INTRODUCTION TO MECHATRONICS
(AEIE 3111)

Time Allotted : 3 hrs   **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i) The most important characteristics of an instrumentation amplifier is
   (a) high common mode gain   (b) high differential mode gain
   (c) high common mode rejection ratio   (d) low common mode gain.

   (ii) In a standard control system, block between the comparator and plant is
   (a) final control element   (b) sensor
   (c) actuator   (d) controller.

   (iii) Which among the following is a measure of a ADC's performance
   (a) Resolution   (b) Input impedance   (c) Sampling rate   (d) Conversion rate.

   (iv) A series combination of thermocouples is used for the measurement of
   (a) small temperature differences between two junctions
   (b) large temperature differences between two junctions
   (c) average temperature of a number of points
   (d) all of these.

   (v) The role of accumulator in any pneumatic/hydraulic system is
   (a) to pump oil/air from a reservoir
   (b) to undo fluctuations in oil/air pressure
   (c) to release pressure if it rises above a safe level
   (d) to retain pressure below a certain level.

   (vi) The Op-amp. can amplify
   (a) A.C. signal only   (b) D.C. signal only
   (c) both A.C. and D.C. signals   (d) neither D.C. nor A.C. signals.

   (vii) Steady state flow rate "Q" for laminar flow is given by
   (a) $Q = K\sqrt{H}$ (b) $Q = K/H$ (c) $Q = KH$ (d) $Q = K + H$.

   (viii) The conversion rate of a DAC depends on which of the following?
   (a) Settling time of converter   (b) Rate of the output analog signal
   (c) both (a) and (d)   (d) Clock speed of input signal.

(ix) Which of the following PLC parts have direct interaction with physical world?
(a) Input Relays   (b) Internal Utility Relays
(c) Counters   (d) Timers.

(x) Two secondary windings of an LVDT have wrongly been connected in phase. The input–output relationship would be
(a) linear with +ve slope   (b) linear with -ve slope
(c) V shaped curve   (d) a constant output.

Group – B

2. (a) Discuss the advantages and disadvantages of mechatronics system.
   [(CO2)(Remember/LOCQ)]
   (b) Describe the key elements of a mechatronics system.   [(CO2)(Remember/LOCQ)]
   6 + 6 = 12

3. A voltmeter having resistance R_m ($\neq \infty$) connected with a potentiometer as a load. If the applied input voltage=E_i, total length of the potentiometer=X_t, displacement of wiper from its zero position=X_o, total resistance of the potentiometer=R_p,
   (i)   determine the output voltage, V_o,
   (ii) determine the maximum input voltage if the heat dissipation is P watt,
   (iii) how to improve the nonlinearity and sensitivity of the potentiometer?
   [(CO3)(Understand/LOCQ)]
   (6 + 3 + 3) = 12

Group – C

4. (a) Find the full bridge sensitivity for strain gauge signal conditioning unit.
   [(CO3)(Understand/LOCQ)]
   (b) A strain gauge forms one arm of the bridge as shown in the Fig.1 below and has a nominal resistance without any load as R_s=250 Ω. Other bridge resistances are R_1=R_2=R_3=250 Ω. The maximum permissible current through the strain gauge is 30 mA. During certain measurement when the bridge is excited by maximum permissible voltage and the strain gauge resistance is increased by 1% over the nominal values; determine the output voltage.   [(CO3)(Evaluate/HOCQ)]
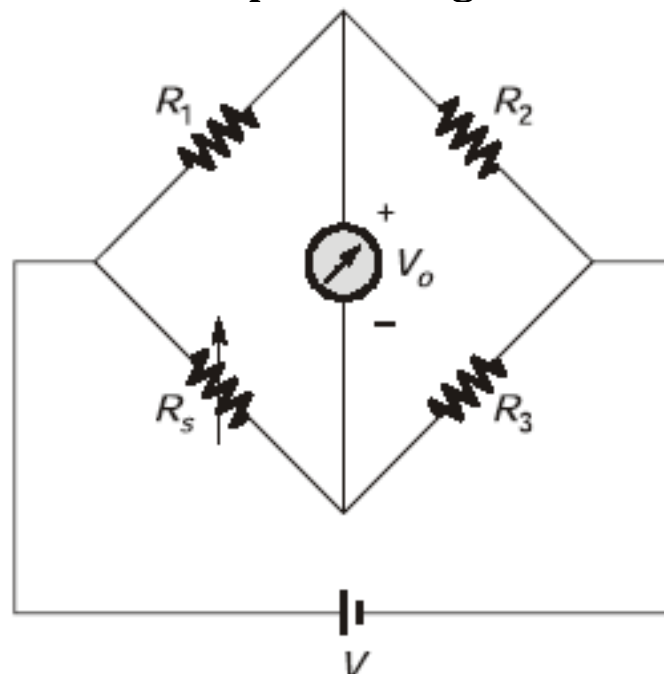

Fig. 1

6 + 6 = 12

5. (a) Estimate the output voltage of an Instrumentation amplifier with neat circuit diagram. Write down its advantages. [(CO1)(Remember/LOCQ)]
   (b) Design a low-pass filter having bandwidth 4 kHz. [(CO1)(Create/HOCQ)]

6 + 6 = 12

Group – D

6. (a) Examine the principle of actuation in case of micro-cantilevers.
   [(CO4)(Analyze/IOCQ)]
   (b) Elaborate on the sensing principle used by MEMS accelerometers.
   [(CO2)(Create/HOCQ)]
   (c) Compare the two different MEMS accelerometers based on construction of the sensing structure. [(CO1)(Understand/LOCQ)]

4 + 3 + 5 = 12

7. (a) Assess the working of a double acting pneumatic cylinders. [(CO2)(Evaluate/HOCQ)]
   (b) Differentiate between single and double acting pneumatic cylinders.
   [(CO3)(Understand/LOCQ)]
   (c) Examine the actuation principle of a MEMS cantilever beam using quartz as actuating element. [(CO1)(Analyze/IOCQ)]

2 + 4 + 6 = 12

Group – E

8. (a) Discuss two stable states in a SMA material. [(CO4)(Create/HOCQ)]
   (b) Categorize the various parts of a data acquisition system. [(CO2)(Analyze/IOCQ)]
   (c) What are DSPs? [(CO1)(Remember/LOCQ)]

3 + 5 + 4 = 12

9. (a) Assess the role of the Sample-Hold block in a data acquisition system.
   [(CO4) (Evaluate/HOCQ)]
   (b) Examine the final output voltage expression of a 8-bit R-2R type DAC.
   [(CO2) (Analyze/IOCQ)]
   (c) Inspect the final output voltage expression of a 4-bit binary weighted resistor DAC.
   [(CO1) (Analyze/IOCQ)]

4 + 5 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	51	24	25

Course Outcome (CO):

After the completion of the course students will be able to:
1. Understand a real time mechatronics system.
2. Identify the key elements of mechatronics systems and its representation in terms of block diagram.

3. Gain knowledge of different types of Sensors required for developing mechatronics systems.
4. Learn the functions of different types of actuators and identify their application areas.
5. Understand concept of signal conditioning and use of interfacing systems such as comparator, filters, amplifiers, etc.
6. Learn the hardware and software interfacing for embedded systems.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.