VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Slot: B2

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING (SCOPE)

CAT-II Examination Winter Semester 2024-2025

Programme and Branch: B.Tech – CSE

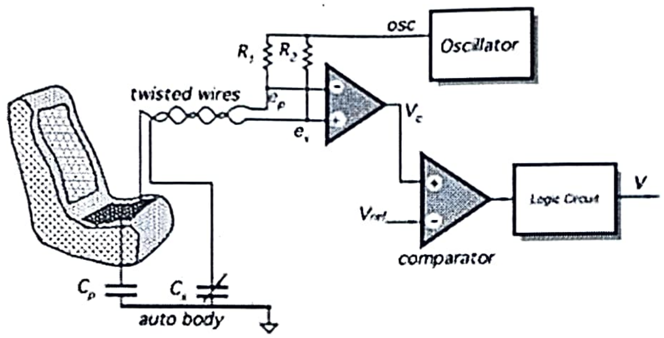
Course Code: BCSE311L

Course Title: Sensors and Actuator Devices **Duration: 90 minutes**

Class Numbers: 1972/ 1976 **Total Marks: 50**

S. No	Answer All Questions	Marks	CO	BL
1	A vaccine research laboratory is developing a high-sensitive optical detection system for low-light imaging applications using photomultiplier tubes (PMTs). The device operates on the principle of the photoelectric effect and enhances detection by increasing the number of released electrons. During testing, the following specifications were used: ✓ A UV light source with a wavelength of $\lambda = 250$ nm was used to illuminate the photocathode, which has a work function of 2.5 eV. ✓ The photomultiplier tube consists of five dynodes, each with an electron multiplication factor of $n_1 = 4$. ➢ **Calculate** the energy of the incident UV photons and determine whether the given light source is capable of ejecting electrons from the photocathode. ➢ **Evaluate** and validate the significance of the statement "***The final output current was observed to be ten times higher than the initial photoelectron count***"	10	CO2	3
2	**Elucidate** why a passive IR sensor is not an optimal solution for pedestrian detection. A self-driving car uses Active Infrared (AFIR) sensors for pedestrian detection in low-visibility conditions. On a foggy winter night, the system fails to detect a pedestrian, triggering a safety issue. Various parameters in the following table depict the given scenario:- (see table below) As per the scenario described, answer the following questions:- ➢ **Analyze** why the AFIR sensor failed to detect the pedestrian in foggy conditions and justify your answers ➢ **Compute** the received power at the detector after 30m travel under foggy condition. ➢ **Assess** the impact of streetlight IR interference on pedestrian detection by computing the pre-filtered and post-filtered Signal-to-Noise Ratio (SNR). ➢ **Verify** the improvement in received power if the system shifts from 950 nm to 10 μm (Long wave IR) in the same conditions. ➢ **Propose** an optimized sensor layout to improve the detection accuracy while minimizing additional power consumption with sufficient justifications	15	CO2	3

Parameter	Value
AFIR Sensor Wavelength, λ	950 nm
Transmitter Power, P_t	100 mW (0.1 W)
Path Distance, d	30 m (round trip)
Detection Threshold, P_{thresh}	10 mW
Fog Attenuation, α	3 dB/m
Streetlight IR Noise	20 mW
Polarization Filter Effectiveness	90% noise reduction
Long Wave IR (Alternative Wavelength), λ'	10 μm
Long Wave IR Attenuation, α'	0.1 dB/m

3	**Investigate** the operation of a magnetometer using the following parameters:- ✓ Principles of operation ✓ Output voltage ✓ Sensitivity	10	CO3	2
4	An automotive company is developing a capacitive seat occupancy detection system for vehicles, as illustrated in the given diagram:-  In this system, a metal plate under the seat cushion, acts as one plate of a capacitor, while the vehicle body serves as the ground. When the seat is unoccupied, the baseline capacitance (C_p) is 50 pF. However, when a person enters the vehicle, their body introduces additional capacitances: ✓ Capacitance between the seat plate and the body (C_a) = 100 pF ✓ Capacitance between the body and the vehicle ground (C_b) = 150 pF With respect to the given scenario, provide answers to the following questions:- ➢ **Calculate** the total capacitance (C) of the system when an occupant is present. ➢ **Analyze** how the oscillator and comparator circuit in the diagram detects changes in capacitance and determines occupancy. ➢ **Find out** if the system can accurately detect a person's presence when the detection threshold is set at 100 pF by performing the necessary calculations. ➢ **Suggest** a modification to improve the sensitivity of the capacitive detection system for automotive applications. ➢ **Discover** any two applications for this capacitive seat occupancy detection system and analyze how it can be integrated with emerging vehicle technologies, such as AI-driven autonomous systems and IoT-based smart transportation networks, to enhance its effectiveness.	15	CO3	4

****Standard Units, $h = 1.602 \times 10^{-19}$ J.s and Speed of Light, $C = 3 \times 10^{8}$ m/s***