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

Notes:

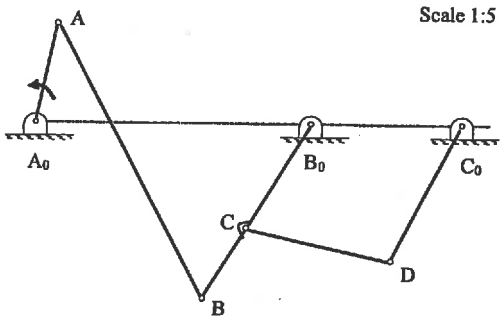
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Any Sharp or Casio approved calculators are permitted.
3. Answer FIVE questions from the six questions provided.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

Marking Scheme

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

1. [20] A six-bar function generation mechanism is given below. At the position shown, the input link rotates at an angular velocity of 20 rad/s (CCW) and an angular acceleration of 100 rad/s^2 (CCW), determine

(a) angular velocities of links AB, B_0B, CD and C_0D,
(b) angular accelerations of links AB, B_0B, CD and C_0D, and
(c) linear accelerations of moving pins B and D.

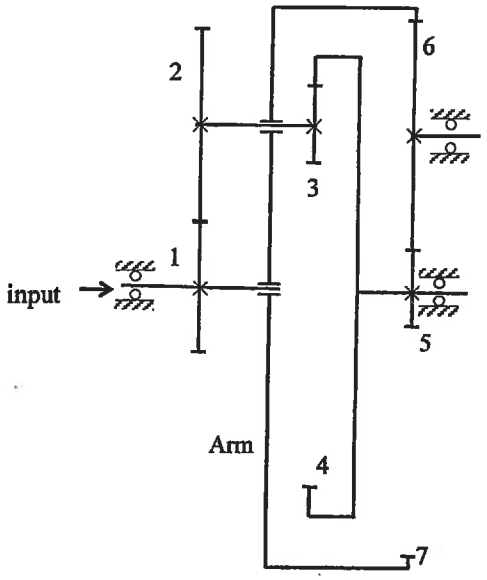


2. [20] A radial cam, rotating at a constant angular velocity of 1000 rpm, is used to produce the following follower motion:
- rise by 20 mm from 0 mm position during [0, 120°],
- fall back to the 0 mm position during [120°,360°]

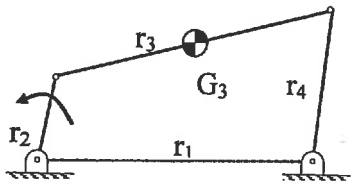
Design the displacement of the cam using the cycloidal displacement. You must present the equations of displacement, velocity, and acceleration and jerk of your cam for both rise and fall, and sketch the rise profile for *s*, *v*, *a*, and *j*, and compute the maximum acceleration and jerk for the rise.

Design a base circle and sketch the cam profile for a flat-faced follower. Compute the pressure angles at the following cam positions: 60°, 240°, and 300°.

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 $z_1 = 26$, $z_2 = 50$, $z_3 = 18$, $z_4 = 94$, $z_5 = 18$, $z_6 = 35$, and $z_7 = 88$.



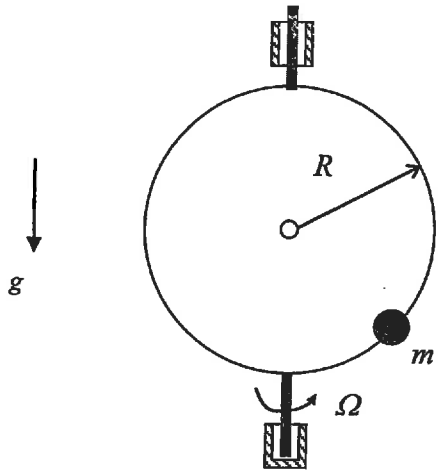
4. [20] A four-bar mechanism is shown below. The input link rotates at an angular velocity of 360 rpm (CCW). The masses of the crank and the follower are negligible. The coupler is considered as a uniform rod (0.1 kg in mass). Devise a balancing scheme to reduce the maximum shaking force.



Not to scale

$r_1 = 145$ mm
$r_2 = 45$ mm
$r_3 = 150$ mm
$r_4 = 80$ mm

5. [20] A circular ring of radius R spins about the vertical axis at a constant angular velocity of Ω. A bead is confined to move on the ring. Determine the natural frequency of free vibration of the bead about the stable equilibrium position. In your calculations, use m = 1 kg, R= 0.25 m, Ω = 10 rad/s, g = 9.81 m/s^2.



6. [20] A 2-DOF vibration system consists of two bodies as shown below. Determine the steady state response for $Q_1 = 10\sin\Omega t$ (N) and $Q_2 = 0$. In your calculations, use $m = 5$ kg, $k = 500$ N/s, c = 15 Ns/m, $\Omega = 20$ rad/s.