National Exams December 2012

07-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.

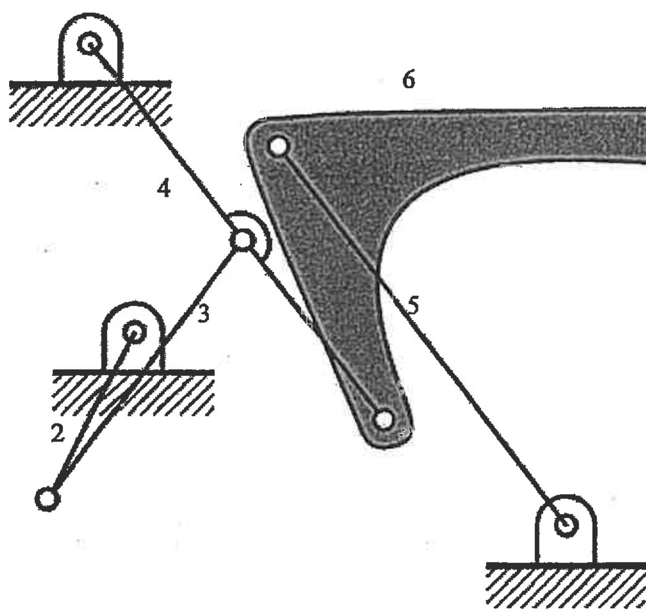
Marking Scheme

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

Part A

1. The crank (input link) of a six-bar mechanism shown below rotates counterclockwise at an angular velocity of 20 rad/s. Determine the angular velocities of links 3, 4, 5, and 6 using the graphical method.

Scale 1:10



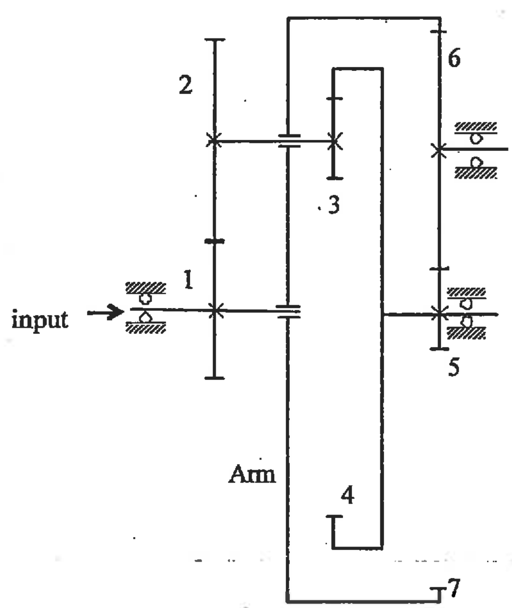
2. A radial cam, rotating at an angular velocity of 1000 rpm, is used to produce the following motion of the follower :

Rise: from 0 to 20 mm during [0, 180°],
Dwell: at the 20 mm lift during [180°, 270°], and
Fall: from 20 mm back to 0 mm during [270°, 360°]

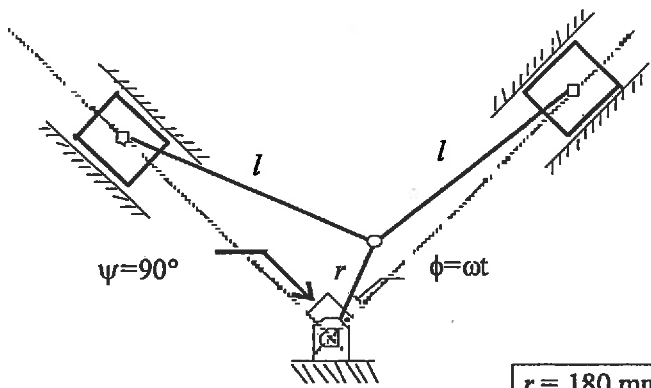
Design the displacement profile for each of the three stages of the follower motion. Since the cam is operated at a moderate speed, it is required that that (i) the profile satisfies the law of cam design and (ii) the maximum acceleration are kept as small as possible.

You must present the equations of displacement, velocity, and acceleration and jerk of your cam profile, sketch the rise profile for s, v, a, and j, and compute the maximum acceleration and the maximum jerk for your cam.

3. A gear reduction box for an electric winding is a compound planetary gear train shown below. When gear 1 rotates at 3600 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of gear 7. Tooth numbers are $z_1 = 30$, $z_2 = 50$, $z_3 = 18$, $z_4 = 94$, $z_5 = 18$, $z_6 = 35$, $z_7 = 88$.



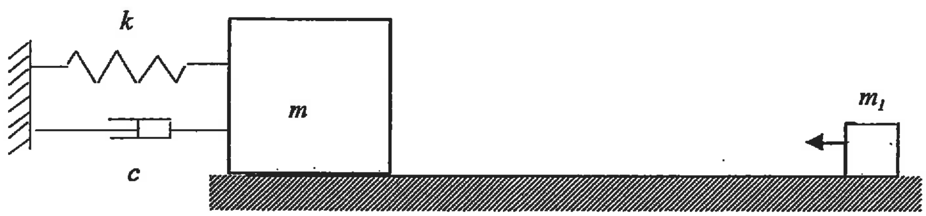
4. A two-cylinder V-shape engine is located in the same axial plane. Determine, when $\phi = 25^\circ$, the primary resultant shaking force caused by the reciprocating masses, namely, the two pistons of mass 1.5 kg each, as the crank shaft rotates at a constant angular speed of 5000 rpm.



r = 180 mm
l = 620 mm

Part B

5. An m-c-k system ($m = 20$ kg, $k = 2000$ N/m, $c = 300$ Ns/m) is initially at rest. A small block of mass $m_1 = 5$ kg travels at a constant velocity of 5 m/s toward mass m. Assume that (i) the surface of ground support is smooth and (ii) the impact is perfectly elastic. Determine the damped free vibrational motion of the system after the impact



6. A uniform bar of mass m and length L is supported by two suspensions. The entire system (used to simulate the bouncing and yawing motion of a vehicle) travels on a rough sinusoidal surface at a constant velocity v. For small amplitude vibration, determine (i) the equations of motion, (ii) the undamped natural frequencies, (iii) the modal vectors, and (iv) the steady state response of the 2-DOF system. In your calculations use $m = 200$ kg, $L = 0.85$ m, $k = 16000$ N/m, $c = 0$ Ns/m, $v = 1.35$ m/s, $a = 1$ m, and $b = 0.01$ m, $y_b = b\sin(2\pi x_b / a)$.