Prof. Anchordoqui

Problems set # 4 **Physics 168**

1. Every few hundred years most of the planets line up on the same side of the Sun. Calculate the total force on the Earth due to Venus, Jupiter, and Saturn, assuming all four planets are in a line. The masses are $M_{\rm V} = 0.815 M_\oplus$, $M_{\rm J} = 318 M_\oplus$, $M_{\rm S} = 95.1 M_\oplus$, and their mean distances from the Sun are 108, 150, 778, and 1430 million km, respectively. What fraction of the Sun's force on the Earth is this. (See Fig. 1, not to scale).

2. Given that the acceleration of gravity at the surface of Mars is 0.38 of what it is on Earth, and that Mars radius is 3400 km, determine the mass of Mars.

3. A flat puck (mass M) is rotated in a circle on a frictionaless air-hockey tabletop, and is held in this orbit by a light cord connected to a dangling block (mass m) through a central hole. Show that the speed of the puck is given by $v = (mgR/M)^{1/2}$. See Fig. 2.

4. A tetherball of mass m is suspended from a length rope and travels at constant speed v in a horizontal circle of radius r Find (a) the tension of the rope and (b) the speed of the ball. See Fig. 1.

5. A projected space station consists of a circular tube that will rotate about its center (like a tubular bicycle tire). The circle formed by the tube has a diameter of about 1.1 km. What must be the rotation speed (revolutions per day) if an effect equal to gravity at the surface of the earth is to be felt?

6. At what minimum speed must a roller coaster be travelling when upside down at the top of a circle so that passengers will not fall out. Assume a radius of curvature of 7.4 m

7. A 1200 kg car rounds a curve of radius 67 m banked at an angle of 12°. If the car is travelling at 95 km/h, will a friction force be required? If so how much and in what direction?

8. Two blocks, of masses m_1 and m_2, are connected to each other and to a central post by cords as shown in Fig. 2. They rotate about the post at a frequency f (revolutions per second) on a frictionless horizontal surface at distances r_1 and r_2 from the post. Derive an algebraic expression for the tension in each segment of the cord.

9. A pilot performs an evasive maneuver by diving vertically at 310 m/s. If he can withstand an acceleration of 9 g's without blacking out, at what altitude must he begin to pull out of the dive to avoid crashing into the sea?

10. A 64.0 kg skydiver falls with terminal speed of 180 km/h with her arms and legs outspread. (a) What is the magnitude of the upward drag force F_d on the skydiver? (b) If the drag force is equal to bv^2, what is the value of b?

11. Amtrak's high speed train, the *Acela*, utilizes tilt of the cars when negotiating curves. The angle of tilt is adjusted so that the main force exerted on the passangers, to provide the centripetal acceleration is the normal force. The passangers experience less friction force against the seat , thus feeling more comfortable. Consider an *Acela* train that rounds a curve with a radius of 620 m at a speed of 160 km/h (approximately 100 mi/h). *(i)* Calculate the friction force needed on a train passanger of mass 75 kg if the track is not bank and the train does not tilt. *(ii)* Calculate the friction force on the passanger if the train tilts to its maximum tilt of 8° towards the center of the curve.

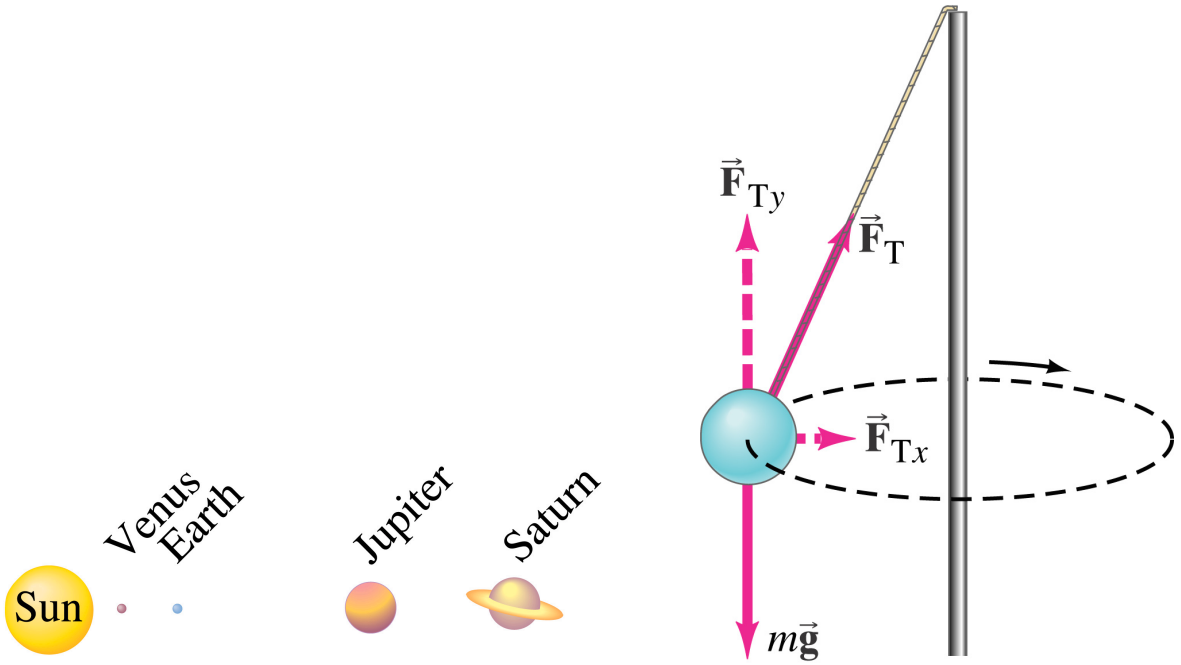

Figure 1: The situations in problems 1 (left) and 3 (right).

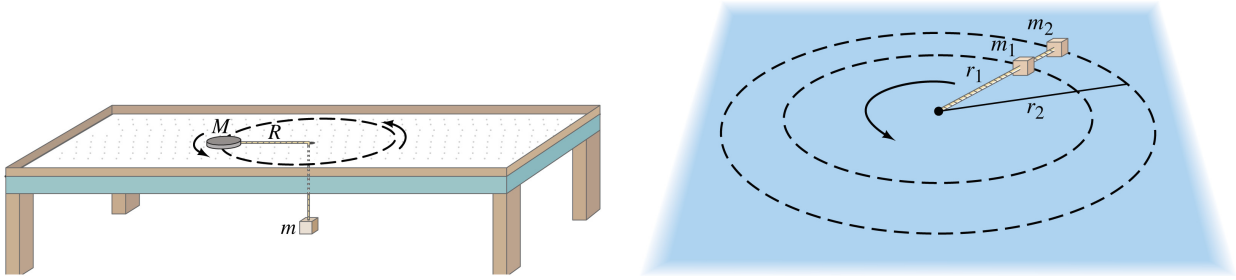

Figure 2: The situations in problems 4 (left) and 9 (right).

12. How long would a day be if the Earth were rotating so fast that objects at the equator were apparently weightless?