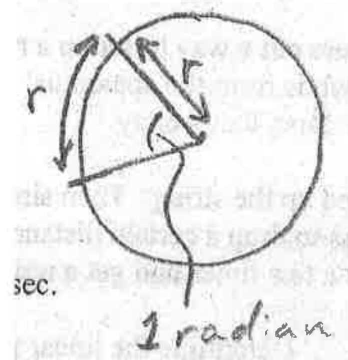
Physics 200 (Stapleton)
Rotational Motion Intro

Name: Answers

1 radian = an angle subtending an arc whose length is equal to the radius of a circle



90° = ½ π radians. 180° = π radians 360° = 2π radians
θ ("theta") = an angle; for this unit we will probably always use radians.
ω (lowercase "omega") = rotational velocity; tells how fast something is rotating, in radians/sec.
v = linear velocity
α ("alpha") = rotational acceleration; tells how fast rotation is speeding up, in radians/sec/sec.
a = linear acceleration
τ = torque
I = moment of inertia; tells how easy or difficult it is to get an object rotating. Units are kg m^2.

τ = Iα (Net torque on a rotating body equals its moment of inertia multiplied by its rotational acceleration; similar to F=ma)

KErotational = ½ $I\omega^2$ (similar to ½ mv^2, for translational kinetic energy)

Total KE of a rolling object = ½ $I\omega^2$ + ½ mv^2

The linear velocity of a revolving object revolving a radius **r** away from a central point is given by
v = rω.

Good Stuff

$$\ell = r\theta \qquad v = r\omega \qquad a_T = r\alpha \qquad a_c = \frac{v^2}{r}$$

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

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t$$

The linear acceleration of a revolving object revolving a radius **r** away from a central point is given by
a = rα

Practice Problems with Angular Acceleration

Conceptual Questions

1. A bicycle odometer (which measures distance traveled) is attached near the wheel hub and is designed for 27-inch wheels. What happens if you use it on a bicycle with 24-inch wheels?

It tells you that you have traveled farther than you actually have.

2. Suppose a disk rotates at constant angular velocity.

a. Does a point on the rim have a centripetal acceleration, a tangential acceleration, or both?

a. $a_{centrip}$ = const. non-zero

$a_{tan} = 0$

$a = \frac{v^2}{r}$

b. What type(s) of acceleration does a point on the rim have if the disk's angular velocity increases at a constant rate?

b. $a_{cent.}$ = increasing

a_{tan} = const + non-zero

Both types: centripetal and tangential

c. In which of these situations is a type of acceleration constantly changing? Which type of acceleration is changing?

Part B: centripetal acceleration is increasing tangential acceleration is constant

3. Could our rotating solar system be described by a single value of the angular velocity ω? Explain.

No. Planets farther from the sun have longer periods, so they have different ω's.

Problems

3. (I) A laser beam is directed at the Moon, 380,000 km from Earth. The beam diverges at an angle θ (Fig. 8–37) of 1.4×10^{-5} rad. What diameter spot will it make on the Moon?

$$l = r\theta$$

$$l = 380{,}000\,km(1.4 \times 10^{-5}\,rad)$$

$$l = 5.32\,km$$

4. (I) The blades in a blender rotate at a rate of 6500 rpm. When the motor is turned off during operation, the blades slow to rest in 3.0 s. What is the angular acceleration as the blades slow down?

$$\frac{6500\text{ rotations}}{\text{minute}}\left(\frac{2\pi\text{ radians}}{\text{rotation}}\right)\left(\frac{1\text{ minute}}{60\text{ sec}}\right) = \frac{681\,rad}{s} = \omega_0$$

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{-681\frac{rad}{s}}{3s} = -227\,rad/s^2$$

5. (II) A child rolls a ball on a level floor 3.5 m to another child. If the ball makes 15.0 revolutions, what is its diameter?

πd is the circumference = distance traveled per rotation

$$(15\text{ revolutions})\left(\frac{\pi d}{\text{revolution}}\right) = 3.5\,m$$

$$\text{diameter} = d = \frac{3.5\,m}{15\pi} = 0.0743\,m$$