National Exams May 2014
Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

Notes:

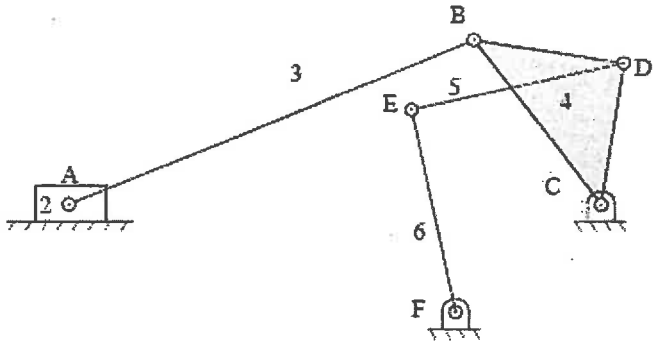
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Any Sharp or Casio approved calculators are permitted.
3. Answer FIVE questions from the six questions provided.
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

1. The slider (input link) of a six-bar mechanism shown below moves to the right at a velocity of 10 m/s. Link 6 is the output link. Determine for the shown position (i) all instant centers, and (ii) the mechanical advantage.

Scale 1: 10

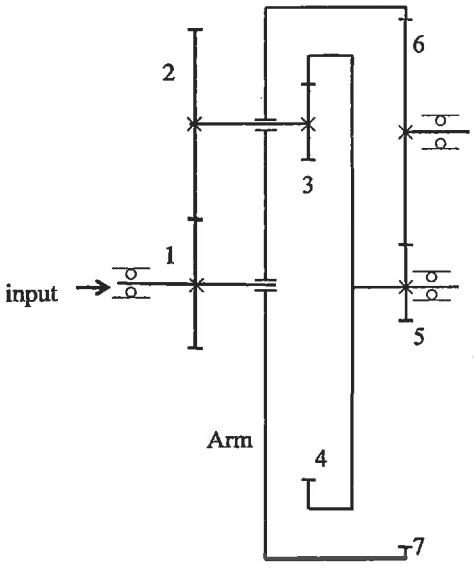


2. A radial cam, rotating at a constant angular velocity of 1800 rpm, is used to produce the following follower motion:
- rise by 25.4 mm from 0 mm position during [0, 90°],
- dwell at 25.4 mm position during [90°, 180°]
- fall back to the 0 mm position during [180°,360°]

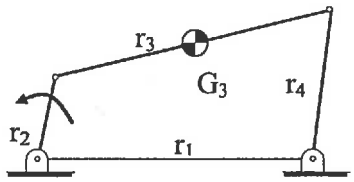
Design the displacement of the cam using the cycloidal displacement. You must present the equations of displacement, velocity, and acceleration and jerk of your cam for both rise and fall, and sketch the rise profile for *s*, *v*, *a*, and *j*, and compute the maximum acceleration and jerk for the rise.

Design a base circle and sketch the cam profile for a flat-faced follower. Compute the pressure angles at the following cam positions: 45° and 270°. Comment on the cam design from the maximum pressure angle requirement.

3. A gear reduction box for an electric winding is a compound planetary gear train shown below. When gear 1 rotates at 1200 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of gear 7. Tooth numbers are $z_1 = 26$, $z_2 = 50$, $z_3 = 18$, $z_4 = 94$, $z_5 = 18$, $z_6 = 35$, and $z_7 = 88$.



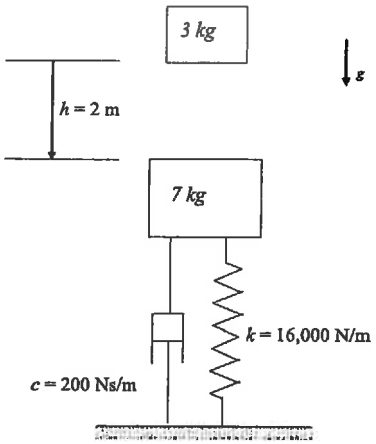
4. A four-bar mechanism is shown below. The input link rotates at an angular velocity of 3600 rpm (CCW). The masses of the crank and the follower are negligible. The coupler is considered as a uniform rod (0.2 kg in mass). Devise a balancing scheme to reduce the maximum shaking force.



Not to scale

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

5. A 7-kig mass rests on a compressive helical spring in the gravitational field as shown below. A second mass of 3 kg, located 2 m above, starts to fall downward. After the collision, the two masses become one and start to vibrate vertically. Determine (i) the natural frequency of the vibration system after impact and (ii) free vibration after the impact.



6. A 2-DOF vibration system consists of two bodies, constrained to move vertically as shown below. Determine the steady state response for the following excitations: $Q_1 = 10\sin\Omega t$ (N) and $Q_2 = 0$. In your calculations, use m = 5 kg, k = 500 N/s, c = 20 Ns/m, and $\Omega = 20$ rad/s.