

### Lecture 1

1. Define Mechatronics. Draw and describe the basic elements of Mechatronics Engineering system.
2. What do you mean by microprocessor, microcontroller and embedded systems?
3. What do you mean by transient response and steady-state response? Describe with proper examples.
4. Draw and describe the components of measurement system.
5. Mention the steps how a digital thermometer works.
6. Mention the key differences between open-loop and closed-loop control system.
7. Draw and describe the basic elements of closed-loop system.

### Lecture 2 and 3

1. Differentiate between sensor and transducer.
2. State the key features of a smart sensor.
3. Define the following terms:
  - i. Span
  - ii. Hysteresis error
  - iii. Non-linearity Error
  - iv. Repeatability/Reproducibility
  - v. Stability
  - vi. Dead Band/Time
  - vii. Resolution
  - viii. Accuracy
  - ix. Precision
4. What do you mean by the following specifications?
  - i. A temperature sensor might have a range of  $-10^{\circ}\text{C}$  to  $100^{\circ}\text{C}$
  - ii. A thermometer reads  $25^{\circ}\text{C}$  when the actual temperature is  $24^{\circ}\text{C}$
  - iii. A temperature-measuring instrument is specified as having an accuracy of  $\pm 2^{\circ}\text{C}$
  - iv. A strain gauge having a sensitivity of  $2 \text{ mV/V}$
5. Consider the significance of the terms in the following specification of a strain gauge pressure transducer:

Ranges: 70 to 1000 kPa, 2000 to 70 000 kPa  
Supply voltage: 10 V d.c. or a.c. r.m.s.  
Full range output: 40 mV  
Non-linearity and hysteresis:  $\pm 0.5\%$  of full range output  
Temperature range:  $-54^{\circ}\text{C}$  to  $+120^{\circ}\text{C}$  when operating  
Thermal zero shift:  $0.030\%$  of full range output/ $^{\circ}\text{C}$

Interpret the following specifications.

### Lecture 6

1. Define the following terms: Force, Moment, Torque, Tensile force, compressive force, shear force, torsional moment, bending moment, gravity force, aerodynamic force, frictional force, free body diagram, displacement, velocity, acceleration, work, energy, power, stress, strain.
2. State the equilibrium conditions for a body.

### Lecture 7

1. Draw and explain the working principle of the following sensors: Displacement sensor, Linear variable differential transformer

### Lecture 8

1. Draw and explain the working principle of the following proximity sensors: Inductive proximity sensor, capacitive proximity sensor, Magnetic proximity sensor

### Lecture 9

1. Draw and explain the following sensors: passive IR sensor, condenser microphone, dynamic microphone

### Lecture 10

1. Describe the construction and working principle of the following sensors: Phototransistor, Photovoltaic cell, Light dependent resistor

### Lecture 11

1. Describe the working principle of the following temperature sensors: Thermocouple, thermistor, resistant temperature detector.

### Lecture 12

1. Describe the working principles of the following flow meters: Venturimeter, Pitot tubes

### Lecture 13

1. Draw the block diagram of hydraulic and pneumatic system.

### Lecture 14

1. Define Grashof condition. Illustrates different forms of the four-bar chain by altering the relative lengths of the links.
2. Draw the position sequence for the links in a slider– crank mechanism
3. Describe the cam mechanism.

### Lecture 15

1. Draw the following gears: Gear train, worm gear, spur gear, helical gear, rack and pinion gear, ratchets and pawls

### Lecture 16 and 17

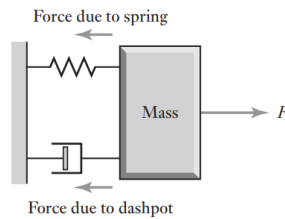
1. Draw and explain the working principle of the following electrical actuation systems: Thyristor, TRIAC, DIAC, UJT

### Lecture 18

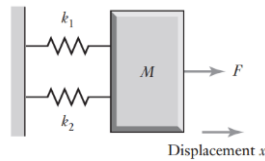
1. Describe the stepper motor driving techniques.

## Lecture 19

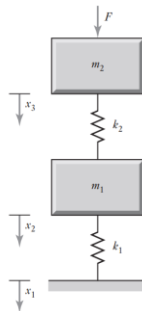
1. Develop the differential equation, describes the relationship between the input of force  $F$  to the system and the output of displacement  $x$ .



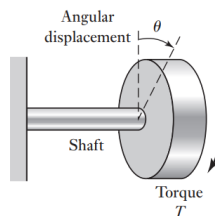
2. Develop the differential equation relating the inputs and outputs for a mechanical system



3. Derive the second-order differential equations to describe the behaviours of the system.

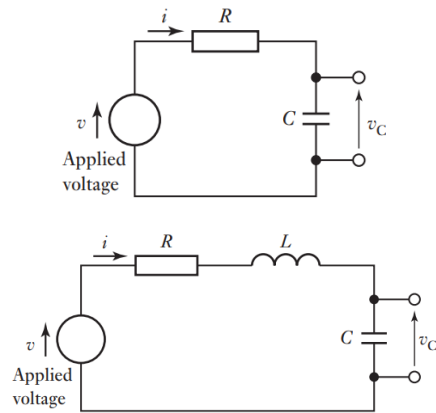


4. Evaluate the relationship between the torque and angular displacement for the system

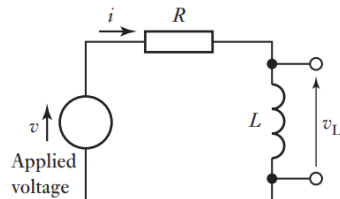


## Lecture 20

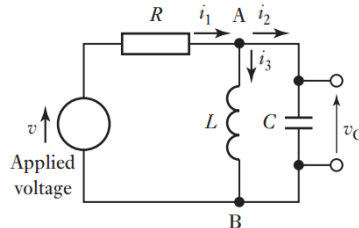
1. Derive the differential equation which gives the relationship between the output  $v_c$  and the input  $v$ .



2. Develop the relationship between the output, the potential difference across the inductor of  $v_L$ , and the input  $v$  for the circuit shown in Figure.

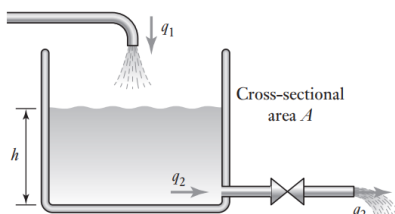


3. Develop the relationship between the output, the potential difference  $v_C$  across the capacitor, and the input  $v$  for the circuit shown in Figure.



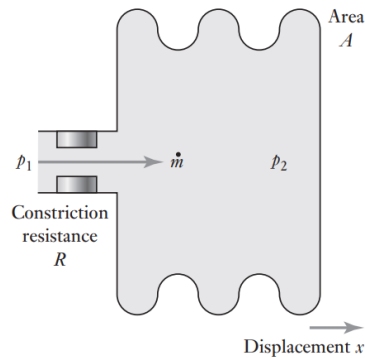
## **Lecture 21**

1. Figure shows a simple hydraulic system, a liquid entering and leaving a container. Develop an equation describing how the height of liquid in the container depends on the rate of input of liquid into the container.



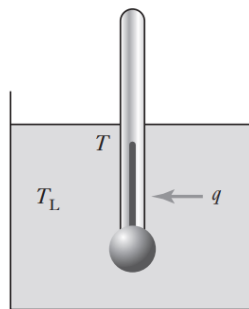
2. A bellows is an example of a simple pneumatic system. Resistance is provided by a constriction which restricts the rate of flow of gas into the bellows and capacitance is provided by the bellows itself. Inertance can be neglected since the flow rate changes only slowly. Develop an equation

describing how the pressure in the bellows  $p_2$  varies with time when there is an input of a pressure  $p_1$ .

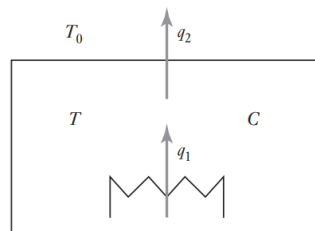


### Lecture 22

1. Consider a thermometer at temperature  $T$  which has just been inserted into a liquid at temperature  $T_L$ . Develop a first-order differential equation, describing how the temperature indicated by the thermometer  $T$  will vary with time when the thermometer is inserted into a hot liquid.



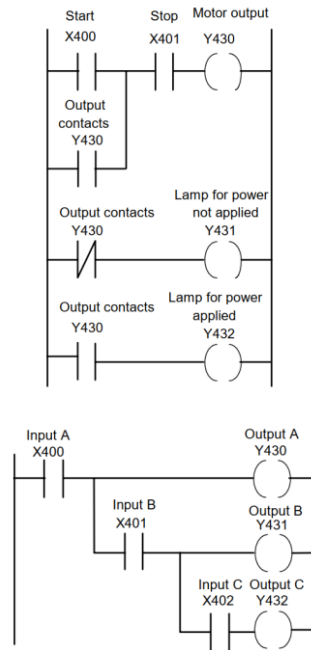
2. Figure shows a thermal system consisting of an electric fire in a room. The fire emits heat at the rate  $q_1$  and the room loses heat at the rate  $q_2$ . Assuming that the air in the room is at a uniform temperature  $T$  and that there is no heat storage in the walls of the room, derive an equation describing how the room temperature will change with time.



### Lecture 23

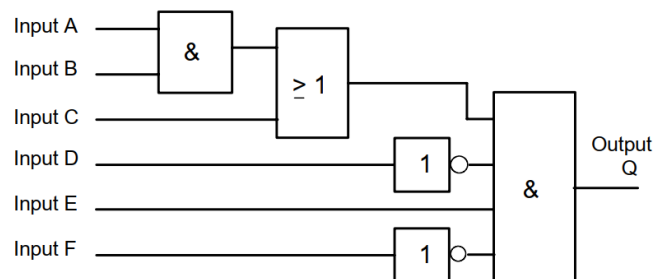
### Lecture 24

1. ~~Draw the ladder diagram for the following logic gates: AND, OR, NOT, NAND, NOR, EX OR~~
2. Consider a motor controlled by stop and start push button switches and for which one signal light must be illuminated when the power is applied to the motor and another when it is not applied. Draw the ladder diagram for this case.
3. Describe the operation of the following ladder diagrams:



### Lecture 25

1. ~~Draw the functional block diagram for the following logic gates: AND, OR, NOT, NAND, NOR, EX OR~~
2. ~~Draw the ladder diagram for the following functional block diagram.~~



3. A signal lamp is required to be switched on if a pump is running and the pressure is satisfactory, or if the lamp test switch is closed. Draw the ladder diagram and functional block diagram.
4. Consider a valve which is to be operated to lift a load when a pump is running and either the lift switch is operated or a switch operated indicating that the load has not already been lifted and is at the bottom of its lift channel. Draw the ladder diagram and functional block diagram.
5. Consider a system where there has to be no output when any one of four sensors gives an output, otherwise there is to be an output. Draw the ladder diagram and functional block diagram.

6. A system is to be activated when two different sets of input conditions are realised. You might just program this as an AND logic gate system; however, if a number of inputs have to be checked in order that each of the input conditions can be realised, it may be simpler to use an internal relay. The first input conditions then are used to give an output to an internal relay. This has associated contacts which then become part of the input conditions with the second input. Draw a ladder program for such a task.
7. Draw a ladder program of internal relays used for resetting a latch circuit.
8. Draw a ladder program of Battery-backed relay program.
9. Consider a fire alarm system, where fire sensors provide inputs to a SET-RESET function block so that if one of the sensors is activated the alarm is set and remains set until it is cleared by being reset. When set it sets of the alarm. Draw the ladder program for this task.

#### Lecture 26

Timers based ladder diagram

#### Lecture 27

Counter, Shift Register related problem based ladder diagram

#### Lecture 28

Practical problem based ladder diagram