12/6/07 ME (mech)(machine Design) PTDC

Con. 3345-07. Sem III System modeling & Analysis – master **BB-1657**

(4 Hours) **[Total Marks : 100**

N.B. (1) Attempt any **five** questions.
(2) Assume any unspecified data if **required**.

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1. (a) According to Newton's law of cooling, the rate at which the temperature of a body changes is proportional to the difference between the instantaneous temperature of the body and the temperature of the surrounding medium. If a body whose temperature is initially 100 °C is allowed to cool in air which remains at the constant temperature 20 °C and if it is observed that is 10 min. the body has cooled to 60 °C, find the temperature of the body as a function of time. **12**

(b) Evaluate each complex function at the indicated value of S and determine its magnitude and phase. **8**

(i) $G(s) = \dfrac{(s+2)}{(s^2+s+1)}$ when $s = j2$

(ii) $F(s) = \dfrac{1}{s^2+3s+2}$ when $s = j2$.

2. (a) Governing differential equation is given as : **8**

$$\ddot{y} + 4y = f(t) \quad \text{with} \quad y(0) = \dot{y}(0) = 0$$

where $f(t) = 0,\ t < 2$
$\qquad\quad = t,\ t \geq 2$

Solve using L.T. method.
State the theorems clearly.

(b) The governing equation for a first order dynamic system is given as $\dot{x} + 2x = \delta(t-1)$. Assuming that the system is subjected to zero initial conditions, determine the response x(t). Roughly sketch the graph of the response curve. **6**

(c) Repeat the problem Q. 2(b) for $\dot{x} + x = u(t-1)$ subjected to zero initial conditions. **6**

3. (a) Define system dynamics. **2**

(b) Describe the significance of system modelling in engineering design. Explain the steps involved in the modelling of a physical system. **6**

(c) Solve the differential equation **12**

$$\ddot{y} + 4\dot{y} + 13y = \frac{1}{3}e^{-2t}\sin 3t$$

for which $y(0) = 1$ and $\dot{y}(0) = -2$.

4. (a) Determine the inverse Laplace transform of **8**

$$F(s) = \frac{2}{(s+3)(s^2+2s+5)}$$

Using (i) Partial Fraction Method
(ii) Convolution Method.

(b) A mechanical system experiencing translational and rotational motion is given by **5**

$$J\ddot{\theta} + B\dot{\theta} + K\theta + Rk(R\theta - x) = Ru(t)$$

$$m\ddot{x} + b\dot{x} - k(R\theta - x) = 0$$

Where J, K, B, R, m, k, and b denote parameters and are regarded as constants. x and θ represent displacement and angular displacement, respectively and u(t) is an applied force. Express the equations in second order matrix form.

(c) Governing differential equation is given as **7**

$$2\ddot{x} + 3\dot{x} + x = f(t)$$

Obtain a state space form.

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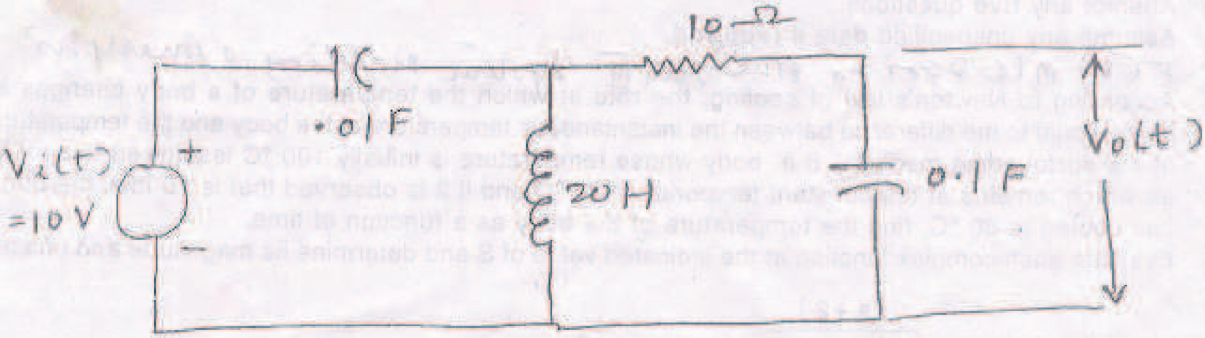
5. (a) Find the state-space relation for the electric network shown below. Output is $V_0(t)$ **10**

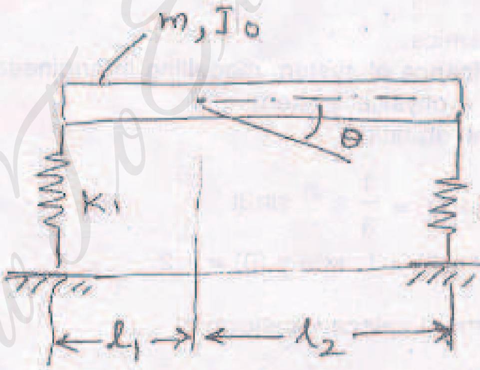


(b) Relate various parameters of a mechanical system to analogous electrical system using voltage force analogy. Name the law governing each system. **5**

(c) Define : **5**

(i) State of dynamic system
(ii) State variable
(iii) State space
(iii) State equation
(iv) Output equation.

6. (a) A machine having mass m = 1500 kg and a mass moment of inertia of J_0 = 400 kg m² is supported on elastic supports as shown in **figure**. If the stiffness of supports are K_1 = 2800 N mm⁻¹ and k_2 = 2100 N mm⁻¹, and the supports are located at l_1 = ·4 m and l_2 = ·5 m, determine the natural frequencies and mode shapes of the machine tool. **12**



(b) Explain the significance of :

(i) Elasticially conjugate points
(ii) Dynamically conjugate points
(iii) Doubly conjugate points.

7. (a) Consider a dynamic system with input f(t) and output x_1, whose state variable equations are **10**

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = [-3x_2 - 2x_2 + f(t)]$$

Directly from these equations, determine input-output equation.

(b) Determine the transfer function for the single degree of freedom mechanical system shown in **figure** below using its state-space form. **10**