National Exams May 2016
07-Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

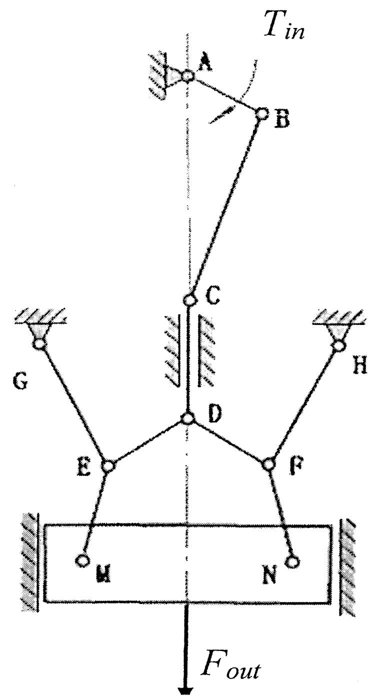
Notes:

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-communicating calculator is permitted.
3. Answer FIVE questions from the six questions provided.
4. Marks for each question are 20.

Part A

1. Determine the mechanical advantage of an 8-bar mechanism at the position shown using a method of your choice. The mechanism has a redundant branch to eliminate any potential lock-in during operation.

Scale 1:15



2. A radial cam (flat-faced follower), rotating at a constant angular velocity of 100 rad/s, is used to produce the following follower motion:

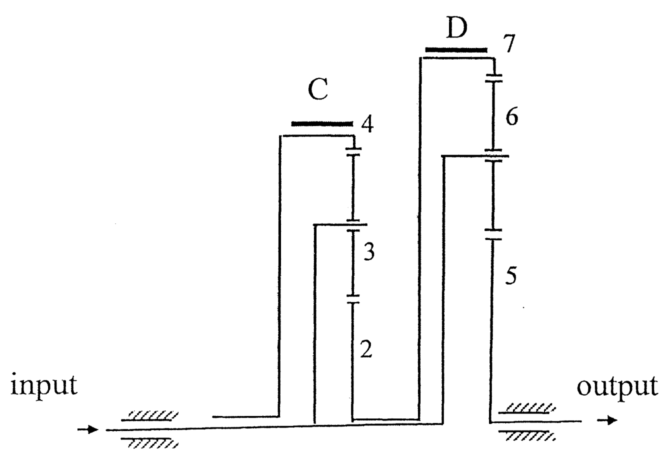
- rise by 1.5 inch from 0 inch position during [0,75°],
- dwell at 1.5 inch position during [75°, 180°]
- fall back to the 0 inch position during [180°, 360°]

Design the displacement profiles for the rise and fall with an objective to minimize the maximum jerk for quietness. You must clearly 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 jerks for the rise and fall.

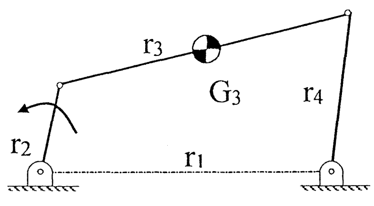
Choose a proper base circle and sketch the cam profile. Compute the pressure angles at $\theta = 37.5^{\circ}$ and $\theta = 127.5^{\circ}$. If the pressure angles are not satisfactory (i.e., greater than 30 degrees), state how the design can be modified to meet the pressure angle requirement, but do not undertake or attempt any iterations due to time limitation.

3. Shown below is a 2-stage PGT. The input shaft rotates at 800 rpm (CCW viewed from the output end). C and D represents two brake pads, which are used to stop gear 4 or gear 7 in order to achieve different speed ratios. All gears in the PGT have identical pitch and a pressure angle of 20 degrees. All gear teeth have full depth (the addendum is $\alpha / P, \alpha = 1.0$). The numbers of teeth for the sun and ring gear in each stage are: N2 = 16; N4 = 50, N5 = 30, N7 = 80.
Determine

(i) the maximum number of equally spaced planets in each stage,
(ii) the output angular velocity when C is activated, and
(iii) the output velocity when D is activated.



4. A four-bar mechanism is shown below. The input link rotates at an angular velocity of 872.5 rpm (CCW). The masses of the crank and the follower are negligible. The coupler is modelled as a uniform rod with a mass of 0.15 kg. Determine the maximum shaking force and design an effective balancing scheme to reduce this maximum shaking force by about 40%

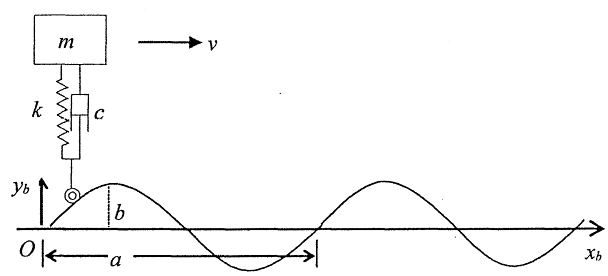


r_1 =145 mm
r_2 = 35 mm
r_3 =150 mm
r_4 = 80 mm

Not to scale

Part B

5. Determine the steady state response of the shown *m-c-k* vibration system (which is a simplified model of the bouncing motion of a mono-cycle with a rider) traveling at a constant velocity v in the horizontal direction. Ignore the size of the small wheel. Use parameters: m = 200 kg, k = 16000 N/m, c =3220 Ns/m, v = 1.35 m/s, a = 1 m, and b = 0.02 m. The curve is $y_b = b\sin\dfrac{2\pi x_b}{a}$.



6. An inverse pendulum has a mass 4 kg, and a mass moment of inertial 0.02 kgm^2 about the axis of rotation. The distance between the mass centre and the axis of rotation is 0.12 m. The stiffness of the rotational spring is 6.4 Nm/rad. Determine (i) the period of natural vibration of small amplitude vibration about one of the stable equilibrium positions, (ii) the response of the pendulum when it is at the equilibrium position in (i) but has an angular velocity of 1.2 rad/s (CCW).