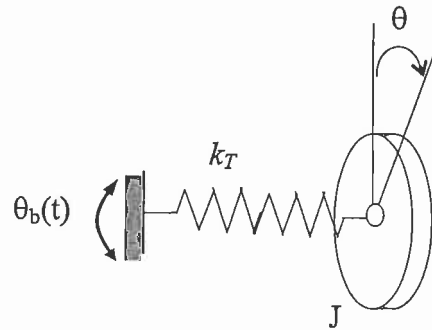


National Exams December 2008
07-Mec-A2, Kinematics and Dynamics of Machines
3 Hours in Duration

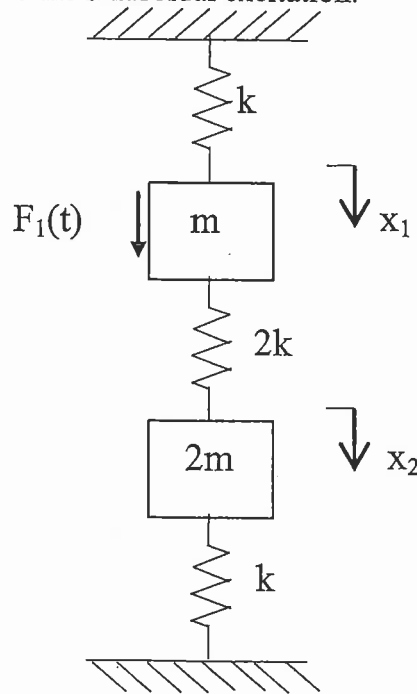
Notes:

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. Four questions constitute a complete exam paper.
4. All questions are of equal value.

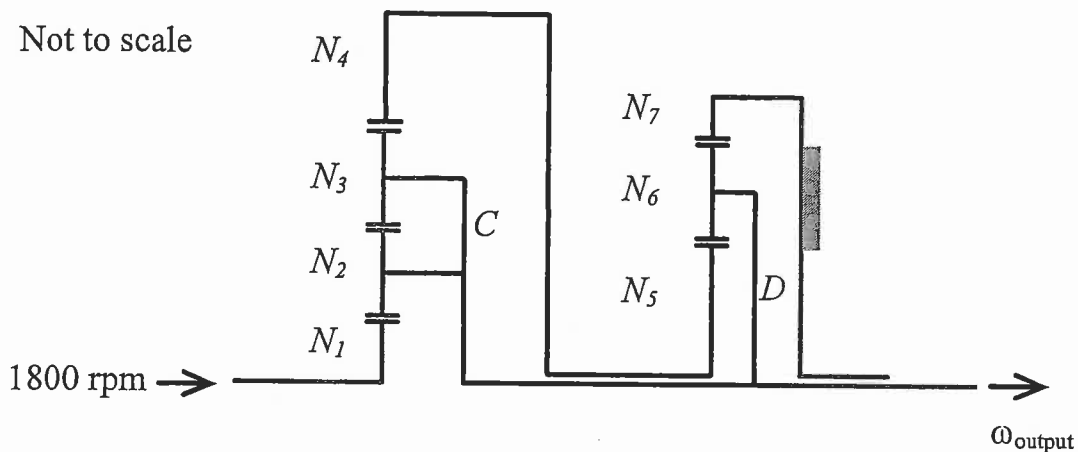
1. [25] A simple torsional vibration system consisting of a disk and a torsional spring is shown below. Determine
 - (a) the natural frequency of the torsional vibration system, and
 - (b) the equation of motion of torsional vibration induced by sinusoidal base motion.



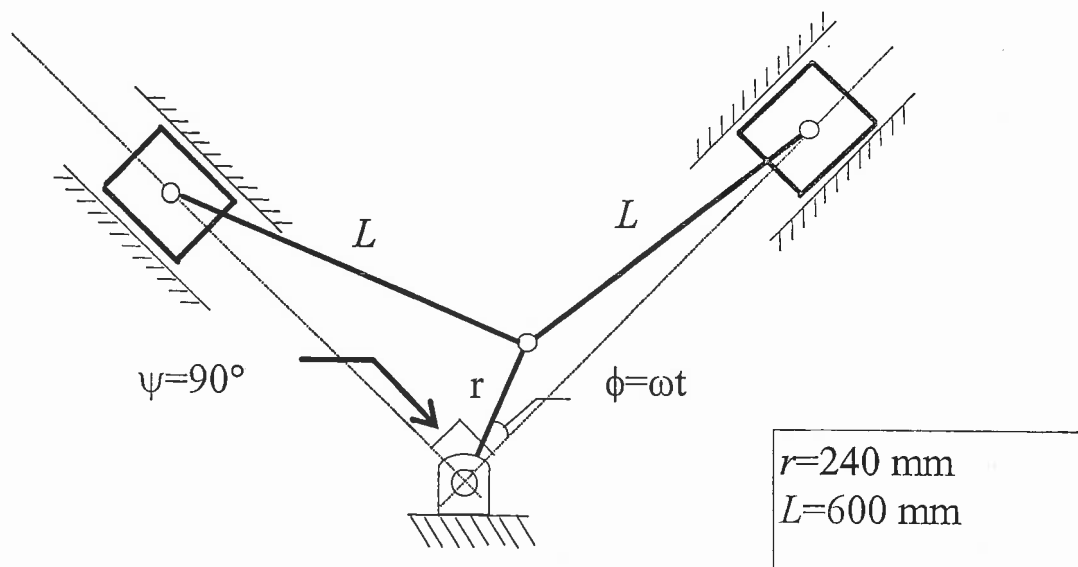
2. [25] A two-degrees-of-freedom mass-spring vibration system is subjected to a harmonic excitation $F_1(t) = F_{1,0} \sin \omega t = 200 \sin 100t$ (N). For $k = 10$ kN/m and $m = 2$ kg, determine
 - (a) the equations of motion in matrix form
 - (b) the two natural frequencies
 - (c) the two modal vectors
 - (d) the modal vectors normalized with respect to the mass matrix,
 - (e) the normalized modal matrix, and
 - (f) the system response due to the sinusoidal excitation.



3. [25] For a planetary gear train shown below, gear 7 is fixed; crank arms C and D are attached to the output shaft; gears 4 and 5 form a compound wheel rotating freely about the output shaft. If the numbers of teeth are $N_1 = 22$, $N_2 = 17$, $N_3 = 20$, $N_4 = 96$, $N_5 = 36$, $N_6 = 18$, determine
- the speed and direction of rotation of the output shaft, and
 - relative rotational speed of gear 2 with respect to crank arm C.



4. [25] A two-cylinder V-shape engine is located in the same axial plane. The crank shaft rotates at a constant angular speed of 1000 rpm. The masses of the two pistons are 1.5 kg each. Other links are considered massless. Determine, when $\phi = 35^\circ$, the primary resultant shaking force.



Not to scale

5. [25] A planar four-bar function generation mechanism is shown below. If the input link rotates at a constant angular velocity of 300 rpm (CCW), determine for the configuration shown,
- the angular velocities of the coupler and output link,
 - the angular accelerations of the coupler and output link,
 - the linear acceleration of the midpoint (mass center) of the output link, and
 - the magnitude and sense of the torque to be applied to input link from base link 1 to overcome the inertia of link 4 ($m_4 = 0.6 \text{ kg}$, $I_{G,4} = 0.025 \text{ kg} \cdot \text{m}^2$).

Scale: full size

