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**PRESIDENCY UNIVERSITY**

**Bengaluru**

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| **End - Term Examinations – JANUARY 2025** |
| Date: 07 – 01- 2025 Time: 09:30 am – 12:30 pm |

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| **School:** SOE | **Program:** B. Tech-ECE | |
| **Course Code:** ECE3045 | **Course Name:** Sensor Technologies | |
| **Semester:** VII | **Max Marks:** 100 | **Weightage:** 50% |

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| **CO - Levels** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| **Marks** | **21** | **21** | **21** | **37** |  |

**Instructions:**

1. *Read all questions carefully and answer accordingly.*
2. *Do not write anything on the question paper other than roll number.*

**Part A**

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| **Answer ALL the Questions. Each question carries 2marks. 10Q x 2M=20M** | | | | |
| **1** | List the differences between absolute sensor and relative sensor with an example for each | **2 Marks** | **L1** | **CO1** |
| **2** | With a neat figure, describe delay time and rise time | **2 Marks** | **L1** | **CO1** |
| **3** | Define long-term stability | **2 Marks** | **L1** | **CO1** |
| **4** | Label the material parameter(s) and geometric parameter(s) that can be varied in a potentiometric sensor and capacitive sensor | **2 Marks** | **L1** | **CO2** |
| **5** | Define Stefan-Boltzmann law | **2 Marks** | **L1** | **CO2** |
| **6** | Write the fundamental property of magnetism in inductive sensor | **2 Marks** | **L1** | **CO2** |
| **7** | Write the current – voltage relationship for the photodiode | **2 Marks** | **L1** | **CO3** |
| **8** | Identify the disadvantages of piezoelectric pressure sensor over the piezoresistive pressure sensor | **2 Marks** | **L1** | **CO3** |
| **9** | Describe the two types of configurations of an Eddy current based proximity sensor | **2 Marks** | **L1** | **CO3** |
| **10** | Outline the various communication protocols that are used to transfer data from the sensor to the data acquisition system | **2 Marks** | **L1** | **CO4** |

**Part B**

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| **Answer the Questions Total 80 Marks.** | | | | | |
| **11** | **a.** | Fiat automobiles produced engines for automobiles and wanted to test the reliability of the engines. The study resulted in a bath-tub shaped curve between the number of failures and reliability. Interpret the various regions and the reason behind the failure | **05 Marks** | **L3** | **CO1** |
| **b.** | A displacement sensor was put to test, and obtained an output voltage of 1.125V when the displacement was 1mm. After moving the object, the output voltage was at 2V when the displacement was 8mm. Examine the sensor, and determine the transfer function. Also, interpret if the sensor has any offset and saturation if the full-scale input is 7dB when the cut-off is 0.9mm. | **10 Marks** | **L3** | **CO1** |
| **or** | | | | | |
| **12.** | **a.** | Environment plays a vital role in developing a sensor as the sensor’s performance largely depends on the environment it is used in. Review the environmental factors that might affect the sensor in detailed. | **05 Marks** | **L3** | **CO1** |
| **b** | An optical sensor was calibrated and a non-linear quadratic transfer function was obtained. The transfer function is I=0.5L2+3L where I is the output current and L is the illumination in lux. Compute the non-linearity error at an illumination of 25lux. | **10 Marks** | **L3** | **CO1** |
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| **13.** | **a** | Proximity sensors are used to determine whether an object is present in the vicinity of the sensor. Several techniques are used to detect the object. Discuss the construction and the role of each element in an inductive transducer | **5 Marks** | **L2** | **CO2** |
| **b** | An oxidation furnace used to grow silicon dioxide on a silicon substrate can be heated to 900°C. Due to this heat, the temperature cannot be measured using direct contact.  (i) Write the energy transfer method the energy is transferred from the furnace to the sensor  (ii) Identify a sensor that can be used for this application and discuss its working principle. | **10 Marks** | **L2** | **CO2** |
| **Or** | | | | | |
| **14.** | **a** | A team of students are developing a piezoelectric based pressure transducer as a part of a hackathon. The piezo-crystal used is quartz with dimensions 2mm × 2mm × 1mm. An external force of 3.34N is applied, and an output voltage was measured. Given the charge density of Quartz is 2 pC/N and its relative permittivity is 3.8, compute the voltage that was obtained. | **5 Marks** | **L2** | **CO2** |
| **b** | To characterize a biological specimen, a transmission and an absorption spectrum needs to be studied. For this, a light dependent resistor is used. Discuss the working of the LDR highlighting its characteristics with diagrams wherever necessary. | **10 Marks** | **L2** | **CO2** |

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| **15.** | **a** | A laboratory uses an ice bath to maintain the cold junction of the thermocouple at 0°C for accurate temperature measurements. However, the experiment requires long duration monitoring, and over time, the temperature of the ice bath rises slightly. Describe the principle of the ice bath method and why is maintaining 0°C critical. | **5 Marks** | **L2** | **CO3** |
| **b** | The usage of ice bath for a longer duration will cause the temperature of the bath to increase slightly. What will happen to the accuracy of the measurement if temperature increases. Discuss two methods to maintain the ice bath at 0°C consistently. | **10 Marks** | **L2** | **CO3** |
| **Or** | | | | | |
| **16.** | **a** | A scientist is designing a pressure sensor using the direct piezoelectric effect. Explain the working of direct piezoelectric effect in this application | **5 Marks** | **L2** | **CO3** |
| **b** | The piezoelectric sensor will be deployed in a high-vibration industrial environment to monitor mechanical stresses on a structure. Discuss two challenges the scientist might face due to the vibrations and suggest methods to mitigate these challenges for accurate pressure measurement. | **10 Marks** | **L2** | **CO3** |

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| **17.** |  | Bosch Industries developed accelerometers and a group of internship students were assigned to test them under different circumstances. They noticed variations in performance with varying environment (especially between plains and hill-stations). The students were asked to look into this issue. Interpret the reason for this performance variation and describe the methods to compensate for this variation with neat circuits. | **15 Marks** | **L2** | **CO4** |
| **Or** | | | | | |
| **18.** |  | A system to interface the sensor and the data acquisition unit is developed by Global Industries. The sensor is placed on one of the arms in a Wheatstone bridge. The other two arms have 500Ω resistors each and the third arm has a potentiostat. If the range of the potentiostat is between 250Ω and 1.2kΩ infer the range of the sensor. The output from the Wheatstone bridge is provided to a balanced differential amplifier. The input resistance of the amplifier is 12kΩ and the feedback resistance is 60kΩ. Assuming, there is a 1% variation in one of the resistors due to temperature, estimate the change in gain of the differential amplifier | **15 Marks** | **L2** | **CO4** |

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| **19.** | **a.** | Dr. Reddy developed a sensor that could produce a signal of only 0.2mV. To amplify this signal, a suitable amplifier is to be designed. An input resistor of 12kΩ and a feedback resistor of 60kΩ is used. Estimate the output voltage produced by the inverting, non-inverting and unity-gain amplifiers, and compare them. | **10 Marks** | **L3** | **CO4** |
| **b.** | The output signal provided by the biopotential electrodes of an electrocardiograph is in the range of a few μV. Some interference noise gets added to the signal reducing the signal-to-noise ratio. To counter the noise, applying your knowledge, construct a suitable amplifier using three operational amplifiers to achieve a common mode rejection ratio of 80dB. | **10 Marks** | **L3** | **CO4** |
| **Or** | | | | | |
| **20.** | **a.** | A three-OpAmp Instrumentation Amplifier is used to amplify the signal obtained from the flow sensor. The IA is designed in such a way that the first stage (non-inverting amplifier pair) has a gain of 10 and the total gain of the amplifier is 15. The following resistors are provided: 22kΩ, 10kΩ, 15kΩ and 45kΩ. Show the instrumentation amplifier circuit. Also, if the differential input is 25mV DC, calculate the output voltage. | **10 Marks** | **L3** | **CO4** |
| **b.** | An industrial pressure sensor provides an output signal between 10μV and 50μV having a frequency of greater than 40Hz. While transmitting the output signal, noise will be added to the signal. Noise is any signal that has a frequency lesser than 40Hz, and the supply frequency of 60Hz. Applying your knowledge, construct suitable filters that removes all the noise. | **10 Marks** | **L3** | **CO4** |

**\*\*\*\*\* BEST WISHES \*\*\*\*\***