Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS

III SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER MAKE-UP EXAMINATIONS, APRIL 2022

SUBJECT: SENSORS AND INSTRUMENTATION [MTE 2155]

31.01.2022

Time: 75min +10 min **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data (if any) can be suitably assumed and justified.

Q. No		M	CO	PO	LO	BL
1A.	Write a ladder logic program that will turn ON light when a count reaches 20. The light has to go OFF when the count 30 is reached.	**5**	**2**	**3**	**5**	**6**
1B.	In wastewater industry, real-time sensing of surface temperature variations on concrete sewer pipes is paramount in assessing the rate of microbial-induced corrosion. However, the sensing systems are prone to failures due to the aggressively corrosive environmental conditions inside sewer assets. Thus, the customer needed to be supplied with full material, process control, testing, and safety documentation. Mention the steps to guide the customer to avoid such sensor failure risks.	**3**	**3**	**6**	**18**	**3**
1C.	Strain gauges are used for making cantilever type load cells as shown in Fig.Q1c. Demonstrate a configuration in which the strain gauges should be placed on the cantilever for maximum sensitivity: elucidate the number of strain gauges to be used for each measurement, the placement/ arrangement of the sensors and the electrical connections for measurement of resistance change.  Fig. Q1C	**2**	**3**	**2**	**2**	**4**
2A	Factories now routinely use cages and guards to avoid unwanted interaction between humans and fixed robots, however as the Health and Safety Executive (HSE) has observed, new collaborative robots are being developed that are designed to be used in the same workspace as humans. Research conducted in Sweden and Japan has indicated that a large number of robotic incidents do not occur during normal operating conditions, but actually either	**4**	**5**	**6**	**9**	**4**

	during programming, maintenance, or adjustments. Mention the three major steps which are involved in such a safety risk assessment procedure and give an example of a risk assessment matrix that could be utilized to quantitively measure the level of risk.					
2B	Draw the flowchart of the seven layers of OSI model.	**4**	**4**	**2**	**2**	**1**
2C	State and explain the working of any differential pressure type flowmeter.	**2**	**3**	**1**	**1**	**2**
3A	Construct a ladder logic diagram that will implement the following function: $X = \ln [10 + A(B \cos^{-1} (4C+5))^{2}]$ If the result is greater than 100, then an output light 'P' will be turned ON. A, B and C are inputs.	**5**	**2**	**3**	**5**	**3**
3B	Fig. Q3B shows the hierarchy of an Industrial Automation & Control System plant which consists of five levels. Identify the levels for each of the following: i. SCARA Robot ii. Relays iii. Programmable Logic Controller	**3**	**4**	**1**	**1**	**2**

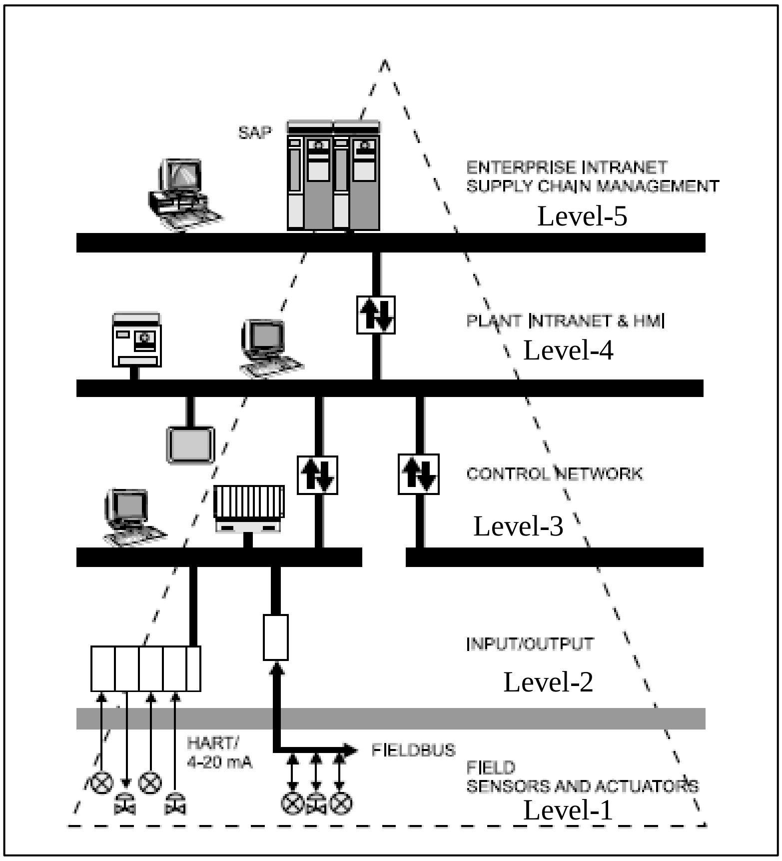

Fig. Q3B

3C	What is the sensitivity of a J-type thermocouple with a temperature range of -100 to +1450°C and an output range of 0 to 20 V?	**2**	**3**	**1**	**1**	**3**
4A	Strain gauges are bonded to a Duralumin cantilever and connected into a bridge circuit for maximum sensitivity. Each gauge has a resistance of 100 Ω and a gauge factor of 2.1. The input voltage is 4 V. The stress is 200 MN/m^2 and the modulus or elasticity for Duralumin is 70 GN/m^2.	**5**	**3**	**1**	**1**	**3**

i. Calculate the output voltage of the bridge if two strain gauges are used for stress measurement (Fig. 4A1). Consider the use of 100 Ω of fixed resistances.

ii. Calculate the output voltage of the bridge if four strain gauges are used for measurement of stress (Fig. 4A2)

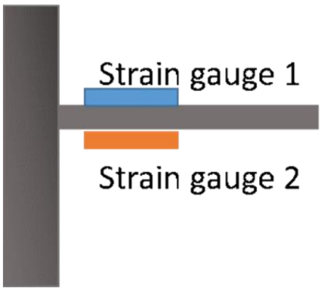

Fig. 4A1

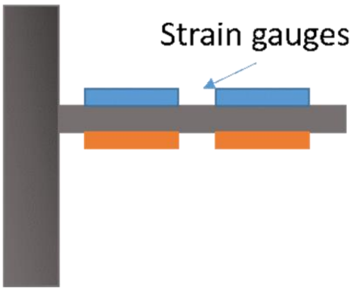

Fig. 4A2

4B	For a piezoelectric crystal of dimension 5mm x 5mm x 5mm and voltage sensitivity 50 x 10^{-3} Vm/N, what is voltage generated for a pressure of 60N?	**3**	**3**	**1**	**1**	**3**
4C	Select suitable sensors for the following applications: i. Non-contact measurement of temperature of a furnace with temperature reaching 2000°C. ii. Measure speed of a wheeled mobile robot developed mainly for indoor applications iii. Measure the force applied by a robotic hand to pick an object iv. Measurement of high frequency vibrations	**2**	**3**	**1**	**2**	**4**
5A	Refer the datasheet of Platinum RTD sensor as attached. Considering linear approximation of the RTD resistance-temperature characteristics, calculate the resistance of the sensor at 25 degree C.	**4**	**3**	**1**	**1**	**3**

Temperature Sensors
Platinum RTDs

FUNCTIONAL BEHAVIOR

$R_T = R_0(1+AT+BT^2-100CT^3+CT^4)$

RT = Resistance (Ω) at temperature T (°C)

R_0 = Resistance (Ω) at 0°C

T = Temperature in °C

$A = \alpha + \frac{\alpha\delta}{100}$ $\quad B = \frac{-\alpha\delta}{100^2}$ $\quad C_{T<0} = \frac{-\alpha\beta}{100^4}$

CONSTANTS

Alpha, α (°C^{-1})	0.00375 ±0.000029	0.003850 ±0.000010
Delta, δ (°C)	1.605 ± 0.009	1.4999 ± 0.007
Beta, β (°C)	0.16	0.10863
A (°C^{-1})	3.81×10^{-3}	3.908×10^{-3}
B (°C^{-2})	-6.02×10^{-7}	-5.775×10^{-7}
C (°C^{-4})	-6.0×10^{-12}	-4.183×10^{-12}

Both β = 0 and C = 0 for T>0°C

SPECIFICATIONS

Sensor Type	Thin film platinum RTD; R_0 = 1000 Ω @ 0°C; alpha = 0.00375 Ω/Ω/°C R_0 = 100 Ω @ 0°C; alpha = 0.00385 Ω/Ω/°C
Temperature Range	TFE Teflon: −200° to +260°C (−320° to +500°F) Fiberglass: −75° to +540°C (−100° to +1000°F)
Temperature Accuracy	±0.5°C or 0.8% of temperature, °C (R_0 ±0.2% trim), whichever is greater ±0.3°C or 0.6% of temperature, °C (R_0 ±0.1% trim), whichever is greater (optional)
Base Resistance and Interchangeability, $R_0 \pm \Delta R_0$	1000 ± 2 Ω (±0.2%) @ 0°C 1000 ± 1 Ω (±0.1%) @ 0°C (optional)

5B	State and explain three thermoelectric laws governing the principle of operation of thermocouples.	**3**	**3**	**1**	**1**	**2**
5C	With neat diagrams, explain the construction, working and application of LVDT.	**3**	**3**	**1**	**1**	**2**