UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME	:	ELECTROMECHANICAL & CONTROL SYSTEM
COURSE CODE	:	BDU 20303
PROGRAMME	:	2 BDC
EXAMINATION DATE	:	JUNE 2013
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER FOUR (4) QUESTIONS ONLY

THIS PAPER CONTAINS FIVE (5) PRINTED PAGES

Q1 (a) Prove the closed-loop transfer function for a system given in **Figure Q1(a)** is as follows;

$$\frac{R}{T} = \frac{M_1}{1 + M_1 M_2}$$

(5 marks)

(b) The actuator for aileron is modeled as an electromechanical system as shown in **Figure Q1(b)**. As given in the figure, R is the resistance of the resistor, L is the inductance of the inductor, B is the damping coefficient, and J is the moment of inertia of the rotating part. If the input signal is voltage, v, and the output signal is rotational velocity, ω,

i) Derive all relevant equations.

ii) From equations derived in part (i), sketch the system's block diagram.

(20 marks)

Q2 (a) The control system of a gas turbine fuel flowrate is modeled as an ordinary differential equation as follows,

$$5\frac{dy}{dt} + 2y = 3u(t)$$

If the ambient pressure, u(t) is the input and is a unit step, and all initial conditions are zero, determine the output response of the fuel flowrate, y(t).

(10 marks)

(b) The open-loop transfer function of an attitude hold system for a fighter jet is given as,

$$G(s) = \frac{K(s+2)}{s(s+5)}$$

K is the gain of the system and the input is a unit ramp. By using final value theorem, obtain the steady state error. For this case, suggest how the steady state error can be reduced.

(15 marks)

Q3 (a) An automatic control system for a control system is represented by the block diagram shown in **Figure Q3**. The design specification of the control system are to have peak time, $T_P = 2$ sec. and settling time, $T_S = 4$ sec. Determine,

i) the value for K_1 and K_2 in order to fulfill the design specifications.

ii) the percentage overshoot M_P of the system.

(15 marks)

(b) The transfer function that relates input voltage V, with the output torque τ, for a DC motor is classified as a first order system. Time response test have been conducted using input voltage of 6V has produced a steady state output torques of 20Ncm. The motor needs only 0.4 seconds to reach the output torque of 12.6Ncm. Develop the transfer function for this DC motor.

(10 marks)

Q4 (a) Explain briefly the root locus method.

(5 marks)

(b) An open-loop transfer function of a missile control system is given as,

$$GH(s) = \frac{K(s+5)}{(s+1)(s^2+4s+8)}$$

For this system, sketch the root locus on a graph paper. When damping ratio ratio, $\zeta = 0.26$, determine the following,

i) the corresponding poles.

ii) gain K.

iii) undamped and damped natural frequencies.

[Note : Use scale of **2 cm : 1 unit** for both axes]

(20 marks)

Q5 (a) With the assist of necessary plot, state the stability conditions of Bode diagram.

(5 marks)

(b) The transfer function of rotor blade stabilizer bar of ZN24 helicopter is given as,

$$G(s) = \frac{10K}{s(1 + 0.1s)(1 + 0.02s)}$$

Plot the Bode diagram on a semilog graph paper. Then determine the phase margin, gain margin and maximum K for stability.

(20 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2012/2013 PROGRAMME : 2 BDC
COURSE : ELECTROMECHANICAL & CONTROL SYSTEM COURSE CODE : BDU20303

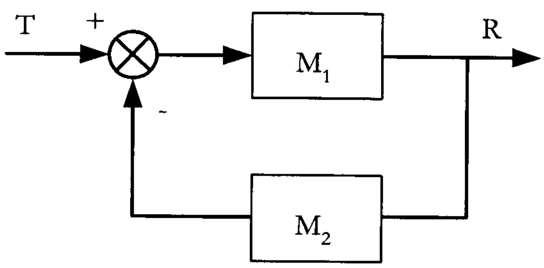

Figure Q1(a)

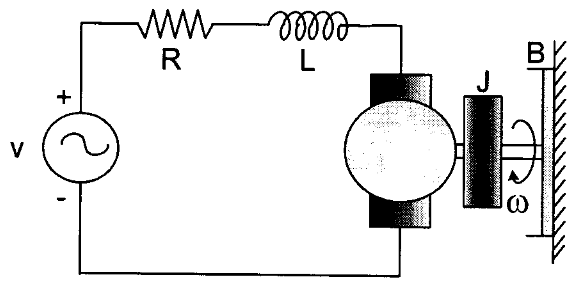

Figure Q1(b)

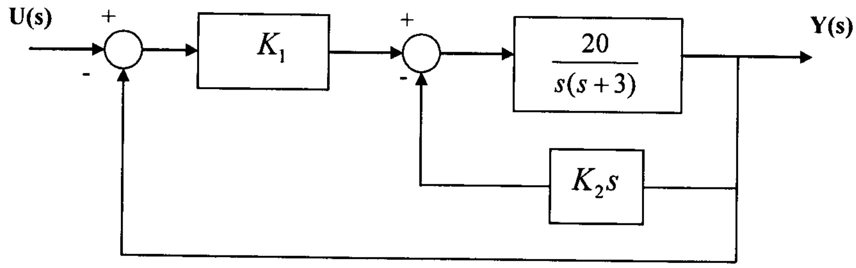

Figure Q3

Laplace Transformation

$L[1] = 1/s$
$L[t] = 1/s^2$
$L[At^n] = An!/S^{n+1}$
$L[e^{-at}] = 1/(s+a)$
$L[\sin \omega t] = \omega/(s^2+\omega^2)$
$L[\text{kos } \omega t] = s/(s^2+\omega^2)$
$L[e^{-at}\sin \omega t = \omega/((s+a)^2+\omega^2)$
$L[e^{-at}\text{kos } \omega t = (s+a)/((s+a)^2+\omega^2)$

$L[d^2y/dt^2] = s^2y(s) - sy(0) – dy(0)/dt$
$L[dy/dt] = sy(s) - y(0)$

Final Value Theorem

$\lim_{t \to \infty} f(t) = \lim_{s \to 0} sF(s)$