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UNIVERSITY EXAMINATIONS 2023/2024

FOURTH YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE PHYSICS

SPH 3456: INSTRUMENTATION AND ELECTRONIC DEVICES

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) With the aid of a block diagram describe the working principle of the following sensor modules.

i. resistive soil moisture sensor (5 Marks)

ii. Ultrasonic proximity sensor (5 Marks)

iii. Photo gate module (5 Marks)

b) The following results were obtained when a pressure transducer was tested in a laboratory under the following conditions:

i. Ambient temperature 20 o c, supply voltage 10 V (standard)

ii. Ambient temperature 20 0C, supply voltage 12 V

iii. Ambient temperature 25 o c, supply voltage 10 V

Input (barg)	0	2	4	6	8	10
Output (mA)						
I	4	7.2	10.4	13.6	16.8	20
II	4	8.4	12.8	17.2	21.6	28
III	6	9.2	12.4	15.6	18.8	22

i. Determine the values of K_M, K_I α and K associated with the generalized model equation (12 Marks)

$O = (K + K_M I_M)I + a + K_1 I_1$

ii. Predict an output value when the input is 5 bags, VS = 12 V and ambient temperature is 25^0C. (3 Marks)

QUESTION TWO (20 MARKS)

Explain the construction and the working principle of the following sensor systems

a) Ion selective sensor (5 Marks)
b) Water flow rate sensor (5 Marks)
c) thermistor (5 Marks)
d) optical image sensor (5 Marks)

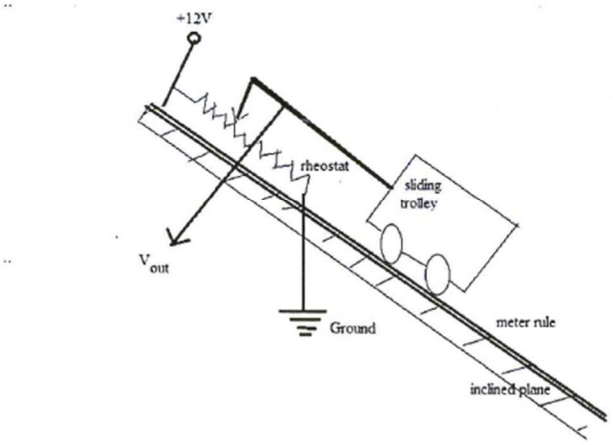
QUESTION THREE (20 MARKS)

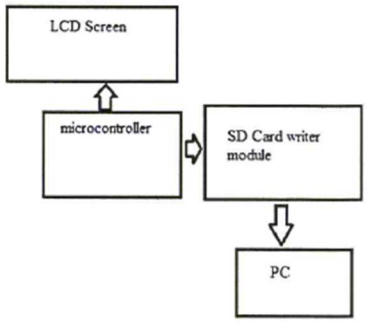
i. Draw the schematic symbol of an op amp (2 Marks)
ii. Draw an equivalent diagram of an op amp circuit (2 Marks)
iii. With the aid of a schematic diagram show how an op amp can be used as a non-inverting voltage pre-amplifier. (3 Marks)
iv. State two advantages of non-inverting configuration ornp amp circuit over inverting configuration (2 Marks)
v. State one amplication of open loop op-amp amplifier circuit (2 Marks)
vi. Derive an expression for voltage gain of an inverting configuration op amp amplifier (4 Marks)

vii. State five characteristics of practical op amps (5 Marks)

QUESTION FOUR (20 MARKS)

You have been tasked with the responsibility of designing a displacement and time measuring electronic gadget to be used by physics students for studying Newton's laws of motion. A schematic diagram of the setup is given in the following diagram.





i. Explain the working principle of the displacement sensing element (2 Marks)

ii. Explain the signal conditioning operation employed in the shown above (3 Marks)

iii. Explain the role of the microcontroller in the above described process (Marks)

iv. Explain how calibration of the displacement sensor would be performed assuming there are no interfering and modifying environmental inputs. (10 Marks)