

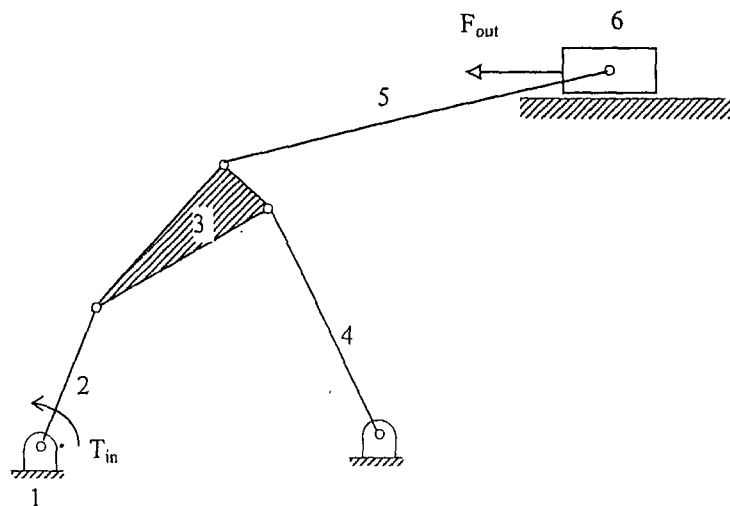
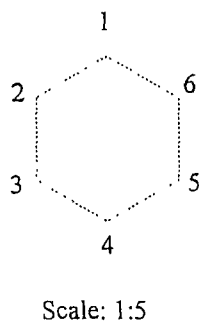
**National Exams December 2010**  
**07-Mec-A2, Kinematics and Dynamics of Machines**  
3 Hours Duration

**Notes:**

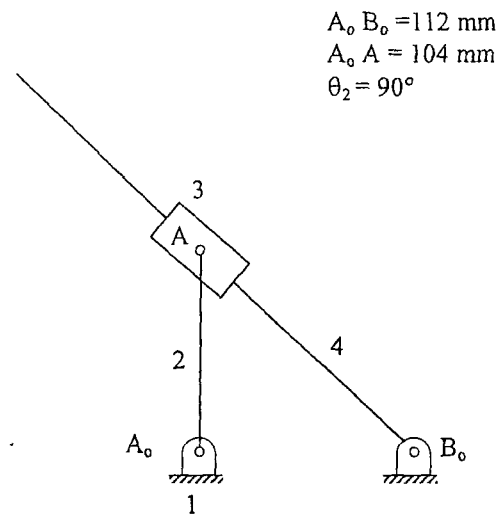
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Any non-communicating calculator is permitted.
3. Answer any FIVE questions from the six.
4. All questions are of equal value.

## Part A

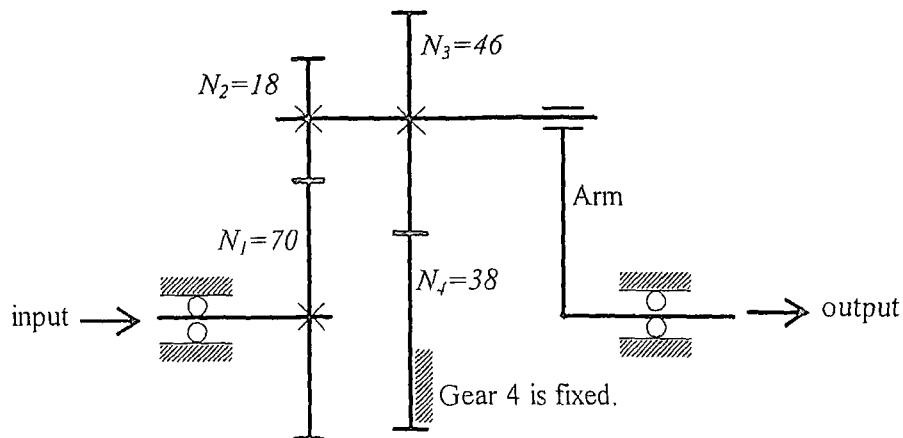
1. A six-bar planar mechanism is shown below. Determine (i) all instant centres, and (ii) the mechanical advantage defined as the ratio of the output force to the input torque.



2. An inverted crank slider mechanism shown below. At the position shown, determine (i) the angular velocity of the follower, the relative velocity  $\bar{v}_{A4/A3}$ , and Coriolis acceleration  $\bar{a}_{A4/A3}^c$ , (ii) the relative sliding acceleration  $\bar{a}_{A4/A3}^s$ , and (iii) the input torque required if the input link rotates at a constant angular velocity of 15 rad/s (ccw). The mass of the slider is 1 kg. The input and output links are massless. The load at the position is zero.

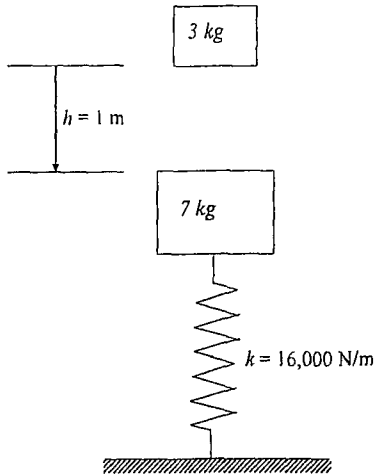


3. A compound epicycle gear train is shown below. When gear 1 rotates at 100 rpm (ccw), determine the angular speed and direction of rotation (ccw or cw) of the arm. All tooth numbers are indicated in the figure.

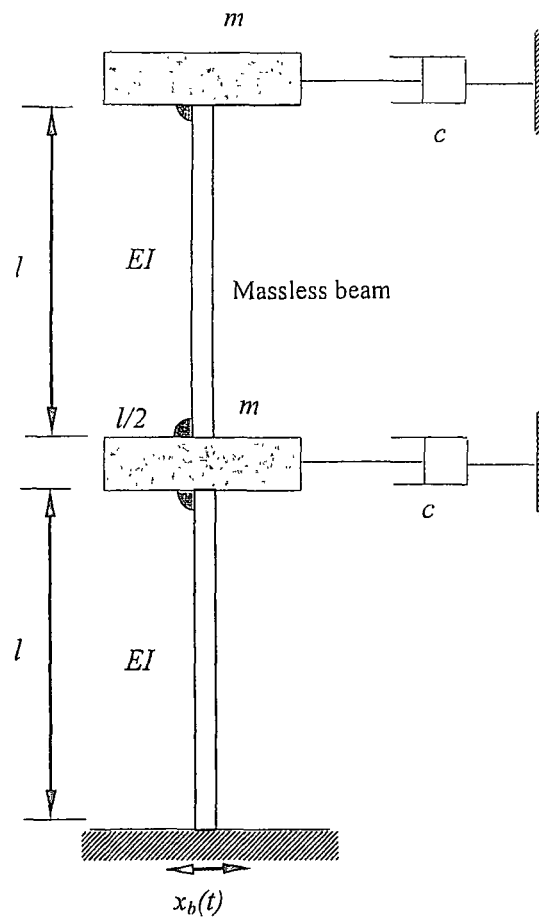


## Part B

4. A 7 kg mass rests on a compressive helical spring in the gravitational field as shown below. A second mass of 3 kg, located 1 meter 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) the largest force in the spring after impact.



5. A vibration system consisting of a massless beam, two blocks constrained to move in the horizontal direction, and two dashpots. For  $EI = 3,000 \text{ Nm}^2$ ,  $l = 1.5 \text{ m}$ ,  $m = 110 \text{ kg}$ ,  $c = 225 \text{ Ns/m}$ , determine the response of the system to the horizontal base motion  $x_b = 20 \sin 25t$  (mm).



6. One locomotive, traveling eastbound at a speed of 90 km/h, collides with a constrained train carrying a single car at rest on the same track. After the collision, the two locomotives become entangled and move as one body on the track. No derailment. Determine (i) the natural frequencies of the dynamic system after the collision, (ii) the corresponding mode shapes, and (iii) the ensuing motion. In your calculations, use  $m = 5\,000\text{ kg}$  and  $k = 10^6\text{ N/m}$ .

