Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.TECH(EE)/SEM-5/EE-503/2011-12

2011

CONTROL SYSTEM – I

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

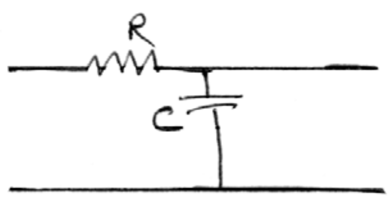
Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

$10 \times 1 = 10$

i) Transfer function of a simple R-C integrator circuit shown in figure is given by



$a = \dfrac{1}{RC}$

a) $\dfrac{1}{s-a}$ b) $\dfrac{1}{s+a}$

c) $\dfrac{a}{s-a}$ d) $\dfrac{a}{s+a}$.

ii) Area under a unit impulse function is

a) infinity b) zero

c) unity d) none of these.

iii) A system has a single pole at origin. Its impulse response will be

a) contrast b) ramp

c) decaying exponential d) oscillatory.

iv) A second order system exhibits 100% overshoot. Its damping coefficient is

a) 0 b) 1

c) < 1 d) > 1.

v) If the Nyquist plot of a certain feedback system crosses the negative real axis at – 0·1 point, the gain margin of the system is

a) 0·1 b) 10

c) 100 d) none of these.

vi) The centre of asymptotes for an open-loop transfer function $G(s) = \dfrac{2(s+2)}{s^2(s+4)}$ is

a) – 1 b) – 3

c) – 4 d) 0.

vii) A slope of 20 dB/decade corresponds to

a) 3 dB/octave b) 6 dB/octave

c) 9 dB/octave d) 20 dB/octave.

viii) A feedback system with the transfer function $G(s) = \frac{6(s+1)(s+6)}{s^3(s+2)(s+4)}$ is a

a) type 5 system
b) type 3 system
c) type 2 system
d) type 0 system.

ix) If the gain of a third order system (all poles) is increased, then the phase margin

a) increases
b) decreases
c) remains same
d) it is not possible to predict.

x) The settling time for an underdamped second order system

a) increases with damping ratio
b) reduces with damping ratio
c) does not depend on damping ratio
d) may increase or decrease with damping ratio.

xi) Without affecting steady-state error, maximum overshoot can be decreased by

a) derivative error control
b) integral error control
c) gain adjustment
d) proportional error control.

xii) A *D* only controller will produce

a) always zero steady state error

b) always infinite steady state error

c) output only if error changes

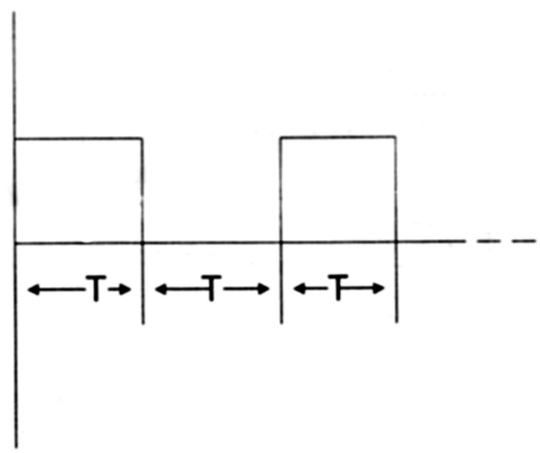
d) none of these.

GROUP – B

(Short Answer Type Questions)

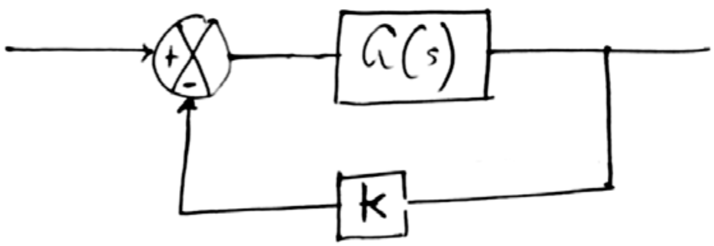
Answer any *three* of the following $3 \times 5 = 15$

2. Obtain the Laplace Transform for the signal shown in figure below :

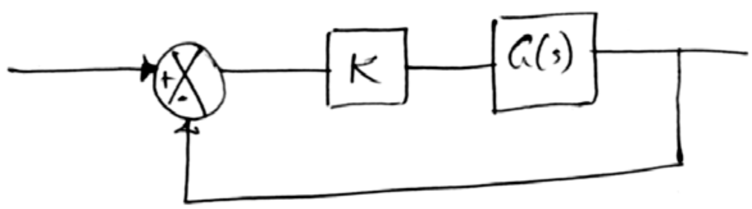


3. A system is defined by $G(s) = \dfrac{k}{s(Ts+1)}$. Calculate the steady state position and velocity error due to a unit ramp input and hence the loop gain to reduce the error by 10%. 2 + 3

4. If $G(s) = \dfrac{W_n^2}{s^2 + 2\xi W_n s + W_n^2}$ is an underdamped second order system, what happens to the peak overshoot of the closed loop system shown in figure below, if the gain k is increased. Substantiate your answer. Assume $k > 0$



How does the peak overshoot change for the same value of k if the configuration is as shown in figure



3 + 2

5. A system is defined by the transfer function $G(s) = \dfrac{k}{(T_1 s + 1)(T_2 s + 1)}$, $T_1, T_2 > 0$. Prove mathematically that the system will be stable.

6. A system is defined by $G(s) = \dfrac{5(1 - 0 \cdot 1s)}{(0 \cdot 2s + 1)(s + 1)}$. Calculate the corner frequencies and the slopes of the asymptotes.

7. For the system defined by $G(s) = \dfrac{k}{(Ts+1)}$ calculate the steady state error due to a unit step input with a PI controller.

8. Define gain margin. What happens to the phase of the system at a particular frequency if the system gain is changed ? Does phase margin change with system gain ?

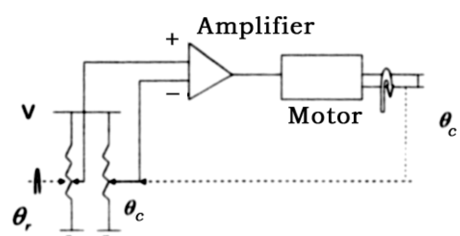
2 + 1 + 2

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

9. Prove that for an underdamped second order system defined by $G(s) = \dfrac{\omega_n^2}{(s^2 + 2\xi\omega_n s + \omega_n^2)}$, the peak overshoot due to a unit step input depends on the damping ξ only. What is the locus of constant ω_n roots ? Symbols carry usual significance. 10 + 5

10. For the DC position control system shown in the figure below draw the signal flow graph assuming the motor to be in the armature controlled mode with armature resistance r_a and inductance L_a and inertial and damping constants J_m and F_m. Assume the amplifier gain to be K_a, the potentiometer gains to be K_p V/radians and appropriate motor emf and torque constants. Hence derive the transfer function $Q_c(s)/Q_r(s)$.



11. Using Routh-Hurwitz Stability Criterion determine the maximum feedback gain K for which the closed loop system will be stable if the open-loop transfer function is $G(s) = \dfrac{5(1-0\cdot 2s)}{(s^2+3\cdot 2s+4)}$. Calculate the frequency of oscillation at this gain.

12. For the system defined by $G(s) = \dfrac{10}{s(0\cdot 1s+1)(0\cdot 05s+1)}$ draw the asymptotic gain and phase plots and calculate the gain and phase margins. What is the output of the system at steady-state if a step of 2 units is applied as an input at $t = 0$? 12 + 3

13. For the system defined by $G(s)H(s) = \dfrac{(1+4s)}{s(s+1)(2s+1)}$ draw the Nyquist plot and hence comment on the stability of the closed loop system.

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