## Chapter 8

## A Good Thing To Know

Equations in this chapter are rotational versions of kinematic equations learned earlier:

a) The rotational VAT equation: $\omega = \omega_0 + \alpha t$

b) The rotational VAX equation: $\omega^2 = \omega_0^2 + 2\alpha\Delta\Theta$

c) The rotational VATX equation: $\Delta\Theta = \omega_0 t + \frac{1}{2}\alpha t^2$

d) The rotational Force equation: $\tau = I\alpha$ and $t = Fxd$

e) The rotational momentum equation: $L = I\omega$

f) The rotational Kinetic Energy equation: $KE_{(rot)} = ½ I\omega^2$

1. $360^o = 2\pi$ radians. Use this information to convert each of the angles given to radians.

3. See equation 8-1a page 195.

4. Change rpm to radians per second to solve for initial angular velocity. Then list your variables and choose from $\omega\alpha t$, $\omega\alpha\Theta$ or $\omega\alpha t\Theta$ to solve for $\alpha$.

6. Convert centimeters to kilometers. Then find the circumference of the tire and calculate how many of those circumferences will “fit” into 8.0 km.

7. Change rpm to radians per second. Then solve.

15. Change rpm to rad/s and revolutions to radians (1 rev = $2\pi$ radians). You have $\omega$, $\omega_o$ (it started from rest) and time. Solve for $\alpha$.

16. Change rpm to rad/s. You are given initial and final angular velocity and time.
    a) List your variables and choose $\omega\alpha t$, $\omega\alpha\Theta$ or $\omega\alpha t\Theta$ to solve for $\alpha$.
    b) Find $\Theta$ in radians and convert to # of revolutions. (1 rev = $2\pi$ radians)

17. a) Change minutes to seconds and revolutions to radians. It started from rest. You now have time, distance and initial angular velocity. Solve for angular acceleration.
    b) Now you have $\omega_o$, $\alpha$, $\Theta$ and time. Find the final $\omega$ and convert to rpm.

18. This problem will take two steps to solve.
    i) Change cm to m and rpm to rad/s. You have initial and final angular velocities and time. List your variables and to solve for angular acceleration.
    ii) You now have initial and final angular velocities, time and angular acceleration. List your variables and solve for distance in radians. Convert radians to meters.

21. Change revolutions to radians and km/hr to rad/s. To convert km/hr to rad/s, multiply by 0.278 to get m/s, and then divide by the radius of the wheel to get rad/s.
($v = r\omega$ so $\omega = v/r$)
You're given the initial and final velocities, and distance (revolutions or radians)
   a) List your variables and choose $\omega\alpha t$, $\omega\alpha\Theta$ or $\omega\alpha t\Theta$ to solve for $\alpha$.
   b) Let 50km/hr (converted to rad/s) be your initial angular velocity. List your variables and choose $\omega\alpha t$, $\omega\alpha\Theta$ or $\omega\alpha t\Theta$ to solve for t.

23. a) $\tau = F \perp d$
   b) Now the force is being applied at a 60o angle. Use $\tau = Fd\sin\Theta$.

24. The 135º angle is meaningless. All velocity vectors occur tangent to the axles. All clockwise rotations are (-) and all counterclockwise rotations are (+). Add the vectors without considering friction. When you have the sum, add the friction so that it opposes. If your sum is (+), subtract the frictional torque. If your sum is (-), add the frictional torque.

27. Find the equation for the moment of inertia of a sphere from figure 8-21 on page 208. You are given mass and radius. Solve for I (moment of inertia).

29. a) Since they did not give a mass for the light rod we have to assume it is negligible. Consider the ball at the end of the rod as a ring when you calculate moment of inertia because as it rotates, all of the mass is concentrated in the perimeter.
   b) Torque in a rotational system is analogous to force. To convert force to torque, multiply by the length of the lever arm (radius).

30. At constant angular speed, there is no net acceleration. Her torque must equal $\tau_{fr.}$

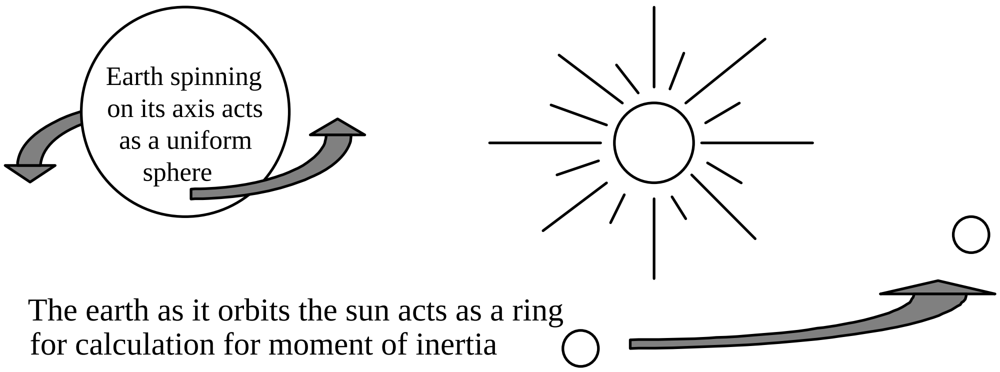
35. Change rev/s to rad/s. (1rev = $2\pi$ rad). You are given initial and final angular velocity (it starts from rest) and time. Choose $\omega\alpha t$, $\omega\alpha\Theta$ or $\omega\alpha t\Theta$ to solve for $\alpha$. Now find the moment of inertia for a rod pivoting about one end on page 208. $\tau = I\alpha$.

38. a) Since the mass of the ball is concentrated at the edge of the circle, its moment of inertia is that of a hoop.
   b) The force of the triceps muscle is exerted over the very small (2.5cm) distance from its attachment to the axis of rotation. Use the torque calculated in part a to find the force.

43. The energy to stop the rotor equals the energy it had, which was rotational kinetic energy.

45. Total KE = linear kinetic energy + rotational kinetic energy.
   ($KE = \frac{1}{2} mv^2 + \frac{1}{2} I\omega^2$)
   You are given mass and linear velocity for linear KE. Find the moment of inertia for the bowling ball (solid sphere) using figure 8-21 on page 208 and convert the linear velocity to angular velocity to find rotational kinetic energy. Add the two for total kinetic energy.

46. a) Change 1rev/24hrs to rad/s.  Use a uniform sphere for moment of inertia of the earth.
b) Change 1rev/365days to rad/s.  Use a ring for the moment of inertia of the earth as it orbits the sun.




47. The work necessary to speed it up will equal the rotational KE it has.  Change revolutions to radians to calculate the angular velocity.   Use the moment of inertia for a cylinder on page 208 and calculate rotational kinetic energy.

48. a) Using energy transfer equations, derive an equation for the speed of a rotating object at the base of an incline (see class notes and Example 8-13 on page 211 of the text. Use ½ $mv^2$ to calculate translational KE, and ½ $I\omega^2$ for rotational KE.
b) To find the ratio just divide the translational KE by the rotational KE.
c) Can you find mass or radius in either final equation?

51. A ball on the end of a string acts as a ring for calculation of moment of inertia.

52. a) Convert rpm to rad/s.  Consider the skater to be a cylinder (pg. 208) when you calculate the moment of inertia.  Height will not matter.
b) $\tau = I\alpha$.  You have $\omega_o$, $\omega$ (the skater stops) and time; find angular acceleration. Use the moment of inertia calculated in part a to find torque.

57. a) Convert rev/s to rad/s.  Consider the wheel to be a cylinder (pg. 208) when you calculate the moment of inertia.
b) $\tau = I\alpha$.  You have $\omega_o$, $\omega$ (it stops) and time; find angular acceleration.  Use the moment of inertia calculated in part a to find torque.

60. This is a “two things stick together” problem expressed in terms of angular momentum. (See problems 4 – 6 from chapter 7).  Use moment of inertia (I) in place of m (see figure 8-21 on page 208 for the moment of inertia of a rod and disk) and $\omega$ in place of v.  Change rev/s to rad/s.  Use m for both masses (they are equal).  Use 2r for the length of the rod, and r for the radius of the disk.  Set up the equations using symbols for numbers where values are not given.

62. This is a two-things-stick-together problem. Use the two-things-stick-together equation from chapter 7, substituting moment of inertia for mass, and angular velocity for linear velocity. The moment of inertia for the merry-go-round is given. The people are all standing the same distance from the axis of rotation so their combined masses rotating will have the same moment of inertia as a ring. See figure 8-21 on page 208 for the equation for the moment of inertia for a ring. Solve for final angular velocity. The second part of the problem is a something-blows-up problem as outlined on page 23 of this book. Assume when the people jump off, they take no angular velocity with them and solve for the final angular velocity of the merry –go-round.