MACHAKOS UNIVERSITY

University Examinations 2022/2023

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE MECHANICAL ENGINEERING

EMM 305: METROLOGY

DATE: December 2022   **TIME: 2 HOURS**

INSTRUCTIONS

I) This paper contains **FIVE (5)** questions.

II) Question **ONE** is **COMPULSORY** and carries 30 marks

III) Answer any other **TWO (2)** questions.

SECTION ONE (COMPULSORY) [30 MARKS]

QUESTION ONE

a) Define the following terms as applied in metrology using neat sketches;

    i.   Least Count on a Micrometer Screw Gauge. [2 marks]

    ii.   Repeatability. [2 marks]

b) List **FOUR** types of Comparators based on the principle used for obtaining magnification [2 marks]

c) Using a neat sketch, illustrate the major parts of an **Optical Projector** Comparator. [5 marks]

d) With a neat sketch, describe gear inspection process using Parkinson gear tester. [8 marks]

e) A spur gear of 3 mm module has 40 teeth. Calculate the following proportions. Pitch Circle diameter, addendum, dedendum working height and base pitch for a pressure angle of 20°. [3 marks]

f) A shaft is fitted into a hole with **nominal size** of **25 mm**. **H7p6** fit is selected for the application. With reference to BS4500A attached, determine:

    i.   The upper and lower limit for the hole, [2 marks]

    ii.   The tolerance of the hole, [1 mark]

    iii. The upper and lower limit for the shaft, [2 marks]

    iv. The tolerance of the shaft, [1 mark]

    v.   The maximum and minimum clearance of the fit, [2 marks]

SECTION TWO (ANSWER ANY TWO)   [20 MARKS EACH]

QUESTION TWO

a) Enumerate **SIX** factors that contribute to Surface irregularities formation   [6 marks]

b) List and state the importance of **FOUR** types of standards grades in metrology.[4 marks]

c) Highlight **SIX** advantages of wavelength standards.   [6 marks]

d) Give the readings of depth micrometer screw gauge and vernier calipers shown in **Fig. Q2 (a)** and **(b).**   [4 marks]

QUESTION THREE

a) Using a neat sketch, illustrate the major parts of a vernier caliper.   [5 marks]

b) List **SIX** advantages of Autocollimators.   [6 marks]

c) Represent diagrammatically the tolerance zone of the following shaft and hole pairs and calculate the sizes of **GO** and **NOT GO** (plug and ring) gauges to inspect them. Neglect gauge tolerances.

Shaft size: $35^{-0.050}_{-0.025}$

Hole size: $35^{-0.00}_{-0.04}$

[9 marks]

QUESTION FOUR

a) Using neat diagrammatic illustration, explain the wringing process as applied in slip gauges angular measurement.   [4 marks]

b) Use Table I to determine the gauge blocks to choose in order to obtain the following lengths.   [6 marks]

   i.   83.995 mm.   iii.   3.9525 mm.

   ii.   29.7575 mm.

Table I: Range of Gauge Blocks.

Range (mm)	Steps (mm)	No. of pieces
1.01 – 1.49	0.01	49
0.5 - 9.5	0.5	19
25 - 100	25	4
1.0025 - 1.0075	**0.0025**	**3**

c) Enumerate **SIX** characteristics of a good comparator. [6 marks]

d) Discuss **FOUR** systems utilized by mechanical comparators to amplify displacement. [4 marks]

QUESTION FIVE

a) Enumerate **FIVE** purposes for which screw threads are used. [5 marks]

b) Discuss **THREE** methods that can be used for surface roughness analysis. [9 marks]

c) Using neat sketches, explain how minor diameter of a screw thread can be measured using external micrometer. [6 marks]
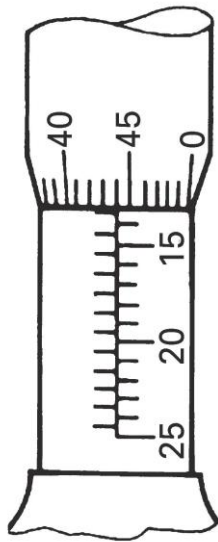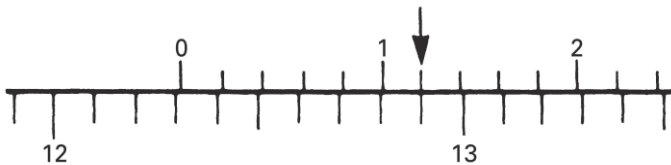

Fig. Q2 (a)   Fig. Q2 (b)

BRITISH STANDARD
SELECTED ISO FITS—HOLE BASIS

Diagram to scale for 25 mm diameter

Holes / Shafts

Nominal sizes		Clearance fits												Transition fits				Interference fits				Nominal sizes	
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6	H7	k6	H7	n6	H7	p6	H7	s6	Over	To
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	mm	mm
—	3	+60/0	−60/−120	+25/0	−20/−60	+25/0	−14/−39	+14/0	−6/−16	+10/0	−2/−8	+10/0	0/−6	+10/0	+6/0	+10/0	+10/+4	+10/0	+12/+6	+10/0	+20/+14	—	3
3	6	+75/0	−70/−145	+30/0	−30/−78	+30/0	−20/−50	+18/0	−10/−22	+12/0	−4/−12	+12/0	0/−8	+12/0	+9/+1	+12/0	+16/+8	+12/0	+20/+12	+12/0	+27/+19	3	6
6	10	+90/0	−80/−170	+36/0	−40/−98	+36/0	−25/−61	+22/0	−13/−28	+15/0	−5/−14	+15/0	0/−9	+15/0	+10/+1	+15/0	+19/+10	+15/0	+24/+15	+15/0	+32/+23	6	10
10	18	+110/0	−95/−205	+43/0	−50/−120	+43/0	−32/−75	+27/0	−16/−34	+18/0	−6/−17	+18/0	0/−11	+18/0	+12/+1	+18/0	+23/+12	+18/0	+29/+18	+18/0	+39/+28	10	18
18	30	+130/0	−110/−240	+52/0	−65/−149	+52/0	−40/−92	+33/0	−20/−41	+21/0	−7/−20	+21/0	0/−13	+21/0	+15/+2	+21/0	+28/+15	+21/0	+35/+22	+21/0	+48/+35	18	30
30	40	+160/0	−120/−280	+62/0	−80/−180	+62/0	−50/−112	+39/0	−25/−50	+25/0	−9/−25	+25/0	0/−16	+25/0	+18/+2	+25/0	+33/+17	+25/0	+42/+26	+25/0	+59/+43	30	40
40	50	+160/0	−130/−290	+62/0	−80/−180	+62/0	−50/−112	+39/0	−25/−50	+25/0	−9/−25	+25/0	0/−16	+25/0	+18/+2	+25/0	+33/+17	+25/0	+42/+26	+25/0	+59/+43	40	50
50	65	+190/0	−140/−330	+74/0	−100/−220	+74/0	−60/−134	+46/0	−30/−60	+30/0	−10/−29	+30/0	0/−19	+30/0	+21/+2	+30/0	+39/+20	+30/0	+51/+32	+30/0	+72/+53	50	65
65	80	+190/0	−150/−340	+74/0	−100/−220	+74/0	−60/−134	+46/0	−30/−60	+30/0	−10/−29	+30/0	0/−19	+30/0	+21/+2	+30/0	+39/+20	+30/0	+51/+32	+30/0	+78/+59	65	80
80	100	+220/0	−170/−390	+87/0	−120/−260	+87/0	−72/−159	+54/0	−36/−71	+35/0	−12/−34	+35/0	0/−22	+35/0	+25/+3	+35/0	+45/+23	+35/0	+59/+37	+35/0	+93/+71	80	100
100	120	+220/0	−180/−400	+87/0	−120/−260	+87/0	−72/−159	+54/0	−36/−71	+35/0	−12/−34	+35/0	0/−22	+35/0	+25/+3	+35/0	+45/+23	+35/0	+59/+37	+35/0	+101/+79	100	120
120	140	+250/0	−200/−450	+100/0	−145/−305	+100/0	−84/−185	+63/0	−43/−83	+40/0	−14/−39	+40/0	0/−25	+40/0	+28/+3	+40/0	+52/+27	+40/0	+68/+43	+40/0	+117/+92	120	140
140	160	+250/0	−210/−460	+100/0	−145/−305	+100/0	−84/−185	+63/0	−43/−83	+40/0	−14/−39	+40/0	0/−25	+40/0	+28/+3	+40/0	+52/+27	+40/0	+68/+43	+40/0	+125/+100	140	160
160	180	+250/0	−230/−480	+100/0	−145/−305	+100/0	−84/−185	+63/0	−43/−83	+40/0	−14/−39	+40/0	0/−25	+40/0	+28/+3	+40/0	+52/+27	+40/0	+68/+43	+40/0	+133/+108	160	180
180	200	+290/0	−240/−530	+115/0	−170/−355	+115/0	−100/−215	+72/0	−50/−96	+46/0	−15/−44	+46/0	0/−29	+46/0	+33/+4	+46/0	+60/+31	+46/0	+79/+50	+46/0	+151/+122	180	200
200	225	+290/0	−260/−550	+115/0	−170/−355	+115/0	−100/−215	+72/0	−50/−96	+46/0	−15/−44	+46/0	0/−29	+46/0	+33/+4	+46/0	+60/+31	+46/0	+79/+50	+46/0	+159/+130	200	225
225	250	+290/0	−280/−570	+115/0	−170/−355	+115/0	−100/−215	+72/0	−50/−96	+46/0	−15/−44	+46/0	0/−29	+46/0	+33/+4	+46/0	+60/+31	+46/0	+79/+50	+46/0	+169/+140	225	250
250	280	+320/0	−300/−620	+130/0	−190/−400	+130/0	−110/−240	+81/0	−56/−108	+52/0	−17/−49	+52/0	0/−32	+52/0	+36/+4	+52/0	+66/+34	+52/0	+88/+56	+52/0	+190/+158	250	280
280	315	+320/0	−330/−650	+130/0	−190/−400	+130/0	−110/−240	+81/0	−56/−108	+52/0	−17/−49	+52/0	0/−32	+52/0	+36/+4	+52/0	+66/+34	+52/0	+88/+56	+52/0	+202/+170	280	315
315	355	+360/0	−360/−720	+140/0	−210/−440	+140/0	−125/−265	+89/0	−62/−119	+57/0	−18/−54	+57/0	0/−36	+57/0	+40/+4	+57/0	+73/+37	+57/0	+98/+62	+57/0	+226/+190	315	355
355	400	+360/0	−400/−760	+140/0	−210/−440	+140/0	−125/−265	+89/0	−62/−119	+57/0	−18/−54	+57/0	0/−36	+57/0	+40/+4	+57/0	+73/+37	+57/0	+98/+62	+57/0	+244/+208	355	400
400	450	+400/0	−440/−840	+155/0	−230/−480	+155/0	−135/−290	+97/0	−68/−131	+63/0	−20/−60	+63/0	0/−40	+63/0	+45/+5	+63/0	+80/+40	+63/0	+108/+68	+63/0	+272/+232	400	450
450	500	+400/0	−480/−880	+155/0	−230/−480	+155/0	−135/−290	+97/0	−68/−131	+63/0	−20/−60	+63/0	0/−40	+63/0	+45/+5	+63/0	+80/+40	+63/0	+108/+68	+63/0	+292/+252	450	500