26/20/2025. ME. 245

L-2/T-1/IPE **Date: 26/08/2025**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2023-2024

Sub: **ME 245** (Engineering Mechanics and Theory of Machines)

Full Marks: 280 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SaS

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** including **Q. No 1.**

Question No. 1 is COMPULSORY.

1. (a) Briefly describe the advantages and disadvantages of chain drive system. **(10)**

(b) A spring-mass-damper system as shown in Fig. 1(b) is vibrating freely. Determine its naturally frequency and damping ratio. **(10)**

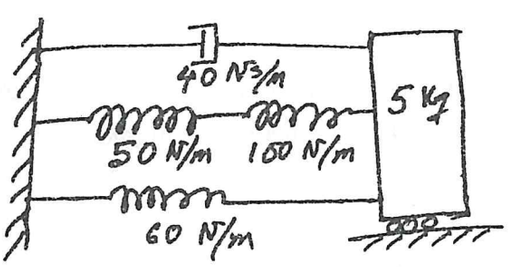

Figure 1(b)

(c) In a mechanism as shown in Fig. 1(c), the crank *AB* rotates about *A* at a uniform speed of 200 rpm. The lever *DC* oscillates about the fixed point *D*, being connected to *AB* by the connecting link *BC*. The block *F* moves, in horizontal guides being driven by the link *EF*. The dimensions of the various links are: **(20)**

AB = 150 mm; *BC* = 450 mm; *CE* = 300 mm; *DE* = 150 mm; and *EF* = 350 mm. For the given configuration. Find (i) velocity of slider *F*, (ii) angular velocity of *DC*, and (iii) rubbing speed at pin *C* which is 50 mm in diameter.

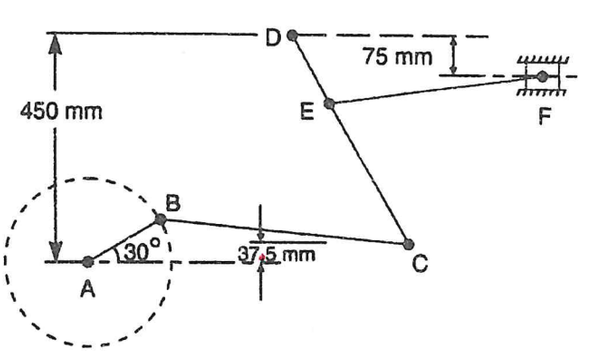

Figure 1(c)

Contd P/2

ME 245/IPE

Contd.... for Q. No. 1

(d) The gears in an epicyclic gear train are arranged as shown in Fig. 1(d). The number of teeth on the gears A and D are 40 and 90, respectively. Determine the number of revolutions made by the arm, when gear A makes one revolution clockwise and gear D makes half a revolution anticlockwise. **(20)**

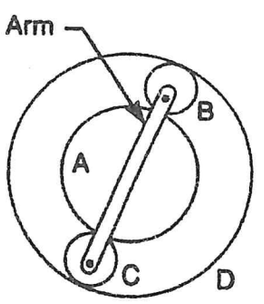

Figure 1(d)

2. (a) A two degrees of freedom undamped vibration system is shown in Fig. 2(a). For free vibration, determine the natural frequencies and amplitude ratios for the normal modes. **(30)**

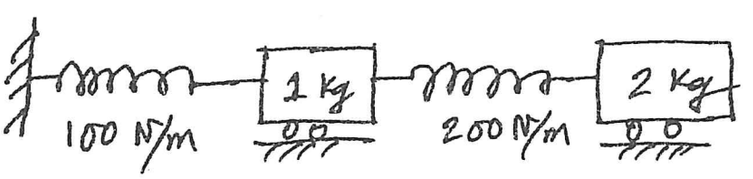

Figure 2(a)

(b) Calculate the whirling speed of a shaft 25 mm diameter and 1.2 m long carrying a mass of 1 kg at its midpoint. Young's modulus of the material is 200 GPa. Neglect the deflection due to its own mass. Assume the shaft to be freely supported. [$\delta_{mid} = \frac{WL^3}{48EI}$]. **(10)**

3. (a) Four masses *A, B, C* and *D* are attached to a shaft and revolve in the same plane. The masses are 15 kg, 10 kg, 20 kg and 15 kg, respectively and their radii of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of masses *B, C* and *D* are 60°, 135° and 270°, respectively from mass *A*. Find the magnitude and position of the balancing mass at a radius of 50 mm. **(20)**

(b) An open belt of width 100 mm connects two pulleys mounted on parallel shafts with their centers 2.4 m apart. The diameter of the larger and smaller pulley is 450 mm and 300 mm, respectively. The coefficient of friction between the belt and the pulley is 0.3 and the maximum tension in the belt is limited to 1400 N. If the larger pulley rotates at 120 rpm, find the maximum power that can be transmitted. **(20)**

Contd P/3

40

4. A cam rotating clockwise at a uniform speed of 800 rpm is required to give a knife edge follower the motion as below: **(40)**

(a) Follower to move outwards through 50 mm during 100° of cam rotation,

(b) Follower to dwell for next 60° of cam rotation,

(c) Follower to return to its starting position during next 80° of cam rotation,

(d) Follower to dwell for the rest of the cam rotation.

The minimum radius of the cam is 50 mm and the line of stroke of the follower is offset by 20 mm from the axis of the cam shaft. If the displacement of the follower takes place with uniform and equal acceleration and retardation on both the outward and return strokes, draw the profile of the cam and find the maximum velocity and acceleration during outstroke and return stroke.

SECTION – B

There are **FOUR** questions in this section. Answer **Q. No. 5** and any **TWO** from the rest. Symbols used have their usual meaning and interpretation. Assume reasonably any missing data. Parts of all the questions must be answered sequentially.

5. (a) Three forces, $\mathbf{F_1} = -2\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}$ N, $\mathbf{F_2} = -5\mathbf{j} + 6\mathbf{k}$ N and $\mathbf{F_3} = 4\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}$ N act on a particle. Find (i) the magnitude and direction of the resultant force, (ii) the fourth force necessary for static equilibrium, (iii) Now suppose, the fourth force is zero and mass of the particle is 1 kg that starts moving under the action of the three forces. Find the kinetic energy of the particle and the distance it travels after 1s (iv) 'The concept of mass moment of inertia can be ignored in this problem'— Briefly justify the statement. **(30)**

(b) (i) With a neat free hand sketch, show a 2D hinge support and a 2D fixed/clamped support. Next, show the forces and or, couples that can be restrained in your drawn supports. (iii) A light bar AB supports a 15-kg block at its midpoint C as shown in Figure for Q.5 b. Rollers at A and B rest against surfaces, and a horizontal cable AD is attached at A. (i) Neatly draw the free diagram of the bar if all surfaces of contact are rough (ii) Simplify the problem assuming smooth or, frictionless surfaces of contact and hence determine the tension in cable AD. **(30)**

6. (a) Determine the force in members FH, GH, and GI of the roof truss shown in Figure for Q.6 a. **(20)**

(b) A rectangular metal sheet is cut at the centre to make a circular opening as shown in the Figure for Q. 6 b. The height, width of the rectangle and the diameter of the hole are h, b and d respectively. Calculate polar moment of inertia and the polar radius of gyration about the upper right corner (point C) of the metal sheet. **(20)**

Contd P/4

ME 245/IPE

7. (a) The elevator shown in Figure for Q.7 a, moves downward with a constant velocity of 4 m/s. Determine (i) the velocity of the cable C (ii) the relative velocity of the counterweight W with respect to the elevator. **(20)**

(b) Two 10° wedges of negligible weight are used to move and position the 400-lb (181.4 kg) block as shown in Figure for Q.7 b. Knowing that the coefficient of static friction is 0.25 at all surfaces of contact, determine the smallest force P that should be applied as shown to one of the wedges. **(20)**

8. (a) A 500-g collar can slide without friction on the curved rod BC in a horizontal plane as shown in Figure for Q.8 a. Knowing that the undeformed length of the spring is 80 mm and that k = 400 kN/m, determine the velocity that the collar should be given at A to reach B with zero velocity. **(20)**

(b) Knowing that at the instant shown in Figure for Q.8 b, the angular velocity of crank AB is 2.7 rad/s clockwise, determine (i) the angular velocity of link BD, (ii) the velocity of the midpoint of link BD. **(20)**

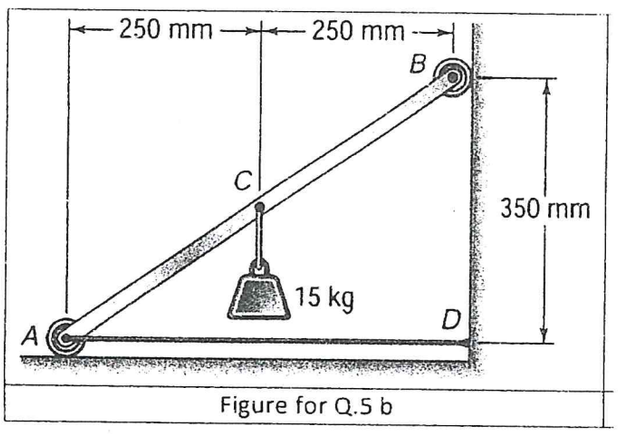

Figure for Q.5 b

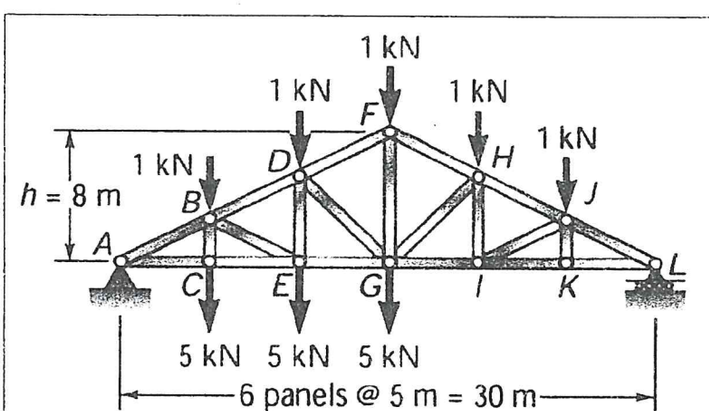

Figure for Q.6 a

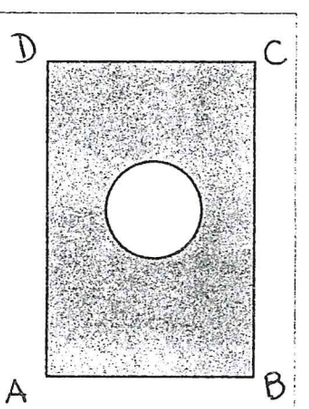

Figure for Q.6 b

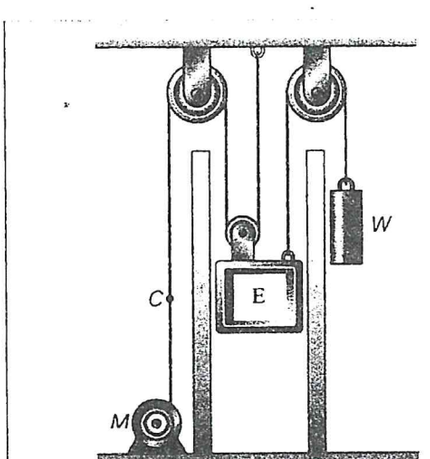

Figure for Q.7 a

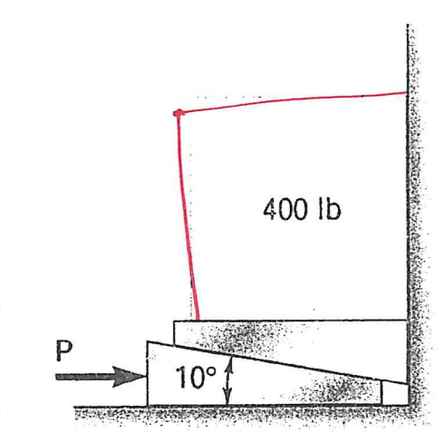

Figure for Q.7 b

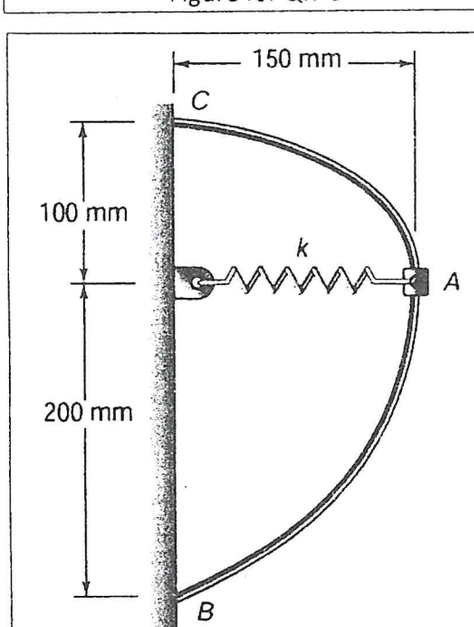

Figure for Q.8 a

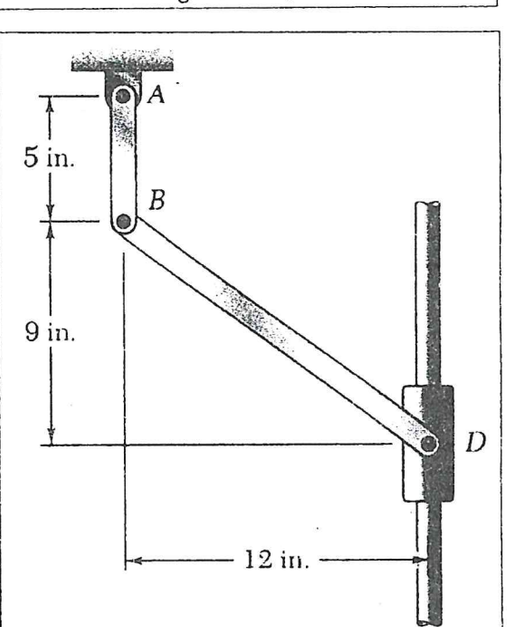

Figure for Q.8 b