UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	INSTRUMENTATION AND CONTROL
COURSE CODE	:	BNR 20703
PROGRAMME	:	2 BND
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1   (a)   Explain the following terms:

   (i)   error.

   (ii)   accuracy.

   (iii)   precision.

   (iv)   measurement.

(8 marks)

(b)   Calculate the following problems with the correct number of significant figures.

   (i)   72.60 m + 0.0950 m

   (ii) 1.30×10^2 cm + 2.4×10^4 cm

   (iii)   3.0 cm x 4.000 cm

   (iv)   0.0045 mm^2 ÷ 0.90 mm

(4 marks)

(c)   Successive measurements of the temperature of a liquid over a period of time produced the following data: T_1 = 25.05 °C, T_2 = 25.02 °C, T_3 = 25.03 °C, T_4 = 25.07 °C, T_5 = 25.55 °C, T_6 = 25.06 °C, T_7 = 25.04 °C, T_8 = 25.05 °C, T_9 = 25.07 °C, T_{10} = 25.03 °C, T_{11} = 25.02 °C, T_{12} = 25.04 °C, T_{13} = 25.02 °C, T_{14} = 25.03 °C and T_{15} = 25.05 °C. Calculate:

   (i)   average temperature.

   (ii)   mean deviation from average.

   (iii)   standard deviation.

   (iv)   probable measurement error.

(4 marks)

(d)   A 150 ± 10% Ω resistor is connected to the terminals of a power supply operating at 200 ± 0 V_{dc}.

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(i)   Calculate the current if the resistor varies over the range of ± 10% of its expected value.

(ii)   Calculate the current error.

(4 marks)

(e)   The output voltage of an amplifier was measured by six different students using the same oscilloscope with the following results: 20.20 V, 19.90 V, 20.05 V, 20.10 V, 19.85 V, and 20.00 V. Calculate the most precise measurement.

(5 marks)

Q2   (a)   List the advantages and disadvantages of closed-loop versus open loop control systems.

(5 marks)

(b)   Sketch the schematics for antenna pointing system using:

(i)   open loop system.

(5 marks)

(ii)   closed loop system.

(5 marks)

(c)   Reduce the block diagram in Figure Q2(c) to a single block representing the transfer function, $T(s) = \dfrac{C(s)}{R(s)}$.

(10 marks)

Q3   (a)   Figure Q3(a) shows an RLC circuit. All initial conditions are zero. Determine the transfer function of the circuit, $\dfrac{V_C(s)}{V(s)}$.

(10 marks)

(b)   Figure Q3(b) shows a mechanical system. Determine the transfer function, $\dfrac{X_2(s)}{F(s)}$.

(15 marks)

Q4   (a)   A system has a transfer function

$$T(s) = \frac{25}{s^2 + 4s + 25}$$

Calculate:

(i)   natural frequency.

(3 marks)

(ii)   damping ratio.

(3 marks)

(iii)   peak time.

(2 marks)

(iv)   rise time.

(2 marks)

(v)   percentage of overshooting.

(2 marks)

(vi)   settling time (5% criterion).

(3 marks)

(b)   Figure Q3(b) shows a block diagram of an armature controlled dc motor. The parameters of the motor are:

- Armature coil inductance, L: 0.4 H
- Armature coil resistance, R: 5 Ω
- Torque constant, K_t: 0.5 N-m/A
- Rotor inertia, J_m: 0.1 N-m-s^2/rad
- Viscous friction constant, B_m: 0.2 N-m-s/rad
- Back e.m.f. constant, K_b: 0.3 V-s/rad

Determine the transfer function of the motor, $\dfrac{\Omega_m(s)}{V_a(s)}$ in the simplest numerical form. Consider the load torque equals to zero.

(10 marks)

Q5   (a)   Describe the three conditions of stability and explain on how the system will fall into that condition using a pole placement example.

(6 marks)

(b)   The simplified form of a block diagram for a position servomechanism is shown in Figure Q5(b).

(i)   Calculate the characteristic equation of the system.

(2 marks)

(ii)   Develop the Routh-Hurwitz table.

(14 marks)

(iii)   Calculate the range of K that results in stable system.

(3 marks)

Q6   (a)   Explain the operation of the on-off controller by using an example.

(5 marks)

(b)   Sketch the controller output to a ramp input for:

(i)   P mode only.

(ii)   D mode only.

(iii)   P + D mode.

(3 marks)

(c)   Sketch the controller output to a step input for:

(i)   P mode only.

(ii)   I mode only.

(iii)   P + I mode.

(3 marks)

(d)   Calculate the controller gain of a temperature controller with a 80% PB if its input range is 40 °C to 90 °C and its output is 4 mA to 20 mA.

(4 marks)

(e)   A controller gives an output in the range 4 mA to 20 mA to control the speed of a motor in the range 140 rev/min to 600 rev/min. If the motor speed is proportional to the controller output, calculate the motor speed when the controller output is

(i)   8 mA.

(ii)   40%.

(5 marks)

(f)   Figure Q6(f) shows a control system designed to control the level of water in the container to a constant level. It uses a proportional controller with K_p equal to 10. The valve gives a flow rate of 10 m^3/h per percent of controller output. The flow rate is proportional to the controller input.

   (i)   If the controller output is initially set to 50%, calculate the outflow from the container.

   (ii)   If the outflow increases to 600 m^3/h, calculate the new controller output to maintain the water at constant level.

(5 marks)

- END OF QUESTION -

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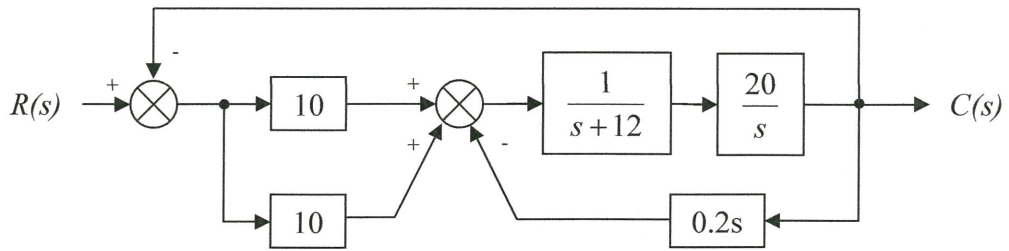COURSE NAME   : INSTRUMENTATION AND CONTROL   COURSE CODE: BNR 20703
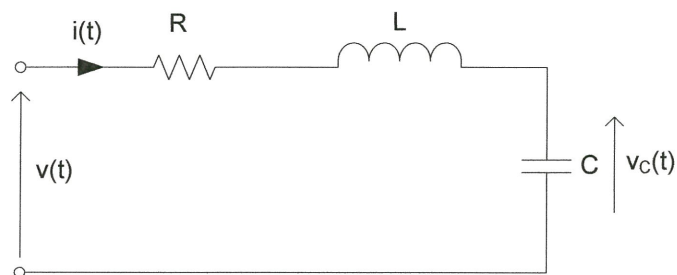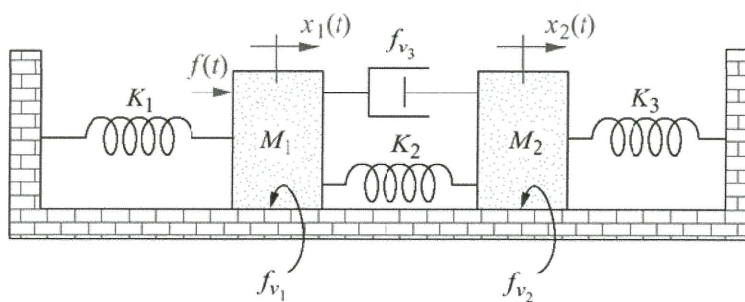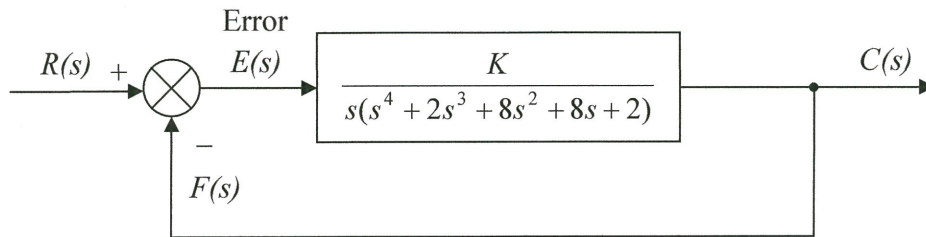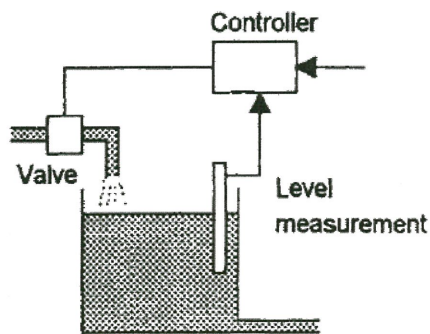

Figure Q2(c)

Figure Q3(a)

Figure Q3(b)

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Figure Q5(b)

Figure Q6(f)