METROLOGY AND INSTRUMENTATION

Time: 180 minutes Max marks:100

Use of Statistical Tables and Formulae for Uncertainties in Regression and Calibration are permitted. All questions carry 5 marks each, except where mentioned otherwise.

1. A manufacturer claims that the new model of his car gave a better mileage compared to those of other manufacturers. Explain how will you plan an experiment to test this claim, as per the sequence outlined by Montgomery.

2. Three thermometers having least counts of 0.01^{o}C are each compared with a master Platinum Resistance thermometer at four different temperatures and the following data was obtained:

Master temperature ^{o}C	30.000	40.000	50.000	60.000
Thermometer A	30.02	40.04	50.02	60.04
Thermometer B	30.05	39.95	50.05	59.95
Thermometer C	30.10	40.10	50.11	60.11

Identify the most precise, least precise, most accurate and least accurate thermometers. Justify your choices.

3. Explain how the basis of the length standard evolved in the SI system.

4. The displacement of the wing tip during wind tunnel testing of a model aeroplane gave the following results during one cycle of period 2s:

Time (s)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Displacement (mm)	0.87	2.71	2.71	0.87	-1.00	-1.48	-1.09	-1.09	-1.48	-1.00

Express the displacement as a function of time using a Fourier series.

(10 marks)

5. A mercury bulb thermometer has a bulb diameter of 12mm. If the specific heat of mercury is 800J/kgK and the heat transfer coefficient when the bulb is inserted into still water is estimated as 0.001J/m^{2}sK, calculate the time constant of the thermometer. Make suitable assumptions.

6. Sketch how the magnitude ratio and phase shift vary for a second order system subjected to a sinusoidal input of various frequencies and damping ratios.

7. The weight and systolic blood pressure for 5 individuals was obtained as follows:

Weight (kg)	65	70	76	82	86
BP (mm of Hg)	124	128	133	150	151

Assuming a linear relationship, predict the BP of an individual of weight 80kg and the associated uncertainty.

(10 marks)

8. The average diameter of a shaft was found to be 25.43mm with a standard deviation of 0.02mm, when eight measurements were taken using a digital vernier with a least count of 0.01mm. Determine the combined standard uncertainty (95%) due to the variation within the shaft and instrument resolution, neglecting other sources of uncertainty.

9. A thin wire is subjected to a tensile load of 100+/-2N(95%). The wire diameter was 1.00+/-0.02mm(95%). Determine the principal tensile stress in the wire and its expanded uncertainty.

10. During digital sampling of an unknown signal, how do you decide the frequency resolution?

11. What are the three types of common errors possible in an A/D Converter? Explain.

12. A slip gauge of nominal length 6mm was checked using an NPL-type absolute length interferometer and the following results obtained:

Colour	Red	Green	Blue	Violet
Radiation wavelength μm	0.6438	0.5086	0.4800	0.4678
Observed fraction	0.96	0.71	0.50	0.47

Determine the actual length of the gauge.

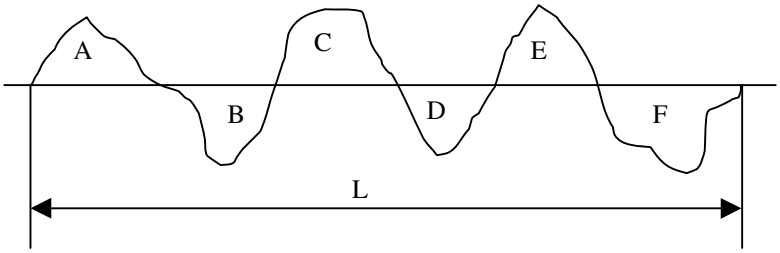
(10 marks)

13. The diameter of an aluminium engine cylinder bore was measured on the shop floor by comparing with a steel slip gauge combination as 58.542mm. The ambient temperature was 35^{o}C. Estimate the true diameter of the cylinder bore, if the coefficients of expansion of steel and aluminium are 11 and 24 X10^{-6}/^{o}C respectively.

14. Select a suitable combination of slip gauges to set up a dimension of 37.535mm from the following M88/2 set:

Size (mm)	1.005	2.001~2.009	2.01~2.49	0.5~9.5	10~100
Increment (mm)	-	0.001	0.01	0.5	10
No of pieces	1	9	49	19	10

15. 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
24	38	65	59	42	19

16. 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.

17. Design GO and NO GO gauges to check the ID of the following component, conforming fully to Taylor's principles. Provide a wear allowance. 60H8 = 60+0.0042mm.