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| **الفرقه الثانيه ميكاترونك – مقرر جديد** |
| **Sensors and Measurement(استشعار وقياسات)** |
| 1 | * Write an essay on the calibration of measuring instruments. Explain what is meant by calibration of instruments, the purpose of calibration of instruments, the types of calibration, the advantages of calibration and the calibration standard. Explain how do you calibrate a temperature sensor.
* A displacement sensor has an input range of 0.0 to 3.0 cm and a supply voltage Vs =0.5V. Results from a calibration experiment are given in the table estimate:

(a)The slope K of the ideal straight line.(b)The maximum non-linearity as a percentage of f.s.d. |
| 2 | * Write an essay on the different static characteristics of a measurement system with examples.
* A temperature measurement system consists of a thermistor, bridge and recorder. The table gives the model equations, mean values and standard deviations for each element in the system. Assuming all probability distributions are normal, calculate the mean and standard deviation of the error probability density function for a true input temperature of 320 K.

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| 3 | * Write an essay on the various types of errors in measurement.
* A thermocouple sensor has an electromotive force (e.m.f.) in μV.

E (T) = 38.74T + 3.319 × 10−2T2 + 2.071 × 10−4T3 − 2.195 ×10−6T4, for the range 0 to 400 ºC. For T = 0 ºC, E(T) = 0 μV and for T = 400 ºC,E(T) = 20 869 μV.1. Calculate the expression for the ideal straight line relationship, E (T) = K · T.
2. Determine the sensitivity of the sensor.
3. Determine the maximum non-linearity of the system, as function of the full-scale (400ºC)
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| 4 | * Write an essay on the Techniques for Measurement Error Reduction.
* A thermocouple sensor has an electromotive force (e.m.f.) in μV.

E (T) = 38.74T + 3.319 × 10−2T2 + 2.071 × 10−4T3 − 2.195 ×10−6T4, for the range 0 to 400 ºC. For T = 0 ºC, E(T) = 0 μV and for T = 400 ºC,E(T) = −22131μV.1. Calculate the expression for the ideal straight line relationship, E (T) = K · T.
2. Determine the sensitivity of the sensor.

Determine the maximum non-linearity of the system, as function of the full-scale (400ºC) |
| 5 | * Write an essay on the accuracy of measuring instruments.
* A displacement sensor has an input range of 0.0 to 3.0 cm and a supply voltage Vs =0.6V. Results from a calibration experiment are given in the table estimate:

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| Displacement x (cm) | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
| Output voltage (mV)  | 0.0 | 21.0 | 41.5 | 56.0 | 65.0 | 70.5 | 74.0 |

(a)The slope K of the ideal straight line.(b)The maximum non-linearity as a percentage of f.s.d. |
| 6 | 1. Write an essay on different temperature measurement devices. Explain the operational principle of each device, its advantages and disadvantages, its cost, and its range of applicability. Which device would you recommend for use in the following cases: taking the temperatures of patients in a doctor’s office, monitoring the variations of temperature of a car engine block at several locations, and monitoring the temperatures in the furnace of a power plant?
2. A steel member with Poisson ratio υp = 0.3 is subject to simple axial tension as shown in Figure below. Strain gauges are mounted on top center, and bottom center. The strain gauge Gauge Factor GF = 2, all Resistors of Wheatstone bridge R = 120 Ω, the change in voltage output is of Wheatstone bridge δEo = 10 µV, and the input voltage Ei = 10 V.

Determine: * Bridge constant for gauge locations 1 and 4.
* Is the system temperature compensated? Verify you answer?
* The axial and transverse strain.
* Repeat all the calculation for graphene based strain gauge sensor.

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| 7 | 1. Describe the principle of operation of non-contact temperature measurement instruments?
2. Explain why we are interested in measuring the emissivity in the radiation pyrometer thermometer?
3. Write an essay on the various mass- and volume-measurement devices used throughout history.
4. In Figure below, two strain gauges are mounted on a cantilever to the same position at both the top and bottom to measure the tensile and bending strains. The resistance of each strain gage is120 Ohm and its gauge factor is 2. Two measurement configurations are used as shown in figures below. For configuration (1) the bridge output voltage e is 0.7 V. For configuration (2) the bridge output voltage e is 0.5 V. The excitation voltage E is 10 V. Calculate:
* The tensile strain at the gauge location
* The bending strain at the gauge location
* The bridge constant for configuration (1)
* The bridge constant for configuration (2)
* Determine using appropriate analysis the configuration in which the variation of temperature of the cantilever has no effect on the measured value of strain.
* Repeat all the calculation for graphene based strain gauge sensor.

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| Configuration (1) | Configuration (2) |

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| 8 | 1. Write an essay on different temperature measurement devices. Explain the operational principle of each device, its advantages and disadvantages, its cost, and its range of applicability. Which device would you recommend for use in the following cases: taking the temperatures of patients in a doctor’s office, monitoring the variations of temperature of a car engine block at several locations, and monitoring the temperatures in the furnace of a power plant?
2. The magnitude of the strain in a cantilever is given by ɛ = 6 (L-X)F/ (W t2 E) where L, W, and t are the length, width, and thickness of the beam respectively, X is the distance of the gauge from the beam’s mounting and E is the modulus of elasticity. If a weight of F=980 N is applied to the end of the cantilever and four strain gauges are fixed at distance X=15 cm from the cantilever base, using the data given in the table below calculate: (i) the strain produced at X=15 cm (ii) the strained resistance of the gauge. (iii) If the strain gauges are mounted in the arms of a Wheatstone bridge as shown in Figure below. R1, and R2 mounted on top; R3 and R4 on bottom of the cantilever. The arms are of equal unstrained resistances of 120 Ohm, calculate the bridge constant and the output voltage of the bridge for an excitation voltage of 5 V? Repeat all the calculation for graphene based strain gauge sensor.

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| Length | Width | Thickness | Young’s Modulus | Gauge Factor | Gauge unstrained resistance |
| L | W | t | E | G | Ro |
| 30 cm | 5 cm | 4 mm | 70x109 Pa | 2 | 120 Ohm |

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| 9 | 1. Write an essay on the various mass- and volume-measurement devices used throughout history.
2. Write an essay on different temperature measurement devices. Explain the operational principle of each device, its advantages and disadvantages, its cost, and its range of applicability. Which device would you recommend for use in the following cases: taking the temperatures of patients in a doctor’s office, monitoring the variations of temperature of a car engine block at several locations, and monitoring the temperatures in the furnace of a power plant?
3. Write an essay on strain measurement: Principle, Types, Features, errors, uncertainty and Applications?
4. Consider the thermopile arrangement shown in the figure below. What will be the output voltage?

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