PHYS:1200 Physics of Everyday Experience

Review questions and exercises for Lecture 11 (M-10)

1. What factors determine the rotational inertia of an object?
2. Two metal spheres, one that is hollow and one that is solid are constructed of different materials but have the same mass and diameter. If the spheres roll down an inclined plane from the same initial height, which one will reach the bottom of the incline first?
3. A wheel requires 2 s to make one full rotation. What is its rotational speed in revolutions per minute (RPM)?
4. What does a point on the rim of a wheel have a higher speed than a point midway between the rim and the axel?
5. What is the law of conservation of rotational momentum?
6. Why does a spinning ice skater spin faster when she pulls her arms in close to her body?
7. Why is a bicycle stable when it is moving but tends to tip over when it stops?

Solutions (Try to do the problems before looking at the solutions.)

1. The rotational inertia of an object depends on its mass and how the mass is distributed relative to the axis of rotation.
2. A hollow sphere has a larger rotational inertia as compared to a solid sphere of the same mass and radius. Since both spheres experience the same torque, the sphere with the smaller rotational inertia will spin faster and thus will reach the bottom of the inclined plane first.
3. The number of revolutions per minute = 1 rev / (2/60) min = 1 rev / (1/30) min = 30 RPM.
4. All points on a rotating wheel have the same angular velocity. A point on the outer rim of the wheel moves through a larger arc length than a point midway between the rim and axel of the wheel in the same time interval. So the linear speed of a point on the rim is twice as large as the linear speed of the midpoint of the wheel.
5. In the absence of any external torques, the total rotational momentum of a rigid body is a constant (conserved).
6. When a spinning skater pulls her arms in close to her body, she lowers her rotational inertia. To conserve her rotational momentum, she spins faster. The rotational momentum is the product of rotational inertia and rotational velocity. Since the product must be constant, if one of these quantities decreases, the other quantity must increase.
7. A spinning bike wheel has rotational momentum which is conserved both in magnitude and direction. So while the bike is moving and the wheels are rotating, the tendency to preserve the rotational momentum keeps the bike from tipping over. When the bike is not moving, it has no rotational momentum.