

# Indian Institute of Technology Kharagpur

## Department of Mechanical Engineering

Session: Spring, 2012-13

End-Semester Examination

Subject: Kinematics of Machines (ME21008)

Number of students: 178

Time: 3 hours

Marks: 100

**Instruction:** Answer all questions. A clean sheet of tracing paper is allowed.

1. (a) Perform the number synthesis for a planar constrained kinematic chain (one degree of freedom) with 8 links and simple hinges. (b) Draw one kinematic chain from each solution set. (6+9)
2. A 4-bar mechanism is required to be synthesized for generating  $\theta_4 = 0.5\theta_2^2$  over the input angle range  $\pi/6 \leq \theta_2 \leq 2\pi/3$  (rad) (take  $O_2$  at the origin and  $O_4$  on the positive  $x$ -axis), where all symbols have their usual meanings. (a) Derive the Freudenstein's equation. (b) Determine three accuracy points using Chebyshev's method. (c) Determine the link length ratios  $l_2/l_1$ ,  $l_3/l_1$  and  $l_4/l_1$  for the mechanism. (5+5+12)
3. A cam controlled switch uses the mechanism as shown in the initial and final positions in Fig. 1. The range of travel of the cam is  $0^\circ$  to  $180^\circ$ , and the slider motion in this range is  $y = 5[1 - \cos(4\theta/3)]$  mm. The minimum radius of curvature of the cam should be 6 mm and the maximum permissible eccentricity is 5 mm. (a) List the three relevant basic dimensions of the cam-follower system. (b) Determine the basic dimensions. (c) Determine the analytical expressions of the cam profile for the relevant portion in the polar form. (3+10+8)
4. In the gear train shown in Fig. 2, a ground-fixed shaft carries the arm PQ ( $|PQ| = 25$  mm) which carries the two connected gears B and C. The ground-fixed internal gear A has number of teeth  $N_A = 50$ , the internal gear C has  $N_C = 80$ , and all gears have  $m = 5$  mm. (a) Determine the number of teeth  $N_B$  and  $N_D$ . (b) If the arm PQ is given one counter-clockwise turn as shown, determine the amount and direction of rotation of gear D. (3+12)
5. A coin of radius  $r$  is rolling with a constant angular speed  $\omega$  while moving on a circular path of radius  $R$  at a constant inclination  $\phi$ , as shown in Fig. 3. At the configuration shown, determine the homogeneous transformation matrix  ${}^gT_c$  from the coin frame  $x_c y_c z_c$  (axis  $x_c$  is normal to the coin, and  $y_c$  is always horizontal) to the ground fixed frame  $x_q y_q z_q$ . (15)
6. A box is to be received from a conveyor and placed on a trolley by a planar mechanism, as shown in Fig. 4. Given the three positions of the coupler (L-shaped link) and the ground hinges: (a) graphically synthesize a 4R mechanism for the purpose and write down the link lengths, and (b) draw the mechanism in one of the configurations. (Synthesize on the sheet provided and attach with the answerscript) (8+4)

SOLVE HERE AND ATTACH WITH THE ANSWERS SCRIPT

NAME:

ROLL NO.:

$l_2 =$

$l_3 =$

$l_4 =$

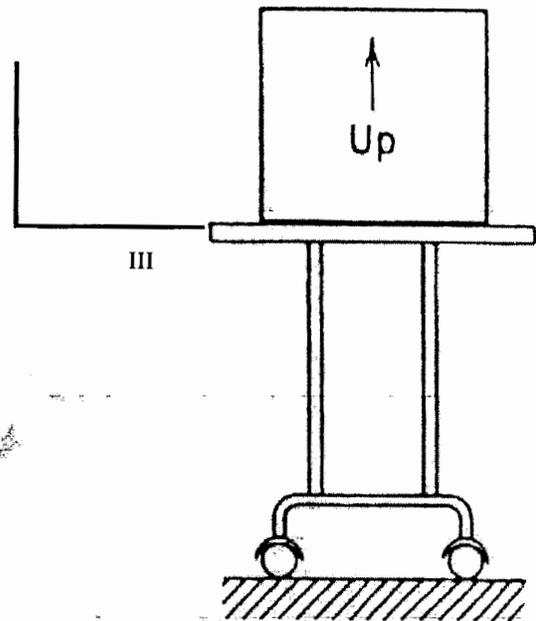
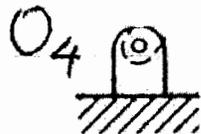
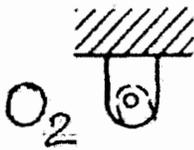
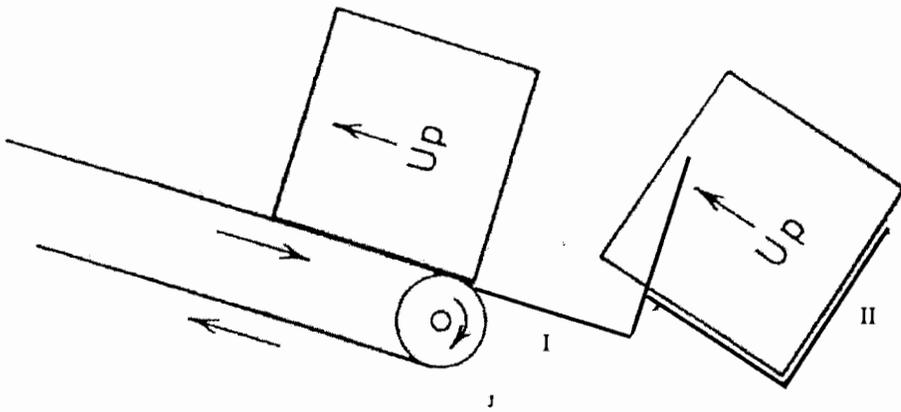


Fig. 4

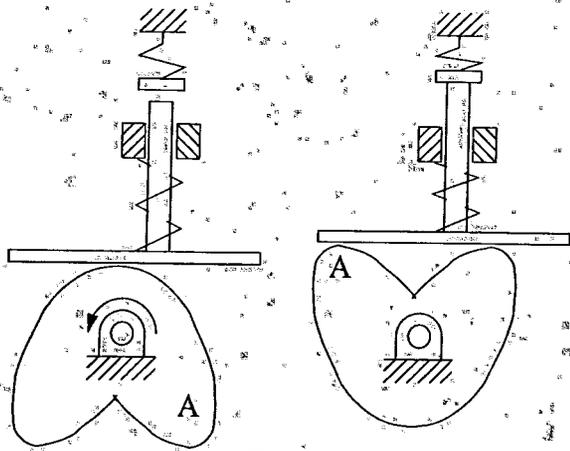


Fig. 1

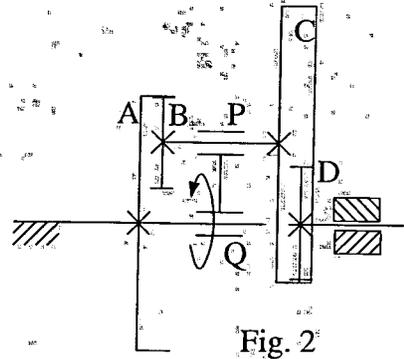


Fig. 2

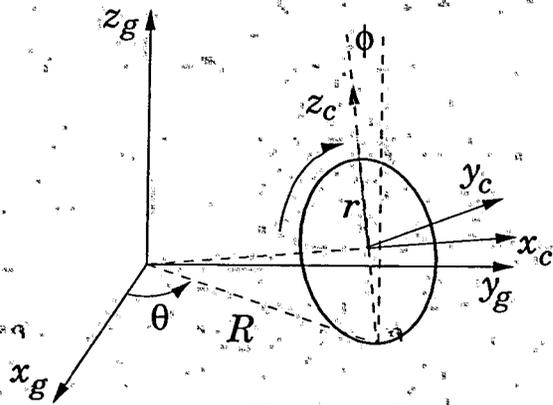


Fig. 3