UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2012/2013

COURSE NAME	:	CONTROL SYSTEM THEORY / CONTROL SYSTEM
COURSE CODE	:	BEH 30603 / BEE 3143
PROGRAMME	:	BEH / BEE
EXAMINATION DATE	:	JANUARY 2013
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1. (a) Explain the following concisely

(i) Control system

(3 marks)

(ii) Block diagram

(3 marks)

(iii) Time-invariant

(3 marks)

(iv) Process control

(3 marks)

(b) Give an example of a real practical application for a closed loop control system. Identify the input and output variables and by using a suitable block diagram, describe the operation of the selected application.

(13 marks)

Q2. Figure Q2 shows an armature-controlled d.c. motor with non zero armature inductance. This motor is assumed to have a constant magnetic field. The parameters for this motor are defined as follows:

k_b = back e.m.f. constant,
k_t = motor torque contanst,
J_m = moment of inertia of the motor and load referred to the motor shaft,
B_m= viscous friction constant of the motor and load referred to the motor shaft.

Draw the block diagram of the armature-controlled d.c motor and derive its transfer function $\theta_m(s)/V_a(s)$ where $\theta_m(s)$ and $V_a(s)$ are the Laplace transform of the angular displacement $\theta_m(t)$ and the motor voltage $V_a(t)$ respectively.

(25 marks)

Q3 (a) Name and sketch the three responses for a second order system.

(6 marks)

(b) A control system is shown in Figure Q3. If the reference input r(t) is a unit step function, derive the expression for its output response c(t). Hence determine:

i. The rise time tr.
ii. The peak-time t_p.
iii. The maximum overshoot and percentage overshoot.

Sketch the output response c(t). (19 marks)

Q4 By using the general rules for sketching a root locus, sketch the root locus for a control system as shown in Figure Q4.

(16 marks)

From the root locus

(a) Determine the range of K so that the system response will be over-damped.

(3 marks)

(b) Obtain the value of K so that the response is critically damped.

(3 marks)

(c) Determine the range of K so that the response is under-damped

(3 marks)

Q5. The open-loop transfer function of a unity feedback control system is given by

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

Design a lead compensator which gives $\omega_n = 4$ rad/sec and $\zeta = 0.5$.

(a) Obtain the closed-loop transfer function and the poles of the uncompensated system.

(4 marks)

(b) Obtain the desired poles if the lead compensator has been added.

(2 marks)

(c) Obtain the angle of the compensator in the desired pole.

(5 marks)

(d) Obtain the poles and zeros of the compensator.

(9 marks)

(e) Obtain the gain of the compensator and hence give the transfer function of the compensator

(5 marks)

-END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION: I/2012/2013
COURSE: CONTROL SYSTEM THEORY/
CONTROL SYSTEM

PROGRAMME : BEE/BEH
COURSE CODE: BEH 30603/ BEE 3143

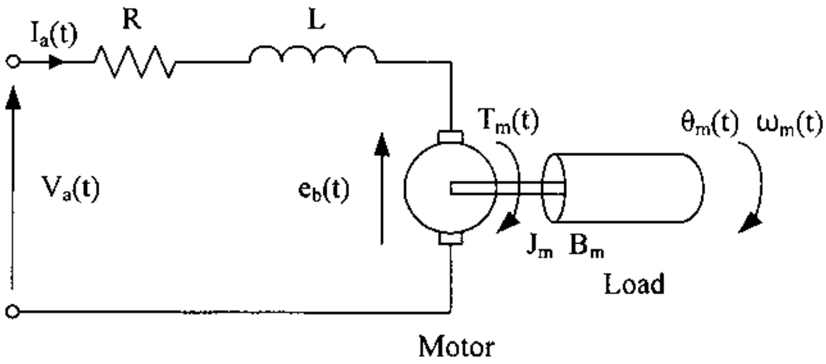

FIGURE Q2

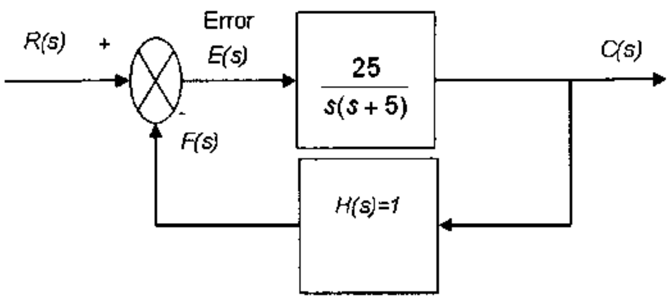

FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION: I/2012/2013
COURSE: CONTROL SYSTEM THEORY/ CONTROL SYSTEM

PROGRAMME : BEE/BEH
COURSE CODE: BEH 30603/ BEE 3143

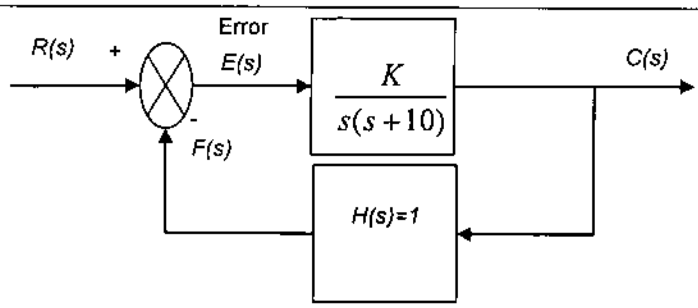

FIGURE Q4

FINAL EXAMINATION

SEMESTER/SESSION: I/2012/2013
COURSE: CONTROL SYSTEM THEORY/ CONTROL SYSTEM

PROGRAMME : BEE/BEH
COURSE CODE: BEH 30603/ BEE 3143

Table 1: Laplace transform table

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{s+a}$
$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$
$e^{-at} \sin \omega t u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at} \cos \omega t u(t)$	$\frac{s+a}{(s+a)^2+\omega^2}$

FINAL EXAMINATION

SEMESTER/SESSION: I/2012/2013
COURSE: CONTROL SYSTEM THEORY/ CONTROL SYSTEM

PROGRAMME : BEE/BEH
COURSE CODE: BEH 30603/ BEE 3143

Table 2: Laplace transform theorems

Name	Theorem
Frequency shift	$\mathscr{L}\left[e^{-at}f(t)\right]=F(s+a)$
Time shift	$\mathscr{L}\left[f(t-T)\right]=e^{-sT}F(s)$
Differentiation	$\mathscr{L}\left[\dfrac{d^n f}{dt^n}\right]=s^n F(s)-\sum_{k=1}^{n} s^{n-k} f^{k-1}(0^-)$
Integration	$\mathscr{L}\left[\int_{0^-}^{t} f(\tau)d\tau\right]=\dfrac{F(s)}{s}$
Initial value	$\lim_{t\to 0} f(t)=\lim_{s\to\infty} sF(s)$
Final value	$\lim_{t\to\infty} f(t)=\lim_{s\to 0} sF(s)$

FINAL EXAMINATION

SEMESTER/SESSION: I/2012/2013
COURSE: CONTROL SYSTEM THEORY/
CONTROL SYSTEM

PROGRAMME : BEE/BEH
COURSE CODE: BEH 30603/ BEE 3143

Table 3: 2nd Order prototype system equations

$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$	$T_r = \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
$\mu_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$	$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$
$T_s = \frac{4}{\zeta\omega_n}$ (2% criterion)	$T_s = \frac{3}{\zeta\omega_n}$ (5% criterion)