Chapter 9

Terms

Be able to define or discuss the following terms and ideas, with their SI units if appropriate.

1. radian
2. revolution
3. degree
4. the unit circle
5. distance traveled on a circular arc (i.e. arclength)
6. angular displacement
7. angular velocity
8. linear velocity
9. angular acceleration
10. uniform circular motion
11. constant angular acceleration
12. direction of angular displacement
13. direction of angular velocity (and using your right-hand to find direction of angular velocity)
14. direction of angular acceleration (must know both angular velocity and whether the object is speeding up or slowing down)
15. torque
16. moment arm
17. direction of torque (and using your right-hand to find direction of torque)
18. moment of inertia (especially for a point particle, ring, solid wheel, sphere and a system composed of a combination of these objects)
19. Newton's second law for rotation
20. Equilibrium
21. Angular momentum
22. Conservation of angular momentum
23. Translational kinetic energy (i.e. kinetic energy of the center of mass)
24. Rotational kinetic energy (i.e. kinetic energy due to rotation about the center of mass, or spin)
25. A wheel that rolls without slipping
26. Conservation of energy

Equations

Understand the meaning and know the SI units of all symbols in these equations; know how to perform each mathematical operation, such as trig functions; know how to solve for any unknown quantity; understand how changing one quantity affects another quantity (if all other quantities remain constant); be able to apply one or more equations to solve a problem.

- distance travelled along a circular arc

$$s = r\Delta\theta \tag{1}$$

- angular velocity

$$\omega = \frac{\Delta\theta}{\Delta t} \tag{2}$$

- linear speed

$$v = \omega r \tag{3}$$

- angular acceleration

$$\alpha = \frac{\omega}{\Delta t} \tag{4}$$

- constant angular acceleration

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \tag{5}$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \tag{6}$$

$$\omega = \omega_0 + \alpha t \tag{7}$$

$$\Delta\theta = \frac{\omega + \omega_0}{2} t \tag{8}$$

- torque

$$\tau = \pm Fl \tag{9}$$

or

$$\tau = \pm F_\perp d \tag{10}$$

- Newton's second law for rotation

$$\Sigma\tau = I\alpha \tag{11}$$

- moment of inertia for a point particle

$$I = mr^2 \tag{12}$$

- moment of inertia for a hollow wheel rotating about its center

$$I = MR^2 \tag{13}$$

- moment of inertia for a solid wheel rotating about its center

$$I = \frac{1}{2}MR^2 \tag{14}$$

- moment of inertia for a sphere rotating about its center

$$I = \frac{2}{5}MR^2 \tag{15}$$

- angular momentum

$$L = I\omega \tag{16}$$

- translational kinetic energy

$$K_{trans} = \frac{1}{2}mv_{c.m.}v^2 \tag{17}$$

- rotational kinetic energy

$$K_{rot} = \frac{1}{2}I\omega^2 \tag{18}$$

- a wheel rolling without slipping

$$v_{c.m.} = R\omega \tag{19}$$

Skills

1. convert between units of rev, rad, and degree.
2. apply the definition of angular velocity for uniform circular motion to calculate angular displacement, angular velocity, or time interval.
3. apply equations for constant angular acceleration to calculate angular displacement, angular acceleration, time interval, final angular velocity, or initial angular velocity.
4. calculate torque due to a force applied tangentially to a wheel.
5. apply Newton's second law for rotation to calculate angular acceleration of moment of inertia.
6. calculate the moment of inertia of an object or system of objects.
7. apply conservation of energy to a wheel that is rolling without slipping.
8. calculate the total kinetic energy of a body that has both translational and rotational kinetic energy.
9. apply conservation of angular momentum to a system for which angular momentum is conserved. Examples include an spinning ice skater or a child on a merry-go-round.

Lab Skills

1. Interpret a graph of x vs. t for an object in uniform circular motion, and from the graph measure the radius and period of the object's motion.
2. Interpret an equation of the form $x = Acos(Bt + C)$ or $y = Asin(Bt + C)$ to determine the radius and angular velocity for an object in circular motion.
3. Interpret a graph of θ vs. t for an object and from the graph determine the angular velocity of the object.