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Program: B.Sc. in ME(5th)/IPE(5th) /BScTE-1st/2Y

Date: 05 December, 2023
Time: 09:00 a.m.– 12:00 p.m.

Semester: Winter

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Final Semester Examination
Course Number: ME 4503
Course Title: Mechanics of Machines

Winter Semester: 2022 - 2023
Full Marks:150
Time: 3.0 Hours

There are 6 (**Six**) questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. Assume reasonable value for missing data. Use graph for **Question 1.**

1. A shaft carries four masses in parallel planes **A, B, C** and **D** in this order along its length. The masses at B and C are 20 kg and 15 kg respectively, and each has an eccentricity of 80 mm. The masses at A and D have an eccentricity (radii) of 100 mm. The angle between the masses at B and C is 120° and that between the masses at B and A is 170°, both being measured in the same direction. The axial distance between planes A and B is 100 mm and that between B and C is 300 mm. If the shaft is in complete dynamic balance. Find the following graphically with required calculations and necessary figures: **(25) (CO4) (PO3)**

i) the magnitude of the masses at A and D.
ii) the distance between planes A and D.
iii) the angular position of the mass at D.

2. A 4-cylinder engine and flywheel coupled to a propeller are approximated to a 3-rotor system in which the engine is equivalent to a rotor of moment of inertia 850 kg-m^{2,} the flywheel to a second rotor of 320 kg-m^2 and the propeller to a third rotor of 30 kg-m^2. The first and the second rotors being connected by a 50 mm diameter and 2-metre-long shaft and the second and the third rotors being connected by a 25 mm diameter and 1.5-meter-long shaft. Neglecting the inertia of the shaft and taking its modulus of rigidity as 80 GN/m^2, determine with necessary figures: **(20) (CO5) (PO2)**
i) Natural frequencies of torsional oscillations in Hertz,
ii) The positions of the nodes in all possible cases.

3. a) Draw the displacement schedule for a follower that rises through a total displacement of 50 mm with constant acceleration for 90° of rotation and constant deceleration for 45° of cam rotation. The follower returns 35 mm with simple harmonic motion in 90° of cam rotation and dwells for 45° of cam rotation. It then returns the remaining 15 mm with simple harmonic motion during the remaining 90° of cam rotation. **(25) (CO6) (PO3)**

b) A cam, with a minimum radius of 50 mm, rotating clockwise at a uniform speed, is required to give a knife edge follower the motion as shown in **Fig. 01**. Draw the profile of the cam when the line of stroke of the follower is offset by 15 mm. The displacement of the follower is to take place with uniform acceleration and uniform retardation. **(5) (CO6) (PO3)**

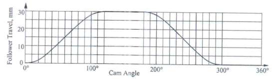

Figure: 01

4. In **Fig. 02** axis y-y is fixed while axis x-x and z-z move with the arm. Gear 7 is fixed to the carrier. Gears 3 and 4, 5 and 6, and 8 and 9 are fixed together, respectively. Gears 3 and 4 move with planetary motion. If the tooth numbers are $N_2 = 16T$, $N_3 = 20T$, $N_4 = 22T$, $N_5 = 14T$, $N_6 = 15T$, $N_7 = 36T$, $N_8 = 20T$, $N_9 = 41T$, and $N_{10} = 97T$, determine the speed and direction of the output shaft. **(25) (CO3) (PO3)**

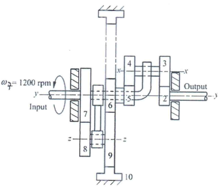

Figure: 02

5. a) Find the equivalent spring constant in terms of d and equivalent mass of the system shown in **Fig. 03**, with references to θ Assume that the bars AOB and CD are rigid with negligible mass. **(13) (CO5) (PO2)**

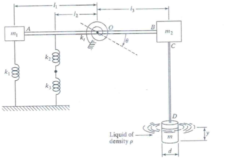

Figure: 03

b) A massless bar of length 1 m is pivoted at one end and subjected to a force F at the other end. Two translational dampers, with damping constants and $c_1 = 10$ N-s/m and $c_2 = 15$ N-s/m are connected to the bar as shown in **Fig. 04.** Determine the equivalent damping constant c_{eq} of the system so that the force F at point A can be expressed as $F = c_{eq}v$, where v is the linear velocity of point A. **(12) (CO5) (PO2)**

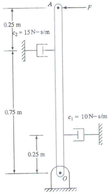

Figure: 04

6. **a)** Derive the general expression for displacement and state the type of damping system for the following vibrating system shown in **Fig 05.** Given, the motion starts from equilibrium with a velocity of 4.5 m/s and m = 5 kg, c = 40 Ns/m, k = 2 kN/m. **(13)** **(CO5)** **(PO2)**

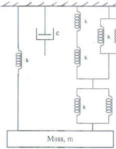

Figure: 05

b) The crate, of mass 250 kg, hanging from a helicopter shown in **Fig. 06(a)** can be modeled as shown in **Fig. 06(b).** The rotor blades of the helicopter rotate at 300 rpm. Find the diameter of the steel cables so that the natural frequency of vibration of the crate is at least twice the frequency of the rotor blades. Assume Young's modulus of steel to be 207×10^9 N/m^2 **(12)** **(CO5)** **(PO2)**

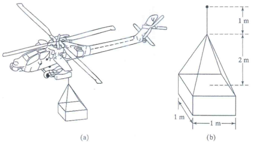

Figure: 06

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