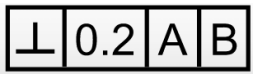
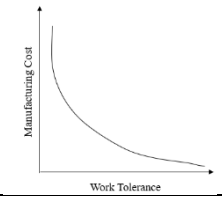
Academic year 2025 - 26 (ODD Sem)

DEPARTMENT OF INDUSTRIAL ENGINEERING& MANAGEMENT

Date	17th December 2025	**Maximum Marks**	10 + 50
Course Code	IM235AI	**Duration**	120 Min
Sem	III Semester	CIE – II	

Digital Metrology
Scheme & Solution

Part – A

Sl. No.	Questions	M	BT	CO
1)	a) **Unilateral Tolerance:** A tolerance in which variation is permitted in **only one direction** (either above or below the nominal dimension). b) **Bilateral Tolerance:** A tolerance in which variation is permitted **both above and below** the nominal dimension.	02	L2	CO3
2)	A Feature Control Frame is represented as a rectangular box divided into compartments, indicating the geometric characteristic, tolerance value, datum references, and material condition symbols. 	01	L1	CO3
3)	a) **Interchangeability:** The ability of manufactured parts to be replaced by identical parts without any custom fitting, adjustment, or modification. This ensures that components from different production batches can function together seamlessly. b) **Selective Assembly:** A method where components produced by a machine are classified into groups based on their size or dimensions. Parts from the same group are then assembled together to maintain proper fit and function, compensating for manufacturing variations.	02	L2	CO3
4)	As work tolerance becomes tighter, manufacturing cost increases due to precision requirements, inspection, and material wastage. 	02	L2	CO3
5)	Allowance	01	L2	CO3
6)	Gantry	01	L1	CO4
7)	Automatic tool changing.	01	L1	CO4

Part – B

Sl. No.	Questions	M	BT	CO
1.	i. $D = \sqrt{50 \times 30}$ **D = 63.45mm** ii. $i = 0.45\sqrt[3]{D} + 0.001D\ (\mu)$ $= \sqrt[3]{63.245} + 0.001 \times 63.245\ (\mu)$ $= 1.865\ \mu$ **i = 0.001856mm** ---------- **(01)** iii. For Hole 'F8'	(10)	L4	CO3

Fundamental Deviation for 'F', = $5.5D^{0.41}$

FD = 5.5 $(63.245)^{0.41}$

FD = 0.030mm

Tolerance for 'F',

IT8 = 25i

= 25(0.001856)

= 0.0464mm ---------- (01)

iv. For shaft 'e9'

Fundamental Deviation for 'e', = $-11D^{0.41}$

= -11 (63.245)0.41

FD = 0.0602mm

Tolerance for 'e'

IT9 = 40i

= 40 (0.001856)

= 0.07424mm ---------- (01)

Limits for Hole

Maximum Hole Limit = 70.000 + 0.030 + 0.0464 = **70.0764mm ---------- (01)**

Minimum Hole Limit = 70.000 + 0.030 = **70.03mm ---------- (01)**

Limits for Shaft

Maximum Shaft Limit = 70.000 – 0.0602 = **69.9398mm ---------- (01)**

Mimimum Shaft Limit = 70.000 – 0.0602 – 0.074 = **69.8658mm ---------- (01)**

Maximum and Minimum Clearance **---------- (01)**

Maximum Clearance = Maximum Hole Limit - Mimimum Shaft Limit

= 70.0764 – 69.8658

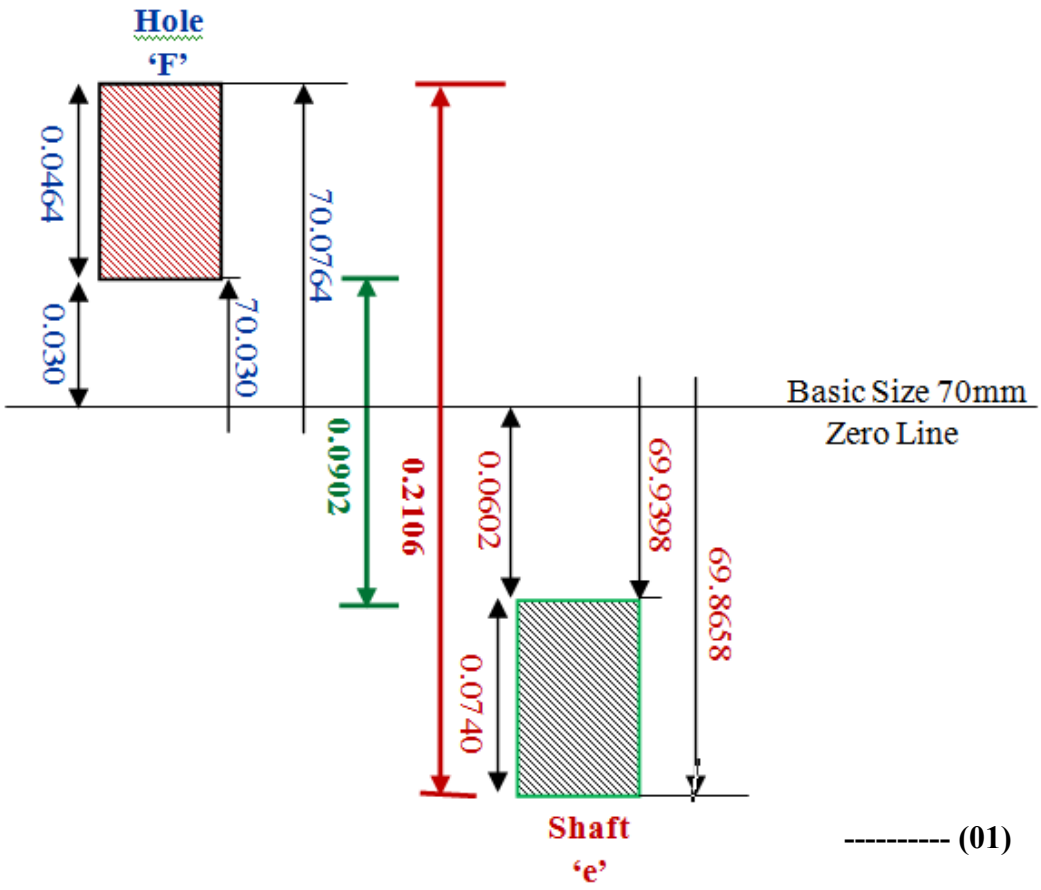
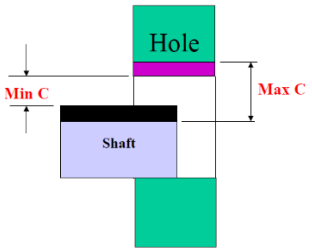
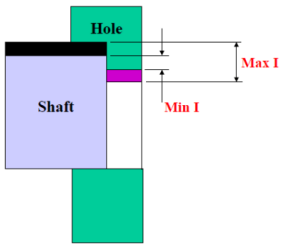
= 0.2106mm

Minimum Clearance = Minimum Hole Limit - Maximum Shaft Limit

= 70.030 – 69.9398

= 0.0902mm

Since Maximum shaft limit is less than the minimum hole limit, it is **"CLEARANCE FIT" ---------- (01)**

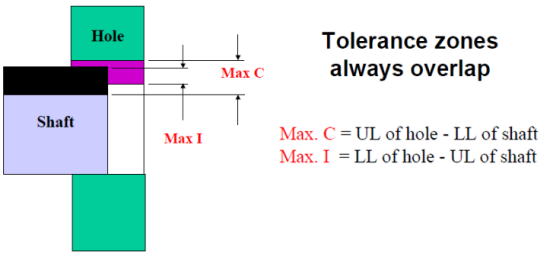
	 ---------- **(01)**			
2.	**Fit:** It is an assembly condition between 'Hole' & 'Shaft' **(01)** **Types of Fit:** **Clearance fit: (01 + 01 + 01)** In this type of fit, the largest permitted shaft diameter is less than the smallest hole diameter so that the shaft can rotate or slide according to the purpose of the assembly.  **Tolerance zones never meet** Max. C = UL of hole - LL of shaft Min. C = LL of hole - UL of shaft **Examples:** • **Bearings in shafts**: Used in rotating machinery to ensure smooth rotation with minimal friction. • **Door hinges**: A loose fit ensures free movement. • **Bolt and hole assembly**: A bolt is smaller than the hole diameter to allow insertion and removal. **Interference Fit: (01 + 01 + 01)** It is defined as the fit established when a negative clearance exists between the sizes of holes and the shaft. In this type of fit, the minimum permitted diameter of the shaft is larger than the maximum allowable diameter of the hole. In case of this type of fit, the members are intended to be permanently attached.  **Tolerance zones never meet but crosses each other** Max. I = LL of hole - UL of shaft Min. I = UL of hole - LL of shaft **Examples**: • **Press-fit gears on shafts**: Used in heavy machinery to prevent slippage during	(10)	L3	CO3

operation.

- **Bushings in housings**: Ensures a secure, immovable connection.
- **Shrink-fit components**: A ring heated to expand and placed over a shaft, creating a tight fit when cooled.

Transition Fit: **(01 + 01 + 01)**

In this type of fit, the diameter of the largest allowable hole is greater than the smallest shaft, but the smallest hole is smaller than the largest shaft, such that a small positive or negative clearance exists between the shaft & hole.



Examples:

- **Coupling hubs**: Ensures tight alignment without extreme force or looseness.
- **Piston and cylinder in engines**: Provides controlled movement while minimizing clearance for better efficiency.

Keyed shafts and pulleys: Allow slight movement while maintaining alignment.

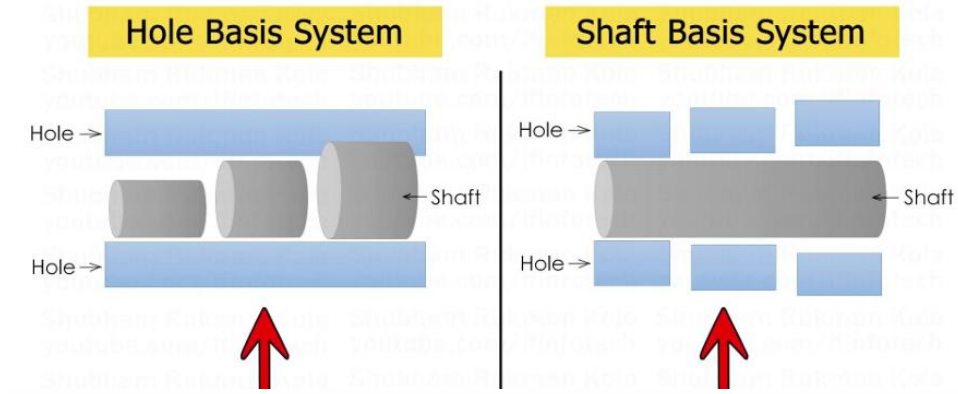
3.

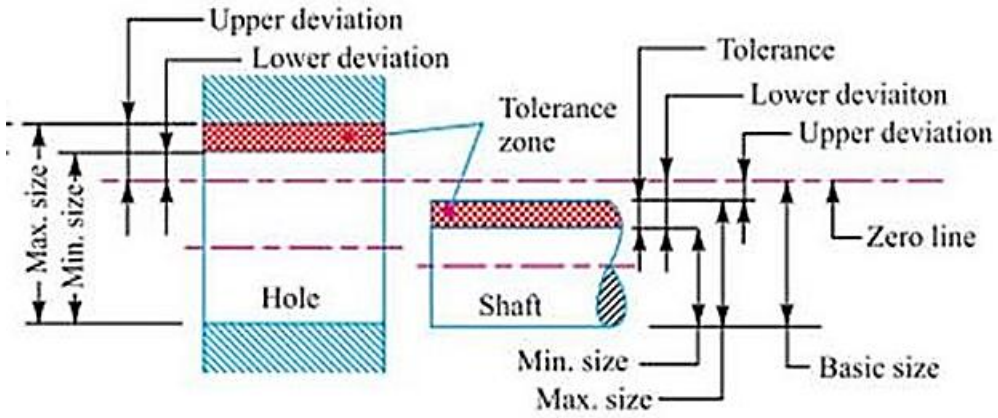
1. **Upper deviation (1.5)**
   The term upper deviation refers to the algebraic difference between the maximum limit and the basic size.
   The upper deviation of a hole is demoted by a symbol ‘ES’ and of a shaft is denoted by a symbol 'es’.
2. **Lower deviation (1.5)**
   The term lower deviation refers to the algebraic difference between the minimum limit and basic size.
   The lower deviation of a hole is denoted by a symbol ‘EI’ and of a shaft it is denoted by a symbol ‘ei’.
3. **Fundamental deviation**. **(01)**
   The term fundamental deviation refers to the deviation, either the upper or the lower deviation, which is nearest one to the zero line for either a hole or a shaft.
   Fundamental deviation provides the position of the tolerance zone with respect to the zero line
4. **Hole Basis System (01 + 01)**
   The size of the hole remains constant, while the shaft may have varying dimensions to achieve different types of fits, such as clearance, interference, or transition fits.
   Tolerances for holes are typically specified as positive (+) deviations from the nominal size.
5. **Shaft basis system (01 + 01)**
   The size of the shaft remains constant, while the hole may have varying dimensions to accommodate different fits.
   Tolerances for shafts are typically specified as negative (-) deviations from the nominal size.

Implementing hole and shaft basis systems in manufacturing is crucial for making sure parts fit together correctly and work well. Manufacturers use standard rules for sizes and tolerances during production to ensure precision. This helps to reduce errors during assembly and improves product quality, making them more reliable and durable. It also saves costs by minimizing the need for fixes or replacements. These systems also make it easier to manage inventory and maintenance. Ultimately,

(10) | L2 | CO3

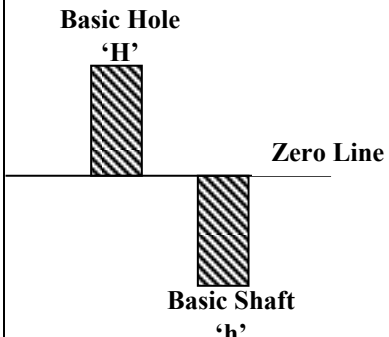
following these systems ensures that products perform as expected and are consistent across production. **(02)**

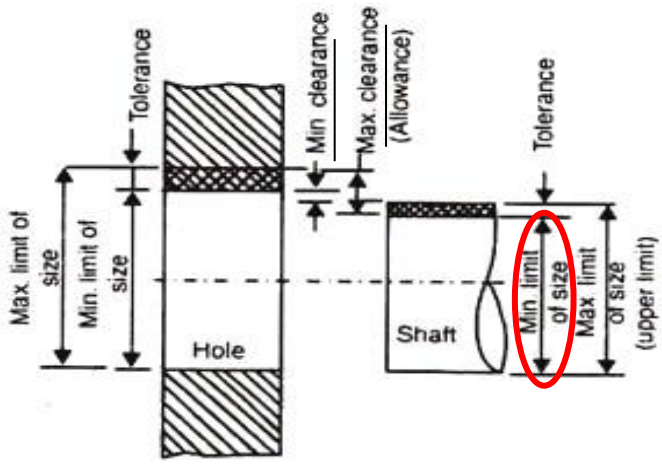




4.

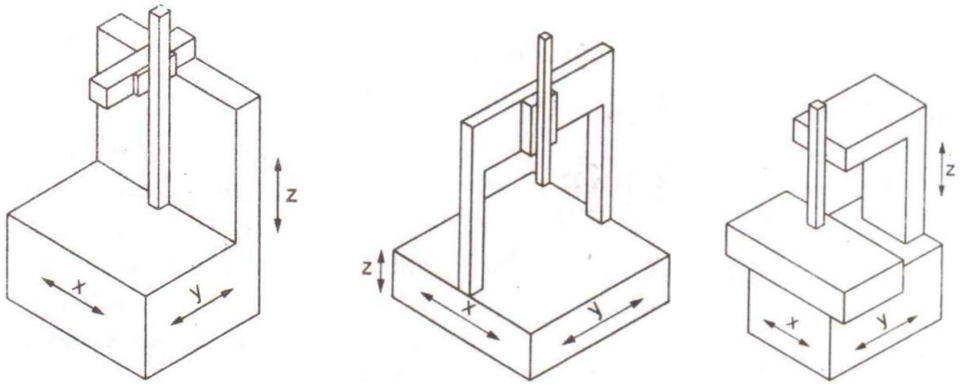
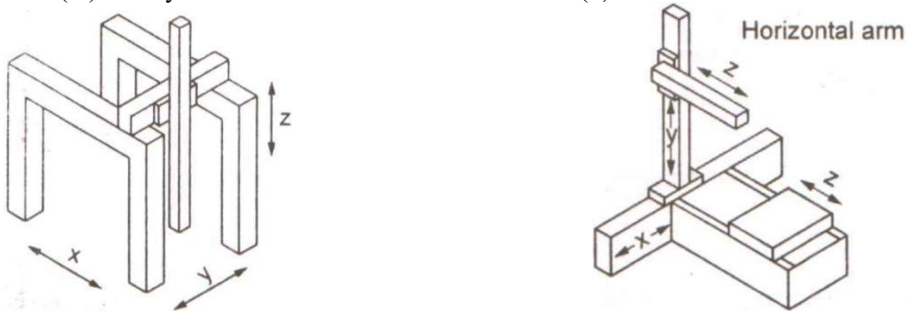
1. **Basic Hole:** A hole with a lower deviation or Fundamental Deviation of zero. The fundamental deviation for the 'H' hole is zero
2. **Basic Shaft:** A Shaft with a Upper deviation or Fundamental Deviation of zero. The fundamental deviation for the 'h' shaft is zero.
3. **Minimum Limit of Size:** The term minimum limit of size referred to the minimum or smallest permissible size of a component
4. **Maximum clearance:** The difference between the maximum size of hole and the minimum size of the shaft.
5. **Minimum Clearance:** The difference between the minimum size of hole and the maximum size of the shaft.





2 Marks each

(10) | L2 | CO3

5.	**Main structure of a Coordinate Measuring Machine** A CMM consists of five main elements : (i) Cantilever (ii) Bridge Type (iii) Column Type  (iv) Gantry (v) Horizontal  **Any 4 – 2 marks each**	(10)	L2	CO4

BT-Blooms Taxonomy, CO-Course Outcomes, M-Marks

Marks Distribution	Particulars		CO1	CO2	CO3	CO4	CO5	L1	L2	L3	L4	L5	L6
	Quiz	Max Marks	--	--	08	02	--	03	07	--	--	--	--
	Test		--	--	40	10	--	--	30	10	10	--	--

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