Program: B.Sc in Mechanical Engineering
Semester: 8th Semester

Date: 20 February, 2023
Time: 2:00 pm – 3:30 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester: Mid Semester Examination
Course Number: MCE 4807
Course Title: Mechatronics

Summer Semester: 2021 - 2022
Full Marks: 75
Time : 1.5 Hours

There are 3 **(THREE)** questions. Answer all 3 **(THREE)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. Formula is provided at the end of this question paper. Show all steps and calculations.

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1. a) Figure 1 shows an example of a mechatronics system illustrating different manufacturing process activities. Discuss the technologies that defined a mechatronic system such as in the following example. **(15 Marks) (CO 1)(PO 1)**

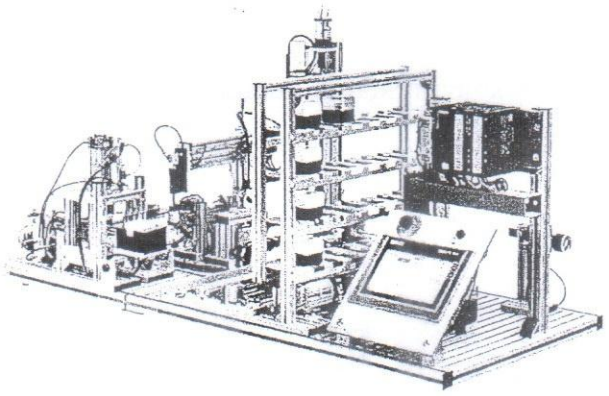

Figure 1: An example of a mechatronics system in manufacturing
(https://www.christiani-international.com)

b) A mechatronic system is often exposed to external disturbance forces such as illustrated in Figure 2 that can trigger inaccurate motions and reduction in system performance.
Discuss methods that can be applied to compensate this disturbance related errors. **(10 Marks) (CO 1)(PO 1)**

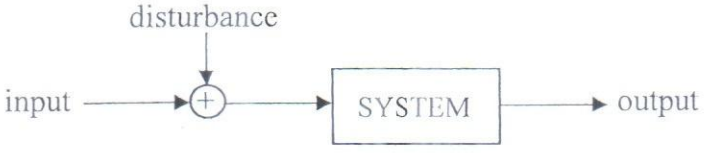

Figure 2: Block diagram of a system with an input disturbance

2. a) An electrical circuit is shown in Figure 3. Write the voltage equations for each mesh. Solve for the transfer function relating input voltage to voltage drop across the inductor. **(10 Marks) (CO 2)(PO 2)**

2.

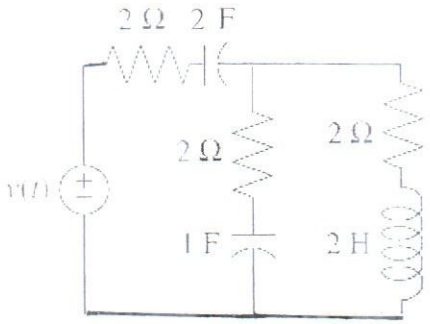

Figure 3: An electrical circuit

b) A DC motor develops 40Nm of torque at a speed of 100rad/s when applied with a 5 volts of input voltage. The motor stalls with 80Nm of torque. Figure 4 shows a schematic diagram of the motor-load configuration. Solve for the transfer function $G(s)=\frac{\theta_L(s)}{E_a(s)}$. Given: **(15 Marks) (CO 2)(PO 2)**

Armature inertia, J_a = 5 kgm^2; armature damping, D_a=1Nms/rad

Load inertia, J_L = 8 kgm^2; load damping, D_L=4Nms/rad

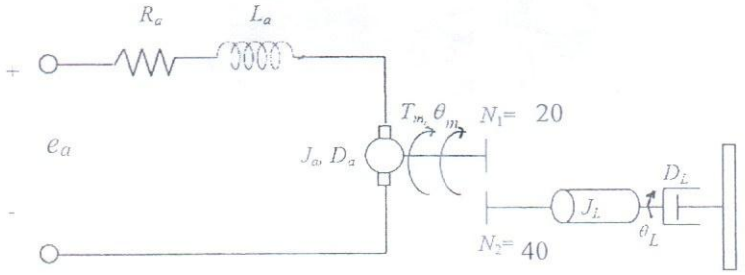

Figure 4: An electromechanical circuit

3. a) Discuss relation between damping ratio and percentage overshoot (%OS) with an aid of a graph. **(10 Marks) (CO 2)(PO 2)**

b) A second order system of a mechatronics system exhibits the following transient response characteristics for a step input of 4 volts: **(10 Marks) (CO 2)(PO 2)**

% overshoot = 10%

Settling time = 2 sec.

Peak time = 0.4 sec.

Rise time = 0.1 sec.

Sketch the step response of this system.

c) Suggest a control design approach that will improve the speed of response for the system in Q3-b. Justify your suggestion. **(5 Marks) (CO 2) (PO 2)**

FORMULA SHEET

$$\frac{\theta_m(s)}{E_a(s)}=\frac{K_t/(R_aJ_m)}{s\left[s+\frac{1}{J_m}(D_m+\frac{K_tK_b}{R_a})\right]} \qquad T_m=-\frac{K_bK_t}{R_a}\omega_m+\frac{K_t}{R_a}e_a$$