Master of Mechanical/Nuclear Engineering - First Year - Semester 2025

SUBJECT: Experimental Methods in Thermofluid System

Time: Three hours Full Marks 100

USE SEPARATE ANSWER SCRIPTS FOR PART-I and PART-II

All parts of a question must be answered together and in sequence. If any required data is not provided, you may make reasonable assumptions and clearly state them.

PART-I

[Question No. 1 is compulsory. Attempt any two questions from Questions 2, 3, and 4]

1. Answer **any two** from (a), (b) and (c) for Q1

(a) Describe the Seebeck effect as used in thermocouples. Why must reference junction compensation (cold junction compensation) be applied in practical thermocouple measurements? 5

(b) Differentiate between a Constant Current Anemometer (CCA) and a Constant Temperature Anemometer (CTA) with respect to: (i) Method of operation (ii) Measurement response time 5

(c) Describe how 3-wire and 4-wire configurations are used to correct or eliminate the effect of lead wire resistance. Support your answer with simple circuit diagrams and explanation 5

2 (a) For an underdamped second order system explain with a sketch the meaning of the terms – rise time, peak time, 2% settling time, maximum percentage overshoot. 6

(b) What will be (i) the undamped natural frequency, (ii) the damping ratio, (iii) the damped natural frequency, (iv) the maximum percentage overshoot and (v) the 2% settling time for a measurement system that is represented by the following equation

$4d^2q_o/dt^2 + 8dq_o/dt + 16q_o = 16q_i$

A first-order linear time-invariant system is described by the differential equation:

$$\tau\frac{dy(t)}{dt} + y(t) = Kx(t)$$

where τ is the time constant and K is the system gain. 14

3 (a) If the input to the system is a sinusoidal signal $x(t) = Asin\ (\omega t)$ derive the expression for the steady-state output response $y(t)$ 14

(b) From the response obtained, derive expressions for the amplitude ratio (AR) and phase lag (ϕ) of the system. 6

4 (a) Derive the differential equation relating the input pressure difference $\Delta p(t)$ and the output displacement $h(t)$ of the mercury column.

Assume: The manometric fluid is incompressible and the motion is resisted by viscous damping, 14

(b) Derive the transfer function of the manometer system in the Laplace domain 6

PART-II

[Attempt any two questions from Questions 5, 6, and 7]

5 (a) Explain the functional components of a measuring instrument with suitable example. 10

(b) Find the uncertainty in measurement of *Fr;*

$Fr = u/\sqrt{(gh)}$

u is measured 10 times [in m/s] as 20.2, 21.0, 20.7, 20.5, 20.8, 20.0, 20.8, 20.9, 20.0, 21.0

g is measured 5 times [in m/s^2] as 9.81, 9.80, 9.81, 9.80, 9.81

h is measures 12 time [in mm] as 1000, 1011, 1010, 1019, 1022, 1021, 1011, 1018, 1012, 1010, 1009, 1008. 15

6 (a) Comment on the relative advantages and disadvantages between null and defection methods of measurement. Cite suitable examples against your comments. 6

(b) Explain the suitability of Gimbal suspension. 5

(c) The discharge co-efficient (C_q) of an orifice can be found by collecting the water that flows through during a timed interval when it is under a constant head, h. The formula is,

$$C_q = W/t\rho A\sqrt{(2gh)}$$

Find the error in measurement of C_q if the following data are given:

$W = 900 \pm 1$ kg

$A = \pi r^2$, $r = 0.5 \pm 1\%$ mm

$t = 600 \pm 2$ sec

$g = 9.81 \pm 0.5\%$ m/sec^2

$\rho = 997 \pm 0.25\%$ kg/m^3

$h = 6 \pm 0.1$ m

If C_q must be measured within $\pm 0.5\%$ of the numerical mean values given, what errors are allowable n the measured data? 14

7 (a) Consider a man driving a car along a road. He sees the opportunity to pass and decides to accelerate.

If the light waves entering his eyes are considered input and accelerator-pedal travel as output, is the man functioning as an active or passive transducer? Explain.

If accelerator-pedal travel is considered input and car velocity as output, is the car engine functioning as an active or passive transducer? Explain. 6

(b) Write short Notes on: i. Threshold and Resolution, ii. Static Sensitivity and Linearity, iii. Hysteresis 4x3

(c) What do you mean by signal filtering? Give suitable example of input and output filtering for elimination of spurious inputs to an instrument. 7