BENGAL ENGINEERING AND SCIENCE UNIVERSITY SHIBPUR

B.E. 3rd Semester (AE & ME) Final Examination: 2012-13

AM311: Engineering Dynamics

Time allowed: 3hrs **Full marks: 70**

Attempt any three questions from each half

1st Half

Q1 (a) A uniform solid circular cylinder of mass *m* and radius *r* is suspended by a mass less rough belt as shown in Fig. 1. One end of the belt is fixed and the other end pulls a block of mass *M* moving on a smooth horizontal plane. Both the hanging sections of the belt are vertical. If NO SLIP between the belt and the cylinder is permitted find out the accln. of the block. (6½)

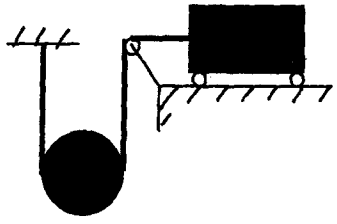

Fig. 1

(b) A wooden block of mass *m* is attached to a rigid rod of negligible mass and length *l*. The upper end of the rod is hinged to another block of mass *M* that can move on a horizontal plane freely. A bullet of mass m_b hits the wooden block horizontally with a speed V_0 (as shown in Fig. 2) and gets embedded in the block. What is the minimum required magnitude of V_0 so that the pendulum can make complete rotation about the hinge.

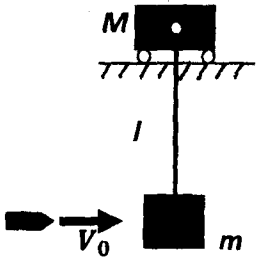

Fig. 2 (5)

Q2 (a)

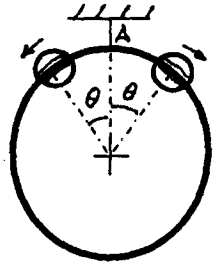

Fig. 3

A smooth ring of mass *M* and radius *r* hangs from a thread. Two identical beads of mass *m* each slides down the ring without friction on the two sides as shown in Fig. 3. The beads are released simultaneously from the top position *A* with negligible speed. Prove that the ring will start to rise at some point of time during the sliding of the beads only if $M \leq \frac{1}{3} m$. Also find the value of angle θ when that starts happening. (6½)

(b) The muzzle speed of a cannon shot is *V*. If the target be at a horizontal distance *S* from the gun and be at a height *H* find out the minimum value of *V* so that the target can be hit.

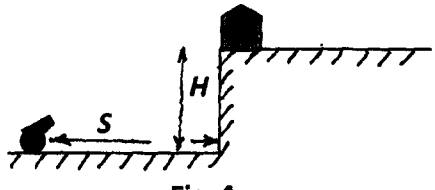

Fig. 4 (5)

Q3. (a)

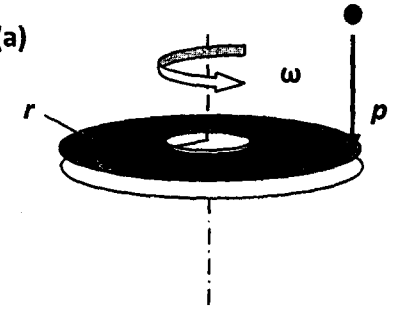

Fig. 5

A space station is in the form of a circular disc with radius *r*, mass *m*, diametric moment of inertia *I* and axial moment of inertia I_0. It is rotating about the axis of symmetry with a constant angular speed ω as in Fig. 5. A small particle of a very small mass hits the rim of the station with a momentum *p* in a direction normal to the plane of the disc and gets embedded on to the body of the space station. Neglecting the change in the inertial properties of the station due to addition of the particle determine the subsequent rotational motion of the station. (6½)

(b) After the Lunar Exploration Module (LEM) returns to the Command Module orbiting the moon in a circular orbit at an altitude of 140 km above the surface of the Moon, the astronauts come back to the Command Module. Then the LEM is detached and its speed is reduced so that it crashes on to the lunar surface making an angle of 60° with the vertical. If the mass and the radius of the moon be 6.99×10^{22} kg and 1740 km, respectively find out the required amount by which the speed of the LEM has to be reduced. (5)

Q4. A uniform, heavy circular cylinder of mass *m* and radius *r* rolls without slipping on a horizontal plane surface with a speed v_0 as shown in Fig. 6. It encounters a deep notch of width *b* on the surface whose longitudinal axis is parallel to the axis of the cylinder. If there is no slip or rebound during the subsequent motion find out the expression for the speed of the cylinder after it crosses the notch.

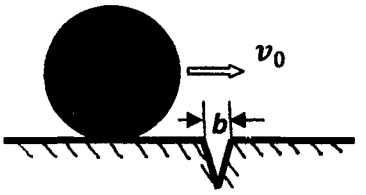

Fig. 6 (11½)

2nd Half

Q5. (a) An Earth satellite is placed in a circular polar orbit at a height *H* above the Earth surface, the radius of the Earth being *R*, as shown in Fig. 7. As the satellite goes over the north pole at *A* its retro rocket is activated to reduce its speed so that the satellite lands at a point *B* on the equator. Find out the required reduction of speed if the mass of the Earth be M_E.

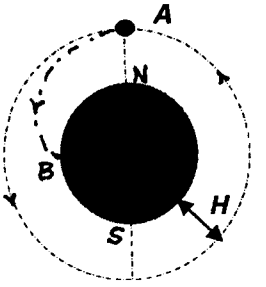

Fig. 7 (5)

(b)

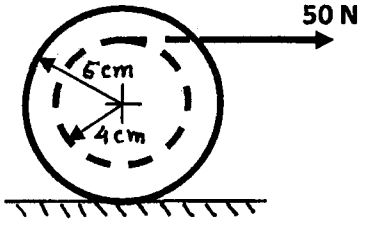

Fig. 8

A heavy yo-yo with a mass of 10 kg and axial moment inertia 0.75×10^{-2} kg - m^2 rests on a rough horizontal plane as shown in Fig. 8. Its hub and rim radii are 4 cm 5 cm, respectively. The coefficient of friction between the yo-yo and the plane is 0.3. (i) A light string wound around the hub is pulled horizontally with a force of 50 N. Find out the acceleration of the centre of the yo-yo. (ii) If the string is pulled with a force of 60 N what will be the acceleration magnitude? (6½)

Q6. (a) A rigid but mass less bent wire carries 6 identical particles of mass *m* each. The lengths of the different sections of the wire are indicated in Fig. 9. Whole assembly rotates about point *O* with velocity $\hat{\imath}\omega_x + \hat{\jmath}\omega_y + \hat{k}\omega_z$ where the magnitudes of the three components ω_x, ω_y and ω_z are 1, 2 and 3 rad per second, respectively. Find out the angular mom-mentum and the kinetic energy of the system. (6½)

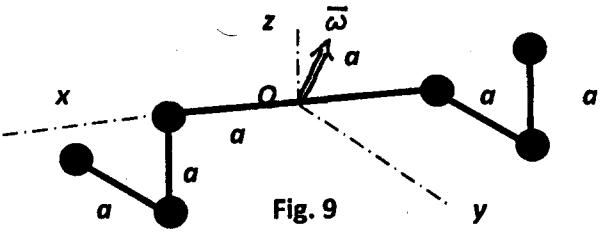

Fig. 9

(b) A space craft with its engine shut off describes an elliptic orbit under the action of a central force directed towards one of its foci. When the spacecraft reaches at one extremity of the minor axis a burst from its rocket engine puts the spacecraft in a circular orbit. Find out the direction and magnitude of the momentary impulse from the rocket engine. (5)

Q7. (a) A uniform circular disc of radius *r* and mass *m* is mounted on a mass-less rigid shaft *OA* that is hinged to a vertical shaft at *O*. The disc rests on a rough horizontal plane as shown in Fig. 10. The vertical shaft rotates at a constant angular speed Ω carrying along with the disc.

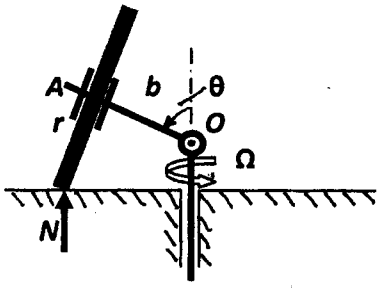

Fig. 10

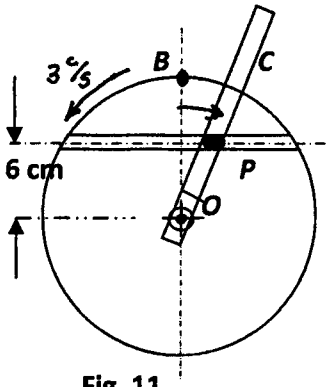

Fig. 11

If the shaft *OA* makes an angle θ with the vertical shaft and there is no slip between the disc and the horizontal plane on which it rolls find out the contact force *N* at the point of contact between the floor and the disc. (6½)

Q 7. (b) Using self explanatory neat sketches and diagrams explain the working principle of a gyro-compass. Your answer must be brief and to the point. (5)

Q8. (a) A slotted disc rotates about the fixed hinge *O* with a constant counter clockwise angular velocity 3 rad / sec. Simultaneously the slotted lever *OC* rotates with respect to the disc with a constant angular speed (relative to the radial line *OB* drawn on the disc) of 2 rad / sec in the clockwise direction (Fig.11). Determine the magnitude of the resultant acceleration of the pin *P* at the instant when angle $BOC = 30^{\circ}$. (6½)

(b) A uniform bar of length *L* and mass *M* hangs from a fixed hinge *O* as shown in Fig. 12. A particle of mass *m* hits the bar horizontally at a distance *x* from the hinge as shown in the figure. Find out the distance *x* so that no impulsive reaction is felt at the hinge. (5)

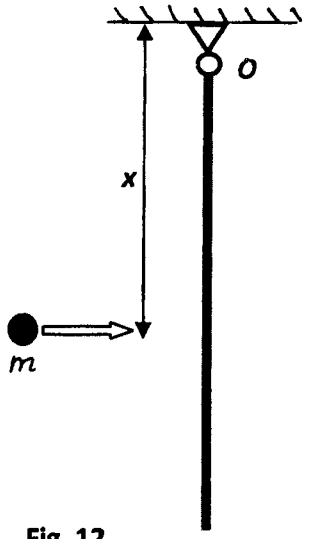

Fig. 12