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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

FIFTH SEMESTER B.TECH. (INSTRUMENTATION AND CONTROL ENGG.)

END SEMESTER EXAMINATIONS, DEC 2016/JAN 2017

SUBJECT: SYSTEM MODELLING AND SIMULATION [ICE 319]

Duration: 3Hrs Max. Marks: 50

Instructions to Candidates:

- Answer **any five full** questions.
- Missing data may be suitably assumed.

1. a) Obtain the transfer function X1(s)/U(s) and X2(s)/U(s) for the mechanical system shown in figure Q1(A). (4)

b) Consider m1=m2=1kg, k1=k2=k3=300 N/m, b=30 N-s/m in figure Q1(A). Then: (2)
1) Write the MATLAB Code for obtaining transfer function $X_1(s)/U(s)$.
2) Write the MATLAB Code for converting thus obtained transfer function model into State space representation.

c) Find the linearized transfer function, G(s) =V(s)/I(s), for the electrical network shown in figure Q1(C). The network contains a non-linear resistor whose voltage-current relationship is defined by $i_r=e^{vr}$. The current source, i (t), is a small-signal generator. (4)

2 a) Write the electrical analogous of Mass, Spring and Dashpot in Force-Current Analogy. Draw the force-Current analogous electrical circuit for the mechanical system shown in figure Q2(A). Write the mathematical equations of the obtained electrical analogous circuit. (5)

b) Draw the schematic of an armature controlled DC Motor and derive its transfer function. (5)

3. a) Consider the liquid level system shown in figure Q3 (A). In the system, Q_1 and Q_2 are steady-state inflow rates H_1 and H_2 are steady-state heads. The quantities q_{i1}, qi_2, h_1, h_2, q_1, and q_o are considered small. Obtain a state-space representation for the system when h_1 and h_2 are the outputs and q_{i1} and q_{i2} are the inputs. (5)

b) Consider a thin, glass-wall, mercury thermometer system shown in figure Q3(B). Assume that the thermometer is at a uniform temperature $\boldsymbol{\theta}$ (ambient temperature) and that at t = 0 it is immersed in a bath of temperature $\boldsymbol{\theta} + \theta_b$, where θ_b is the bath temperature (which may be constant or changing) measured from the ambient temperature $\boldsymbol{\theta}$. Define the instantaneous thermometer temperature by $\boldsymbol{\theta}+\theta_a$ so that θ_a is the change in the thermometer temperature satisfying the condition that $\theta_a(0) = 0$. Obtain a mathematical model for the system. Also, obtain an electrical analog of the thermometer system. (5)

4. a) Consider the mechanical system shown in figure Q4(A). If m=10kg, b =30 N-s/m, k= 500 N/m, P=10N and ω=2rad/. What is the steady-state output x(t)? The displacement x is measured from the equilibrium position before the input p(t) is applied. (5)

b) Define Transmissibility and obtain the expression for transmissibility for the automobile suspension system shown in figure Q4 (B). (5)

5. a) Briefly explain about the different control surfaces of an aircraft. (3)

b) Derive the rotation matrix for transforming earth axis system to body axis system. Express the weight vector of an aircraft in the body axis system. (5)

c) An aircraft's attitude varies in roll, pitch, and yaw as defined in figure. Q5(C). Draw a functional block diagram for a closed-loop system that stabilizes the roll as follows: The system measures the actual roll angle with a gyro and compares the actual roll angle with the desired roll angle. The ailerons respond to the roll angle error by undergoing an angular deflection. The aircraft responds to this angular deflection, producing a roll angle rate. Identify the input and output transducers, the controller, and the plant. (2)

6 a) Obtain the transfer function X(s)/θ(s) for a ball and beam system, where x is the position of ball on the beam and θ is the beam angle. Consider both rotational and translational motion of the ball. (4)

b) Figure. Q6(B) shows the schematic of an inverted pendulum system with cart where the pendulum is constrained to move in the vertical plane. For this system, the control input is the force F that moves the cart horizontally.(M is the total mass of the system and m the mass of the inverted pendulum, I is the moment of inertia of the inverted pendulum). Considering only the angular position of the pendulum as the output, obtain the transfer function of this system (3)

c) Obtain the state space model of the above system considering the angular position of the pendulum θ and the horizontal position of the cart x as the outputs. (3)

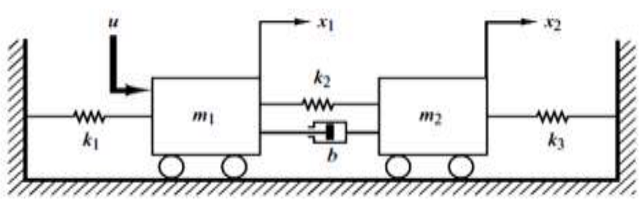

Figure:Q1(A)

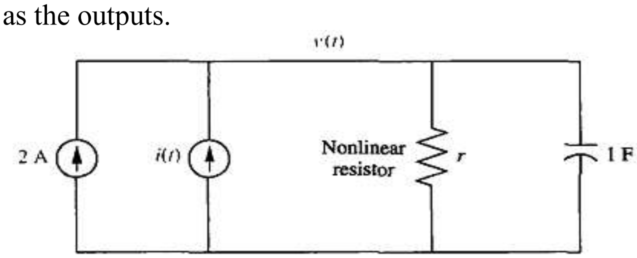

Figure: Q1(C)

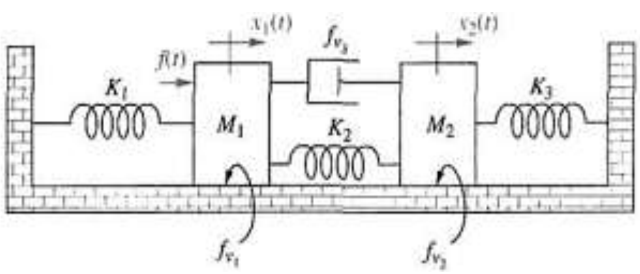

Figure: Q2(A)

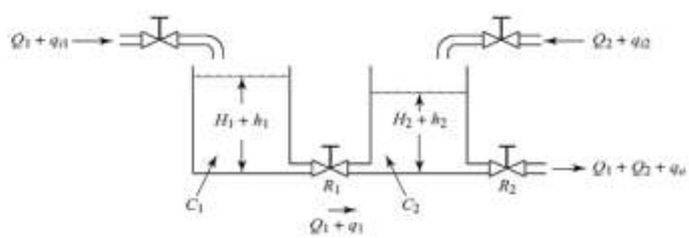

Figure: Q3(A)

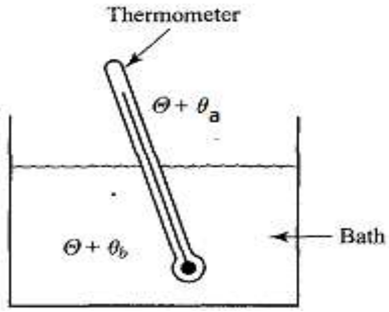

Figure: Q3(B)

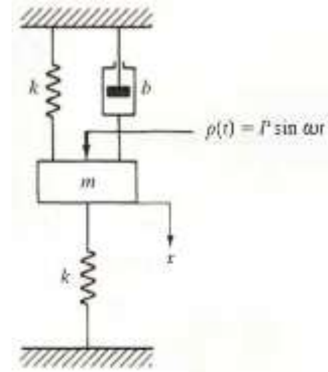

Figure:Q4(A)

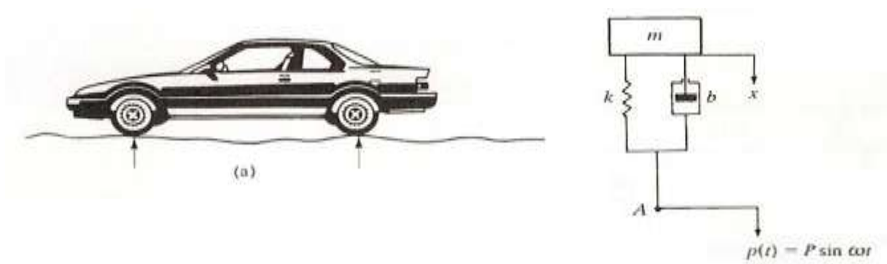

Figure: Q4 (B)

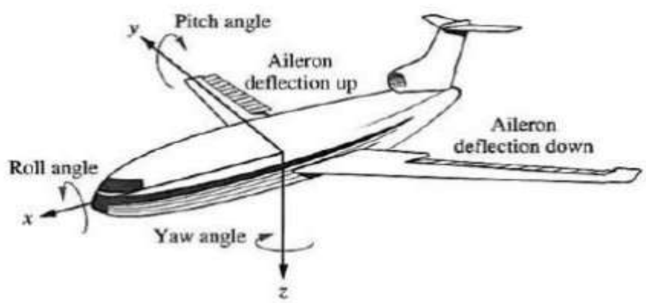

Figure: Q5(C)

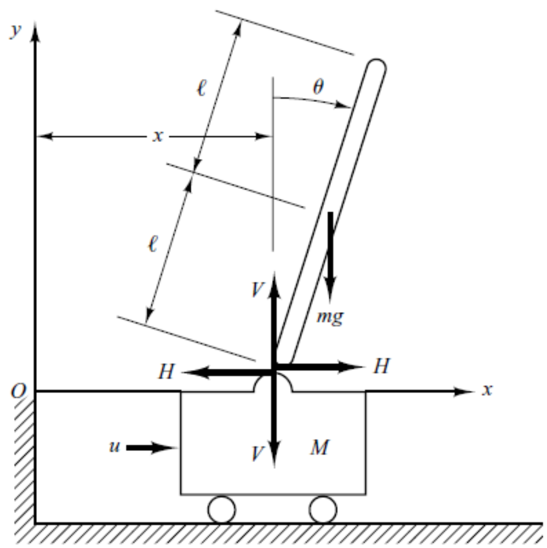

Figure: Q6(B)