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FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA30703
PROGRAMME	:	BDD
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	1) PART A (OPTIONAL): ANSWER **THREE(3)** QUESTIONS 2) PART B (COMPULSORY): ANSWER **ALL** QUESTIONS

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

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PART A (OPTIONAL):
ANSWER **THREE(3)** OUT OF FOUR QUESTIONS

Q1 (a) State if the following sentences are true or false:

(i) Signal processing elements exist to improve the quality of the output of a measurement system in some way.

(ii) The output of passive instruments is produced entirely by the quantity being measured.

(iii) The output of active instruments is produced by the quantity being measured simply modulates the magnitude of some external power source.

(iv) The static characteristics of measuring instruments are concerned only with the steady-state reading that the instrument settles down to, such as accuracy of the reading.

(v) The dynamic characteristics of a measuring instrument describe its behavior between the time a measured quantity changes value and the time when the instrument output attains a steady value in response.

(vi) The resistive potentiometer is the displacement-measuring device.

(vii) The device for measuring the acceleration is the accelerometer.

(viii) The method of measuring mass is to use a spring balance. (8 marks)

(b) Refer to the Op Amp circuit in **Figure Q1 (b)**. If $v_i = 0.5V$, calculate:

(i) The output voltage, v_O

(ii) The current in $10k\,\Omega$ resistor (6 marks)

(c) Calculate v_o and i_o in the summing amplifier shown in **Figure Q1(c).** (6 marks)

Q2 (a) A basic car auto-cruise system is expected to take over the throttle of a car and maintain a steady speed as set by the driver. Draw a simple block diagram consists listed as below:

Set point and system output

Error signal

Controller and Sensor block

Driving mechanism block

Three samples of disturbances

Feedback path (5 marks)

(b) Block diagram of a feedback control system of an airplane speed control system is shown in **Figure Q2 (b)**. Using the block diagram reduction method, solve for output Y(s) when:

(i) Input D(s) = 0, (7 marks)

(ii) Input R(s) = 0, and (5 marks)

(iii) Input R(s) and D(s) are both applied (i.e., R(s) ≠ 0, D(s) ≠ 0). (3 marks)

Q3 A translational mechanical system is shown in **Figure Q3**. Symbols of *b1, b2* and *b3* are damping coefficients, *k* is spring coefficient and r is external force. The system moves with two displacements *x1* and *x2* as shown in the figure. The input and output of the system are external force, r and displacement *x1*, respectively.

(i) Draw the free body diagram for the system shown in **Figure Q3,** (5 marks)

(ii) Write the equation of motion for the system, (5 marks)

(iii) Obtain the Laplace transform of equation in (ii), assuming zero initial conditions, and (5 marks)

(iv) Sketch the block diagram by using equations in (iii). (5 marks)

Q4 Consider the system with closed loop transfer function as **Figure Q4**.

(i) Determine the open loop poles, zeros, number of branches, angle of asymptotes and the centroid,

(5 marks)

(ii) Calculate the breakaway points (if any) and angle of departure or angle of arrivals (if any),

(5 marks)

(iii) Calculate the intersection point of root locus with $\zeta = 0.45$ and find K value, and

(5 marks)

(iv) Sketch the root locus for the system.

(5 marks)

PART B (COMPULSORY): ANSWER **ALL** TWO QUESTIONS

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

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

(i) Find poles and zeroes, angle and value of asymptotes, breakaway point and draw the root locus. (10 marks)

(ii) Obtain the time constant and the gain K of a proportional controller such that the damping ratio of the closed-loop poles will be equal to 0.707. (5 marks)

(iii) Determine the time constant and the gain K and the location of dominant poles, to have critically damped response. (5 marks)

Q6 (a) Define the stability condition used for Nyquist plot and Bode plot by using a sketch respectively.

(5 marks)

(b) Consider the system with open loop transfer function below.

$$G(s) = \frac{0.1s}{(1 + \frac{s}{10^2})(1 + \frac{s}{10^3})}$$

(i) Write down the zeroes and poles of the transfer function. (2 marks)

(ii) Draw the asymptotic Bode plots (only gain) for each component of the transfer function above. Use frequencies from 100 to 105 rad/sec. Add all the components together to get an asymptotic approximation for the Bode plot of G(s). Finally, plot the phase curve instead of the gain to get more accurate Bode-plot based on the asymptotic approximation.

(13 marks)

- END OF QUESTION –

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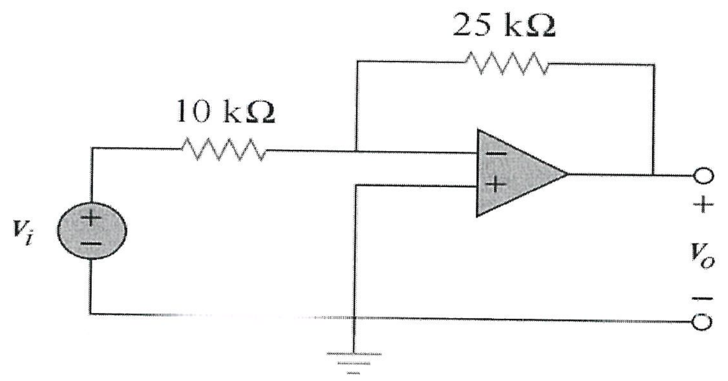

Figure Q1 (b)

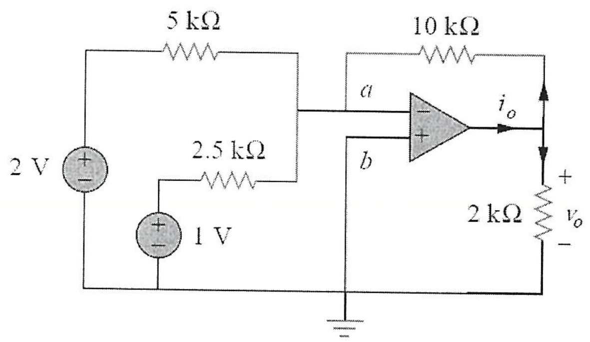

Figure Q1 (c)

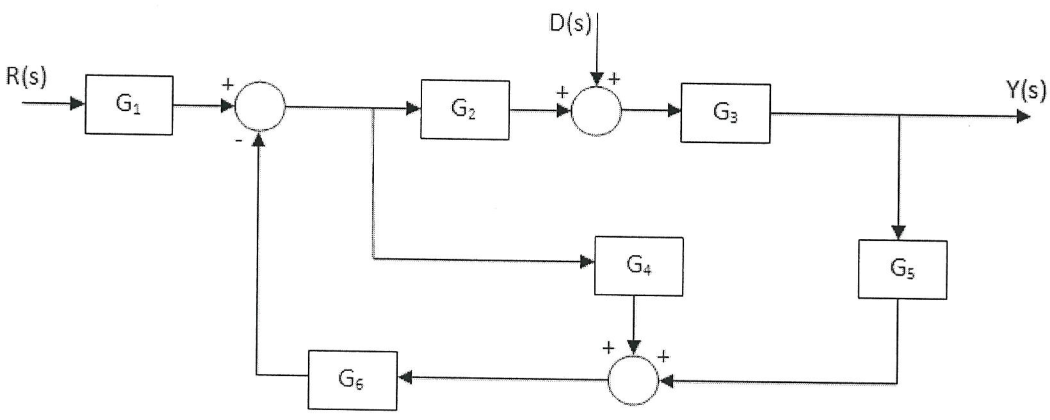

Figure Q2 (b)

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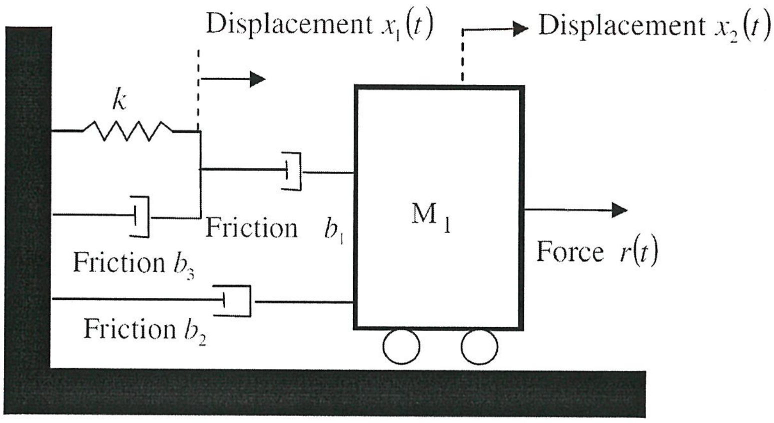

Figure Q3

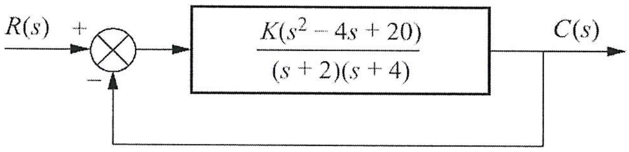

Figure Q4

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REFERENCE

The most commonly used transform pairs

Original	Image
a	$\frac{a}{s}$
t	$\frac{1}{s^2}$
t^2	$\frac{2}{s^3}$
$t^n, n \in N$	$\frac{n!}{s^{n+1}}$
e^{at}	$\frac{1}{s-a}$
te^{at}	$\frac{1}{(s-a)^2}$
t^2e^{at}	$\frac{2}{(s-a)^3}$
$t^ne^{at}, n \in N$	$\frac{n!}{(s-a)^{n+1}}$

Original	Image
$\sin(\omega t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos(\omega t)$	$\frac{s}{s^2+\omega^2}$
$\sinh(\omega t)$	$\frac{\omega}{s^2-\omega^2}$
$\cosh(\omega t)$	$\frac{s}{s^2-\omega^2}$
$t\sin(\omega t)$	$\frac{2s\omega}{(s^2+\omega^2)^2}$
$t\cos(\omega t)$	$\frac{s^2-\omega}{(s^2+\omega^2)^2}$
$e^{at}\sin(\omega t)$	$\frac{\omega}{(s-a)^2+\omega^2}$
$e^{at}\cos(\omega t)$	$\frac{s-a}{(s-a)^2+\omega^2}$

$$C(s) = R(s) \cdot \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}, \quad T = \frac{1}{\left(\zeta - \sqrt{\zeta^2 - 1}\right)\omega_n}$$