



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

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

[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.
 - ii. 29.7575 mm.
 - iii. 3.9525 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]

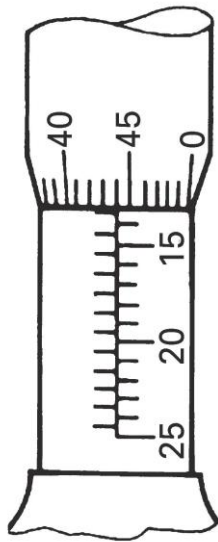


Fig. Q2 (a)

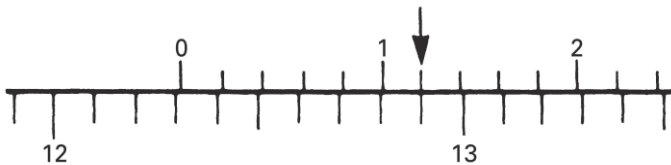


Fig. Q2 (b)

SELECTED ISO FITS—HOLE BASIS

		Clearance fits										Transition fits						Interference fits						Nominal sizes									
Over	Tolerance	H9		H9		H8		H7		g6		H7		h6		H7		k6		H7		n6		H7		p6		H7		s6		Over	Tb
		mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm	mm	0.001 mm		
3	+60 -120	+25 -60	+25 -60	+14 -14	+14 -14	+18 -18	+18 -18	+10 -10	+10 -10	-2 -2	-2 -2	+10 -10	+10 -10	+6 -6	+6 -6	+10 -10	+10 -10	+6 -6	+6 -6	+12 -12	+12 -12	+10 -10	+10 -10	+12 -12	+12 -12	+10 -10	+10 -10	+12 -12	+12 -12	+20 -20	+20 -20	3	3
6	+75 -145	+30 -78	+30 -78	+18 -18	+18 -18	+22 -22	+22 -22	+12 -12	+12 -12	-4 -4	-4 -4	+12 -12	+12 -12	+9 -9	+9 -9	+12 -12	+12 -12	+9 -9	+9 -9	+20 -20	+20 -20	+12 -12	+12 -12	+20 -20	+20 -20	+12 -12	+12 -12	+27 -27	+27 -27	+32 -32	+32 -32	6	6
10	+90 -200	+36 -84	+36 -84	+22 -22	+22 -22	+27 -27	+27 -27	+15 -15	+15 -15	-5 -5	-5 -5	+15 -15	+15 -15	+10 -10	+10 -10	+15 -15	+15 -15	+10 -10	+10 -10	+24 -24	+24 -24	+15 -15	+15 -15	+32 -32	+32 -32	+15 -15	+15 -15	+32 -32	+32 -32	+43 -43	+43 -43	10	10
18	+110 -240	+45 -93	+45 -93	+27 -27	+27 -27	+33 -33	+33 -33	+18 -18	+18 -18	-7 -7	-7 -7	+18 -18	+18 -18	+12 -12	+12 -12	+18 -18	+18 -18	+12 -12	+12 -12	+32 -32	+32 -32	+18 -18	+18 -18	+48 -48	+48 -48	+18 -18	+18 -18	+48 -48	+48 -48	+58 -58	+58 -58	18	18
30	+130 -280	+52 -100	+52 -100	+33 -33	+33 -33	+40 -40	+40 -40	+21 -21	+21 -21	-20 -20	-20 -20	+21 -21	+21 -21	+15 -15	+15 -15	+21 -21	+21 -21	+15 -15	+15 -15	+39 -39	+39 -39	+21 -21	+21 -21	+58 -58	+58 -58	+21 -21	+21 -21	+58 -58	+58 -58	+68 -68	+68 -68	30	30
40	+160 -330	+62 -120	+62 -120	+40 -40	+40 -40	+48 -48	+48 -48	+25 -25	+25 -25	-25 -25	-25 -25	+25 -25	+25 -25	+18 -18	+18 -18	+25 -25	+25 -25	+18 -18	+18 -18	+50 -50	+50 -50	+25 -25	+25 -25	+68 -68	+68 -68	+25 -25	+25 -25	+68 -68	+68 -68	+78 -78	+78 -78	40	40
50	+190 -380	+74 -150	+74 -150	+46 -46	+46 -46	+54 -54	+54 -54	+30 -30	+30 -30	-30 -30	-30 -30	+30 -30	+30 -30	+21 -21	+21 -21	+30 -30	+30 -30	+21 -21	+21 -21	+60 -60	+60 -60	+30 -30	+30 -30	+78 -78	+78 -78	+30 -30	+30 -30	+78 -78	+78 -78	+88 -88	+88 -88	50	50
65	+220 -450	+87 -180	+87 -180	+54 -54	+54 -54	+62 -62	+62 -62	+35 -35	+35 -35	-34 -34	-34 -34	+35 -35	+35 -35	+25 -25	+25 -25	+35 -35	+35 -35	+25 -25	+25 -25	+72 -72	+72 -72	+35 -35	+35 -35	+88 -88	+88 -88	+35 -35	+35 -35	+88 -88	+88 -88	+98 -98	+98 -98	65	65
80	+250 -500	+100 -200	+100 -200	+63 -63	+63 -63	+72 -72	+72 -72	+40 -40	+40 -40	-40 -40	-40 -40	+40 -40	+40 -40	+28 -28	+28 -28	+40 -40	+40 -40	+28 -28	+28 -28	+80 -80	+80 -80	+40 -40	+40 -40	+98 -98	+98 -98	+40 -40	+40 -40	+98 -98	+98 -98	+108 -108	+108 -108	80	80
100	+290 -550	+115 -230	+115 -230	+72 -72	+72 -72	+81 -81	+81 -81	+46 -46	+46 -46	-44 -44	-44 -44	+46 -46	+46 -46	+33 -33	+33 -33	+46 -46	+46 -46	+33 -33	+33 -33	+90 -90	+90 -90	+46 -46	+46 -46	+108 -108	+108 -108	+46 -46	+46 -46	+108 -108	+108 -108	+118 -118	+118 -118	100	100
120	+320 -600	+130 -260	+130 -260	+81 -81	+81 -81	+90 -90	+90 -90	+52 -52	+52 -52	-49 -49	-49 -49	+52 -52	+52 -52	+36 -36	+36 -36	+52 -52	+52 -52	+36 -36	+36 -36	+100 -100	+100 -100	+52 -52	+52 -52	+118 -118	+118 -118	+52 -52	+52 -52	+118 -118	+118 -118	+128 -128	+128 -128	120	120
140	+360 -650	+140 -280	+140 -280	+90 -90	+90 -90	+100 -100	+100 -100	+60 -60	+60 -60	-48 -48	-48 -48	+60 -60	+60 -60	+40 -40	+40 -40	+60 -60	+60 -60	+40 -40	+40 -40	+110 -110	+110 -110	+60 -60	+60 -60	+128 -128	+128 -128	+60 -60	+60 -60	+128 -128	+128 -128	+138 -138	+138 -138	140	140
160	+400 -700	+155 -310	+155 -310	+100 -100	+100 -100	+110 -110	+110 -110	+68 -68	+68 -68	-48 -48	-48 -48	+68 -68	+68 -68	+46 -46	+46 -46	+68 -68	+68 -68	+46 -46	+46 -46	+120 -120	+120 -120	+68 -68	+68 -68	+138 -138	+138 -138	+68 -68	+68 -68	+138 -138	+138 -138	+148 -148	+148 -148	160	160
180	+450 -780	+170 -340	+170 -340	+110 -110	+110 -110	+120 -120	+120 -120	+78 -78	+78 -78	-48 -48	-48 -48	+78 -78	+78 -78	+54 -54	+54 -54	+78 -78	+78 -78	+54 -54	+54 -54	+130 -130	+130 -130	+68 -68	+68 -68	+148 -148	+148 -148	+68 -68	+68 -68	+148 -148	+148 -148	+158 -158	+158 -158	180	180
200	+500 -850	+185 -370	+185 -370	+120 -120	+120 -120	+130 -130	+130 -130	+88 -88	+88 -88	-48 -48	-48 -48	+88 -88	+88 -88	+62 -62	+62 -62	+88 -88	+88 -88	+62 -62	+62 -62	+140 -140	+140 -140	+68 -68	+68 -68	+158 -158	+158 -158	+68 -68	+68 -68	+158 -158	+158 -158	+168 -168	+168 -168	200	200
225	+550 -950	+200 -400	+200 -400	+130 -130	+130 -130	+140 -140	+140 -140	+98 -98	+98 -98	-48 -48	-48 -48	+98 -98	+98 -98	+72 -72	+72 -72	+98 -98	+98 -98	+72 -72	+72 -72	+150 -150	+150 -150	+68 -68	+68 -68	+168 -168	+168 -168	+68 -68	+68 -68	+168 -168	+168 -168	+178 -178	+178 -178	225	225
250	+600 -1050	+220 -440	+220 -440	+140 -140	+140 -140	+150 -150	+150 -150	+108 -108	+108 -108	-48 -48	-48 -48	+108 -108	+108 -108	+81 -81	+81 -81	+108 -108	+108 -108	+81 -81	+81 -81	+160 -160	+160 -160	+68 -68	+68 -68	+178 -178	+178 -178	+68 -68	+68 -68	+178 -178	+178 -178	+188 -188	+188 -188	250	250
280	+650 -1150	+240 -480	+240 -480	+150 -150	+150 -150	+160 -160	+160 -160	+118 -118	+118 -118	-48 -48	-48 -48	+118 -118	+118 -118	+90 -90	+90 -90	+118 -118	+118 -118	+90 -90	+90 -90	+170 -170	+170 -170	+68 -68	+68 -68	+188 -188	+188 -188	+68 -68	+68 -68	+188 -188	+188 -188	+198 -198	+198 -198	280	280
315	+700 -1250	+260 -520	+260 -520	+160 -160	+160 -160	+170 -170	+170 -170	+128 -128	+128 -128	-48 -48	-48 -48	+128 -128	+128 -128	+100 -100	+100 -100	+128 -128	+128 -128	+100 -100	+100 -100	+180 -180	+180 -180	+68 -68	+68 -68	+198 -198	+198 -198	+68 -68	+68 -68	+198 -198	+198 -198	+208 -208	+208 -208	315	315
355	+750 -1350	+280 -560	+280 -560	+170 -170	+170 -170	+180 -180	+180 -180	+138 -138	+138 -138	-48 -48	-48 -48	+138 -138	+138 -138	+110 -110	+110 -110	+138 -138	+138 -138	+110 -110	+110 -110	+190 -190	+190 -190	+68 -68	+68 -68	+208 -208	+208 -208	+68 -68	+68 -68	+208 -208	+208 -208	+218 -218	+218 -218	355	355
400	+800 -1450	+300 -600	+300 -600	+180 -180	+180 -180	+190 -190	+190 -190	+148 -148	+148 -148	-48 -48	-48 -48	+148 -148	+148 -148	+120 -120	+120 -120	+148 -148	+148 -148	+120 -120	+120 -120	+200 -200	+200 -200	+68 -68	+68 -68	+218 -218	+218 -218	+68 -68	+68 -68	+218 -218	+218 -218	+228 -228	+228 -228	400	400
450	+850 -1550	+320 -640	+320 -640	+190 -190	+190 -190	+200 -200	+200 -200	+158 -158	+158 -158	-48 -48	-48 -48	+158 -158	+158 -158	+130 -130	+130 -130	+158 -158	+158 -158	+130 -130	+130 -130	+210 -210	+210 -210	+68 -68	+68 -68	+228 -228	+228 -228	+68 -68	+68 -68	+228 -228	+228 -228	+238 -238	+238 -238	450	450
500	+900 -1650	+340 -680	+340 -680	+200 -200	+200 -200	+210 -210	+210 -210	+168 -168	+168 -168	-48 -48	-48 -48	+168 -168	+168 -168	+140 -140	+140 -140	+168 -168	+168 -168	+140 -140	+140 -140	+220 -220	+220 -220	+68 -68	+68 -68	+238 -238	+238 -238	+68 -68	+68 -68	+238 -238	+238 -238	+248 -248	+248 -248	500	500