Physics 21 Problem Set 7

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due Tuesday, Feb. 22 at 5pm

Course Announcements:

Reading for these Problems: RHK4 13-5 through 13-7, Chapter 14; KK 7.3-7.6.

PSR Fellows, who are advanced Physics Majors, are available to help you in the PSR Wed. & Thurs. from 6-8pm, and Sunday in 1640 Broida, 6-8pm.

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1. (RHK4 13.31) A wheel with rotational inertia 1.27 kg·m^2 is rotating with an angular speed of 824 rev/min on a shaft whose rotational inertia is negligible. A second wheel, initially at rest with rotational inertia of 4.85 kg·m^2, is suddenly coupled to the same shaft.

   (a) What is the angular speed of the resultant combination fo the shaft and the two wheels?

   (b) What fraction of the original kinetic energy is lost?

2. (RHK4 13.42) a top is spinning at 28.6 rev/second about an axis making an angle of 34.0° with the vertical. Its mass is 0.492 kg, and its rotational inertia is 5.12×10^{-4} kg·m^2. The center of mass is 3.88 cm from the pivot point. The spin is clockwise seen from above. Find the magnitude (in revolutions/second) and direction of the angular velocity of precession.

3. KK 7.6. I like this problem because you can do the experiment yourself. The problem can seem daunting at first, but break it down into steps. I'd suggest you first identify ω the angular velocity of the coin's rotation about its axis in terms of v and b, and, also, the angular velocity Ω of the coin's motion about the center of the big circle, in terms of v and R. Next focus on the 'spin' angular momentum of the coin, about the center of the coin... get its magnitude in terms of mass M, b, and v. Then visualize how that spin changes as the coin makes its journey about the circle of radius R. It precesses ! (well, one component of the spin is precessing... one component never changes). The 'orbital' angular momentum of the coin about the center of the big circle never changes, so torques aren't influencing it. The time rate of change of the spin direction must come from a torque. What torque? Since you (at least initially) view the rotation as being about the center of mass of the coin, think about the torque provided by the normal force of the floor on the coin (how is that related to the weight of the coin?) and the friction. The friction must provide the centripetal acceleration, so you know how to express that force in terms of M, v, and R. That should do it... for a bigger challenge work the problem about the point of contact of the coin with the floor... works out the same, a little easier, actually... you need the parallel axis theorem.

4. (RHK4 14.1) An eight-member family, whose weights in pounds are indicated, is balanced on a see-saw, as shown in Fig 1. What is the number of the person who causes the largest torque, about the pivot point, directed:

   (a) out of the page, and,

   (b) into the page?

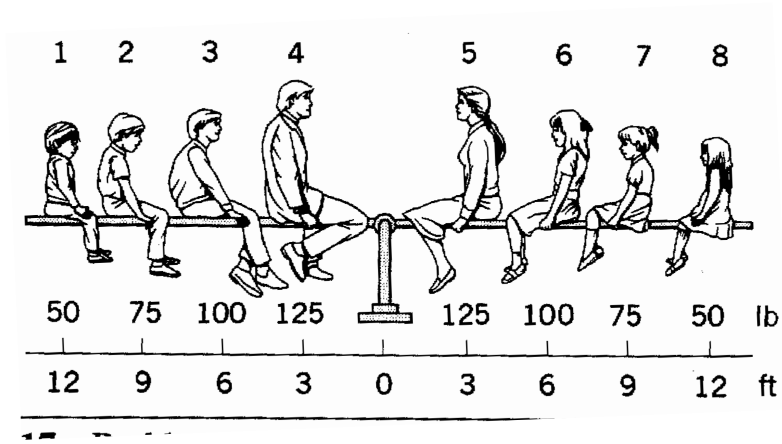

Figure 1: Problem 4.

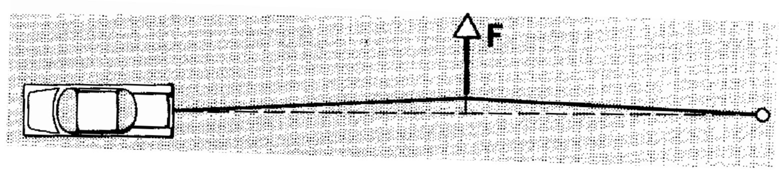

Figure 2: Problem 5.

5. (RHK4 14.9) In Fig. 2, a clever woman has figured out how to get her car out of mud on the shoulder of a road. She ties one end of a rope tightly around her front bumper and the other end around a tree 64 feet away from the bumper. Initially, there is negligible tension in the rope; just enough to keep it straight. Then she pushes sideways on the rope at its midpoint with a force $F = 100\,\text{lbs}$, displacing the center of the rope 1 ft from its initial position, and the car just starts to move. At that instant, prior to significant displacement of the car, find the force exerted by the rope on the car. Assume the rope stretches to cover the increased rope length.

6. (RHK4 14.17) Consider the static forces that arise when standing tip-toe. Figure 3 shows the anatomical structures in the lower leg and foot that are involved when the heel is raised up off the floor so the foot contacts the floor at one point near the toes, at point P in the figure. The calf muscle pulls up on the heel, and the foot bones, which you can approximate as a single solid

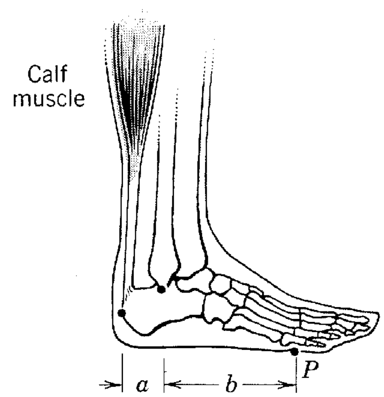

Figure 3: Problem 6.

plank, pivot around the point where the lower leg bone attaches to the foot. Call the weight of the person W, and assume they stand on one foot. Denote the force with which the calf pulls up on the heel as C; additionally denote the component of the force of the leg bone on the foot bone as P, which can be either positive or negative. Solve for C/W and P/W in terms of the quantities in the figure, and numerically evaluate these quantities for a person with mass of 65 kg, $a = 5\,\text{cm}$, and $b = 15\,\text{cm}$.

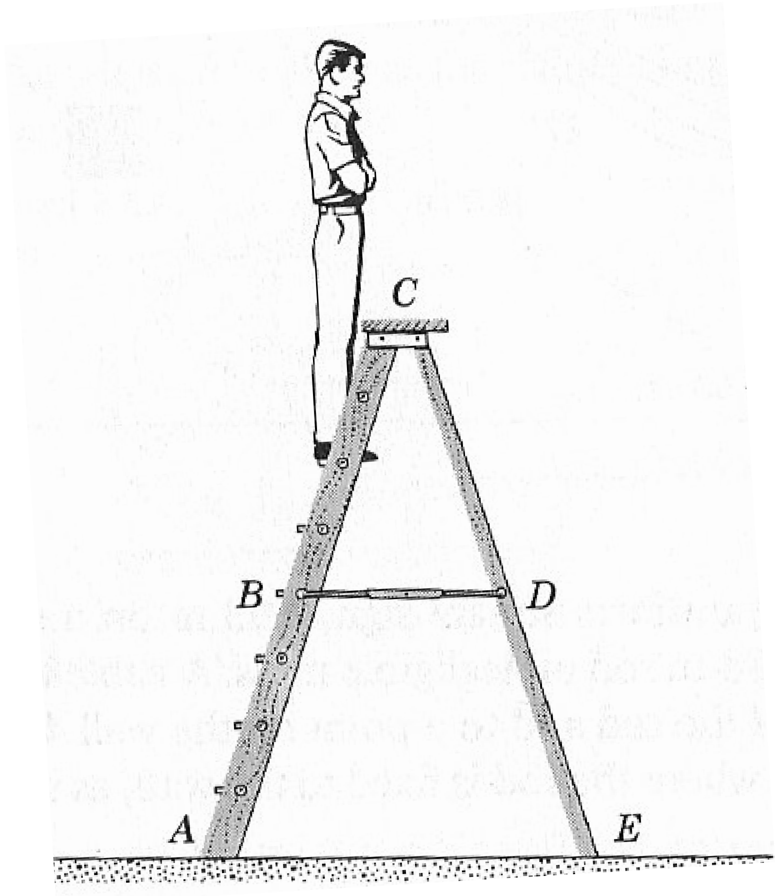

Figure 4: Problem 7.

7. (RHK4 4.33) In the stepladder shown in Fig. 4 AC and CE are 8 ft long and hinged at C. A tie rod spans BD and is 2.5 ft long, halfway up. A man weighing 192 lbs climbs up 6 ft along the ladder. Assume that the floor is frictionless and neglect the weight of the ladder, and find:

   (a) the tension in the tie road, and,

   (b) the forces exerted by the floor on the ladder.

   It helps to analyze the two sides of the ladder separately; one of Newton's Laws helps a lot in analyzing the forces at point C, where the hinge is.