Physics 206a

Homework Assignment X—corrected version
due March 23, 2007
(This assignment looks longer than it is. Most of the problems are actually quite easy—#4 is probably the hardest. So don't worry about the length of the assignment—just get to work on it and it will be done sooner than you expect.)

1. Superman wants to stop the Earth from spinning.
    a. Assuming a constant angular acceleration, what torque would he have to exert on it to stop it in one hour?
    b. If he exerts the torque by pushing on a point on the equator, what force does he have to exert?
    c. Rather than pushing on a point on the equator, he pushes on a point in Edwardsville, IL. Now what force does he have to exert?
2. The propeller on an airplane has a diameter of 223 cm and a mass of 26.8 kg. The desired rotation rate of the propeller is 2700 rpm. The engine provides a torque of $\tau = 550 N \cdot m$. How long does it take for the propeller to reach operating speed when the airplane's engine is started?
3. Two children sit on the ends of a see-saw. The distance between the children is 3 meters. Child "A" has a mass of 22 kg and child "B" has a mass of 31 kg. The pivot of the see-saw is halfway between them. They begin with child "B" in the air and child "A" on the ground. At this time, the see-saw makes an angle relative to the horizontal of 0.2 radians. What is the magnitude (size) of the net torque on the see-saw?
4. A yoyo has a total mass of 185 grams and a radius of 6 cm. Consider the yoyo to be a perfect solid disk. The hub has a radius of 3 millimeters. The yoyo begins with its string completely wound around the hub. (Neglect the thickening of the hub due to the string.) When the string is held and the yoyo allowed to fall by "unwinding," what total downward acceleration will the yoyo experience? (Hint: Determine the angular acceleration and then calculate the amount of string played out due to the rotation. Remember that linear acceleration and angular acceleration are related, in this case.)
5. Consider again the yoyo described in the previous problem. Use conservation of energy to determine the angular and linear speeds of the yoyo after it has descended ½ meter.
6. An ice skater whose mass is 55 kg is spinning at 11 radians per second. She can be approximated as a cylinder 50 cm in diameter. Someone throws a cat to her and the cat attaches itself to her with its sharp claws (neglect the speed with which the cat is thrown). The mass of the cat is 7 kg. What will her angular speed be with the cat attached?

7. Two men are standing on a merry-go-round which is turning at a constant angular speed, ω. One man is standing very near the center of the merry-go-round, the other is standing very near the edge. The man at the center is trying to throw a baseball directly to his friend at the edge but for some reason the ball always winds up very far from its intended target. Please explain the mistake the man at the center is making. (This is an example of the "coriolis" effect.)

8. Consider again the situation in the previous problem (#7). The angular speed of the merry-go-round is $0.1\,\frac{\text{radian}}{\text{second}}$ and it is 12 meters in diameter. The baseball is thrown with a velocity in the $\hat{x}$ direction of $13\,\frac{\text{meters}}{\text{second}}$ (i.e., ignore the $\hat{y}$ component of the velocity). How far (measured along an arc) from the catcher does the ball wind up?

9. Yet again, consider the merry-go-round of problem #7. The catcher perceives that a force is acting on the ball to skew its path. This is a "fictitious force." What size force would be needed to cause the motion observed by the catcher if it were real?

10. What is the "orbital angular momentum" of the earth? That is, the angular momentum due to the earth revolving around the sun.

11. Using Newton's law of gravitation, derive the acceleration due to gravity experienced by an object of mass m at the surface of the Earth. Show that this acceleration is independent of the mass of the object.

12. If the radius of the earth changed and became ½ of its current value (but the mass stayed the same), what answer would you get for the previous problem?

13. Determine the acceleration due to gravity for an object on the surface of the Moon.