AML701 Mechanics and Mathematics

Major Test

Duration: 2 hr (1:00 PM - 3:00 PM) Total Marks: 40 Date: 23-Nov-2017

Instructions:
(a) Write all answers clearly. Copy is strictly prohibited. Mobile is not allowed in the exam hall.

Problem 1: A slender rod CDE of length L and mass M is attached to a pin support at its midpoint D. A second identical rod AB is rotating about a pin support at A with an angular velocity $\vec{\Omega}$ when its end B strikes end C of rod CDE. Denoting by e the coefficient of restitution between the rods, determine the angular velocity of each rod immediately after the impact. (12)

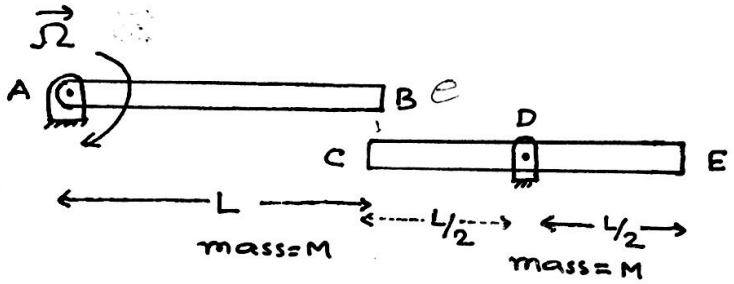

Fig: 1

Problem 2: A homogeneous disk of mass m and radius r is welded to a vertical shaft AB with which it forms an angle $\beta = 45^0$ as shown in figure. Knowing that the shaft rotates with an angular velocity $\vec{\omega}$. Determine the kinetic energy of the disk. (Given $I^G_{xx} = mr^2/4$, $I^G_{yy} = mr^2/2$, $I^G_{zz} = mr^2/4$, G is centre of mass of disk.) (8)

Problem 3: A rod BC of mass m is attached by pins to two uniform disks as shown. Disk-1 has mass m_1 and radius r_1 while disk-2 has mass m_2 and radius r_2. Knowing that the system is released from rest in the position shown. Determine the velocity of the rod after disk-1 has rotated through 90^0 in clockwise direction. Assume rolling without friction at the contact with ground. (10)

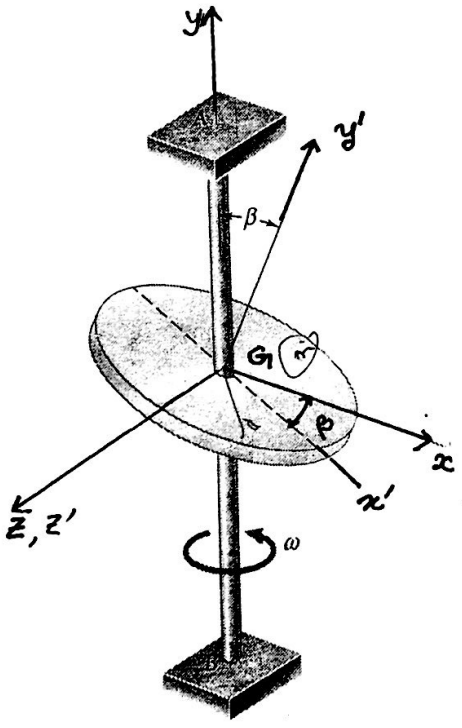

Fig: 2

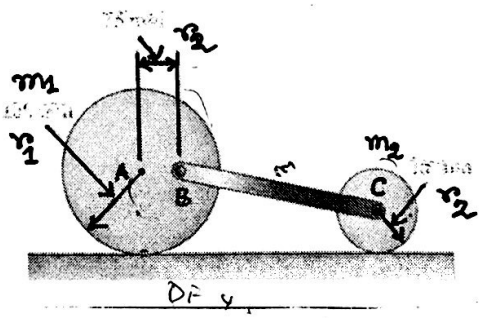

Fig: 3

Problem 4: A model of submarine of mass $m = 200kg$ travels under a sea such that the propeller at B rotates with an angular velocity 10 rad/s and an angular acceleration 2.6 rad/s^2 with respect to the submarine as shown in figure. At that instant, the submarine is also able to roll, yaw and pitch with angular velocities $\omega_x = 1\ rad/s$, $\omega_y = 2\ rad/s$ and $\omega_z = 3\ rad/s$ and angular accelerations $\dot{\omega}_x = 4\ rad/s^2$, $\dot{\omega}_y = 5\ rad/s^2$ and $\dot{\omega}_z = 6\ rad/s^2$ in x, y and z directions respectively with respect to the fixed frame as shown in figure. Suppose that x, y and z axes are principal axes at the centre of mass C with $I^C_{xx} = 120kg.m^2$, $I^C_{yy} = 90kg.m^2$ and $I^C_{zz} = 100kg.m^2$. Determine the rate of change of angular momentum at P with respect to the fixed frame, i.e $\frac{d\vec{H}_P}{dt}|_F$ (Given $\vec{PC} = 4\hat{i}$ and ignore the mass of propeller. Assume all rotations are anti-clockwise directions). (10)

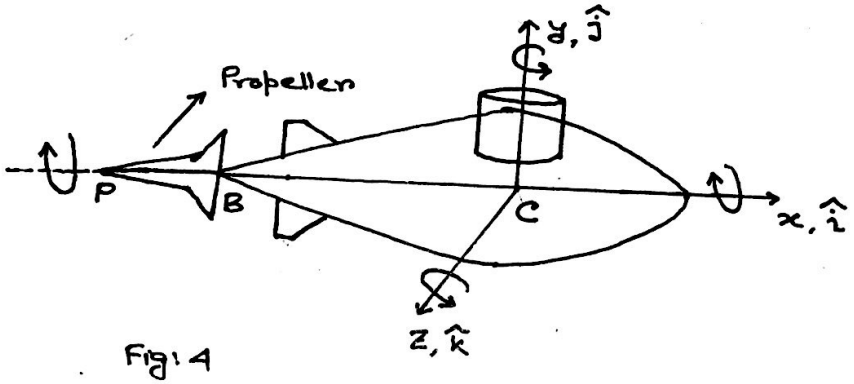

Fig: 4