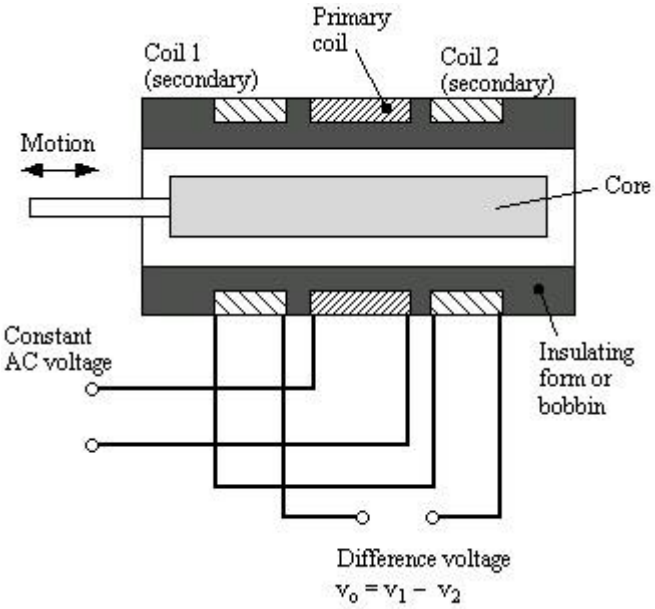
00.00 **(4 MARKS)**

Q1. B) Attempt any ONE:

a) Name of highest magnification -Electrical Comparators ----------1Marks

Electrical comparators are also known as electro-mechanical measuring systems as these employ an electro-mechanical device, which converts a mechanical displacement into electric signal.

Linear Variable Differential Transducer or Transformer (LVDT) is the most popular electro-mechanical device used to convert mechanical displacement into electrical signal.



----------**2M**

Construction of LVDT:

This is a most widely used inductive transducer to translate the linear motion into electrical signals. Its basic constructions are shown in figure. This device has one primary and two secondary windings. A movable soft iron core is placed inside the coils. The core is attached to the moving part on which the displacement measurement is to be done. The secondary windings have equal number of turns and are identically placed on either side of the primary windings. The primary winding is connected to an alternating current source. A magnetic flux generated by this coil and it is disturbed by the armature so that voltage is induced in the two secondary coils. The assembly is placed in stainless steel housing and the frequency of a.c. applied to primary winding may be between 50Hz to 20KHz. As the two secondary windings S_1 and S_2 are connected in series opposition as shown in figure. Therefore the net output from the transformer is then the difference between the voltage of the two secondary windings.

Working of LVDT:

The position of the magnetic core determines the flux linkage with each windings. When the core is placed centrally, equal but opposite e.m.f.'s are induced in the secondary winding and zero output is recorded. This is termed as normal (Null) position.

A variation in the position of the core from its null position produces an unbalance in the reactance. The voltage induced in the secondary winding towards which core is displaced increases. At the same time induced voltage decreases from the other secondary coil. Thus due to displacement of core; the result will be a voltage rise in one secondary and decrease in the other secondary and thus produces a differential voltage (E_0) which varies linearly with change in the core position.----------

EXPLANATION 3 MARKS

Uses of LVDT:

1. It can be used for wide range
2. Acting as a secondary transducer it can be used to measure force, weight, pressure etc.
3. Acting as a primary transducer, converts the displacement directly into electrical output.

b) Distinguish between Measuring instrument & gauges. (6 MARKS FOR ANY 6 POINTS)

SR.NO	Measuring instrument	Gauges
1	It will give true reading of job.	It will not give true reading of job.
2	It carries a calibrated scale.	It does not required calibrated scale.
3	It is time consuming hence it is not used in mass production.	It is easy and rapid to use in mass production.
4	Skilled operators are required for handling	Unskilled operator can handle the gauges.
5	It is complicated in construction	Simple in construction
6	e.g. Vernier	e.g. Snap gauge

Q2. Attempt any four:

a) i)**Repeatability** – It is the ability of measuring instrument to repeat the output readings constantly, when quantity is measured number of times under same condition within short interval of time.

Any instrument is subject to a large number of sources of variation like environmental changes, variability in operator performance and in instrument parameters. The repeatability is characterized by the dispersion of indications when the same quantity is repeatedly measured.

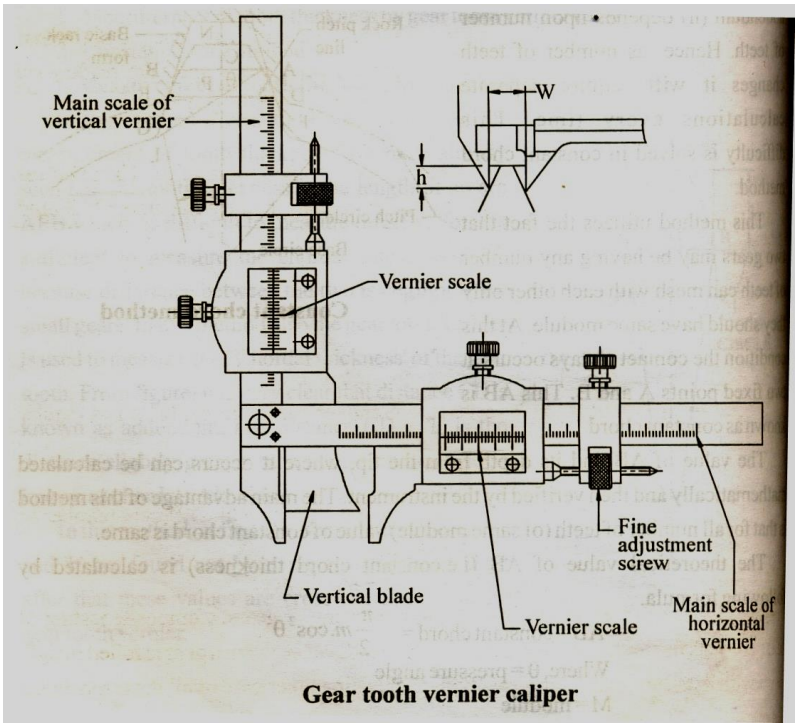
ii)**Reproducibility** –It is the closeness of agreement between the results of measurement of the same quantity when individual measurements are carried out by different observers, by different methods under different condition. It may also be expressed quantitatively in terms of the dispersion of the results. **(2 MARK FOR EACH)**

b) Gear tooth vernier

It is used to measure the thickness (W) of gear teeth at the pitch line or chordal thickness of teeth and the distance (h) from the top of a tooth to the chord.

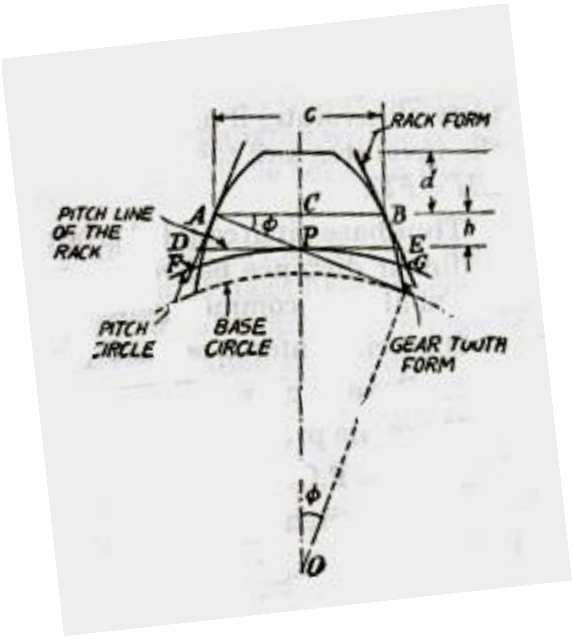
The value of 'h' obtained by calculation is set on vertical caliper, and thickness 'W' is measured with horizontal caliper. **(2 Marks)**

Fig: (2 Marks)



Gear tooth vernier caliper

C) Constant Chord Method



(1 MARK)

Constant chord of a gear is measured where the tooth flanks touch the flanks of the basic rack. The teeth of the rack are straight and inclined to their centre lines at the pressure angle as shown in Fig.

The gear tooth and rack space are in contact in the symmetrical position at the points of contact of the flanks, the chord is constant at this position irrespective of the gear of the system in

mesh with the rack. This is the property utilized in the constant chord method of the gear measurement.

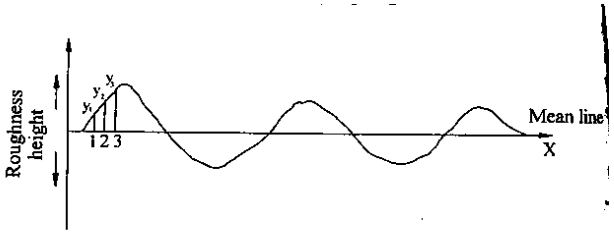
The measurement of tooth thickness at constant chord simplified the problem for all number of teeth. Line AB is known as constant chord. The value of c and its depth from the tip (d), where it occurs can be calculated mathematically and then verified by an instrument. **(2 MARKS)**

$$\therefore d = m\left(1 - \frac{\pi}{4}\cos\emptyset\ \sin\emptyset\right)$$

c=AB = constant chord

c=AB = $\pi/2$ m. $\cos^2\emptyset$---------1 MARK

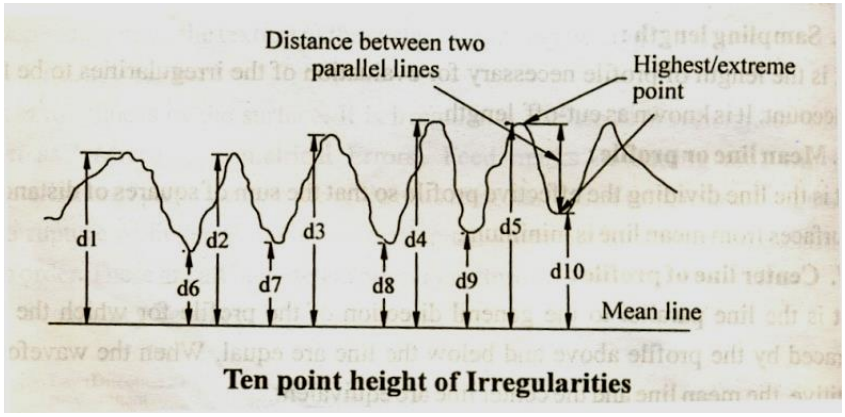
d) Ra Value – It is the arithmetic mean deviation of surface profile from mean line mathematically.



Arithmetic mean deviation for mean line

$$Ra = \frac{\sum_{o}^{n} y_i}{n}$$

Where n = no. of division over sampling length. **(2 Marks)**



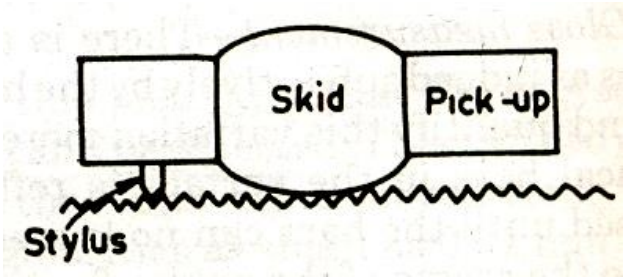
Ten point height of Irregularities

Rz value – It is average difference between peak value and valley values with a sampling length measure from mean length mathematically.

$$R_z = \frac{(R_1 + R_3 + R_5 + R_7 + R_9) - (R_2 + R_4 + R_6 + R_8 + R_{10})}{5}$$

(2 Marks)

e) Stylus Probe Instruments **(1 MARK)**

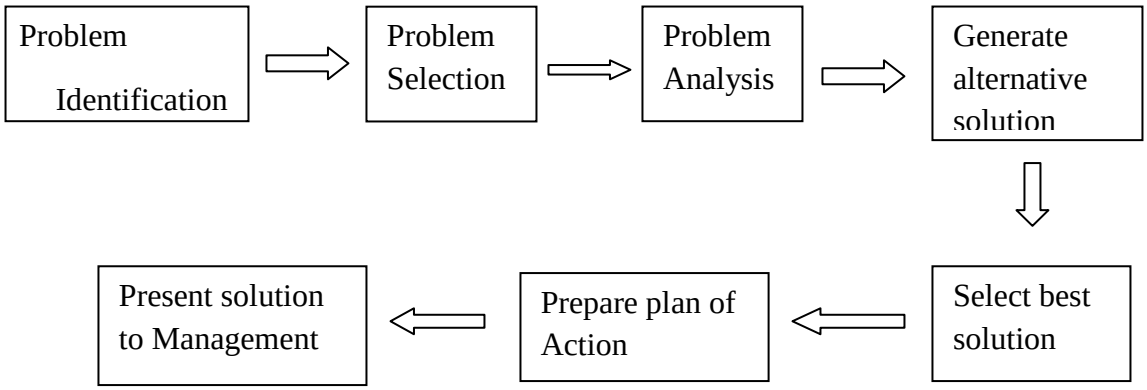


1. A skid or shoe which is drawn slowly over the surface either by hand or by motor drive. The skid when moved over the surface follows its general contours and provides a datum for the measurements.
2. In case a skid is not used and only a probe is used then probe will trace the actual profile, but upward and downward movement of probe will be dependent upon the setting of the work under probe. But since the roughness of the surface does not depend upon the position of the work, it will be necessary to choose a datum from which the measurement is to be taken.
3. A line touching the crest of the profile, that is, the envelope line which defines the macro-geometrical form is generally chosen as datum line and this is obtained by using a skid of such a size which can span a large number of surface undulations.
4. A stylus or probe which moves over the surface with the skid.
5. The stylus for R_a measurement on new instrument can have a radius of 10 microns ±30%.
6. The stylus should be cone shaped with a spherical tip.
7. It moves vertically up and down relative to skid movement due to roughens of the surface.

8. It is desired that if the skid is moving up then the stylus must also be moving up. But when the pitch between the skid and stylus is comparable to that of half the wavelength of surface, then record will not be desirable one, e.g., in the skid and stylus position shown in Fig. skid is moving up, while stylus is giving downward indication. **(3 MARKS)**

Q.3. Attempt **any four**:

a) **Procedure of problem solving :(1M FOR FIG.)**



Problem Identification – In quality circle discussions all members present a problem about Metrology and Quality Control. All members tell about all problems.

Problem Selection – There is many problems in industry. All members discuss the seriousness of Problem. They are find those kind of problem which may seriously affect on Production.

Problem Analysis – In this selected problem discuss with all parameters means they discuss with Seriousness of product.

Generate alternative solution –There is many problem in production therefore all quality circle members give suggestion on selected problem.

Select best solution – After all, solutions given by members is discussed deeply. All members with their thinking capacity, discuss on best solution and fix it.

Prepare plan of Action – After selecting best solution prepare plan of action for solving this Problem permanently.

Present solution to Management – Prepare plan of action is represent in front of management. Management is discussing only about cost and implementation.

(3Marks)

b) Quality Audit

Definition – A systematic and independent examination to determine whether quality activities and related results comply (compare) with plant arrangement and whether this arrangement are implemented effectively and are suitable to achieve objectives**. (1mark)**

Significance of Quality Audit –

1) To check whether the system is working properly.
2) To know are there non conformities in the system.
3) To know whether identified problems have been corrected.
4) To make focus on potential problems.
5) Checking the performance and understanding the shop personal.
6) Quality audit are performed to find whether end product satisfy the desired quality specification.
7) Quality audit are important for proper functioning of all equipment and machinery.
8) Collecting the customer complaints regarding quality and steps taken to correct them. **(3marks)**

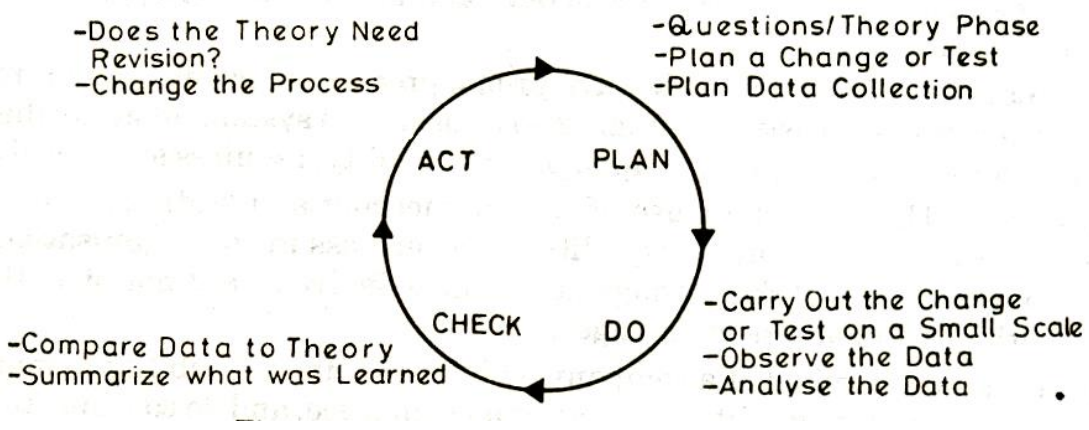
c) Advantages of ISO 9000 series :(2 Marks)

1) ISO 9000 series enables to meet the requirement of any internationally uniform quality system.
2) To enhance foreign exchange.
3) Reputation of organization increases.
4) Due to excellent quality, less scrap and rework increases in profit.
5) Sales increases which gives job security to employee.
6) Due to excellent quality, inspection cost, Q. C. and Q. A. cost reduces.
7) Complete customer satisfaction.
8) Motivate the employee and develop pride in them for achieving excellence.

Limitations of ISO 9000 series – :(2 Marks)

1) Lost of documentation is required for implementation of ISO 9000.
2) Implementation is very much depending on resources.
3) Assessment and registrations are expensive.
4) The expenses requires for giving necessary training to the employee are also heavy.

d) PDCA Cycle –



(1M FIG)

P – Plan

1) Lay down and plan policy and objectives of TOM.
2) Make planning of method to achieve the objective of organization.

D – Do

1) Provide education & training to workers and managers to achieve objectives.
2) Implement TOM by introducing new work concept.

C – Check

1) Check the result by observing them and find causes of non-conformance.
2) Use abilities of the reasons.

A- Act

1) Try to act for preventing undesired effects.
2) Measure the instrument and design for future. **(3Marks)**

e) Distinguish between Variable Inspection and Attribute Inspection.(4 Marks for 4 points)

Sr.no	Variable Inspection	Attribute Inspection
1	Measurement by variables involve the use of scale, vernier or micrometer etc. (i.e. a measuring instrument)	Measurement by attributes involves the use GO-NOGO gauge or visual inspection.
2	Continuous data is obtained by variable Inspection.	Discrete data is obtained by attribute Inspection.
3	Variable inspection measures the values	Attribute inspection only judges whether the quality characteristic is present or absent.

4	Measurements by variables are generally expensive and time consuming	Measurement by attributes are generally less expensive and quick.
5	Variable inspection gives detail information About the quality characteristic.	It tells us only whether the part is to be accepted or rejected
6	It may cause fatigue to the operator	Gives no fatigue to the operator
7	Control charts used are X and R char σ chart	Control charts used are p, Pn, C, etc.

Q 4. A) Attempt any three

a) Distinguish between 'Alignment Test' and 'Performance Test' (4 Pts, 4 Marks)

Sol:

Alignment Test		**Performance test**	
1	Various geometric checks are carried out known as alignment test	1	Actual performance of job on machine tool is performance test
2	This test are carried out at static conditions	2	These tests are carried out at working condition.
3	This test are checking position of component and displacement to one another	3	It is checking of job manufacturing on machine and tolerance limit as per design.
4	Alignment of axis of lathe spindle to saddle movement	4	Manufacturing of lathe.

b) Explain the parallelism testing. What is the procedure for testing parallelism of two planes in which one plane is moving? (Def: 01mk, Fig: 01mk, Explanation: 01mk)

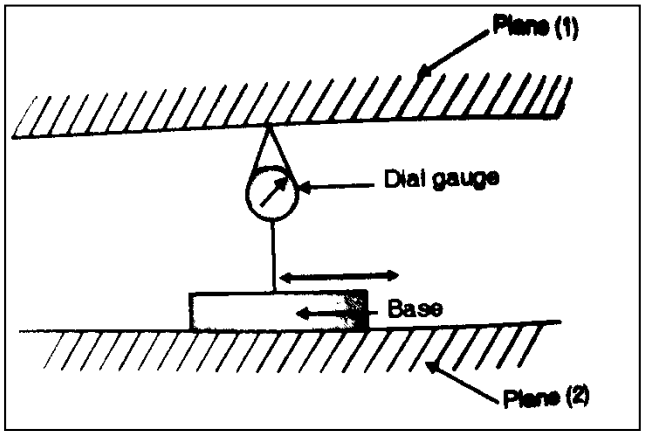
Sol:

Definition: Two lines or planes are called parallel to each other when the distance between them, measured in perpendicular plane remains constant.

Parallelism between two planes:

-If the parallelism of plane (1) and (2) is to be checked, the arrangement of setup is as shown in fig 1 is to be made.

- The dial gauge is to be arranged on a base with a stand.
- Note the reading of dial gauge at initial position.
- Move the base on plane as shown in fig.
- Note the variation in reading of dial gauge.
- If the variation is within the given range, then the plane (1) and (2) are parallel to each other.



c) Calculate the alignment error for the headstock and tailstock for the following data:

Initial reading of dial indicator = 0.1mm,

Final reading of dial indicator = 0.2 mm

Movement of carriage along the longitudinal direction = 100 mm

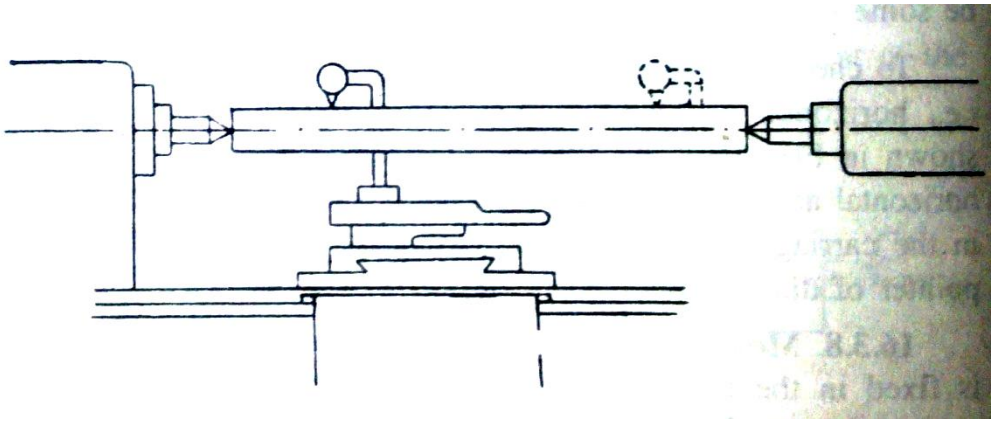


Fig. 2 Marks

Dial indicator verifies the distance of center axis with the surface.

For the movement of dial indicator along the carriage it shows error as difference between the two readings.

∴ Alignment Error = (Final reading of dial indicator - Initial reading of dial indicator) / (L)

= (0.2 – 0.1) / 100

= 0.001 mm per mm length. **(02 Mark)**

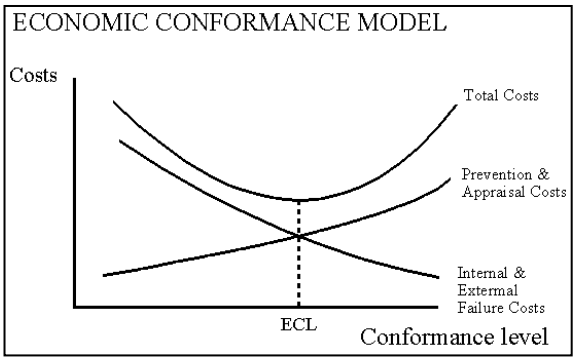
d) Explain the economics of quality of conformance.(Fig: 02 Marks, Explanation: 02 Marks)

Sol:

The quality cost conformance model provides an example of a constrained optimization approach. In this model the **economic conformance level** (ECL) is obtained where prevention and appraisal costs are equal to external and internal failure costs. Prevention and appraisal costs increase as the level of conformance quality increases. Conformance quality refers to conformance to specifications as opposed to design quality, i.e., service functions or features.

Failure costs are expected to decrease as the level of conformance quality increases. Therefore, the total costs associated with conformance quality will be U-shaped as indicated in the exhibit below.

Prevention costs include quality engineering, training and related supervision costs. Appraisal costs include inspection, testing and supervision related to these activities. Internal failure costs include spoilage, scrap, rework and the associated downtime costs, while external failure costs include warranty costs and the costs of lost customers.



B) Attempt any one:

a) Describe how Scratch inspection and Microscopic inspection is carried out. (03 Marks each)

Sol:

Scratch inspection:

In scratch inspection a softer material like lead, babbit or plastic is rubbed over the surface to be inspected and that soft material acts as the sample.

The ups and downs are impressed on material and can be inspected using various methods of the surface finish testing.

Microscopic inspection:

Microscopic inspection is the best method of inspection, in which job is observed under microscopic. Limitation is of a small portion is to be inspected at a time therefore several readings are needed to get average.

Master piece can be used and by magnification of the surface, testing is done under microscope.

b) Compare single and double sampling plan. (Any 3 Pts, 6 Marks)

Sr.No.	Points	Single sampling plan	Double sampling plan
1	Average number of pieces inspected per lot.	Largest	In between single and multiple plans
2	Cost of administration.	Lowest	In between single and multiple plans
3	Information available regarding prevailing quality level.	Largest	In between single and multiple plans
4	Acceptability to producers	Less (gives only one chance of passing the lot)	Most acceptable.

Q 5. Attempt any two:

a) **Why sine bar is not preferred for measuring angle more than 45^0?**

Sol: (Fig: 02 Marks, Derivation: 04 Marks, Explanation: 02 Marks)

We know that $\sin\theta = \frac{h}{l}$ is the basic principle of working of sine bar.

Differentiating equation,

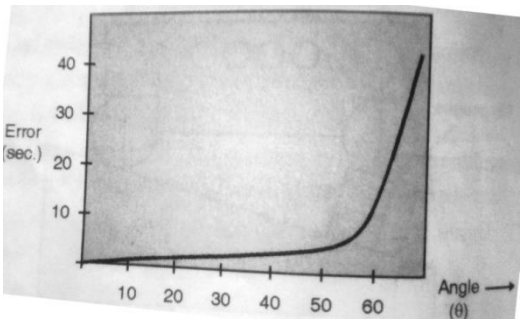
$$\text{Cos}\,\theta.d\theta = \frac{l.dh - hdl}{l^2}$$

$$= \frac{dh}{l} - \frac{h.dl}{l^2}$$

$$= \frac{dh}{l}\sin\theta - \frac{dl}{l}\sin\theta$$

$$= \tan\theta\left(\frac{dh}{h} - \frac{dl}{l}\right)$$

This indicates that error is a function of $\tan\theta$ and below 45^0 error is smaller which suddenly increases above 45^0.

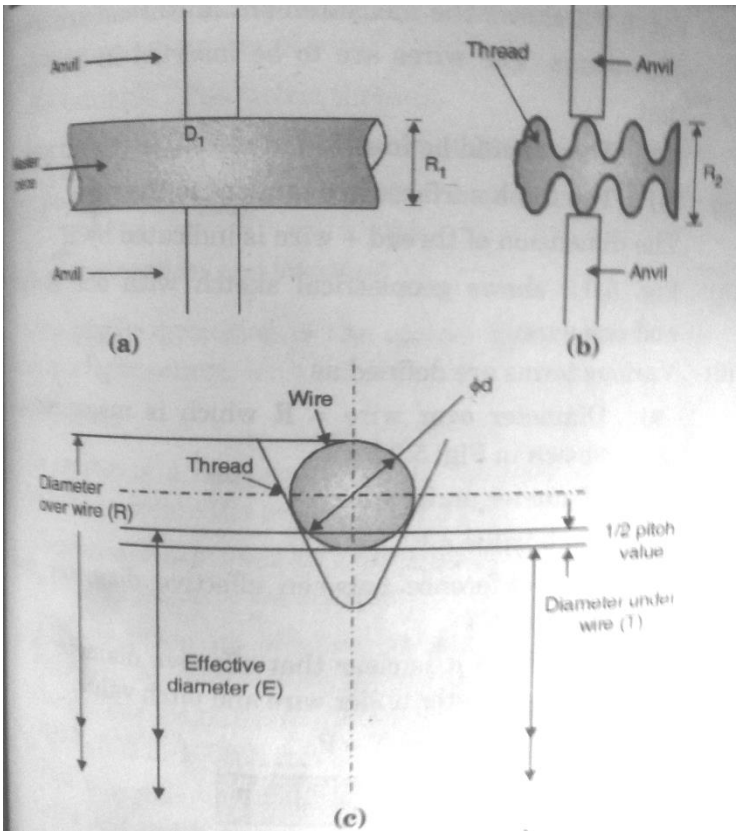


Because of this sine bar is preferred for measuring angle below 45^0.

b) Explain in brief two wire method for thread measurement.(Fig: 02 Marks, Explanation: 06 Marks)

1) Effective diameter can be measured by using floating carriage instrument which is more accurate.
2) For measurement of effective diameters following methods can be used.
   a. Two wire method
   b. Three wire method
   c. Direct micrometer method
3) Two wire method consists of use of two identical best size best size of wires.
4) Fig shows the measurement of (thread and wire) dimensions. The wires are to be inserted in such way that
   a. They should be inserted in the same thread and
   b. The flank surfaces are tangent to the wire

The dimension of thread + wire is indicated by 'R'.



5) Fig shows geometrical sketch with one thread and one wire.
6) Various terms are defined as:
   a. Diameter over wire = R which is measured as shown in fig.
   b. Diameter under wire = T
   c. Pitch value = P

(It is the difference between effective diameter and diameter under wire)

7) From fig it is clear that effective diameter E is addition of diameter under wire and pitch value.

$\therefore E = T + P$

$$E = (R - 2d) + P$$

($\because T = R-2d$)

Where, E = Effective diameter,

R = diameter over wire,

d = wire diameter,

P = Pitch value

8) For reducing various types of errors master piece can be used at the time of measurement.

c) State the importance of QS 14000 standard. (Brief Explanation: 08 Marks)

Sol: ISO 14000 is a series of standards, and guideline reference documents, which cover the following: environmental Management Systems, Environmental Auditing, Eco Labeling, Life Cycle Assessment, and Environmental Aspects in Product Standards, Environmental Performance Evaluation.

One of these standards in particular, ISO 14001, has assumed additional importance, because it is intended for registration by third party.

Increased awareness of sustainable development gives environmentally credible companies a competitive edge in national and international markets. A certified Environmental Management System proves that your business is taking active steps to fulfill your responsibilities.

The standard requires organization to identify all environmental implement actions to improve processes in prioritized areas with significant aspects.

ISO 14001 lays forth a best practice for proactive management of the environmental impact of your organization. When you have an ISO 14001 certified Environmental Management System you go beyond mere compliance. Your focus becomes continual improvement.

Elements of the standard: It contains the core elements for an effective environmental management system. It can be applied to both service and manufacturing sectors. The standard requires a company to define environmental objectives and targets and the management system necessary to requires that the company adheres to that system's processes, procedures and activities. The main elements of the standard are:

1. Environmental policy

2. Planning

3. Implementation and operation

4. Checking the corrective action

5. Management review

The international ISO 14001:2004 environmental management standard applicable to any type of organization.

Q 6. Attempt any two:

a) Following are the inspection results of magnets for '5' observations. Draw proper control chart and conclude

Week number	**1**	**2**	**3**	**4**	**5**
Number of magnets inspected	**724**	**728**	**724**	**720**	**730**
Defectives found	**48**	**83**	**70**	**80**	**58**

Sol:

1. P- chart is to be drawn**. (01 Marks)**
2.

Number	Jobs inspected	defectives	% defectives
1	724	48	6.6
2	728	83	11.4
3	724	70	9.6
4	720	80	11.1
5	730	58	7.9
Total	$\sum n$ = 3626	$\sum d$ = 339	

(Chart: 02 Marks)

3. $\overline{P} = \frac{\sum d}{\sum n} = \frac{339}{3626} = 0.093 = 9.3\ \%$ **(01 Marks)**

4. UCL – P = $\overline{P} + 3 \times \sqrt{\frac{P\,(1-P)}{n}}$

$= 0.093 + 3 \times \sqrt{\frac{0.093\,(1-0.093)}{725.2}}$

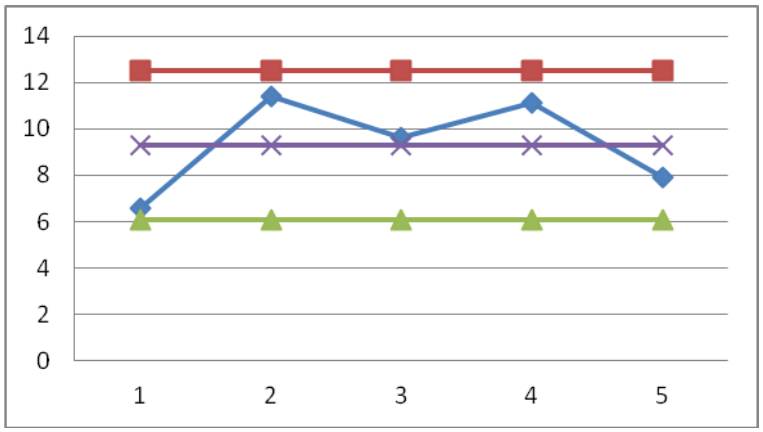
$= 0.125 = 12.5\ \%$ **(01 Marks)**

$\left[\because\ n = \frac{3626}{5} = 725.2\right]$

5. LCL – P = $\overline{P} - 3\times \sqrt{\frac{\overline{P}(1-\overline{P})}{n}} = 6.1\ \%$ **(01 Marks)**

6.

(Chart: 02Marks)



b) In the lot of 50 pieces, each sub-group is of 5-pieces and for sub-group X-bar and R- values for the "length of pieces" is as under.

Sr. No.	X-bar	R
1	2.12	0.03
2	1.99	0.01
3	1.80	0.02
4	2.00	0.04
5	1.99	0.02
6	2.45	0.01
7	1.85	0.05
8	1.70	0.04
9	1.98	0.06
10	2.30	0.03

By using general formulae, prepare X-bar and R-chart and write the interpretation of chart.

Sol:

Observations in Sample (n)	X-Chart Factors for Control Limits (A2)	R-Chart Factors for Control Limits (D3)	R-Chart Factors for Control Limits (D4)
2	1.88	0.00	3.27
3	1.02	0.00	2.57
4	0.73	0.00	2.28
5	0.58	0.00	2.11
6	0.48	0.00	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78

Assuming values of $A_2 = 0.577$, $D_3 = 0$ and $D_4 = 2.114$

$\overline{\overline{X}} = \frac{\Sigma \overline{X}}{N} = 2.018$ **(01)**

$\overline{R} = \frac{\Sigma R}{N} = 0.031$ **(01)**

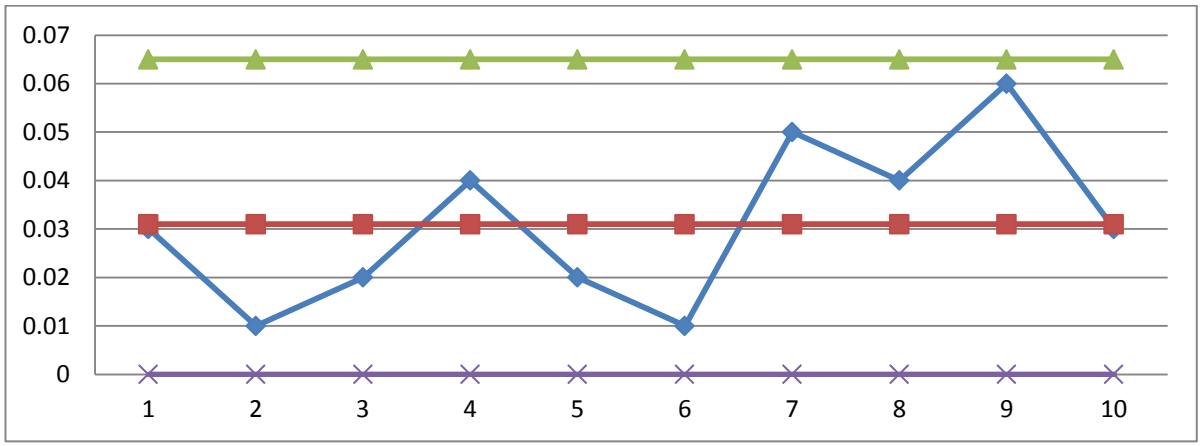
UCL - $\overline{\overline{X}}$ = $\overline{\overline{X}}$ + A_2. $\overline{R}$ = 2.018 + 0.577 × 0.031 = 2.035887 ≈ 2.04 **(01)**

LCL - $\overline{\overline{X}}$ = $\overline{\overline{X}}$ - A_2.$\overline{R}$ = 2.018 - 0.577 × 0.031 = 2.000113 ≈ 2.00 **(01)**

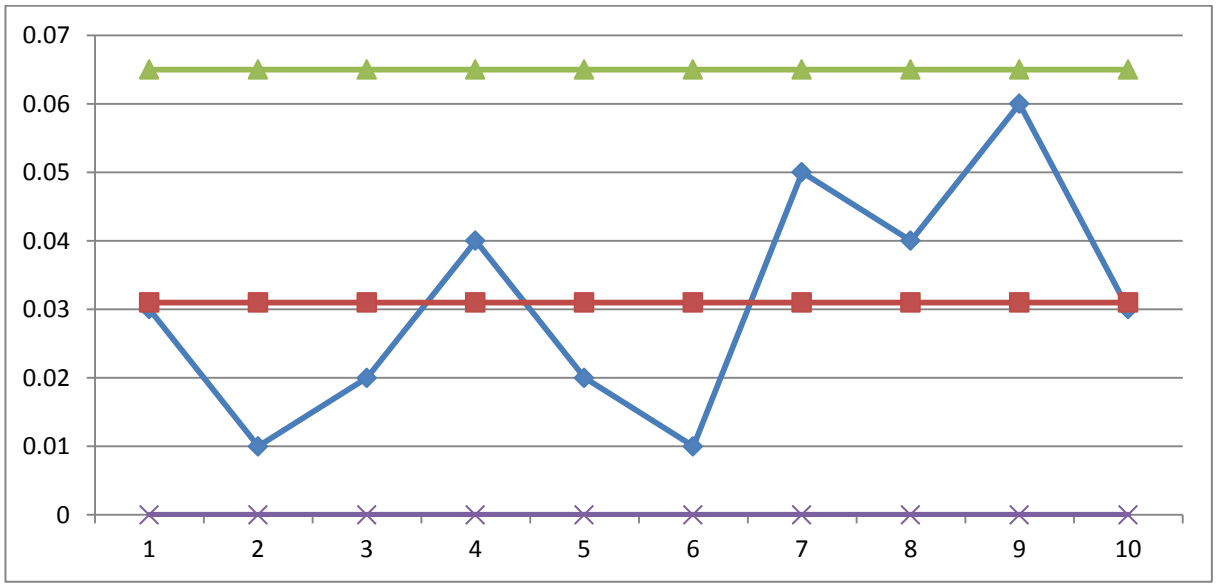
LCL – R = D_3× $\overline{R}$ = 0 ×0.031 = 0 **(01)**

UCL – R = D_4× $\overline{R}$ = 2.114 ×0.031 = 0.065534 **(01)**

X- Bar Chart



R Chart



Graph: From graph it is seen that Process is out of control. (**Graph: 02 Marks**)

c) Define Process capability and state how it is achieved? (Def: 02Marks, Explanation: 02 Marks)

Sol. Process capability is defined as minimum spread of specific measurement variation which will include 99.7 % of the measurement of given process.

That is, the process capability = 6σ. The process capability is also called as 'natural tolerance'.

Process capability = 6σ

Process capability study is carried out to measure the ability of the process to meet the specified tolerance.

Process capability achieves importance:

1. Determination of centering of process.
2. Determination of position of process compared to tolerance.
3. Find piece to piece variations.
4. Measurement of actual variability.
5. Reduction of wastage of production.
6. Saves money and time.

Method to find process capability

Procedure to calculate process capability

1) Calculate average $\overline{X}$ and range R for each sample.
2) Calculate the grand average $\overline{\overline{X}}$. (This measures centering of process.)
3) Calculate control limits and plot $\overline{X}$ - R chart. (This measure stability of process.)
4) Calculate process capability 6σ.

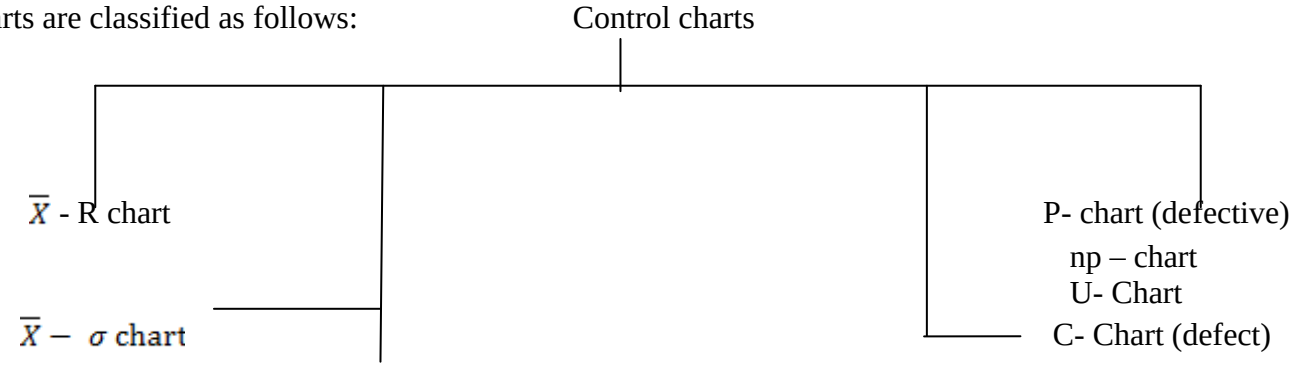
$$\therefore 6\sigma = 6\left(\frac{\overline{R}}{d_2}\right)$$

(This measures job to job variability of the process.)

2. Classify the "Quality Control Charts". (04 Points, 04 Marks)

Sol:

The charts are classified as follows:



(For measurable quality characteristics, **variables**) (For **attribute** data)
