

Indian Institute of Technology Kharagpur

Department of Mechanical Engineering

Session: Spring, 2011-12

End-Semester Examination

Subject: Kinematics of Machines (ME21008)

Number of students: 171

Time: 3 hours

Marks: 100

Instruction: Answer all questions

1. 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)
2. 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° to 180° , 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 in the polar form. (3+12+8)
3. A single-stage reduction gear-box uses two straight-tooth spur gears to produce a transmission ratio 0.8. The module $m = 5$ mm, the pressure angle $\phi = 20^\circ$, and $a = m$ (with usual nomenclature). (a) Determine the minimum number of teeth on the pinion for no interference without undercutting. (b) For the minimum number of teeth determined in (a), what should be the number of teeth on the gear so that the transmission ratio is closest to 0.8? (c) What should be the minimum number of teeth on the pinion and gear for achieving the transmission ratio exactly? (d) Derive the expression of contact ratio. (e) For the given data and the answer of (c), calculate the contact ratio. (8+2+4+8+3)
4. In the gear train shown in Fig. 3, 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 ω while moving on a circular path of radius R at a constant inclination ϕ , as shown in Fig. 2. 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 $x_g y_g z_g$. (15)

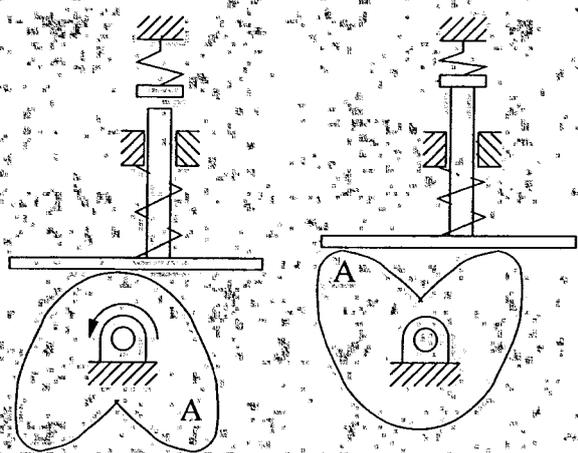


Fig. 1

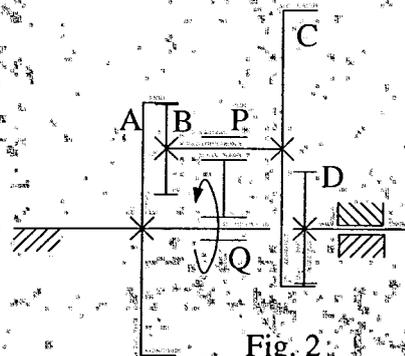


Fig. 2

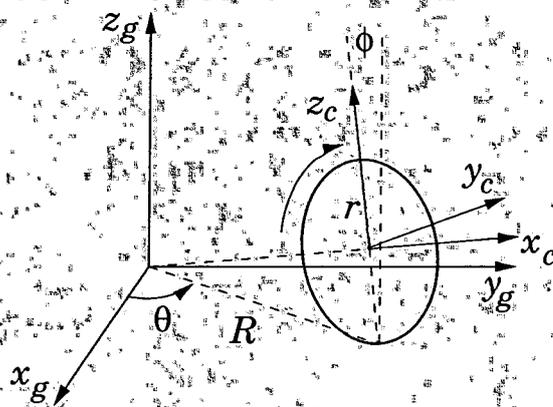


Fig. 3