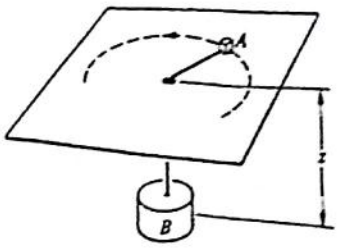
BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI, RAJASTHAN

Mid Semester Examination (Closed Book): 2017-18, 1st Semester

MEOW: PHY F111, 14th October 2017, Duration: 90 mins., Full Marks: 90

Instruction(s): All questions are compulsory. Answer all parts of a question together. Write your final answer of each sub-part inside a box.

Q1. A frictionless table has small hole at its center. Block 'A' of mass M_A is connected to block 'B' of mass M_B hanging beneath by a string of negligible mass which passes through the hole. Initially block 'B' is held stationary and 'A' rotates at constant radius 'r_0' with steady angular velocity 'ω_0'. Considering $M_B > M_A$, what should be the minimum value of angular velocity 'ω_0' so that the block 'B' will begin to rise up. (8)



Q2. A rocket sled moves up on an incline snow plane of angle 'θ'. A retarding friction force acts on the sled. Coefficient of friction between the sled and snow is 'μ'. Sled's total initial mass is M_0 and its engine expels mass in the opposite direction of motion of sled with a relative velocity v_R and with a rate 'b' Kg/s.

(a) Find expression of instantaneous acceleration and instantaneous speed of the sled at later times as a function of μ, v_R and b. **(10)**

(b) The engine is turned off when the sled's total mass reduces to half of its total initial mass. Find the maximum speed achieved by the sled. **(5)**

Q3. A circus acrobat of mass 50 kg leaps straight up with initial velocity 20 m/s from a trampoline. As he rises up, he takes a trained monkey of mass 15 kg off a platform a height 10 meters above the trampoline. Find the maximum height attained by the pair (Take, $g = 10\ m/s^2$). **(7)**

Q4. A circular platform of radius 'R' rotates with constant angular velocity ω in the counter clockwise direction. A car of mass 'M' runs with a constant speed v_0 in a circular path in a counterclockwise direction on the platform. The maximum frictional force between the car and the surface of the circular platform is F_{max}.

(a) Show that the car does not skid as long as it moves in a circular path of radius 'r' such that $R_1 < r < R_2$ (where, $0<R_1<R_2<R$). That is the car does not skid within the annular region bounded by R_1 and R_2.

(b) Find all the fictitious forces (with correct magnitude and directions) on the car as observed in the rotating frame of the circular platform.

(c) Find the fictitious force (with correct magnitude and direction) in the non-inertial frame of the car.

(d) Find the magnitude and the direction of all the fictitious forces on the car as observed in the rotating frame of the circular platform if the car were running with a speed v_0 in the clockwise direction? **(8+4+3+3)**

Q5. A chain of mass M and length L is suspended vertically with its lowest end touching a scale. The chain is released and falls onto the scale.

(a) What is the reading of the scale when a length of chain, x, has fallen.

(b) What is the maximum reading on the scale. **(8+4)**

Q6. Consider a ball of mass m and radius R on a horizontal surface with friction. When given an initial speed V_0 it initially slides without rolling. The moment of inertia of the ball about the center is $I_0=\beta mR^2$, where β is a constant. Answer the following questions:

(a) Write down the translational and rotational **(about the center of mass of the ball)** equations of motion of the ball until it attains the condition of rolling without slipping. Find the speed of the ball when it begins to roll without slipping. **(7)**

(b) Find the speed of the ball when it begins to roll without slipping by doing torque analysis about the point of contact. **(5)**

(c) What is the kinetic energy lost while sliding? **(3)**

(d) Note that in the above analysis we did not make any specific assumptions (constant or changing) about the nature of friction. Now assume that the coefficient of kinetic friction is μ, independent of position of the ball. Find the time 't' taken, and distance 'd' traveled by the ball when it begins to roll without slipping. **(7)**

(e) Calculate the work done by the friction force and verify that it is equal to change in kinetic energy calculated in part (c). (Hint: If you do it naively, your answer may not match with part (c)). **(8)**

END