1. A thermometer has a resistance of 1 kΩ at temperature 298 K and 465 Ω at temperature 316 K. Find the temperature sensitivity in K^{-1} [i.e. $(1/R)(dR/dT)$, where R is the resistance at the temperature T (in K)], at 316 K.

   Consider a semiconductor thermometer. The resistance at T = 100°C is 1 k at T = 100°C, and at T = 0°C it is 100 K. Calculate the resistance at T = 40°C.

2. What are the meanings of the terms "Sensors" and "Transducers"?

3. What are the applications that you can apply to sensors and transducers?

4. Compare and contrast the sensors and transducers?

5. Compare and contrast analogue and digital sensors?

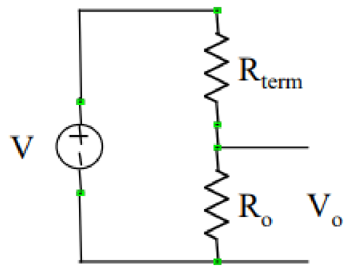
6. What are the sensor characteristics that should be considered for selecting a sensor?
7. What are the features that should be considered when choosing a sensor?
8. What are the basic requirements of a sensor?
9. Compare and contrast advantages and disadvantages of "passive" and "active" sensors? Give examples.
10. What are "absolute sensor" and "relative sensor"?
11. What is a RTD?
12. What is Seebeck Effect?
13. What is Peltier Effect?
14. What is Thomson Effect?
15. Let us consider a semiconductor thermistor. The resistance at T = 100 °C is 1 kΩ at T = 100 °C, and at T = 0 °C it is 100 kΩ. Calculate the resistance at T = 40 °C.

    The semiconductor thermistor is characterized by the following relationship:

    $$R(T) = R_{T_0}.\exp\left[B.\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$

    To calculate B, let us replace in the above equation T = 100 °C = 373 K and T_0 = 0 °C = 273 K, and the respective resistance values.

16. The following figure shows a voltage divider where R_{term} is a RTD sensor whose characteristics is $R = R_0(1+\alpha(T-T_0))$



V_i=5 V
R_o=1KΩ
α=0.05 K^{-1}
T_o=273K=0°C

Calculate the maximum tolerable measurement error of V_0 in order to obtain a resolution less that 0.1 K in the range 0 – 100 °C.

17.

1. What is the meaning of electric current?

2. What is the capacitance (***C***) of a parallel plate capacitor and give the relevant equation for ***C***. State all the symbols are used.

3. State Hooke's law of elasticity. State all the symbols clearly.

4. To deform a resistor and cause strain, it should be stressed.

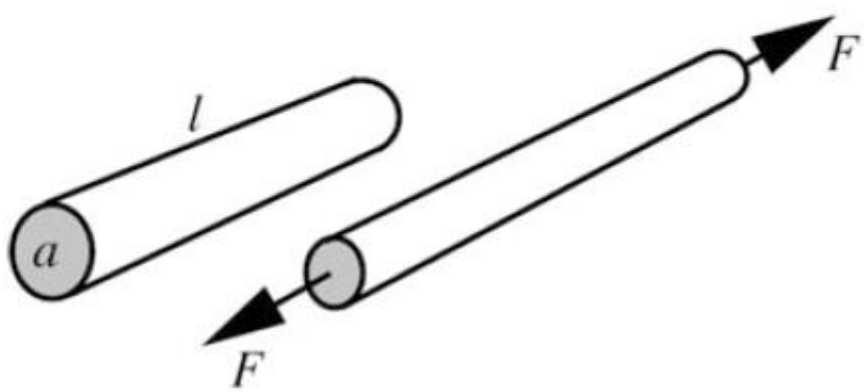


Figure 1.0. Strain changes geometry of conductor and its resistance.

i. Write an expression for the stress ***σ***, in terms of ***F*** and the cross-sectional area ***a***.

ii. What is the strain of a material and write an expression for the Strain. Clearly define the symbols are used.

iii. Write an expression for the Young's modulus, ***Y*** of the material in terms of **stress** and **strain**.

iv. Plot Stress – Strain plot for Brittle, Ductile, and Plastic.

18.

a) What is an actuator?

b) Explain the working mechanisms of hydraulic, pneumatic, and electric actuators.

c) What are the advantages and disadvantages of above actuators? Compare and contrast them.

d) Why do we need signal conditioning in a sensory systems?

19.

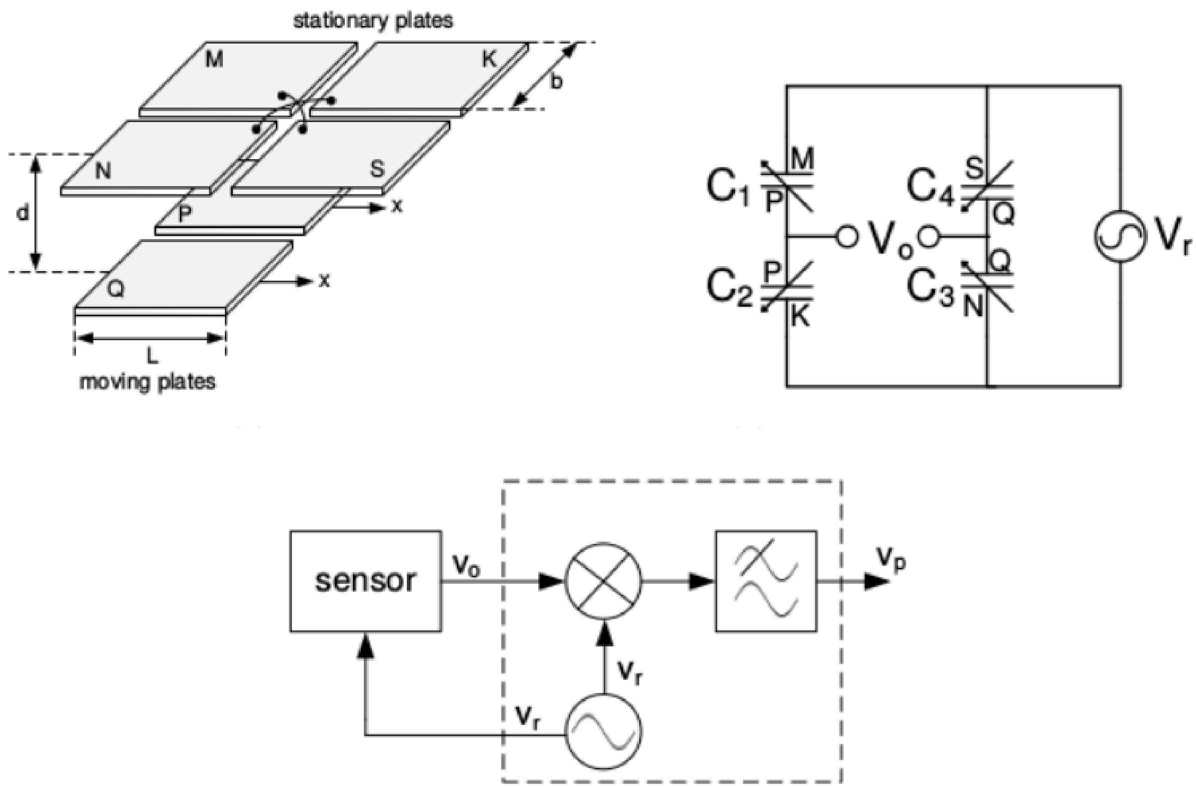


Figure 2.0

The above figure 2.0 illustrates a capacitive sensor that can be used to provide a linear displacement to measure. The sensor consists of two sets of flat electrodes which are at a fixed mutual distance d = 0.5 mm have been placed on each other. All six, the plates have the same length L = 10 mm and the same width b = 10 mm. The upper four fixed plates (N, M , K, S) are cross-linked and form a capacitive bridge with the bottom two moving plates (P , Q).

In the space between the fixed and moving plates is air (E_r = 1, E_0 = 8.85 pF/m = 8.15 x 10^{-12} pF/m). The electrically equivalent circuit of this sensor (including a power supply voltage V_r) is shown in Figure (b).The supply voltage V_r produces a sinusoidal voltage having a frequency ω_r = 2 x 10 kHz.

Show that the capacitance C_1 is equal to: $C_1 = \frac{\varepsilon_0 \varepsilon_r b}{d}\left(\frac{L}{2} - x\right)$

(b) Show that the output voltage of the sensor, V_0, is equal to: $V_0 = -\frac{2x}{L}V_r$, with x is the linear displacement of the sensor. Assuming that $C_1 = C_2 = C_3$ and C_4.

20. Obtain an expression for the total capacitance of the capacitive water level sensor (Figure 3.0). Capacitive water level sensor (a); capacitance as function of water level (b) (sensor’s dimensions are a = 10 mm, b = 12 mm, H = 200 mm, liquid—water). Find the sensitivity of the sensor.

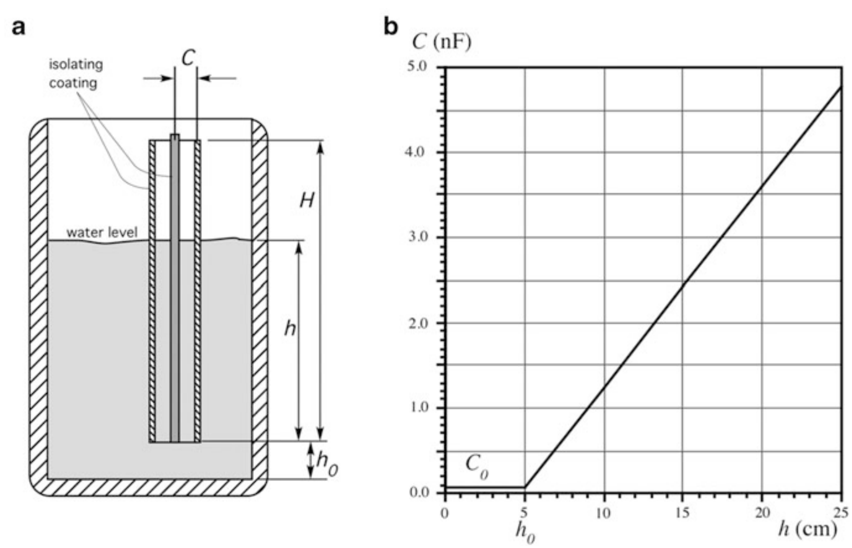


Figure 3.0

21.

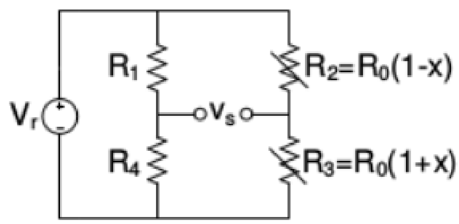


Figure 4.0

a). Show that the output voltage v s of the sensor circuit is equal to: $V_s = -\frac{x}{2}V_r$

b). What value needs to have the supply voltage *V*r to the sensitivity of the sensor circuit, issued image in Figure 4.0, to maximize a change in *x*?

c). Show that the output voltage v_s of the sensor circuit that is shown in Figure 3 is equal to 5.00 mV if there is a pressure of 100 x10^6 N/m^2 is exerted on the metal strip, and *V*r = 10 V.

22. Following is a schematic diagram depicts of usage of a resistive displacement sensor for measuring rotation of an object. The resistance of the variable resistor varies from 0 to R_T linearly when angle of rotation is changes θ from 0º to 270º. The sensor circuit is connected to a voltmeter with internal resistance $R_m = R_{T/a}$, where *a* is a positive constant.

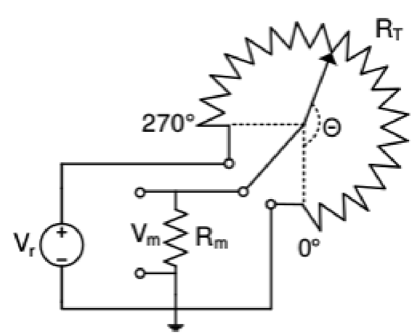


Figure 5.0

a) Show that the voltage V_m over the resistance R_m is $V_m = -\frac{270^\circ}{(270^\circ)^2 + a\theta(270^\circ - \theta)}V_r$

b) Show that the relative error ε in the output voltage V_m excreted due to load resistor R_m is

$$\varepsilon = \frac{a\theta(270^\circ - \theta)}{(270^\circ)^2 + a\theta(270^\circ - \theta)} V_r$$

c) What is the ratio of resistors R_T/R_m that should be maintain in order to keep relative error of V_m less than 5 % ?