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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE	:	CONTROL SYSTEM
COURSE CODE	:	BEX 31603/ BEE 3143
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	APRIL/ MAY 2011
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS PAPER CONSISTS OF NINE (9) PAGES

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Q1 (a) With a proper block diagram, explain briefly an open loop control system and closed loop control system.

(5 marks)

(b) Figure Q1(b) shows a cross-section of a Digital Single Lens Reflex (DSLR) camera. Based on the diagram, explain the basic operation of the camera.

(6 marks)

(c) From your answer in Q1(b), identify the type of control system implemented in the camera and generate the control system block diagram for the DSLR camera.

(8 marks)

(d) List three (3) advantages and three (3) disadvantages of DSLR camera.

(6 marks)

Q2 (a) Determine the transfer function $\frac{C(s)}{R(s)}$ for a system shown in Figure Q2(a) using block diagram reduction technique.

(13 marks)

(b) To design an engine vibration control system, a model of an engine mounted to the car's body is developed as shown in Figure Q2(b).

(i) Derive the differential equation(s) representing the system.

(6 marks)

(ii) Derive the transfer function $\frac{X_b(s)}{X_e(s)}$.

(6 marks)

Q3 (a) The closed loop transfer function for unity feedback system with negative feedback is given by:

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 5s + \omega_n^2}$$

The poles of $\frac{C(s)}{R(s)}$ for underdamped response are given by:

$$s_1, s_2 = \frac{-2\zeta\omega_n \pm \sqrt{4\zeta^2\omega_n^2 - 4\omega_n^2}}{2}$$

The s-plane plot for the system is shown in Figure Q3(a).

(i) Determine the value of α.

(4 marks)

(ii) Calculate rise time, T_r.

(1 marks)

(iii) Calculate peak time, T_p.

(1 marks)

(iv) Calculate overshoot.

(2 marks)

(v) If the system is designed to have $\theta = 60^0$, determine the percentage of increasing overshoot compared to the results in Q3(a)(iv).

(4 marks)

(b) Figure Q3(b) shows a unity feedback system with:

$$G(s) = \frac{120}{s^4 + 14s^3 + 71s^2 + 154s + 120}$$

where K=1.

(i) List down three (3) common test signal and its Laplace representation.

(3 marks)

(ii) Identify the system type.

(1 marks)

(iii) Calculate the steady state error if step input is applied.

(5 marks)

(iv) Find the value of K to give the steady state error of 0.2.

(3 marks)

(v) Find the steady state error for a parabolic input.

(1 marks)

Q4 (a) Figure Q4(a)(i) shows a position control system of a painting robot. The pole-zero plot of the robot dynamics is shown in Figure Q4(a)(ii). Find the value of the gain K of the controller using Routh Hurwitz stability criterion in order to obtain a stable system.

(13 marks)

(b) Draw a Bode plot for a closed loop control system with unity feedback where;

$$G(s) = \frac{200}{(s+2)(s+4)(s+5)}$$

(12 marks)

Q5 (a) List at least one (1) function of Routh Hurwitz stability criterion in sketching root locus.

(2 marks)

(b) The characteristic equation for the unity feedback system with negative feedback is:

$$1+KG(S)H(S)=1+\frac{K(s+3)}{(s+6)(s^2+4s+5)}$$

By using root locus techniques,

(i) Construct its root locus.

(12.5 marks)

(ii) From the root locus calculate the value of K so that the damping ratio is $\zeta =$ 0.422.

(4.5 marks)

(iii) Determine all the closed loop poles for the value of K obtained in Q5 b(ii).

(6 marks)

Q6 A positioning control system of an automatic drill with unity feedback has a plant (process) with the transfer function of:

$$G(s)=\frac{100}{s^3+13s^2+46s+48}$$

and a controller with the gain of K. The system is operated at the damping ratio of 0.5.

(a) A compensator cascading with the process will be added to reduce the steady state error by 50% while the damping ratio is maintained. What kind of compensator is suitable for this purpose?

(3 marks)

(b) Design the compensator. Choose the zero of the compensator equals to 0.1.

(12 marks)

(c) The compensator will be realized using an RC circuit and an amplifier. Calculate the value of each component in circuit of the compensator. Take $C = 1\mu F$.

(10 marks)

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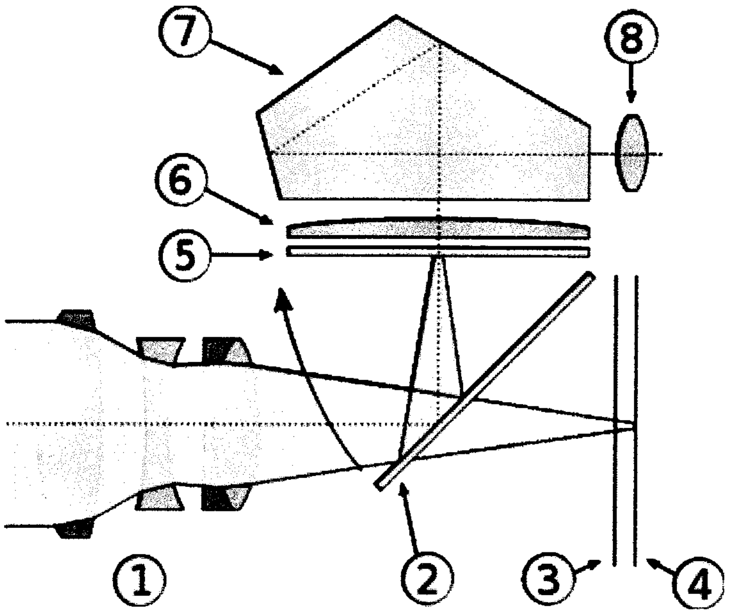

Legend:

1. 4-element lens
2. Reflex mirror
3. Focal-plane shutter
4. Image sensor
5. Matte focusing screen
6. Condenser lens
7. Pentaprism
8. Eyepiece

Figure Q1(b)

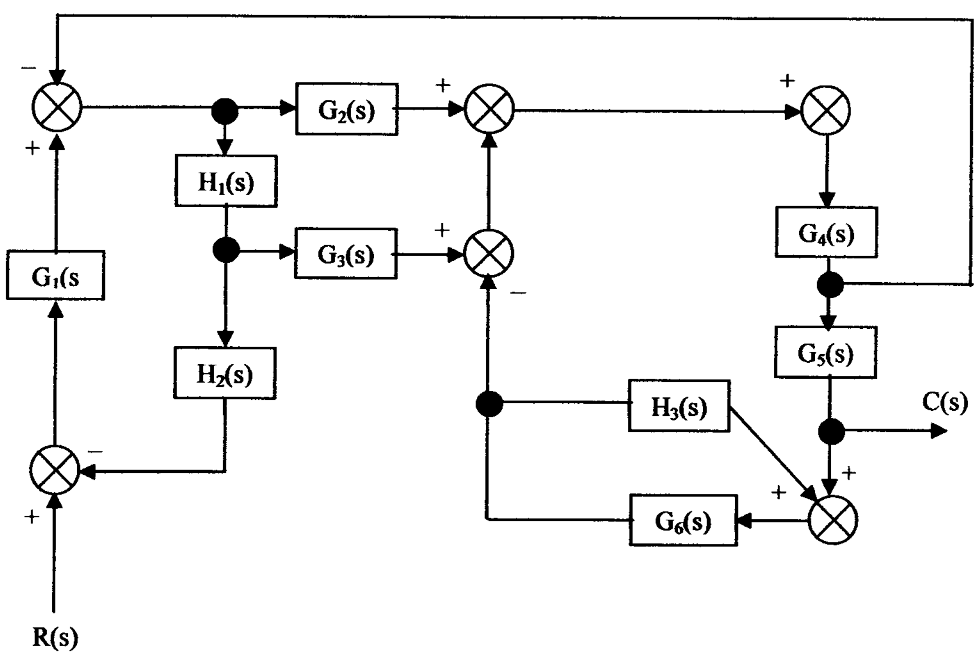

Figure Q2(a)

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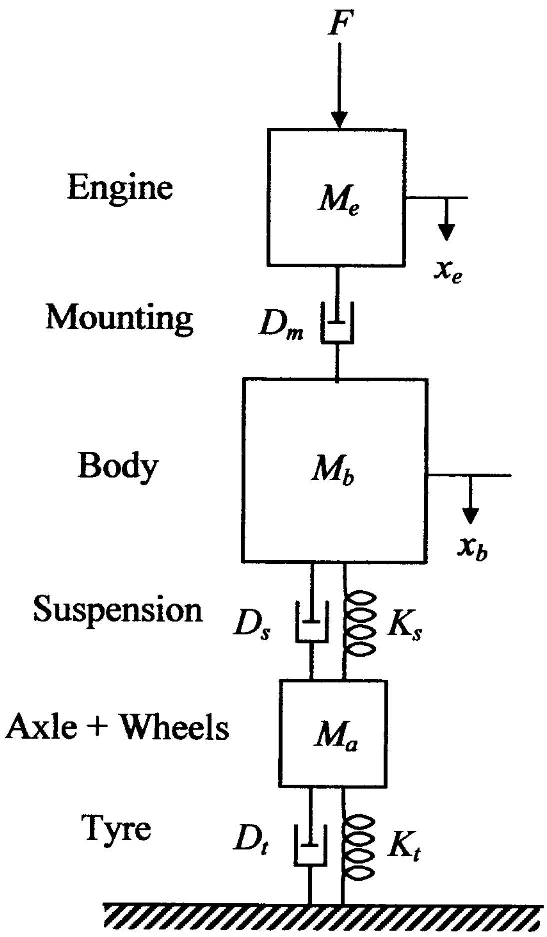

Figure Q2(b)

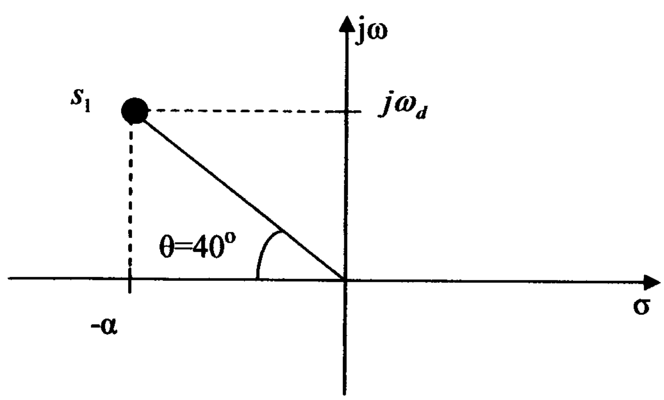

Figure Q3(a)

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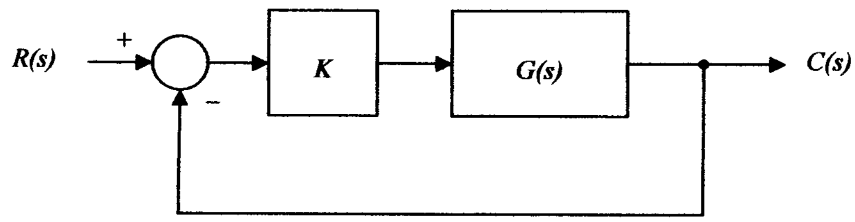

Figure Q3(b)

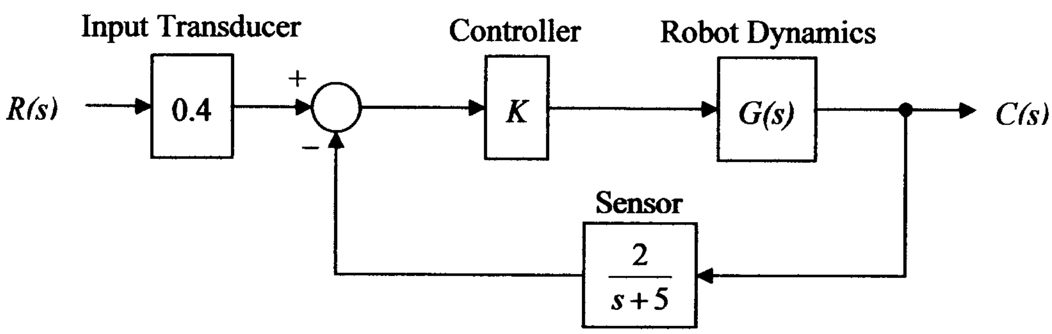

Figure Q4(a)(i)

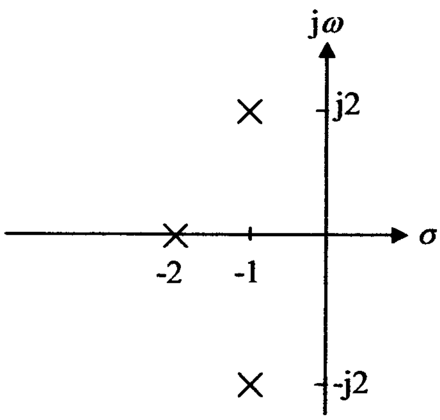

Figure Q4(a)(ii)

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Table 1
Laplace transform table

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

Table 2
Laplace transform theorems

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

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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)