BIRZEIT UNIVERSITY

Department of Mechanical and Mechatronics Engineering
Control Theory ENME438
Final exam, Time: 11 – 01:30 pm, January 18, 2016, Total marks: 40 marks
First Semester 2015/2016

Name: **ID Number:**

This exam serves to the following ABET outcomes:

(a) Ability to apply mathematics, science and engineering principles (Q.1, Q.2).
(e) Ability to identify, formulate and solve engineering problems (Q.3, Q.4, Q.5).

Q.1. If the circuit shown in Figure. 1 is a proportional-integral-derivative (PID) controller,

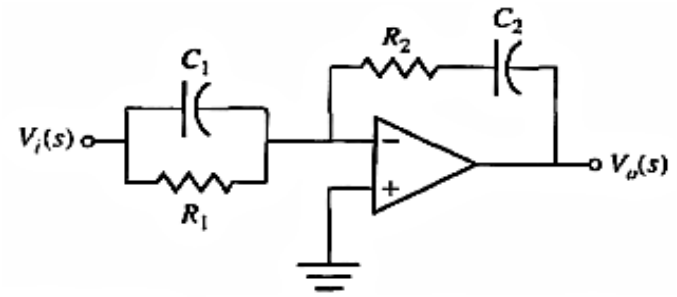

Figure-1 Inverting Operational Amplifier

1. Find the transfer function of the circuit (V_o(s) / V_i(s)). **4 Marks**
2. Show that the transfer function can be expressed as. **3 Marks**

$$G(s) = \frac{V_o}{V_i} = K_P + \frac{K_I}{s} + K_D s$$

where the gains K_P, K_I and K_D are functions of C_1, C_2, R_1 and R_2.

Q.2. For the system shown in Figure 2:

1. Find K_p, K_v and K_a. **3 Marks**
2. Find steady state error for an input of 50u(t), 50tu(t) and 50 t^2u(t). **3 Marks**
3. State the system type. **1 Mark**

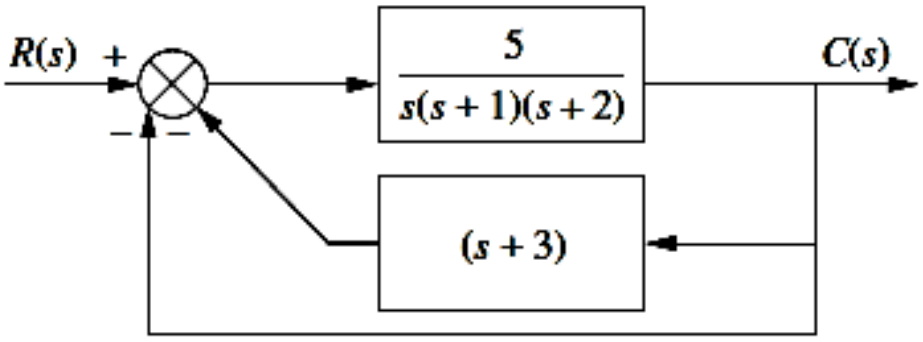

Figure-2 Control System

Q.3. Figure 3 shows mechanical rotational system. Find N_1 / N_2 so that the settling time for a step torque input is 16 seconds.

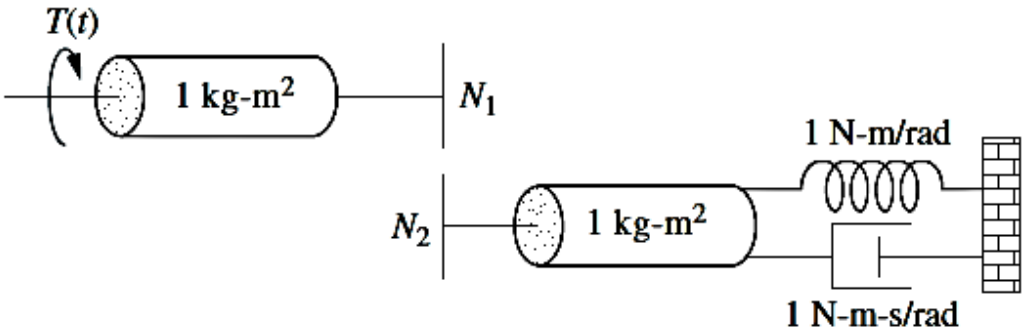

Figure-3 Rotational Mechanical System

8 Marks

Q. 4. Using Root-Locus method; design phase-lead compensator for the unity feedback system shown in Figure 4.

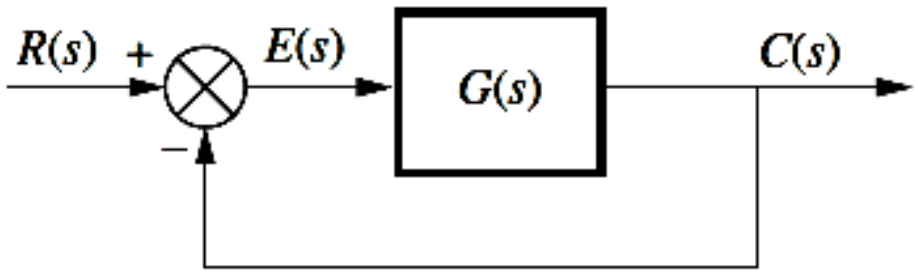

Figure-4 Unity Feedback System

The system is given by G (s) = $\frac{K_1}{S^2}$; where the desired specifications to be as follows:

1. Settling Time, $T_s \leq 4$ sec.
2. Percent Overshoot, $P.O. \leq 35\%$.
3. Place the zero of the compensator at -1.

10 Marks

Q.5. Using attached Bode Plot sketch paper; sketch the Bode Plot (Magnitude and Phase angle) for:

$$TF = \frac{100 \times 10^3 (s+1)}{(s+10)(s+1000)}$$

Make sure to place the break frequency clearly on the sketch paper for full mark

8 Marks