Prof. Anchordoqui

Problems set # 8 **Physics 168**

1. A bowling ball that has 11 cm radius and 7.2 kg mass is rolling without slipping at 2 m/s on a horizontal ball return. It continues to roll without slipping up a hill to a height h before momentarily coming to rest and then rolling back down the hill. Model the ball as a uniform sphere and find h.

2. A cue stick strikes a cue ball horizontally at a point distance d above the center of the ball. Find the value of d for which the cue ball will roll without slipping from the beginning. Express your answer in terms of the radius R of the ball.

3. A uniform solid ball of mass m and radius R rolls without slipping down a plane inclined at an angle ϕ above the horizontal. Find the frictional force and the acceleration of the center of the mass.

4. A bowling ball of mass M and radius R is released at floor level so that at release it is moving horizontally with speed $v_0 = 5$ m/s and is not rotating. The coefficient of kinetic friction between the ball and the floor is $\mu_k = 0.08$. Find (a) the time the ball slides, and (b) the distance the ball skids.

5. An Atwood's machine consists of two masses, m_1 and m_2 which are connected by a massless inelastic cord that passes over a pulley. If the pulley has radius R and moment of inertia I about its axle, determine the acceleration of the masses m_1 and m_2.

6. Two masses $m_1 = 18$ kg and $m_2 = 26.5$ kg are connected by a rope that hangs over a pulley. The pulley is a uniform cylinder of radius 0.26 m and mass 7.5 kg. Initially, m_1 is on the ground and m_2 rests 3 m above the ground. If the system is now released, use conservation of energy to determine the speed of m_2 just before it strikes the ground. [Assume the pulley is frictionless]

7. A person stands, hands at his side, on a platform that is rotating at a rate of 1 rev/s. If he raises his arms to a horizontal position, the speed of rotation decreases to 0.8 rev/s. (a) Why? (b) By what factor has his moment of inertia changed? (See Fig. 1)

8. A figure skater can increase her spin rotation rate from an initial rate of 1 rev every 2 s to a final rate of 3 rev/s. If her initial moment of inertia was 4.6 kg m^2, what is her final moment of inertia? How does she physically accomplish this change?

9. Determine the angular momentum of the Earth (a) about its rotation axis (assume the Earth is a uniform sphere); (b) in its orbital around the Sun (treat the Earth as a particle orbiting the Sun). The Earth has a mass $M_\oplus = 6 \times 10^{24}$ kg and radius $R_\oplus = 6.4 \times 10^6$ m, and is 1.5×10^8 km from the Sun.

10. Hurricanes can involve winds in excess of 120 km/h at the outer edge. Make a crude estimate of (a) the energy and (b) the angular momentum of such a hurricane, approximating it as a rigidly rotation uniform cylinder of air (density 1.3 kg/m^3) of radius 100 km and height 4 km.

11. An asteroid of mass 1×10^5 kg, traveling at a speed of 30 km/s relative to the Earth, hits the Earth at the equator tangentially, and in the direction of the Earth rotation. Use angular momentum to estimate the percent change in the angular speed of the Earth as a result of the collision.

12. (a) Use conservation of angular momentum to estimate the angular velocity of a neutron

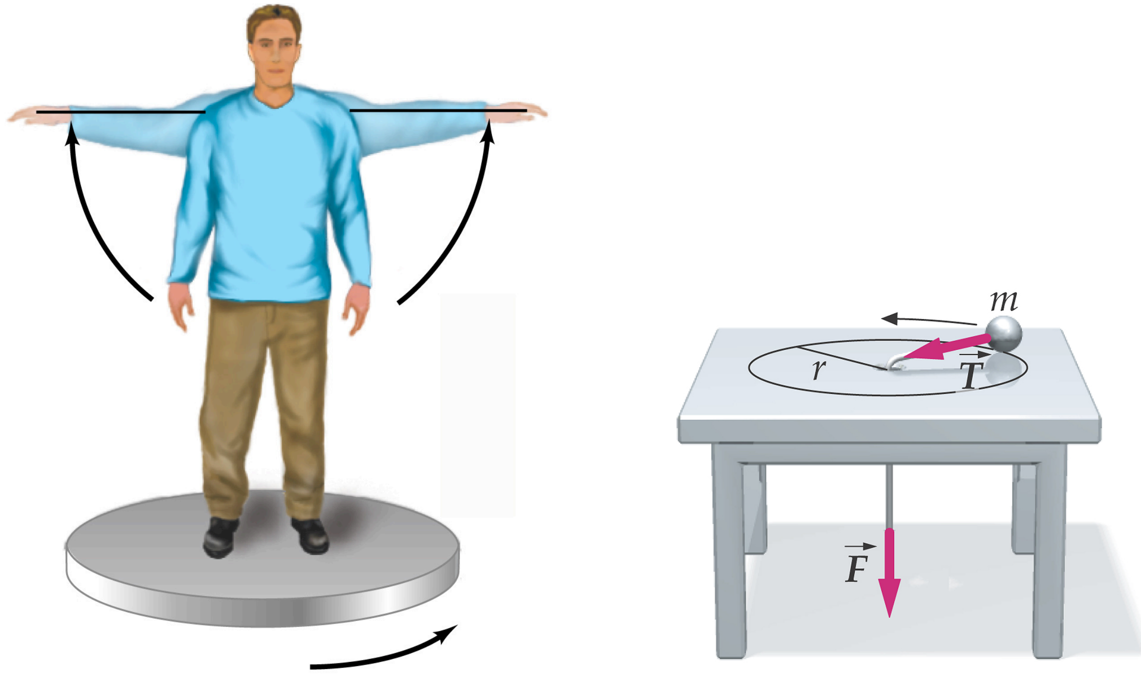

Figure 1: The situation in problems 6 (left) and 13 (right).

star which has collapsed to a diameter of 20 km, from a star whose radius was equal to that of the Sun (7×10^8 m), of mass 1.5 $M_\odot$, and which rotated like our Sun once a month. (b) By what factor the rotational kinetic energy change after the collapse?

13 A particle of mass m moves with speed v_0 in a circle with radius r_0 on a frictionless table top. The particle is attached to a string that passes through a hole in the table as shown in Fig. 1. The string is slowly pulled downward until the particle is a distance r_f from the hole, after which the particle moves in a circle of radius r_f. (a) Find the final velocity in terms of r_0, v_0, and r_f. (b) Find the tension when the particle is moving in a circle of radius r in terms of m, r, and the angular momentum $\vec{L}$. (c) Calculate the work done on the particle by the tension force $\vec{T}$ by integrating $\vec{T}\ .\ d\vec{\ell}$. Express your answer in terms of r and L_0.

14. If $\vec{A} = 3\hat{j}$, $\vec{A} \times \vec{B} = 9\hat{i}$, and $\vec{A}\ .\ \vec{B} = 12$, find $\vec{B}$.