$$= \frac{2.40 \text{ m/s} - (15.0 \text{ m/s})(\sin 20.0°)}{9.80 \text{ m/s}^2}$$

$$= 1.92 \text{ s}$$

$$x = v_{xi}t$$

$$= (v_i \cos \theta)(t)$$

$$= (15.0 \text{ m/s})(\cos 20.0°)(1.92 \text{ s})$$

$$= 27.1 \text{ m}$$

11. Critical Thinking Suppose that an object is thrown with the same initial velocity and direction on Earth and on the Moon, where g is one-sixth that on Earth. How will the following quantities change?

a. v_x

will not change

b. the object's time of flight

will be larger; $t = \frac{-2v_y}{g}$

c. y_{max}

will be larger

d. R

will be larger

Practice Problems

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12. A runner moving at a speed of 8.8 m/s rounds a bend with a radius of 25 m. What is the centripetal acceleration of the runner, and what agent exerts force on the runner?

$a_c = \frac{v^2}{r} = \frac{(8.8 \text{ m/s})^2}{25 \text{ m}} = 3.1 \text{ m/s}^2$, **the frictional force of the track acting on the runner's shoes exerts the force on the runner.**

13. A car racing on a flat track travels at 22 m/s around a curve with a 56-m radius. Find the car's centripetal acceleration. What minimum coefficient of static friction between the tires and road is necessary for the car to round the curve without slipping?

$a_c = \frac{v^2}{r} = \frac{(22 \text{ m/s})^2}{56 \text{ m}} = 8.6 \text{ m/s}^2$

Recall $F_f = \mu F_N$. **The friction force must supply the centripetal force so** $F_f = ma_c$. **The normal force is** $F_N = -mg$. **The coefficient of friction must be at least**

$$\mu = \frac{F_f}{F_N} = \frac{ma_c}{mg} = \frac{a_c}{g} = \frac{8.6 \text{ m/s}^2}{9.80 \text{ m/s}^2} = 0.88$$

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14. An airplane traveling at 201 m/s makes a turn. What is the smallest radius of the circular path (in km) that the pilot can make and keep the centripetal acceleration under 5.0 m/s^2?

$$a_c = \frac{v^2}{r}, \text{ so } r = \frac{v^2}{a_c} = \frac{(201 \text{ m/s})^2}{5.0 \text{ m/s}^2} = 8.1 \text{ km}$$

15. A 45-kg merry-go-round worker stands on the ride's platform 6.3 m from the center. If her speed as she goes around the circle is 4.1 m/s, what is the force of friction necessary to keep her from falling off the platform?

$$F_f = F_c = \frac{mv^2}{r} = \frac{(45 \text{ kg})(4.1 \text{ m/s})^2}{6.3 \text{ m}} = 120 \text{ N}$$

Section Review

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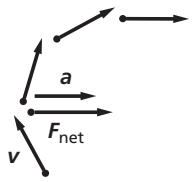
16. Uniform Circular Motion What is the direction of the force that acts on the clothes in the spin cycle of a washing machine? What exerts the force?

The force is toward the center of the tub. The walls of the tub exert the force on the clothes. Of course, the whole point is that some of the water in the clothes goes out through holes in the wall of the tub rather than moving toward the center.

17. Free-Body Diagram You are sitting in the backseat of a car going around a curve to the right. Sketch motion and free-body diagrams to answer the following questions.



a. What is the direction of your acceleration?

Your body is accelerated to the right.

b. What is the direction of the net force that is acting on you?

The net force acting on your body is to the right

c. What exerts this force?

The force is exerted by the car's seat.

18. Centripetal Force If a 40.0-g stone is whirled horizontally on the end of a 0.60-m string at a speed of 2.2 m/s, what is the tension in the string?

$$F_T = ma_c$$

$$= \frac{mv^2}{r}$$

$$= \frac{(0.0400 \text{ kg})(22 \text{ m/s})^2}{0.60 \text{ m}}$$

$$= 0.32 \text{ N}$$

19. Centripetal Acceleration A newspaper article states that when turning a corner, a driver must be careful to balance the centripetal and centrifugal forces to keep from skidding. Write a letter to the editor that critiques this article.

The letter should state that there is an acceleration because the direction of the velocity is changing; therefore, there must be a net force in the direction of the center of the circle. The road supplies that force and the friction between the road and the tires allows the force to be exerted on the tires. The car's seat exerts the force on the driver that accelerates him or her toward the center of the circle. The note also should make it clear that centrifugal force is not a real force.

20. Centripetal Force A bowling ball has a mass of 7.3 kg. If you move it around a circle with a radius of 0.75 m at a speed of 2.5 m/s, what force would you have to exert on it?

$$F_{net} = ma_c$$

$$= \frac{mv^2}{r}$$

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