16. In civil aviation, a "standard turn" for level flight of a propeller-driven airplane is one in which the airplane makes a complete circular turn in 2.0 min. If the plane's speed is 180 m/s, what is the radius of the circle? What is the centripetal acceleration of the plane?

$v = 180$ m/s
$T = 2$ min $= 120$ s

$v = 2\pi r/T$; $\quad r = vT/2\pi = (180 \text{ m/s})(120 \text{ s})/(2\pi)$

$r = 3440$ m

$a_c = v^2/r = (180 \text{ m/s})^2 / 3440 \text{ m} = 9.42 \text{ m/s}^2$

19. A 55.0-kg ice skater is moving at 4.00 m/s when she grabs the loose end of a rope, the opposite end of which is tied to a pole. She then moves in a circle of radius 0.800 m around the pole. (a) Determine the force exerted by the horizontal rope on her arms. (b) Compare this force with her weight.

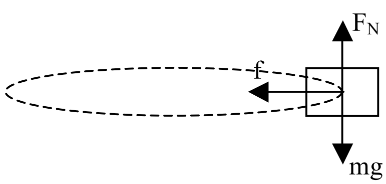
$m = 55.0$ kg
$v = 4.00$ m/s
$r = 0.800$ m

a) $F_c = mv^2/r = (55.0 \text{ kg})(4.00 \text{ m/s})^2 / 0.800 \text{ m}$
$F_c = 1100$ N

b) $mg = (55.0 \text{ kg})(9.8 \text{ m/s}^2) = 539$ N

So, F_c is more than twice her weight.

21. A 2000-kg car rounds a circular turn of radius 20 m. If the road is flat and the coefficient of friction between tires and road is 0.70, how fast can the car go without skidding?



$m = 2000$ kg; $\quad r = 20$ m; $\quad \mu_s = 0.70$

$f_s \le \mu_s F_N \qquad f_{s\,max} = \mu_s F_N$
$F_N = mg$

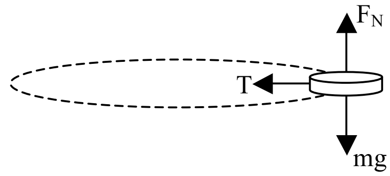
Friction (f) is the only force pointing toward the center of the circle, it alone supplies the centripetal force.

$f_{s\,max} = \mu_s F_N = \mu_s mg = m(v_{max})^2/r$

$$v_{max} = \sqrt{\mu g r} = \sqrt{(0.7)(9.8 \; m/s^2)(20 \; m)}$$

$v_{max} = 11.7$ m/s

25. An air puck of mass 0.25 kg is tied to a string and allowed to revolve in a circle of radius 1.0 m on a frictionless horizontal table. The other end of the string passes through a hole in the center of the table, and a mass of 1.0 kg is tied to it (Fig. P7.25). The suspended mass remains in equilibrium while the puck on the tabletop revolves. (a) What is the tension in the string? (b) What is the horizontal force acting on the puck? (c) What is the speed of the puck?



a) $T = Mg = 9.8$ N

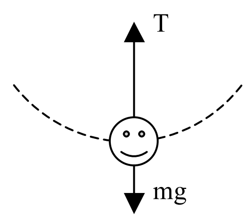
b) Tension

c) $T = mv^2/r$

$$v = \sqrt{\frac{Tr}{m}} = \sqrt{\frac{(9.8 \; N)(1 \; m)}{(0.25 \; m)}} = 6.26 \text{ m/s}$$

26. Tarzan (m = 85 kg) tries to cross a river by swinging from a 10-m-long vine. His speed at the bottom of the swing (as he just clears the water) is 8.0 m/s. Tarzan doesn't know that the vine has a breaking strength of 1000 N. Does he make it safely across the river? Justify your answer.

$m = 85$ kg; $\quad r = 10$ m; $\quad v_{bottom} = 8.0$ m/s



Since the center of the circle is up (from the bottom of the swing)…

$T - mg = mv^2/r$

$T = mv^2/r + mg = (85 \text{ kg})(8 \text{ m/s})^2/ (10 \text{ m}) + (85 \text{ kg})(9.8 \text{ m/s}^2)$
$T = 1380$ N
Since T would need to be greater than T_{max}, the vine breaks. ☹

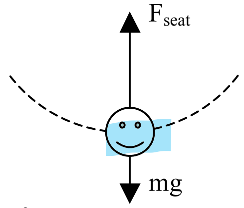
27. A 40.0-kg child takes a ride on a Ferris wheel that rotates four times each minute and has a diameter of 18.0 m. (a) What is the centripetal acceleration of the child? (b) What force (magnitude and direction) does the seat exert on the child at the lowest point of the ride? (c) What force does the seat exert on the child at the highest point of the ride? (d) What force does the seat exert on the child when she is halfway between the top and bottom?

Diam = 18 m; $\quad m = 40$ kg; $\quad$ 4 rotations/minute

$r = 9$ m $\quad T = 15$ s $\quad v = 2\pi r/T = 3.77$ m/s

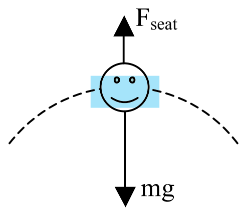
a) $a_c = v^2/r = 1.58$ m/s

b)



$F_{seat} - mg = mv^2/r$
$F_{seat} = mg + mv^2/r$
$F_{seat} = (40\ kg)(9.8\ m/s^2) + (40\ kg)(3.77\ m/s)^2\ /\ 9\ m$
$F_{seat} = 455\ N$

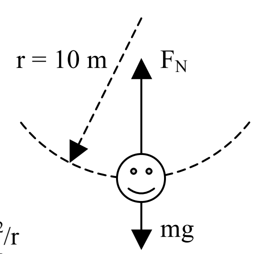
c)



$mg - F_{seat} = mv^2/r$
$F_{seat} = mg - mv^2/r$
$F_{seat} = (40\ kg)(9.8\ m/s^2) - (40\ kg)(3.77\ m/s)^2\ /\ 9\ m$
$F_{seat} = 329\ N$

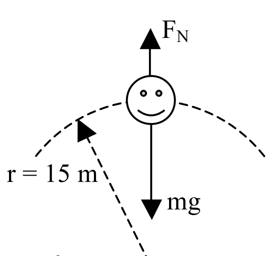
28. A roller-coaster vehicle has a mass of 500 kg when fully loaded with passengers (Fig. P7.28). (a) If the vehicle has a speed of 20.0 m/s at **A**, what is the magnitude of the force that the track exerts on the vehicle at this point? (b) What is the maximum speed the vehicle can have at **B** in order for gravity to hold it on the track?

a)



$F_N - mg = mv^2/r$
$F_N = mg + mv^2/r$
$F_N = (500\ kg)(9.8\ m/s^2) + (500\ kg)(20\ m/s)^2\ /\ 10\ m$
$F_N = 24{,}900\ N$

b)



$mg - F_N = mv^2/r$

but, at v max, normal force drops to zero
(if car goes airborne, FN = 0)
$mg = mv^2/r$
$v = \sqrt{gr} = 12.1\ m/s$

43. An athlete swings a 5.00-kg ball horizontally on the end of a rope. The ball moves in a circle of radius 0.800 m at an angular speed of 0.500 rev/s. What are (a) the tangential speed of the ball and (b) its centripetal acceleration? (c) If the maximum tension the rope can withstand before breaking is 100 N, what is the maximum tangential speed the ball can have?

m = 5 kg
r = 0.8 m

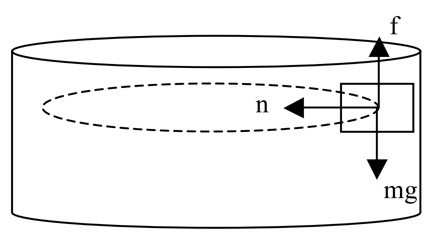
0.5 rev /s so 1 rev in 2 s

a) $v = 2\pi r / T = 2.52\ m/s$
b) $a_c = v^2/r = 7.90\ m/s^2$

Tension = mv^2/r

$$v_{max} = \sqrt{\frac{T_{max} r}{m}} = 4\ m/s$$

51. In a popular amusement park ride, a rotating cylinder of radius 3.00 m is set in rotation. The people on the ride eventually reach a constant speed of 15.0 m/s. The floor then drops away, leaving the riders suspended against the wall in a vertical position. What minimum coefficient of friction between a rider's clothing and the wall is needed to keep the rider from slipping? (*Hint:* Recall that the magnitude of the maximum force of static friction is equal to μn, where n is the normal force—in this case, the force causing the centripetal acceleration.



Friction keeps the rider from sliding down the wall, so it points upward

The normal force of the wall points toward the center of the circle, it is the only force supplying the centripetal force.

$f_s\ max = \mu_s n$

f = mg (not sliding up or down the wall)

$mg = \mu_s n$

$F_N = mv^2/r$

$mg = \mu\ (mv^2/r)$

$\mu = g\ /(v^2/r) = gr/v^2 = 0.131$