National Exams December 2011
Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

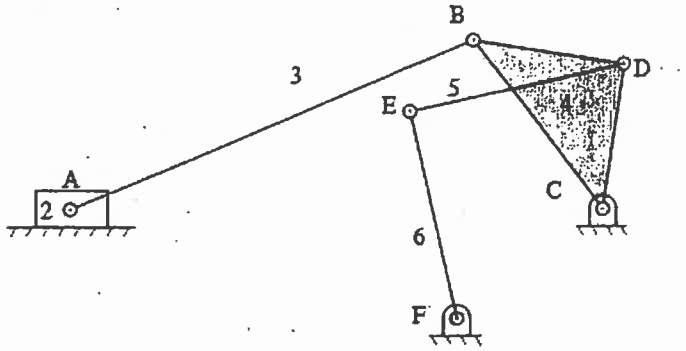
Notes:

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 any FIVE questions from the six questions provided.
4. All questions are of equal value.

Part A

1. The slider (input link) of a six-bar mechanism shown below moves to the right at a velocity of 6 m/s. Determine (i) the angular velocities of links 4, 5, and 6, and the angular accelerations of links 4, and 6, using the graphical velocity analysis method.

Scale 1:5



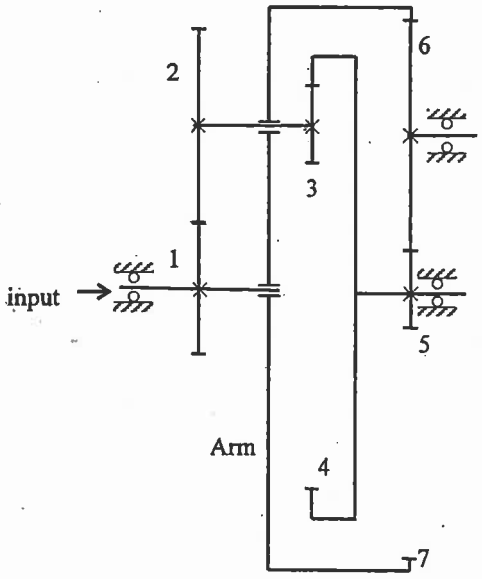
2. A radial cam, rotating at an angular velocity of 600 rpm, is used to produce a 20 mm follower lift with the following specifications:

Rise: from 0 to 20 mm during [0, 90°],
Dwell: at the 20 mm lift during [90°, 270°], and
Fall: from 20 mm back to 0 mm during [270°, 360°]

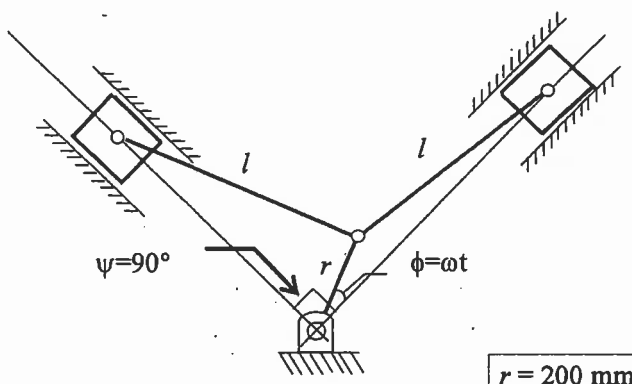
Design the displacement profile for each of the three stages of the follower motion. Since the cam is operated at a moderate speed, it is required that that (i) the profile satisfies the law of cam design and (ii) both the jerk and the maximum acceleration are kept as small as possible.

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 1000 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of gear 7. Tooth numbers are $z_1 = 26$, $z_2 = 50$, $z_3 = 18$, $z_4 = 94$, $z_5 = 18$, $z_6 = 35$, $z_7 = 88$.



4. A two-cylinder V-shape engine is located in the same axial plane. Determine, when $\phi = 35°$, the primary resultant shaking force caused by the reciprocating masses, namely, the two pistons of mass 1.3 kg each, as the crank shaft rotates at a constant angular speed of 3000 rpm.

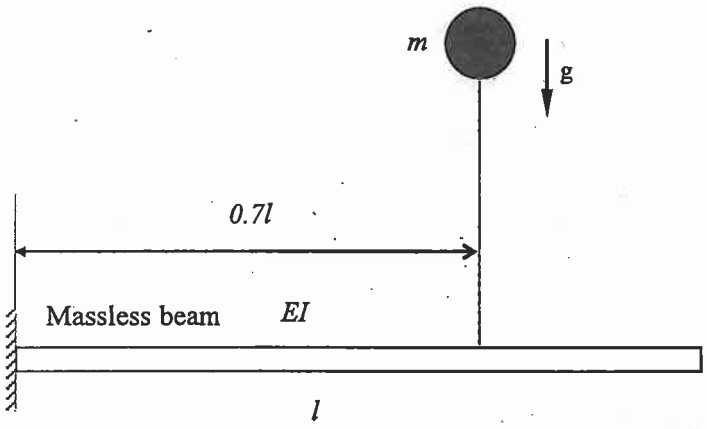


$r = 200$ mm

$l = 600$ mm

Part B

5. A 5 kg point mass starts to fall in the gravitational field from 2 m above the cantilever beam of rectangular cross section (width 6 cm, thickness 1 cm, l = 0.5 m, Young's modulus E =200 GPa). After the point mass strikes with the beam, it remains fixed to the beam. Determine (i) the natural frequency of the vibration of the beam-mass system, the amplitude of its vibration at the tip with reference to its equilibrium position, and the largest bending stress in the beam after impact.



6. A two-car run-away train travels at an initial velocity v_0 (east bound). It collides with a locomotive (mass 1.5 m, at rest) on the same track. After the collision, the front car gets entangled with the locomotive. Determine the ensuing vibro-rigid motion of the system. Ignore friction and aerodynamic resistance. You must consider the energy loss during the perfectly plastic collision.