National Exams December 2015
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 20.

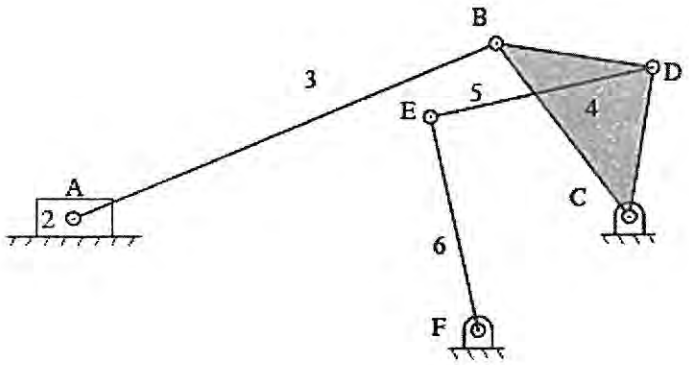
Marking Scheme

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 2 m/s. Determine the angular velocities of links 4, 5, and 6 using the graphical velocity analysis

Scale 1:5



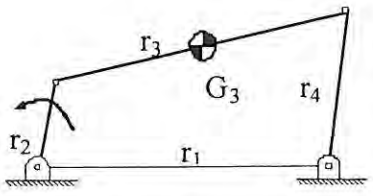
2. A radial cam, rotating at a constant angular velocity of 900 rpm, is used to produce the following follower motion:
- rise by 1 inch from 0 inch position during [0,120°],
- dwell at 1 inch position during [120°, 180°]
- fall back to the 0 inch position during [180°, 360°]

Design the displacement of the cam with an objective to minimize the maximum acceleration. You must present the equations of displacement, velocity, and acceleration and jerk of your cam for both rise and fall, sketch the rise profile for s, v, a, and j, and compute the maximum acceleration and jerk for the rise.

Select a base circle and sketch the cam profile for a flat-faced follower. Compute the pressure angle at $\theta = 60^\circ$. Sketch the cam profile and specify any iterations needed from the computed two pressure angles. Do not carry out any iterations.

3. Design a two-stage planetary gear train which transfers 6 MW (Mega Watt) of power from the wind turbine blades for powering an AC generator. The desired speed ratio is 1:105. Assuming that the turbine blades rotates at a speed of 17 rpm. Sketch clearly the configuration and specify the tooth number and module or diametral pitch for each gear. In your design, you must give consideration to the following requirements:
(i) Motions of the input and output axes must be fixed-axis rotation;
(ii) Dynamic forces are balanced for each stage; and
(iii) Gear meshing interference must be avoided.

4. A four-bar mechanism is shown below. The input link rotates at an angular velocity of 1745 rpm (CCW). The masses of the crank and the follower are negligible. The coupler is considered as a uniform rod (0.2 kg in mass). Design an effective balancing scheme to reduce the maximum shaking force by 50%.

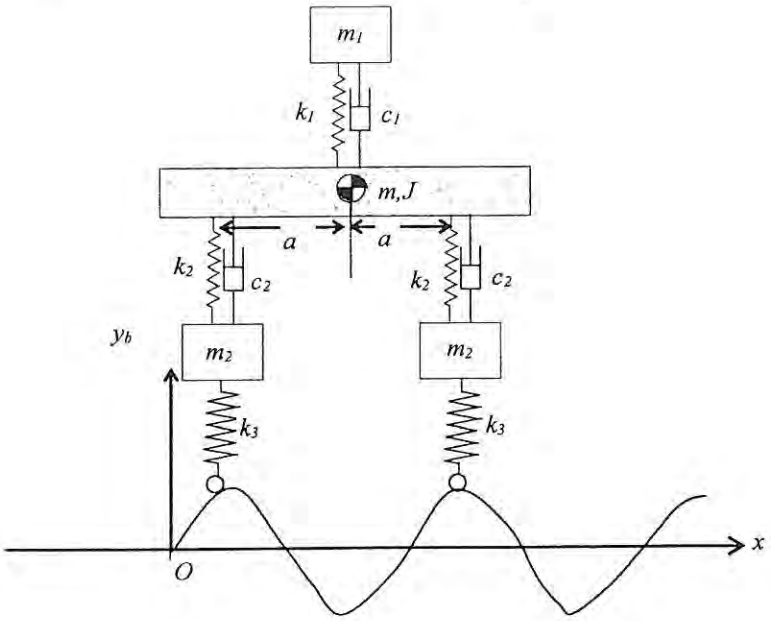


$r_1 = 145$ mm
$r_2 = 45$ mm
$r_3 = 150$ mm
$r_4 = 80$ mm

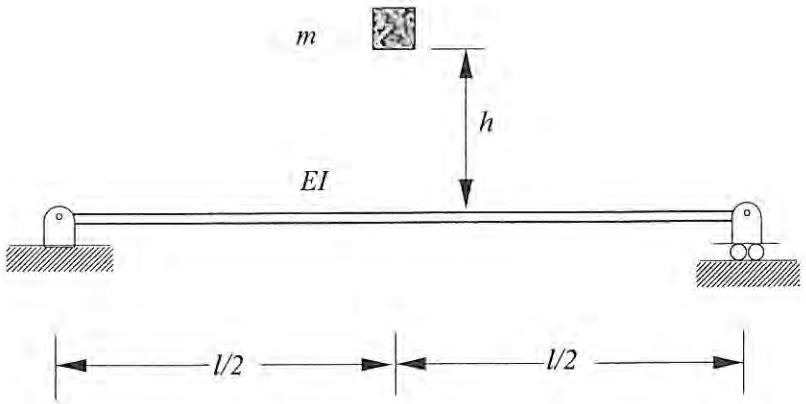
Not to scale

Part B

5. [20] The schematic below is a simplified mechanical model to evaluate the dynamic response of a motorcycle and its rider over a bumpy road. The rider, the front and rear tires, considered as point masses, respond vertically. The frame of mass m and mass moment of inertial J about its mass center can move vertically and rotate at the same time about the mass center. Select an appropriate set of generalized coordinates and derive the equations of motion of the system using the Lagrange equations. The bumpy base is considered to be $y_b = B\sin\dfrac{\pi x}{b}$



6. [20] A block of mass m is dropped from the position shown onto a massless beam, simply supported at both ends. If the impact is perfectly plastic, determine (a) the maximum deflection in beam, (b) the maximum dynamic bending stress, and (c) the time taken from the initial impact to the moment that the maximum bending stress is reached.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