PM 2K601 METROLOGY & INSTRUMENTATION

Time: 180 minutes   Maximum marks: 100

Use of statistical tables is permitted.
Assume suitable data where required and state the same clearly.
Illustrate your answers with neat sketches, wherever applicable.
For numerical problems, define all variables in the equations and explain the logic behind each step
Answer all questions

1. a) Explain the necessity of carrying out an experiment in random order.
   b) Describe the response of a first order system to a sine function input.
   c) What do you mean by the uncertainty of a measurement? How can it be quantified?
   d) Describe the working of a successive approximation Digital to Analog converter.
   e) What is the working principle of an autocollimator?
   f) Describe the pneumatic displacement transducer and its characteristic curve.
   g) State the law of homogeneous materials, the law of intermediate materials, and the law of intermediate temperatures.
   h) Make a neat sketch of a Bridge type CMM and name the important parts.

   (8 X 5 = 40 marks)

2.
   a) A thermometer was calibrated using a platinum resistance thermometer bath with the following results:

Increasing input:	100	200	300	400	500	(^{o}C)
Thermometer reading:	101	199	302	401	498	
Decreasing input:	500	400	300	200	100	(^{o}C)
Thermometer reading:	498	399	298	198	100	

   Specify the percent maximum hysteresis error based on full scale reading.
   b) Distinguish between analog, discrete time and digital signals.
   c) The temperature in a room varies from 10°C at 00:00hrs to 30°C at 12:00hrs and back to 10°C at 00:00hrs cyclically. Express the temperature in the form of a Fourier series.

   (3 X 5 = 15 marks)

   ## OR

   d) A weight measurement system has the following specification: Range 0-100N, Linearity error 0.2% FSO, Hysteresis error 0.1% FSO, Zero drift 0.1% FSO. Estimate the overall instrument error.
   e) The displacement of a drill (in microns) due to vibration is represented by the equation $s = 10\sin 2\pi t + 0.2\cos 50\pi t$ where t is time in seconds. Determine the fundamental frequency in Hz and fundamental period in seconds.
   f) A thermometer is known to have a time constant of 10s. Plot its time response to a step change from 30°C to 100°C.

   (3 X 5 = 15 marks)

3.
   a) Determine the static sensitivity for the following data by using a least squares regression analysis. Do not use the regression program available in calculator. Show the intermediate calculations clearly.

Input x	5.4	7.2	8.8	10.4	18.4
Output y	0.8	2.2	3.8	6.0	10.0

   b) A micrometer has graduations scribed at 0.01mm intervals. Estimate the uncertainty that is due to resolution, at a 95% probability.
   c) The time dependent vibration of an aircraft wing has a maximum frequency content of 200Hz. What would be an appropriate sampling rate to monitor this vibration? Explain why.

   (3 X 5 = 15 marks)

   ## OR

   d) The voltage output of a UPS was measured at different times with the following results: 220, 229, 231, 225, 224, 232, 219, 221, 222. Determine a 95% uncertainty interval for the voltage output.
   e) From 10 measurements of a parameter, the sample standard deviation is found to be 6 units. For a 95% precision interval of +/-6 units in the mean value, estimate the total number of measurements required.

f) The contents of a 4 bit register is the binary word 1001. Convert this to its decimal equivalent, assuming a straight binary code.

(3 X 5 = 15 marks)

4.

a) What is the meaning of the following symbol on a drawing? Explain how will you determine whether a component conforms to this specification?

b) A set of angle gauges contain the sizes 1°, 3°, 9°, 27°, 41°, 1', 3', 9', 27', 3", 6", 18"& 30". Choose a combination of gauges to set up an angle of $19^\circ15'24"$.

c) The profile tracing of a turned surface is shown below. The sampling length (L) used was
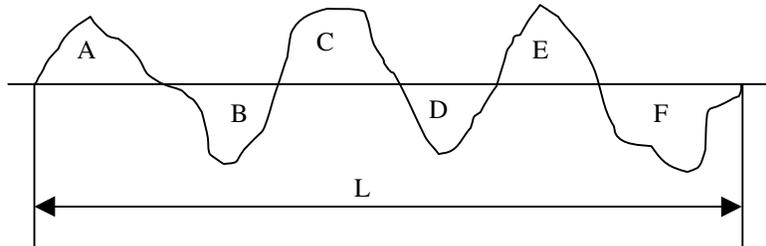
0.8mm, the vertical magnification 4000, and horizontal magnification 120. Determine the value of Ra, if the areas in mm^2 above and below the mean line are as follows:

A	B	C	D	E	F
21	43	37	49	26	13

(3 X 5 = 15 marks)

OR

d) The diameter of an ISO Metric Thread of pitch 5mm measured over three wires of size 3.1mm was found to be 101.48mm. Calculate the effective diameter of the thread.

e) Design a GO plug gauge to check a 75mm thick bush of inner diameter 50+0.056mm, conforming fully to Taylor's principles. No wear allowance is required.

f) Three points were touched on a circular object perpendicular to its axis, using a CMM. The coordinates were (75.315, 61.131), (21.318, 89.240) and (12.899, -6.985). Determine the diameter of the object.

(3 X 5 = 15 marks)

5)

a) Explain the construction and working of a Platinum RTD.

b) What is a deadweight tester? Explain.

c) Sketch an arrangement of two strain gauges on a beam subject to bending, so that temperature compensation is provided.

(3 X 5 = 15 marks)

OR

d) Explain methods for Radiative Temperature measurement.

e) Describe the principle and working of a micromanometer.

f) How can the rotational speed of an object measured using a stroboscope?

(3 X 5 = 15 marks)