National Exams December 2009
07-Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

Notes:

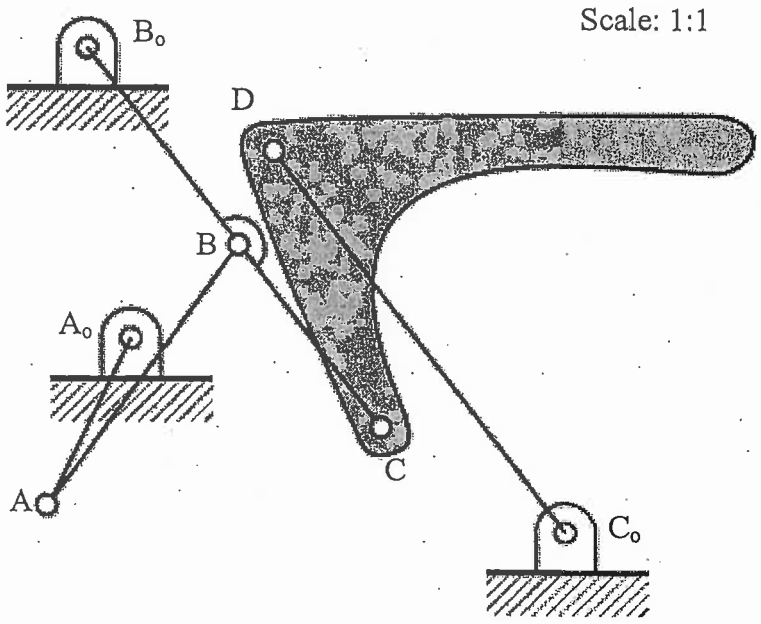
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Any non-communication calculator is permitted.
3. FIVE questions in the following combinations constitute a complete exam paper: three from part A and two from part B, or four from part A and one from part B.
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
7. 20 marks

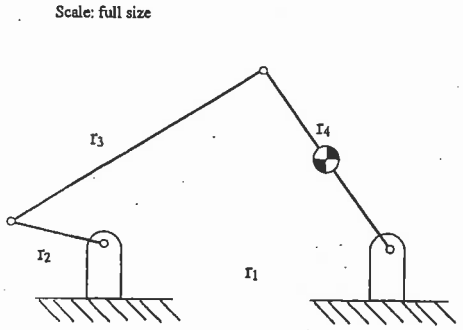
Part A

1. A six-bar mechanism is given below. At the position shown, the input link (A_oA) rotates at a constant angular velocity of 20 rad/s (CCW), determine all instant centers and the angular velocity C_0D.

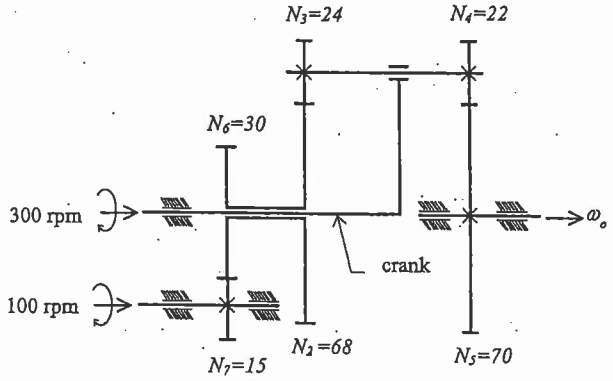


2. A planar four-bar function generation mechanism is shown below. At the configuration shown, the input link rotates at a constant angular velocity of 900 rpm (CCW). Determine,

(a) the angular velocities of the coupler and output link,
(b) the angular accelerations of the coupler and output link,
(c) the linear acceleration of the midpoint (mass center) of the output link, and
(d) the magnitude and sense of the torque to be applied to input link from base link 1 to overcome the inertia of link 4 ($m_4 = 0.2\text{kg}$, $I_{G,4} = 0.0125\text{kg}\cdot\text{m}^2$).



3. A gear transmission system consists of a crank shaft and three pairs of spur gears of identical diametral pitch, as shown below. Determine the output angular velocity ω_o.

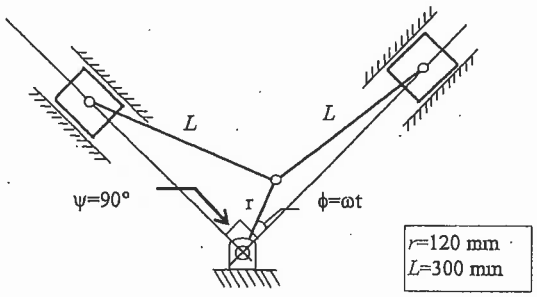


4. A cam, rotating at a constant angular velocity of 100 rad/s, is used to produce a 15 mm follower lift with the following specifications:

Rise: from 0 to 15 mm during [0, 75°],
Dwell: at the 15 mm lift during [75°, 255°], and
Fall: from 15 mm back to 0 mm during [255°, 360°]

Design the displacement profile of the cam during THE RISE ONLY. Since the cam is operated at a high speed, you are required to ensure 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.

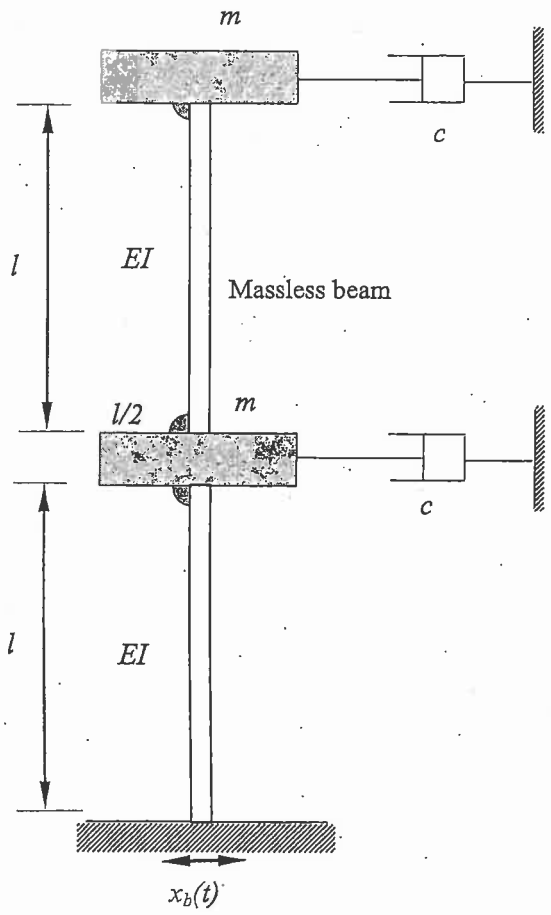
5. A two-cylinder V-shape engine is located in the same axial plane. Determine, when $\phi = 25°$, the primary resultant shaking force caused by the reciprocating masses, namely, the two pistons of mass 1.25 kg each, as the crank shaft rotates at a constant angular speed of 900 rpm.



Not to scale

Part B

6. A vibration system consisting of a massless beam, two blocks constrained to move in the horizontal direction, and two dashpots. For $EI = 2{,}300\ \text{Nm}^2$, $l = 2$ m, $m = 100$ kg, c = 125 Ns/m, determine the response of the system due to the horizontal base motion $x_b = 10\sin 20t$ (mm).



7. Choose an appropriate generalized coordinate (q), establish the equation of motion of small amplitude for the one DOF system consisting of an L-shaped uniform rigid bar shown below, and determine the ensuing motion if the generalized coordinate of your choice is disturbed at time t = 0 as follows: q = 0.01 (m or rad), $\dot{q} = 0$ m/s or rad/s. The rigid bar has a linear density of 1 kg/m. In your answer, ignore the gravitational effect.