National Exams May 2013
Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

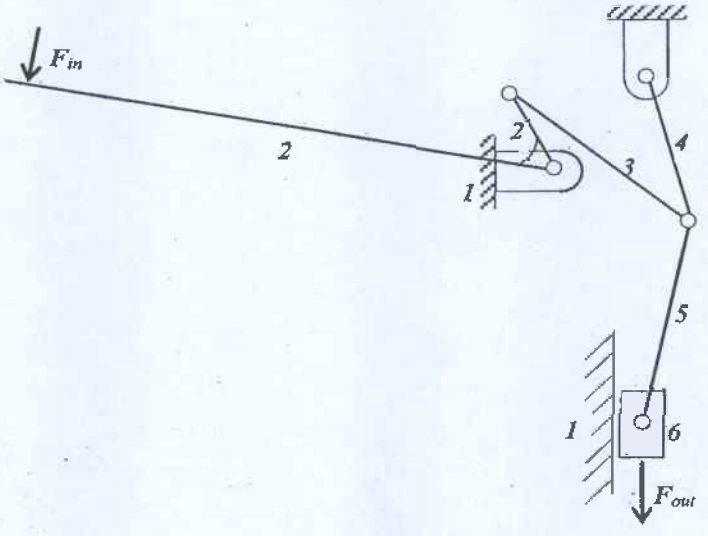
Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Any Sharp or Casio approved calculators are permitted.
3. Answer FIVE questions from the six questions provided.
4. All questions are of equal value.

Part A

1. A mechanical press is designed to produce a large force in order to insert a small part into a larger part. Determine the force produced at the press head at the position shown if a force of 500 N magnitudes is applied to the handle. [Hint: assume a unit input angular velocity (1 rad/s); use the available space to draw a velocity diagram; find out the velocity ratio; determine the mechanical advantage; and then compute the output force.]

Scale 1:15

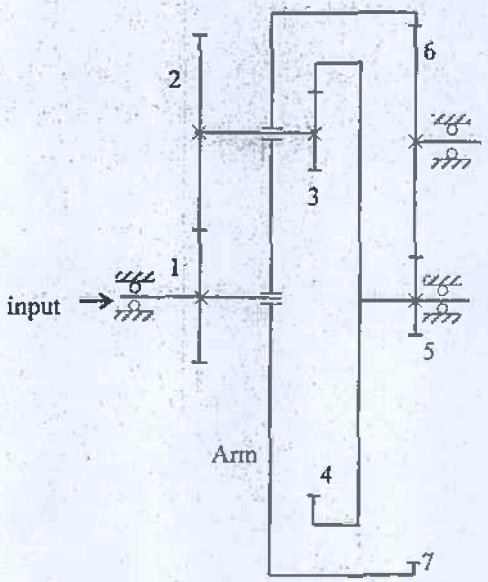


2. [20] A radial cam, rotating at a constant angular velocity of 125 rad/s, is used to produce the following follower motion:
- rise by 25 mm from 0 mm position during [0, 90°],
- fall back to the 0 mm position during [90°,360°]

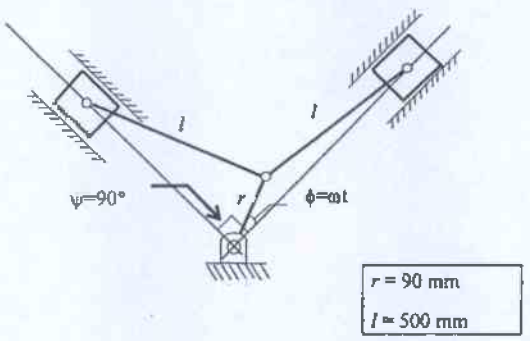
Design the displacement of the cam using the 3-4-5 polynomials. You must present the equations of displacement, velocity, and acceleration and jerk of your cam for the rise period, and sketch the rise profile for *s*, *v*, *a*, and *j*, and compute the maximum acceleration and the maximum jerk for your cam.

Design a base circle and sketch the cam profile for a flat-faced follower. Compute the pressure angles at the following cam positions: 45°, 135°, and 270°.

3. A gear reduction box for an electric winding is a compound planetary gear train shown below. When gear 1 rotates at 1800 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of gear 7. Tooth numbers are $z_1 = 28$, $z_2 = 52$, $z_3 = 18$, $z_4 = 94$, $z_5 = 18$, $z_6 = 35$, and $z_7 = 88$.

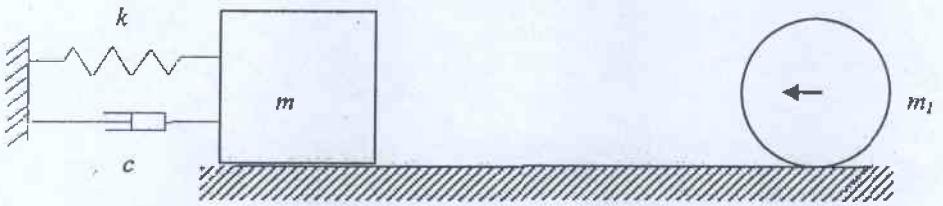


4. For the two-cylinder V-shape engine shown below, determine, when $\phi = 35°$, the primary shaking force caused by the two reciprocating pistons (2.5 kg each in mass). The crank shaft rotates at a constant angular speed of 4000 rpm.

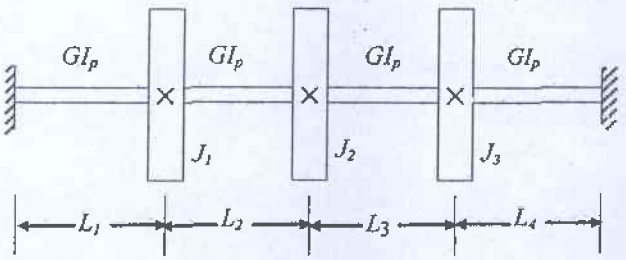


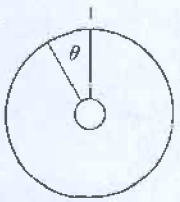
Part B

5. A simple vibration system with m = 10 kg, k =3000 N/m, and c =300 Ns/m is initially at rest. A uniform disk of mass m_1 = 5 kg and radius 0.5 meter rolls on a rough surface without sliding at a constant angular velocity of 10 rad/s toward mass m. Assume that the disk sticks to the mass after impact. Determine the damped free vibrational motion of the system after the impact You may ignore the frictional effect during the ensuing vibration.



6. A shafting system consists of a massless steel (circular) shaft and three rotors. We are concerned with the torsional vibration behaviors of the rotor system. Therefore, only the torsional strain energy and the rotational kinetic energies of the three disks about the shaft axis are considered. Lateral bending is ignored in this problem. Choose a proper set of coordinates and establish the equations of motion for torsional vibration of the multiple DOF system. Find one of the natural frequencies and its corresponding mode shape (vector). Values of parameters are d = 48 mm, $L_1 = L_2 = L_3 = L_4$ = 100 mm; G = 70 GPa, $J_1 = J_2 = J_3$ = 0.01 kg m^2.





Side View

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Marking Scheme

1. 20 marks
2. 20 marks
3. 20 marks
4. 20 marks
5. 20 marks
6. 20 marks