Question 1

Electromagnetic transduction is widely used in the design of sensors

a) List four types of sensors which are based on this principle

b) Use illustrative diagrams to briefly describe the functionality of each of the sensors

Question 2

A feedback system for the control of the temperature of an industrial furnace uses a thyristor to control the electrical power supplied to the furnace. A thermocouple measures the furnace temperature and feeds back a signal to the negative terminal of an operational amplifier (the comparator). The reference input temperature is connected to the positive terminal of the operational amplifier.

System Characteristics

- Mass of furnace, m.
- Specific Heat Capacity of the furnace, C.
- Rate of Heat Loss from the furnace, $P = \alpha(\theta - \theta_r)$

  Where θ is the furnace temperature

  and θ_r is the room temperature

- Electrical Power supplied to the furnace $P = K(\theta_{ref} - \theta)$

  Where θ_{ref} is the reference input temperature and K is the Gain of the Thyristor.

- The thermocouple has unity gain. The system is, therefore, a unity-gain feedback system.

a) Draw a Block Diagram for the feedback system

b) Calculate the Open-loop transfer function

c) Calculate the Closed-loop transfer function

Question 3

a) Define an Encoder.

b) With the use of an illustrative diagram, briefly describe one type of angular encoder.

c) A linear encoder has 400 ferromagnets encoded on a strip of metal which is 200 mm long. If the metallic strip is displaced through a distance of 0.8 cm, how many pulses are generated by the coil ?

d) By considering each pulse to be binary digit 1, give a binary representation of the pulses generated in (c) above.

System Characteristics :

Torque Amplifier

The output Torque is proportional to the input signal to the torque amplifier

Motor and load

The motor and load have a combined moment of inertia J. Their motion is resisted by a frictional torque which is proportional to the speed.

Tachometer

The tachometer has unity Gain.

w (t) and wref are the Angular Speed and the reference Angular Speed respectively.

a) Calculate the Open-loop Transfer Function
b) Calculate the Closed-loop transfer Function
c) The tachometer is replaced by a unity-gain potentiometer to convert the speed control system into a system for the control of Angular Position. The reference speed is replaced by the reference Angular Position.
Calculate:
    i.   The Open-loop Transfer Function
    ii.   The Closed-loop Transfer Function

Question 4

Consider the circuit in fig. 2.

a) Calculate the Transfer Function of the Circuit
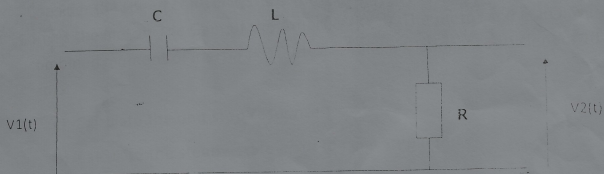b) If the Resistor and Capacitor are transposed, calculate the Transfer Function.

Fig. 2: Circuit for Question 4.