National Exams May 2011
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 any FIVE questions from the six questions provided.
4. All questions are of equal value.

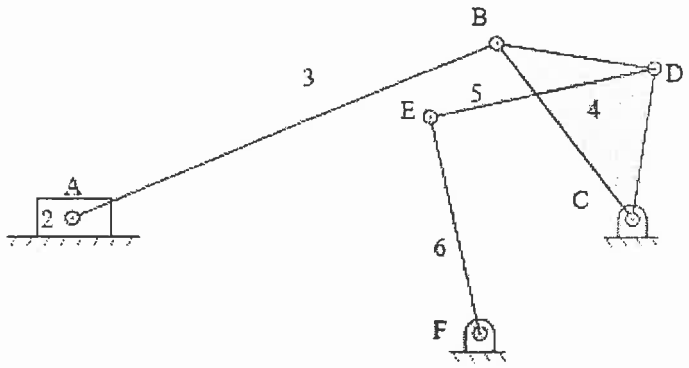
Marking Scheme

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

Part A

1. The slider (input link) of a six-bar mechanism shown below moves to the right at a velocity of 12 m/s. Determine (i) the angular velocities of links 4, 5, and 6, and the angular accelerations of links 4, 4 and 6, using the graphical analysis method.

Scale 1:5



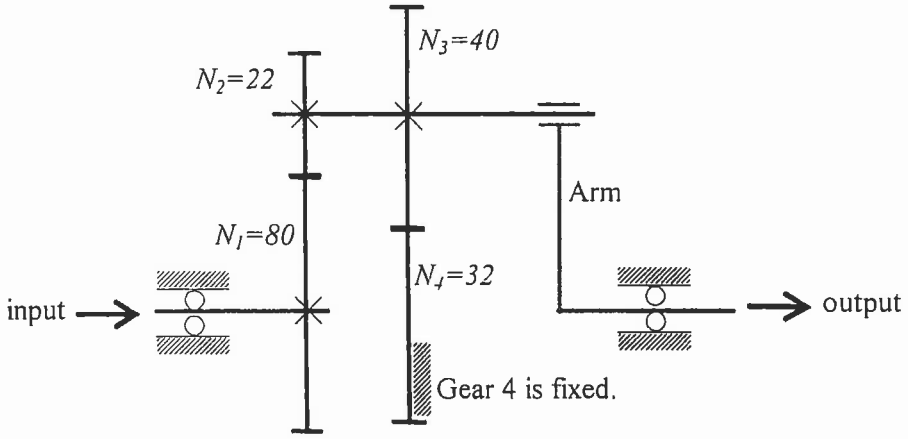
2. A cam, rotating at a constant angular velocity of 175 rpm, is used to produce a 10 mm follower lift with the following specifications:

Rise: from 0 to 10 mm during [0, 90°],
Dwell: at the 10 mm lift during [90°, 270°], and
Fall: from 10 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, you are required to ensure that (i) the profile satisfies the law of cam design and (ii) both the jerk and the maximum acceleration be 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 compound epicycle gear train is shown below. When gear 1 rotates at 1000 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of the arm. All tooth numbers are indicated in the figure.



4. A four-bar function generation mechanism is shown below. When the input link rotates to the 12 o'clock position, its angular velocity is 200 rad/s (CCW) and its angular acceleration is 0. Determine the shaking force and the shaking moment transmitted to the ground from the mechanism at the position shown.

Given:

(a) $r_1 = 71$ mm; $r_2 = 18$ mm; $r_3 = 74$ mm; $r_4 = 48$ mm

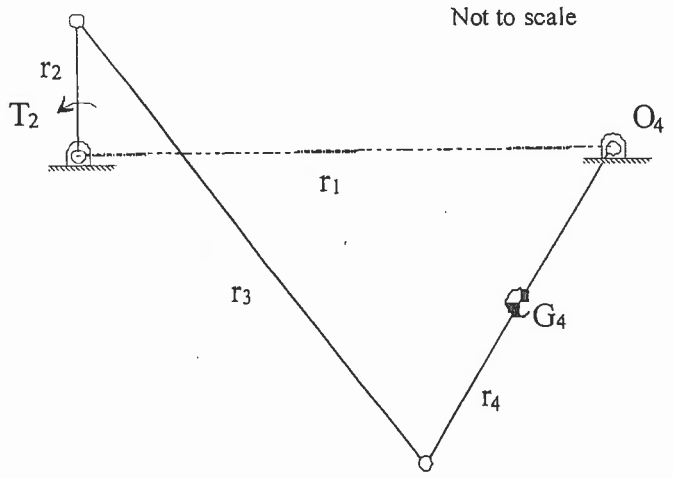
(b) Links 2 and 3 are masslesss; $r_{G4/O4} = 24$mm; $m_4 = 2$kg, $I_{G,4} = 0.01\,\text{kg}\cdot\text{m}^2$).

(c) No friction; No load; there is an input torque (unknown).

(d) the angular positions of the coupler and output link: 307.7° and 237.6°, respectively

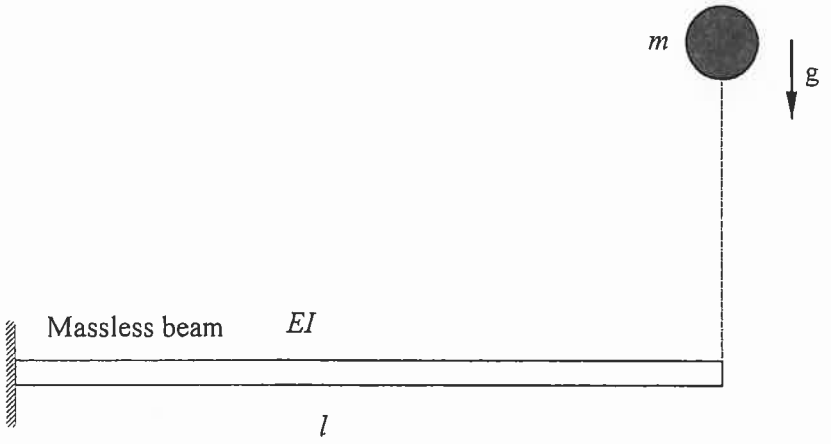
(e) the angular velocities of the coupler and output link: 27.71 rad/s and -48.8 rad/s, respectively.

(f) the angular accelerations of the coupler and output link, 10,100 rad/s^2, 12,210 rad/s^2, respectively.



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 the beam at the tip, 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. Determine the natural frequencies of the 3-DOF system shown and their corresponding mode shapes.