

**Third Class Test for Industrial Instrumentation (EE60031/EE41001)**

**Date:** November 16, 2021

**Time:** 08:00AM – 09:30AM

**Full Marks:** 90

**Answer ALL questions. Make the assumptions you need and state them. You may consult any source of reference except your classmates during the test.**

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1. Answer the following with justification.
  - (a) Can Electromagnetic Flow Meters be used for:
    - i. Measurement of mass flow rate? [5]
    - ii. Measurement of volume flow rate of edible oil or other organic solvents? [5]
  - (b) When is a Venturi tube preferable to an orifice plate? [5]
  - (c) Explain why, for a hotwire anemometers, a constant temperature mode is often preferred over a constant current mode. [5]
2. Draw a block diagram representation of a turbine flow meter and describe the primary/secondary sensing, signal conditioning and signal processing blocks. Identify possible interfering and modifying inputs. [10+5]
3. An ultrasonic Doppler flowmeter is to be used to measure the volume flow rate of a slurry in a steel pipe of diameter 0.2 m. Two piezoelectric crystals, each having a natural frequency of 1 MHz, are positioned, a few millimetres apart, on the outside of the pipe to form an ultrasonic transmission link. The transmitting crystal directs an ultrasonic beam into the pipe so that the beam is moving in an opposite direction to the flow stream. The angle between the ultrasonic beam and the direction of flow is  $60^\circ$ . On average 10% of the ultrasonic power reaching each solid particle is scattered back in the direction of the receiving crystal. Assume that the slurry has the same density as water, sound velocity of 1.5 km/s and a power attenuation coefficient of 1.0/m.
  - (a) Find the difference between the frequencies of the transmitted and received beams when the flow rate is  $1130 \text{ m}^3/\text{h}$ . [10]
  - (b) Estimate the ultrasonic power incident on the receiving crystal for each watt of ultrasonic power leaving the transmitting crystal. State any assumptions made in your calculation. [10+5]
4. An orifice plate is to be used in conjunction with a differential pressure transmitter to measure the flow rate of water in a 0.15 m diameter pipe. The maximum flow rate is  $50 \text{ m}^3/\text{h}$ , the density of water is  $10^3 \text{ kg/m}^3$  and the viscosity is  $10^{-3} \text{ Pa s}$ .
  - (a) Explain why an orifice plate meter is suitable for this application. State your assumptions. [10]
  - (b) Estimate the required orifice plate hole diameter if the transmitter has an input range of 0 to  $1.25 \times 10^4 \text{ Pa}$ . Assume the value of the coefficient of discharge to be 0.6. [20]

*End of Question Paper*