National Exams December 2002

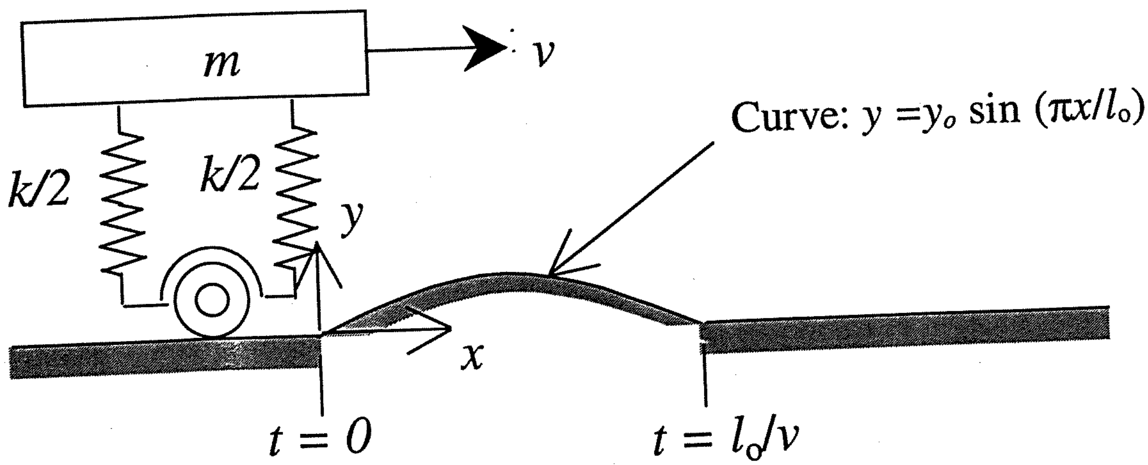
98-Mec-A3, Kinematics and Dynamics of Machines

3 Hours Duration

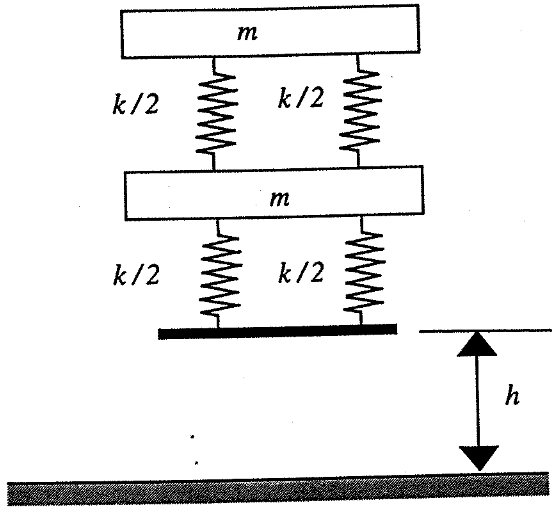
Notes

1. If in doubt 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.
3. Any four questions (25 marks for each question) constitute a complete paper. If you choose to answer more than four questions, only the first four questions as they appear in your answer book will be marked.

1. The following diagram shows a simplified model of a spring-supported vehicle. The vehicle travels at a constant speed (m/s) in the horizontal direction over a speed bump. Determine the response of the vehicle in the vertical direction for $0 \le t \le l_o/v$ and $t > l_o/v$.

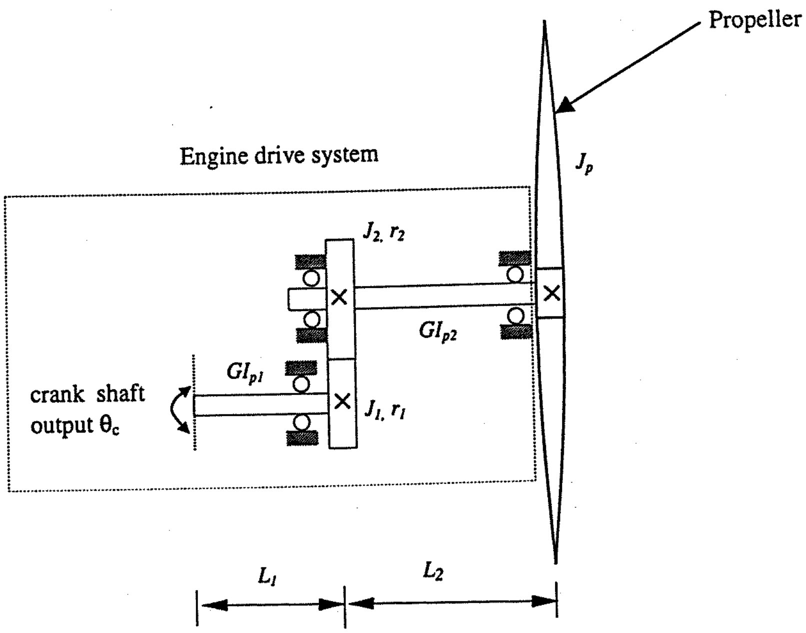


2. A two DOF system shown on next page is dropped from rest at a height h (= 1 m) above the ground. Assuming that the massless bottom plate sticks to the ground after impact, determine.
   (a) the equations of motion for a set of generalized coordinates of your choice,
   (b) the natural frequencies of the system torsional vibration,
   (c) the modal vectors associated with each of the natural frequencies in (b),
   (d) the modal masses and the normalized modal vectors, and
   (e) the ensuing motion (free vibration) of the system after the impact.

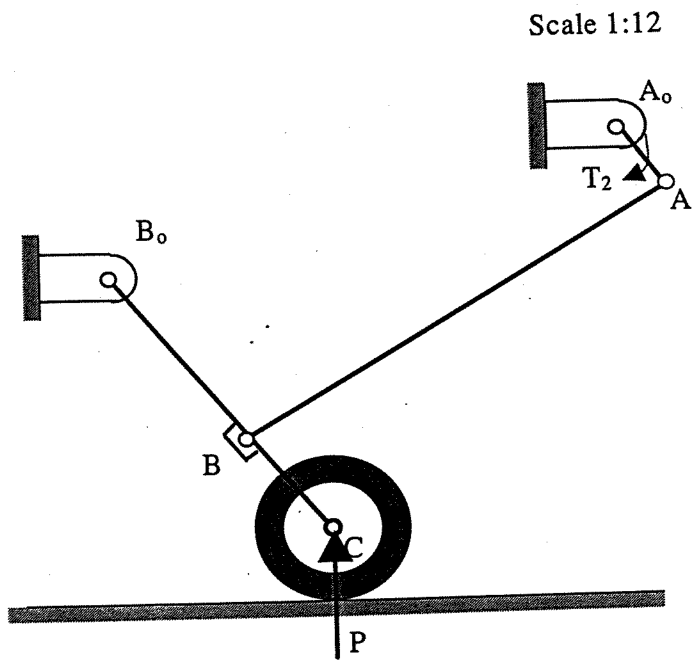


In your calculations, use $m = 20$ kg, and $k = 10$ kN/m.

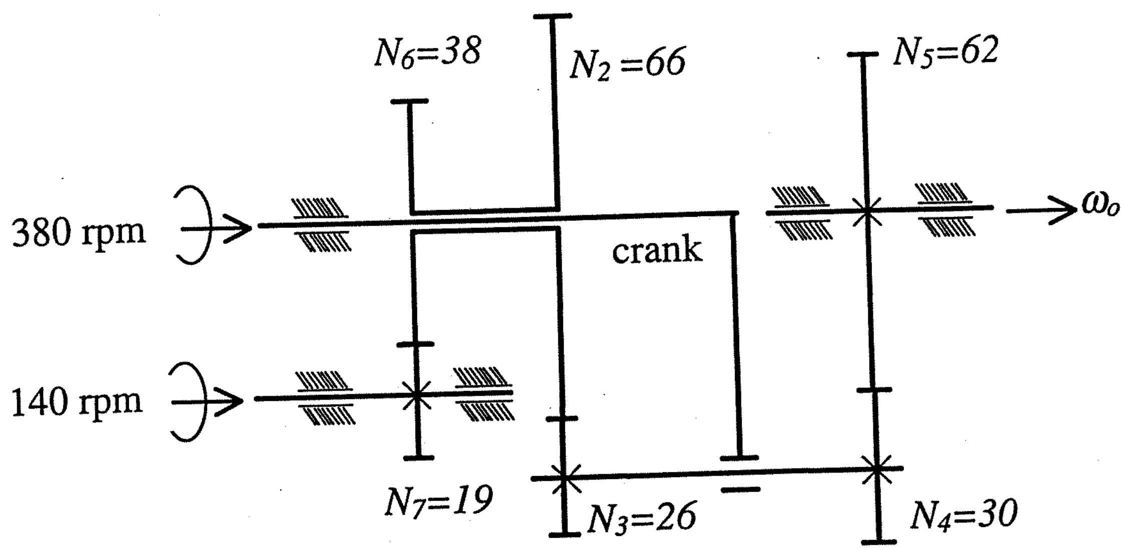
3. An engine-propeller drive train shown below consists of two parallel shafts made of steel (G = 70 GPa), a pair of spur gears having mass moments of inertia and pitch radii $J_1 = 0.02$ kg m^2, $r_1 = 0.075$ m, $J_2 = 0.08$ kg m^2, $r_2 = 0.15$ m, a propeller ($J_p = 2.5$ kg m^2) and a reciprocating engine. The two shafts have the following dimensions: $d_1 = 20$ mm, $L_1 = 100$ mm, $d_2 = 35$ mm, and $L_2 = 150$ mm. If the mass moments of inertia of the two shafts and the aerodynamic torque are negligible, determine the steady state response of system when the crank shaft rotates at $\theta_c(t) = 0.01 \sin 100t$ (rad).



4. A landing gear mechanism is shown below. During landing, a large dynamic force is transmitted to joint C through the tire assembly. For P = 10,000 N, determine (a) the torque T_2, (b) forces at joints A and B. In your calculations, masses of all links may be neglected.



5. A gear train system is shown below. If all gears have identical diametral pitch, determine the output angular velocity ω_o



6. A four-bar mechanism is shown below. The input link rotates at a constant angular velocity of 10 rad/s (CCW). At the position shown, determine
   (a) the type of mechanism,
   (b) the angular velocities of BB_0 and BC,
   (c) the angular accelerations of link B_0B, and
   (d) the linear acceleration of point C.
   [Use the space provided below for velocity and acceleration diagrams]