National Exams May 2018

16-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-communicating calculator is permitted.
3. Everyone answers question 1, and chooses three questions in Part A, and one question from part B.

Marking Scheme

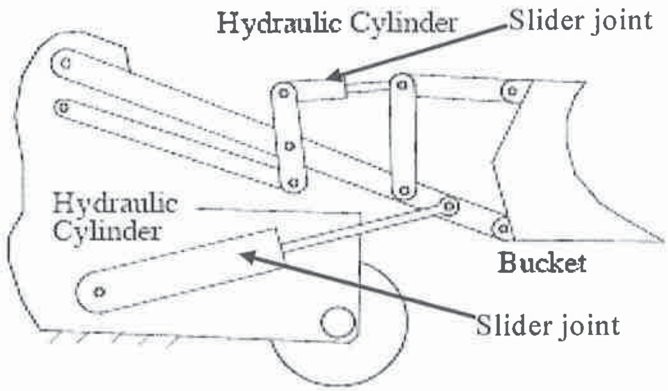
1. 40 marks
2. 20 marks
3. 20 marks
4. 20 marks
5. 20 marks
6. 20 marks
7. 20 marks

Part A

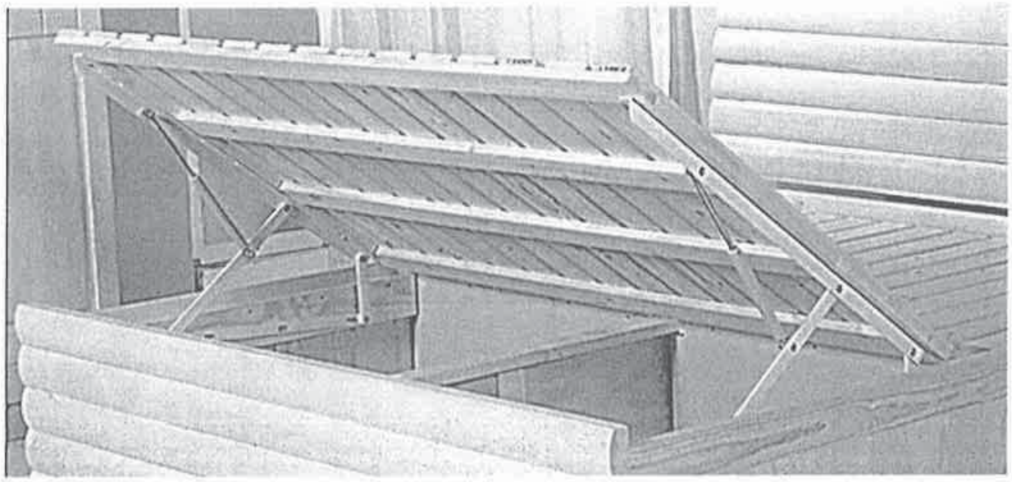
1. This question has four mini-questions. Each mini-question carries 10 marks.

(i) A designer plans to design an 8-bar planar mechanism with the mobility of one ($M = 1$) and ten full joints ($J_1 = 9$, $J_2 = 2$). Sketch neatly a valid mechanism involving at least one prismatic joint.

(ii) Determine the mobility of the mechanism shown below by means of the Gruebler's equation. You must number each valid link clearly and identify the total number links, and the numbers and types of all joints.

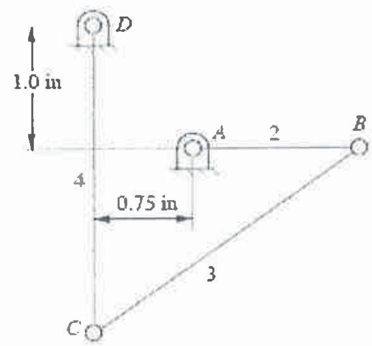


(iii) Below is the mechanism, used to open/close a bed box. Sketch neatly and clearly a skeleton diagram of the mechanism using the standard link/joint notation.



(iv) A four-bar planar mechanism is shown below for one particular configuration. Assuming that the link 2 is the driver (input) link, determine (a) the type of mechanism using the Grashof criterion, (b) the range of motion of the output link, and (c) the extreme values of the transmission angle.

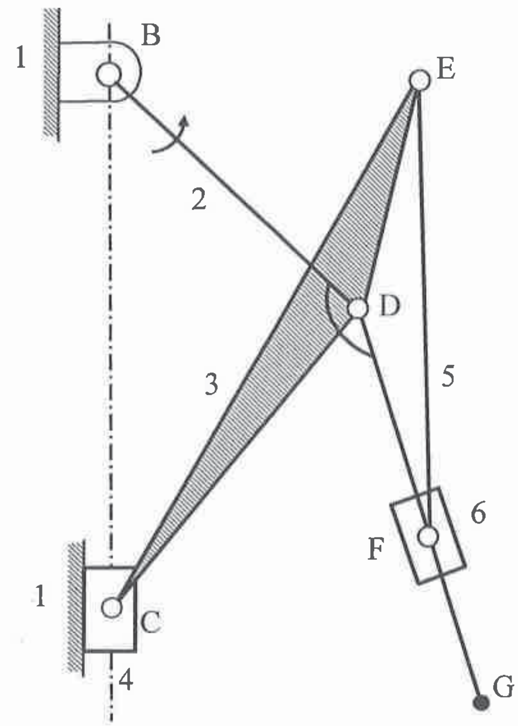
Link lengths: AB = 1.25 in, BC = 2.5 in, CD = 2.5 in



2. [20 mark]
All link dimensions can be measured directly from the diagram below.
For the planar mechanism shown below, link 2 rotates counterclockwise (CCW) at a rate of 30 rad/s. Determine using the instantaneous center method or the graphical velocity (polygon) method

a) the linear velocity of link 6,
b) the angular velocity of link 5,
c) The absolute velocity of point G on link 4.

All link dimensions can be measured directly from the diagram below.



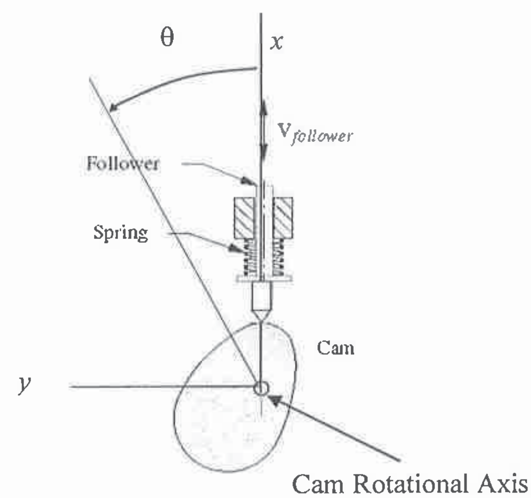
Scale 1:5

3. The cam in a radial cam-follower rotating mechanism rotates at a constant angular speed of 1800 rpm clockwise (CW). Through a guaranteed contact, the following follower motion is

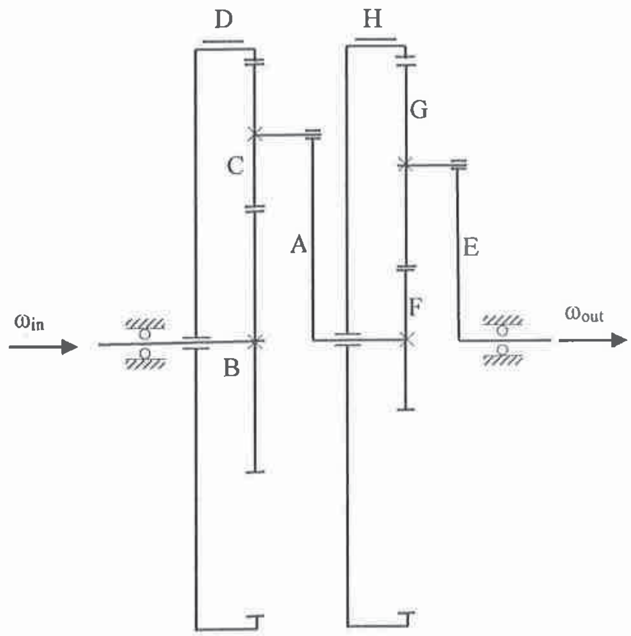
- rise by 40 mm from $\theta = 0$ deg to $\theta = 120$ deg
- dwell at the 40 mm elevation from $\theta = 120$ deg to $\theta = 180$ deg
- fall back to the 0 elevation from $\theta = 180$ to 360 deg

(i) Design the *s*-curve for the fall in accordance with the law of cam design with an additional objective to minimizing the maximum follower velocity, and sketch the *s*-*v*-*a* curves for the fall with maximum values indicated on the diagrams.

(ii) Choose a proper base circle and estimate the maxim pressure angle for the rise and fall motions. If the pressure angle is not satisfactory, point out clearly what you would do to reduce the pressure with the acceptable max value of 30 deg. But do not carry out the additional analysis.



4. A multi-stage compound planetary gear train is shown below. Determine (i) the rotational speed of the output shaft ω_E in rpm (sense and value) if the friction pads at D and H are activated simultaneously and the input rotates at $\omega_{in} = 1450$ rpm counterclockwise (CCW) when viewed from the right. Teeth numbers for selected gears are $N_B = 60$, $N_C = 31$, $N_F = 25$, $N_G = 48$. All gears have identical modules and pressure angles. Suggested Method: tabular method.

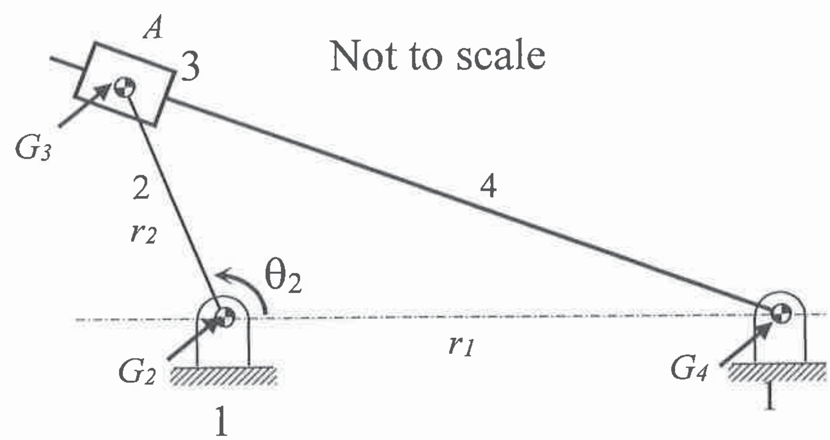


5. An inverted crank sider mechanism is shown below. The crank length is 25 cm. The length of the ground link is 50 cm. The crank rotates at a constant angular velocity of 1750 rpm counterclockwise (CCW). The crank shaft and the follower are considered massless in this problem. The slider as a coupler has a mass of 0.3 kg with a mass center as A3, and a mass moment of inertia of 0.15 kg-m^2.

i) Conduct the kinematical analysis by relating the positions of the coupler and the follower to θ_2 , the velocities (linear and angular) of the coupler and the follower to θ_2 and $\dot{\theta}_2$, and the accelerations (linear and angular) of the coupler and the following to θ_2 and $\dot{\theta}_2$. Note that the crank acceleration (angular) $\ddot{\theta}_2$ is zero.

(ii) Determine the shaking force in terms of θ_2 and $\dot{\theta}_2$, and then compute its magnitudes for θ_2 =0, 45°, and 90°. ·

(iii) Design a balancing scheme to reduce the shaking force magnitudes and state clearly your reasons.



Part B

6. A block travels at a velocity $v = 10$ m/s toward a vibration system at rest. Determine the ensuring motion after the impact is made; the two block sticks together as a single mass. In your calculations, use $m = 1$ kg, $k = 1000$ N/m, and $c = 10$ Ns/m.

7. A shafting system consists of a massless steel (circular) shaft and two gears. We are concerned with the lateral vibration behavior of the shafting system. (i) Choose a proper set of coordinates and establish the equations of motion for lateral vibration of the two-DOF system; (ii) find the two natural frequencies and their corresponding mode shape. Use d=25 mm, L=250 mm; E = 210 GPa