

Chapter 6—Circular Motion and Other Applications of Newton's Laws

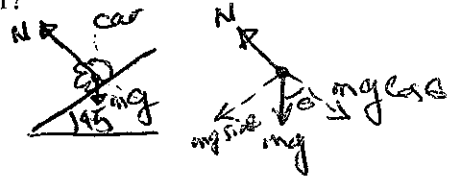
MULTIPLE CHOICE

1. A race car travels 40 m/s around a banked (45° with the horizontal) circular (radius = 0.20 km) track. What is the magnitude of the resultant force on the 80-kg driver of this car?

- a. 0.68 kN
 b. 0.64 kN
 c. 0.72 kN
 d. 0.76 kN
 e. 0.52 kN

$$mg \sin \theta = m \frac{v^2}{R} \quad , \quad mg \cos \theta = N$$

$$\frac{mv^2}{R} = \frac{80(40)^2}{200} = 640 \text{ N}$$



ANS: B

PTS: 2

DIF: Average

2. An airplane travels 80 m/s as it makes a horizontal circular turn which has a 0.80-km radius. What is the magnitude of the resultant force on the 75-kg pilot of this airplane?

- a. 0.69 kN
 b. 0.63 kN
 c. 0.66 kN
 d. 0.60 kN
 e. 0.57 kN

Circular motion, $F = \frac{mv^2}{R}$

$$F = \frac{75(80)^2}{800} \text{ N}$$

ANS: D

PTS: 2

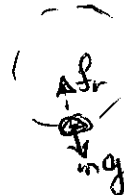
DIF: Average

3. An airplane moves 140 m/s as it travels around a vertical circular loop which has a 1.0-km radius. What is the magnitude of the resultant force on the 70-kg pilot of this plane at the bottom of this loop?

- a. 2.1 kN
 b. 1.4 kN
 c. 0.69 kN
 d. 1.5 kN
 e. 1.3 kN

$$F_r - mg = m \frac{v^2}{R}$$

$$= \frac{70(140)^2}{1000} = 1.37 \text{ kN}$$



ANS: B

PTS: 2

DIF: Average

4. A car travels along the perimeter of a vertical circle (radius = 0.25 km) at a constant speed of 30 m/s. What is the magnitude of the resultant force on the 60-kg driver of the car at the lowest point on this circular path?

- a. 0.37 kN
 b. 0.80 kN
 c. 0.22 kN
 d. 0.59 kN
 e. 0.45 kN

$$\sum F = \frac{mv^2}{R} = \frac{60(30)^2}{250}$$

ANS: C

PTS: 2

DIF: Average

5. A 30-kg child rides on a circus Ferris wheel that takes her around a vertical circular path with a radius of 20 m every 22 s. What is the magnitude of the resultant force on the child at the highest point on this trajectory?

- a. 49 N
 b. 0.29 kN
 c. 0.34 kN
 d. 0.25 kN
 e. 0.76 kN

$$\sum F = \frac{mv^2}{R} \quad , \quad v = \frac{2\pi R}{t}$$

$$F = \frac{m \cdot 4\pi^2 R^2}{R t^2} = \frac{4\pi^2 m R}{t^2} = 48.9 \text{ N}$$

ANS: A

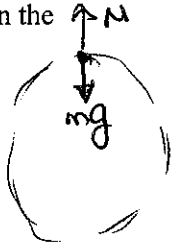
PTS: 2

DIF: Average

6. An amusement ride consists of a car moving in a vertical circle on the end of a rigid boom. The radius of the circle is 10 m. The combined weight of the car and riders is 5.0 kN. At the top of the circle the car has a speed of 5.0 m/s which is not changing at that instant. What is the force of the boom on the car at the top of the circle?

- a. 3.7 kN down
b. 1.3 kN down
c. 6.3 kN up
d. 3.7 kN up
e. 5.2 kN down

$$\begin{aligned} \text{Top: } mg - N &= \frac{mv^2}{R} \\ N &= mg - \frac{mv^2}{R} = m \left(g - \frac{v^2}{R} \right) \\ &= 5 \times 10^3 - \frac{5 \times 10^3 \times (5)^2}{9.8 \times 10} \end{aligned}$$



ANS: D

PTS: 2

DIF: Average

$$= 5 \times 10^3 - 1275.51 = 3.7 \text{ kN}$$

7. A highway curve has a radius of 0.14 km and is unbanked. A car weighing 12 kN goes around the curve at a speed of 24 m/s without slipping. What is the magnitude of the horizontal force of the road on the car?

- a. 12 kN
b. 17 kN
c. 13 kN
d. 5.0 kN
e. 49 kN

$$\begin{aligned} f_s &= \frac{mv^2}{R} = \frac{12 \times 10^3 \times (24)^2}{9.8 \times 0.14 \times 10^3} \text{ N} \\ &= 5.0 \text{ kN} \end{aligned}$$

ANS: D

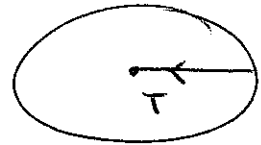
PTS: 2

DIF: Average

8. A 4.0-kg mass on the end of a string rotates in a circular motion on a horizontal frictionless table. The mass has a constant speed of 2.0 m/s and the radius of the circle is 0.80 m. What is the magnitude of the resultant force acting on the mass?

- a. 39 N
b. 20 N
c. 44 N
d. 0 N
e. 30 N

$$\begin{aligned} T &= \frac{mv^2}{R} = \frac{4(2)^2}{0.8} = \frac{16}{0.8} \\ &= 20 \text{ N} \end{aligned}$$



ANS: B

PTS: 2

DIF: Average

9. A stunt pilot weighing 0.70 kN performs a vertical circular dive of radius 0.80 km. At the bottom of the dive, the pilot has a speed of 0.20 km/s which at that instant is not changing. What force does the plane exert on the pilot?

- a. 3.6 kN up
b. 4.3 kN up
c. 2.9 kN down
d. 2.9 kN up
e. 5.8 kN down

$$\begin{aligned} \text{Bottom: } N - W &= \frac{mv^2}{R} \\ N &= \frac{mv^2}{R} + W = \frac{0.7 \times 10^3 \times (0.2 \times 10^3)^2}{9.8 \times 0.8 \times 10^3} + 0.7 \times 10^3 \\ &= 4.3 \text{ kN} \end{aligned}$$

ANS: B

PTS: 2

DIF: Average

10. A car travels around an unbanked highway curve (radius 0.15 km) at a constant speed of 25 m/s. What is the magnitude of the resultant force acting on the driver, who weighs 0.80 kN?

- a. 0.87 kN
b. 0.34 kN
c. 0.80 kN
d. 0.00 kN
e. 0.67 kN

$$\begin{aligned} F &= \frac{mv^2}{R} = \frac{0.8 \times 10^3 \times (25)^2}{9.8 \times 0.15 \times 10^3} \\ &= 340 \text{ N} \end{aligned}$$

ANS: B

PTS: 2

DIF: Average

11. A 0.50-kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the mass is at the lowest point on the circle, the speed of the mass is 12 m/s. What is the magnitude of the force of the string on the mass at this position?

- a. 31 N
b. 36 N
c. 41 N
d. 46 N
e. 23 N

$$T - mg = m \frac{v^2}{R}, T = mg + \frac{mv^2}{R}$$

$$T = 0.5(9.8) + \frac{0.5(144)}{2}$$

$$= 40.9 \text{ N}$$

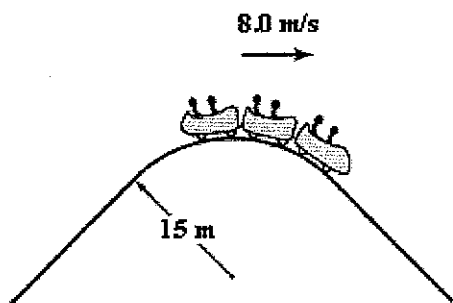


ANS: C

PTS: 2

DIF: Average

12. A roller-coaster car has a mass of 500 kg when fully loaded with passengers. The car passes over a hill of radius 15 m, as shown. At the top of the hill, the car has a speed of 8.0 m/s. What is the force of the track on the car at the top of the hill?



$$m = 500 \text{ kg}, r = 15 \text{ m}, v = 8 \text{ m/s}$$

$$mg - N = m \frac{v^2}{R}$$

$$N = mg - \frac{mv^2}{R}$$

$$= 500(9.8) - \frac{500(64)}{15}$$

$$= 2.76 \text{ kN}$$



- a. 7.0 kN up
b. 7.0 kN down
c. 2.8 kN down
d. 2.8 kN up
e. 5.6 kN down

ANS: D

PTS: 2

DIF: Average

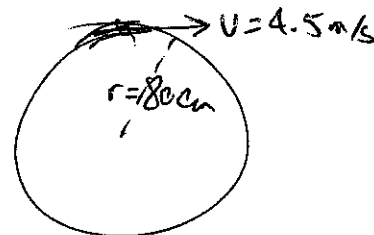
13. A 0.20-kg object attached to the end of a string swings in a vertical circle (radius = 80 cm). At the top of the circle the speed of the object is 4.5 m/s. What is the magnitude of the tension in the string at this position?

- a. 7.0 N
b. 2.0 N
c. 3.1 N
d. 5.1 N
e. 6.6 N

$$m = 0.2 \text{ kg}, r = 0.8 \text{ m}$$

$$T + mg = m \frac{v^2}{R}$$

$$T = \frac{mv^2}{R} - mg = \frac{0.2(4.5)^2}{0.8} - 0.2(9.8) = 3.1 \text{ N}$$



ANS: C

PTS: 2

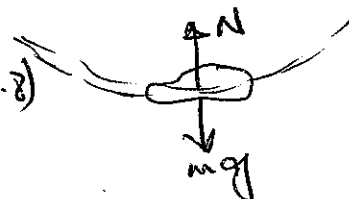
DIF: Average

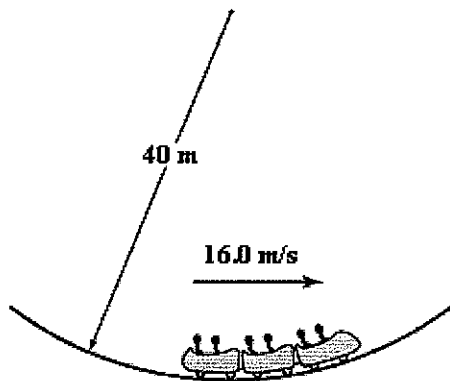
14. A roller-coaster car has a mass of 500 kg when fully loaded with passengers. At the bottom of a circular dip of radius 40 m (as shown in the figure) the car has a speed of 16 m/s. What is the magnitude of the force of the track on the car at the bottom of the dip?

$$N - mg = m \frac{v^2}{R}$$

$$N = \frac{mv^2}{R} + mg = \frac{500(16)^2}{40} + 500(9.8)$$

$$= 8600 \text{ N}$$





- a. 3.2 kN
- b. 8.1 kN
- c. 4.9 kN
- d. 1.7 kN
- e. 5.3 kN

ANS: B PTS: 2 DIF: Average

15. A 0.50 kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the mass is at the highest point of the circle the speed of the mass is 8.0 m/s. What is the magnitude of the force of the string on the mass at this position?

- a. 21 N
- b. 11 N
- c. 16 N
- d. 26 N
- e. 36 N

$$T + mg = \frac{mv^2}{R}$$

$$T = \frac{mv^2}{R} - mg = \frac{0.5(64)}{2} - 0.5(9.8) = 11 \text{ N}$$

ANS: B PTS: 2 DIF: Average

16. A 50-kg child riding a Ferris wheel (radius = 10 m) travels in a vertical circle. The wheel completes one revolution every 10 s. What is the magnitude of the force on the child by the seat at the highest point on the circular path?

- a. 0.29 kN
- b. 0.49 kN
- c. 0.69 kN
- d. 0.20 kN
- e. 0.40 kN

$$mg - N = \frac{mv^2}{R}$$

$$N = mg - \frac{mv^2}{R}, \quad v = \frac{2\pi R}{t}$$

$$N = mg - \frac{m}{R} \left(\frac{2\pi R}{t} \right)^2$$

ANS: A PTS: 2 DIF: Average

17. A 0.30-kg mass attached to the end of a string swings in a vertical circle ($R = 1.6 \text{ m}$), as shown. At an instant when $\theta = 50^\circ$, the tension in the string is 8.0 N. What is the magnitude of the resultant force on the mass at this instant?

$$T - mg \cos \theta = \frac{mv^2}{R}$$

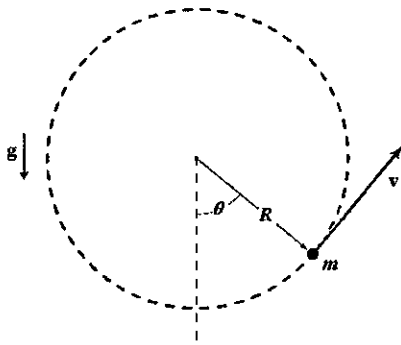
$$T = mg \cos \theta + \frac{mv^2}{R}$$

$$\sum \vec{F}_r = T - mg \cos \theta$$

$$= 8 - (0.3)(9.8) \cos 50$$

$$= 6.11 \text{ N}$$

$$\sum \vec{F}_t = mg \sin \theta = (0.3)(9.8) \sin 50 = 2.25 \text{ N}$$



$$F = \sqrt{F_r^2 + F_T^2}$$

$$= \sqrt{(6.11)^2 + (2.25)^2} = 6.5 \text{ N}$$

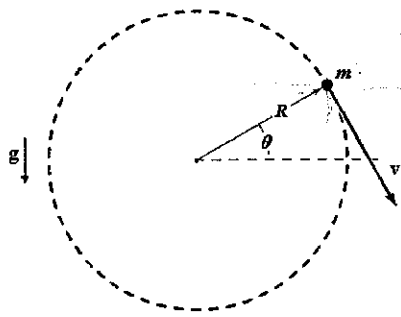
- a. 5.6 N
- b. 6.0 N
- c. 6.5 N
- d. 5.1 N
- e. 2.2 N

ANS: C

PTS: 3

DIF: Challenging

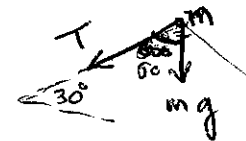
18. An object attached to the end of a string swings in a vertical circle ($R = 1.2 \text{ m}$), as shown. At an instant when $\theta = 30^\circ$, the speed of the object is 5.1 m/s and the tension in the string has a magnitude of 20 N . What is the mass of the object?



$$T + mg \cos 60 = \frac{mv^2}{R}$$

$$m = \frac{T}{\frac{v^2}{R} - g \cos \theta}$$

$$= \frac{20}{\frac{(5.1)^2}{1.2} - 9.8 \cos 60} = 1.19 \text{ kg}$$



- a. 2.0 kg
- b. 1.5 kg
- c. 1.8 kg
- d. 1.2 kg
- e. 0.80 kg

ANS: D

PTS: 3

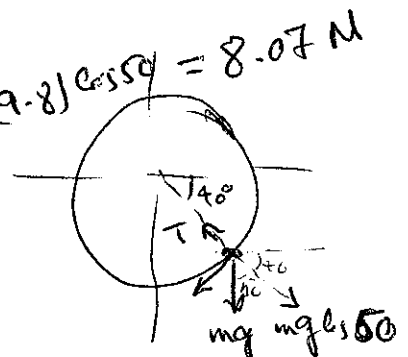
DIF: Challenging

19. A 0.40-kg mass attached to the end of a string swings in a vertical circle having a radius of 1.8 m . At an instant when the string makes an angle of 40° below the horizontal, the speed of the mass is 5.0 m/s . What is the magnitude of the tension in the string at this instant?

- a. 9.5 N
- b. 3.0 N
- c. 8.1 N
- d. 5.6 N
- e. 4.7 N

$$T - mg \cos 50 = \frac{mv^2}{R}$$

$$T = \frac{mv^2}{R} + mg \cos 50 = \frac{0.4(25)}{1.8} + 0.4(9.8) \cos 50 = 8.07 \text{ N}$$



ANS: C

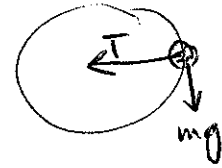
PTS: 3

DIF: Challenging

20. A 0.50-kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the string is horizontal, the speed of the mass is 8.0 m/s. What is the magnitude of the force of the string on the mass at this position?

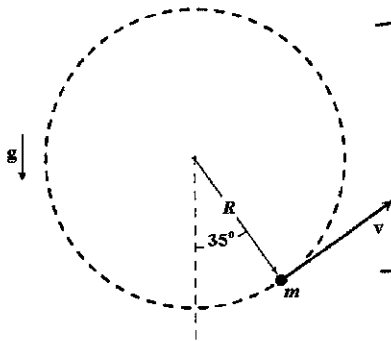
- a. 16 N
 b. 17 N
 c. 21 N
 d. 11 N
 e. 25 N

$$T = \frac{mv^2}{R} = \frac{0.5(64)}{2} \text{ N} = 16 \text{ N}$$



ANS: A PTS: 2 DIF: Average

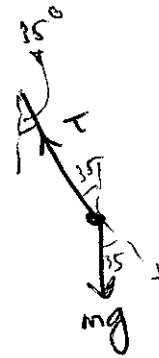
21. A 4.0-kg mass attached to the end of a string swings in a vertical circle of radius 2.0 m. When the string makes an angle of 35° with the vertical as shown, the speed of the mass is 5.0 m/s. At this instant what is the magnitude of the force the string exerts on the mass?



$$T - mg \cos 35 = \frac{mv^2}{R}$$

$$T = \frac{mv^2}{R} + mg \cos 35$$

$$T = \frac{4(25)}{2} + 4(9.8) \cos 35 = 82 \text{ N}$$



- a. 50 N
 b. 82 N
 c. 89 N
 d. 11 N
 e. 61 N

ANS: B PTS: 3 DIF: Challenging

22. A split highway has a number of lanes for traffic. For traffic going in one direction, the radius for the inside of the curve is half the radius for the outside. One car, car A, travels on the inside while another car of equal mass, car B, travels at equal speed on the outside of the curve. Which statement about resultant forces on the cars is correct?

- a. The force on A is half the force on B.
 b. The force on B is half the force on A.
 c. The force on A is four times the force on B.
 d. The force on B is four times the force on A.
 e. There is no net resultant force on either as long as they stay on the road while turning.

$$\frac{mv^2}{R}$$

ANS: B PTS: 1 DIF: Easy

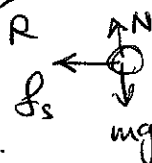
23. A race car traveling at 100 m/s enters an unbanked turn of 400 m radius. The coefficient of (static) friction between the tires and the track is 1.1. The track has both an inner and an outer wall. Which statement is correct?

- a. The race car will crash into the outer wall.
 b. The race car will crash into the inner wall.
 c. The car will stay in the center of the track.
 d. The car will stay in the center of the track if the driver speeds up.
 e. The car would stay in the center of the track if the radius were reduced to 200 m.

$$\mu_s g = 10.78 \text{ m/s}^2$$

$$\frac{v^2}{R} = 25 \text{ m/s}^2$$

$$\frac{v^2}{R} > \mu_s g \rightarrow \text{answer (a)}$$



ANS: A

PTS: 2

DIF: Average

24. A student is sitting on the right side of a school bus when it makes a right turn. We know that the force of gravity acts downwards and a normal force from the seat acts upwards. If the student stays in place when the bus turns, we also know that there must be
- a. no other force on the student.
 - b. a force parallel to the seat directed forward on the student.
 - c. a force parallel to the seat directed to the left on the student.
 - d. a force parallel to the seat directed to the right on the student.
 - e. a force parallel to the seat in a direction between forward and left on the student.



ANS: D

PTS: 1

DIF: Easy

25. For a plane to be able to fly clockwise in a horizontal circle as seen from above, in addition to exerting a force downwards on the air
- a. it must be increasing its speed.
 - b. it must exert a force on the air that is directed to the plane's left side.
 - c. it must exert a force on the air that is directed to the plane's right side.
 - d. it does not need to exert a force: it must only move the wing flaps out.
 - e. it only needs to deflect the air without exerting any additional force on the air.

ANS: B

PTS: 1

DIF: Easy

26. When a car goes around a circular curve on a level road without slipping,
- a. no frictional force is needed because the car simply follows the road.
 - b. the frictional force of the road on the car increases when the car's speed decreases.
 - c. the frictional force of the road on the car increases when the car's speed increases.
 - d. the frictional force of the road on the car increases when the car moves to the outside of the curve.
 - e. there is no net frictional force because the road and the car exert equal and opposite forces on each other.

ANS: C

PTS: 1

DIF: Easy

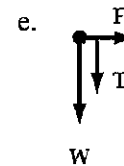
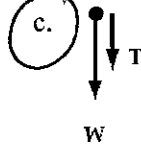
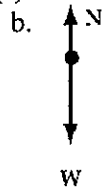
27. An iceboat is traveling in a circle on the ice. Halfway around the circle the sail and the steering mechanism fall off the boat. Which statement is correct?
- a. The boat will continue traveling in the circle because there is no friction.
 - b. The boat will continue to travel in the circle because its velocity exerts a force on it.
 - c. The boat will move off on a line tangent to the circle because there is no force on it.
 - d. The boat will move off tangent to the circle because there is a force on it perpendicular to the boat directed to the outside of the circle.
 - e. The boat will move off to the outside perpendicular to the tangent line since a force directed to the outside of the circle always acts on the boat.

ANS: C

PTS: 1

DIF: Easy

28. A rock attached to a string swings in a vertical circle. Which free body diagram could correctly describe the force(s) on the rock when it is at the highest point?

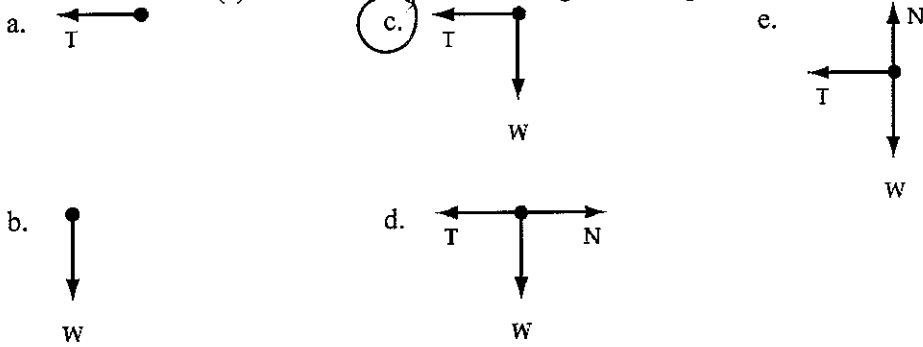


ANS: C

PTS: 1

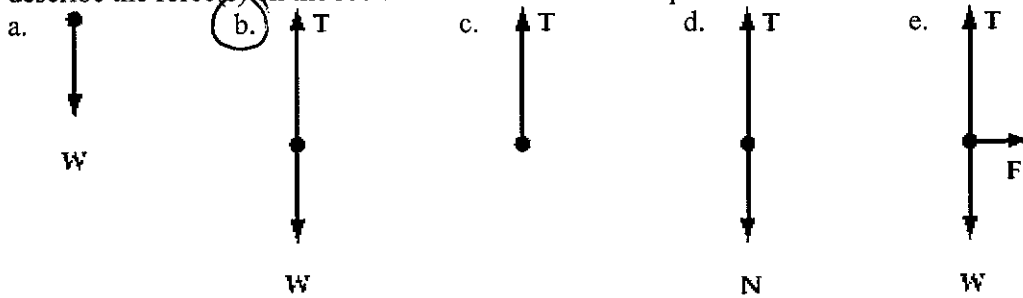
DIF: Easy

29. A rock attached to a string swings in a vertical circle. Which free body diagram could correctly describe the force(s) on the rock when the string is in one possible horizontal position?



ANS: C PTS: 1 DIF: Easy

30. A rock attached to a string swings in a vertical circle. Which free body diagram could correctly describe the force(s) on the rock when it is at the lowest point?



ANS: B PTS: 1 DIF: Easy

31. Two small cylindrical plastic containers with flat bottoms are placed on a turntable that has a smooth flat surface. Canister A is empty; canister B contains lead shot. Each canister is the same distance r from the center. The coefficient of static friction between the canisters and the turntable is μ_s . When the speed of the turntable is gradually increased,

- a. only the lighter container slides outward off the turntable; the heavier one stays on.
- b. only the heavier container slides outward off the turntable; the lighter one stays on.
- c. both containers slide off the turntable at the same turntable speed.
- d. the lighter container slides inward.
- e. the heavier container slides inward.

ANS: C PTS: 1 DIF: Easy

$$f_s = \mu_s N = \mu_s mg$$

$$= \mu_s \frac{v^2}{R}$$

$$\mu_s mg = \frac{v^2}{R} \rightarrow \text{no } m \text{ dependence}$$

32. A hornet circles around a pop can at constant speed once per second in a path with a 12-cm diameter. We can conclude that the hornet's wings must push on the air with force components that are

- a. straight down.
- b. down and inwards.
- c. down and outwards.
- d. down and backwards.
- e. down, inwards and backwards.

ANS: C PTS: 1 DIF: Easy

33. A hornet circles around a pop can at increasing speed while flying in a path with a 12-cm diameter. We can conclude that the hornet's wings must push on the air with force components that are

- a. straight down.

- b. down and inwards.
- c. down and outwards.
- d. down and backwards.
- e. down, backwards and outwards.

ANS: E PTS: 1 DIF: Easy

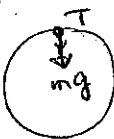
34. Frank says that if you release the string when swinging a ball in a horizontal circle, the ball flies out in the radial direction defined by the string at the instant you release the ball. John says that it flies out along a tangent line perpendicular to the string, and that it then drops straight down to the ground. Which one, if either, is correct?

- a. Frank, because the centrifugal force is no longer counteracted by the string.
- b. Frank, because balls naturally fly straight out.
- c. John, because there is no centrifugal force.
- d. John, because balls fall straight down when released.
- e. Neither, because although there is no centrifugal force, and the ball's velocity is tangent to the circle at the instant of release, the ball then follows a parabolic trajectory.

ANS: E PTS: 2 DIF: Average

35. The equation below is the solution to a problem.

$$\frac{(2.00 \text{ kg}) \left(8.00 \frac{\text{m}}{\text{s}} \right)^2}{5.00 \text{ m}} = 6.00 \text{ N} - (2.00 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (\cos 180^\circ).$$

$$\frac{mv^2}{r} = T + mg \cos \theta$$


The best physical representation of this equation is

- a. a sphere of 2.00 kg mass under a 6.00 N tension when at the bottom of a vertical circle.
- b. a sphere of 2.00 kg mass under a 6.00 N tension when at the side of a vertical circle.
- c. a sphere of 2.00 kg mass under a 6.00 N tension when at the top of a vertical circle.
- d. a sphere of 2.00 kg mass at any point on a horizontal circle.
- e. a 2.00 kg gecko running on the ceiling with a speed of 8.00 m/s.

ANS: C PTS: 2 DIF: Average

36. The equation below is the solution to a problem.

$$\frac{(2.00 \text{ kg}) \left(8.00 \frac{\text{m}}{\text{s}} \right)^2}{5.00 \text{ m}} = 45.2 \text{ N} - (2.00 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (\cos 0^\circ).$$

$$\frac{mv^2}{r} = T - mg \cos \theta$$



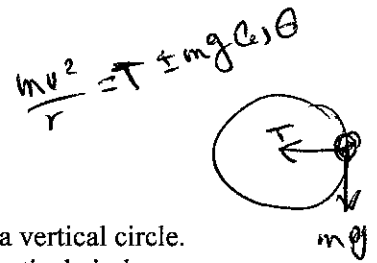
The best physical representation of this equation is

- a. a sphere of 2.00 kg mass under a 45.2 N tension when at the bottom of a vertical circle.
- b. a sphere of 2.00 kg mass under a 45.2 N tension when at the side of a vertical circle.
- c. a sphere of 2.00 kg mass under a 45.2 N tension when at the top of a vertical circle.
- d. a sphere of 2.00 kg mass at any point on a horizontal circle.
- e. a 2.00 kg gecko running on the ceiling with a speed of 8.00 m/s.

ANS: A PTS: 2 DIF: Average

37. The equation below is the solution to a problem.

$$\frac{(2.00 \text{ kg}) \left(8.00 \frac{\text{m}}{\text{s}} \right)^2}{5.00 \text{ m}} = 25.6 \text{ N} - (2.00 \text{ kg}) \left(9.80 \frac{\text{m}}{\text{s}^2} \right) (\cos 90^\circ).$$



The best physical representation of this equation is

- a. a sphere of 2.00 kg mass under a 25.6 N tension when at the bottom of a vertical circle.
- b. a sphere of 2.00 kg mass under a 25.6 N tension when at the side of a vertical circle.
- c. a sphere of 2.00 kg mass under a 25.6 N tension when at the top of a vertical circle.
- d. a sphere of 2.00 kg mass at any point on a horizontal circle.
- e. a 2.00 kg gecko running on the ceiling with a speed of 8.00 m/s.

ANS: B PTS: 2 DIF: Average

38. The coefficient of static friction for the tires of a race car is 0.950 and the coefficient of kinetic friction is 0.800. The car is on a level circular track of 50.0 m radius on a planet where $g = 2.45 \frac{\text{m}}{\text{s}^2}$ compared

to Earth's $g = 9.80 \frac{\text{m}}{\text{s}^2}$. The maximum safe speed on the track on the planet is ___ times as large as the maximum safe speed on Earth.

- a. 0.250
- b. 0.500
- c. 1.00
- d. 2.00
- e. 4.00

$$f_s = \mu_s N = \mu_s mg = \frac{mv^2}{R}$$

$$\mu_s g = \frac{v^2}{R} \rightarrow \textcircled{1}$$

$$\mu_s \frac{g}{4} = \frac{v^2}{R} \rightarrow \textcircled{2}$$

$$\frac{\textcircled{1}}{\textcircled{2}} = \frac{4}{1} = \frac{v_1^2}{v_2^2}$$

$$v_2 = \frac{v_1}{2}$$

ANS: B PTS: 3 DIF: Challenging

39. The coefficient of static friction for the tires of a race car is 0.950 and the coefficient of kinetic friction is 0.800. The car is on a level circular track of 50.0 m radius on a planet where $g = 2.45 \frac{\text{m}}{\text{s}^2}$ compared

to Earth's $g = 9.80 \frac{\text{m}}{\text{s}^2}$. If the car is to be able to travel at the same speed on the planet as on Earth, the radius of the track on the planet must be ___ times as large as the radius of the track on Earth.

- a. 0.250
- b. 0.500
- c. 1.00
- d. 2.00
- e. 4.00

From #38

$$\mu_s g = \frac{v^2}{R_1} \rightarrow \textcircled{1}$$

$$\mu_s \frac{g}{4} = \frac{v^2}{R_2} \rightarrow \textcircled{2}$$

$$\frac{\textcircled{1}}{\textcircled{2}} = 4 = \frac{R_2}{R_1}$$

$$R_2 = 4R_1$$

ANS: E PTS: 3 DIF: Challenging

40. A boy on board a cruise ship drops a 30.0 gm marble into the ocean. If the resistive force proportionality constant is 0.500 kg/s, what is the terminal speed of the marble in m/s?

- a. 0.147
- b. 0.294
- c. 0.588
- d. 1.18
- e. 2.35

$$v_T = \frac{mg}{b} = \frac{30 \times 10^{-3} \times 9.8}{0.5} = \frac{0.294}{0.5} = 0.588 \text{ m/s}$$

ANS: C PTS: 2 DIF: Average

41. A skydiver of 75 kg mass has a terminal velocity of 60 m/s. At what speed is the resistive force on the skydiver half that when at terminal speed?

$$v_T = \frac{mg}{b}; 60 = \frac{75g}{b}, b = \frac{75g}{60} \text{ kg/s}$$

at $v = \frac{v_T}{2}$: $mg - \frac{b}{2} v^2 = ma, a = \frac{g}{2} \Rightarrow mg - b v^2 = m \frac{g}{2}$

$$b v^2 = \frac{mg}{2}, v = \frac{v_T}{\sqrt{2}}$$

- a. 15 m/s
- b. 49 m/s
- c. 30 m/s
- d. 42 m/s
- e. 36 m/s

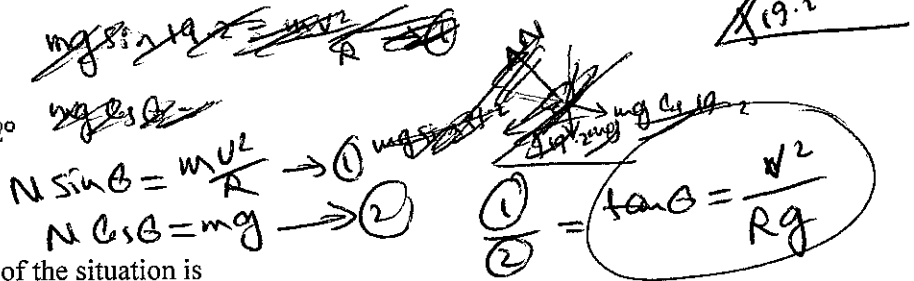
ANS: D

PTS: 2

DIF: Average

42. The following equation was obtained by solving a physics problem:

$$\frac{\left(16.0 \frac{\text{m}}{\text{s}}\right)^2}{(75.0 \text{ m})\left(9.80 \frac{\text{m}}{\text{s}^2}\right)} = \tan 19.2^\circ$$



The best physical representation of the situation is

- a. A car traveling at 16.0 m/s is 19.2° into a turn of a quarter circle on a level road.
- b. A mass on a string that is originally horizontal has fallen to where the angle between the string and the vertical direction is 19.2°.
- c. A mass on a string originally horizontal has fallen 19.2° from the horizontal direction.
- d. A car traveling at 16.0 m/s is on a circular curve banked at 19.2°.
- e. A car traveling at 16.0 m/s and going over a semicircular mountain-top road is 19.2° down from the top.

ANS: D

PTS: 1

DIF: Easy

43. An airplane flies in a horizontal circle of radius 500 m at a speed of 150 m/s. If the plane were to fly in the same 500 m circle at a speed of 300 m/s, by what factor would its centripetal acceleration change?

- a. 0.25
- b. 0.50
- c. 1.00
- d. 2.00
- e. 4.00

$$\frac{v^2}{R} = a_{c1} \rightarrow (1)$$

$$\frac{4v^2}{R} = a_{c2} \rightarrow (2)$$

$$\frac{a_{c2}}{a_{c1}} = \frac{4v^2/R}{v^2/R} = 4$$

$$a_{c2} = 4a_{c1}$$

ANS: E

PTS: 1

DIF: Easy

44. An airplane flies in a horizontal circle of radius 500 m at a speed of 150 m/s. If the radius were changed to 1 000 m, but the speed remained the same, by what factor would its centripetal acceleration change?

- a. 0.25
- b. 0.50
- c. 1.00
- d. 2.00
- e. 4.00

$$\frac{v^2}{R} = a_{c1} \rightarrow (1)$$

$$\frac{v^2}{2R} = a_{c2} \rightarrow (2)$$

$$\frac{a_{c2}}{a_{c1}} = \frac{v^2/2R}{v^2/R} = \frac{1}{2}$$

$$a_{c2} = \frac{1}{2} a_{c1}$$

ANS: B

PTS: 1

DIF: Easy

45. An airplane flies in a horizontal circle of radius 500 m at a speed of 150 m/s. If the plane were to fly in the same 1 000 m circle at a speed of 300 m/s, by what factor would its centripetal acceleration change?

- a. 0.25
- b. 0.50
- c. 1.00

$$\frac{v^2}{R} = a_{c1} \rightarrow (1)$$

$$\frac{4v^2}{2R} = a_{c2} \rightarrow (2)$$

$$\frac{a_{c1}}{a_{c2}} = \frac{v^2/R}{4v^2/2R} = \frac{2}{4} = \frac{1}{2}$$

$$a_{c1} = \frac{1}{2} a_{c2} \rightarrow a_{c2} = 2a_{c1}$$

PROBLEM

51. A sample of blood is placed into a centrifuge of radius 15.0 cm. The mass of a red corpuscle is 3.0×10^{-16} kg, and the centripetal force required to make it settle out of the plasma is 4.0×10^{-11} N. At how many revolutions per second should the centrifuge be operated?

ANS: 150 rev/s (9 000 rpm)

PTS: 3 DIF: Challenging

$$r = 15 \times 10^{-2} \text{ m}, m = 3 \times 10^{-16} \text{ kg}, F = 4 \times 10^{-11} \text{ N}$$

$$F = \frac{mv^2}{R}, v = \sqrt{\frac{FR}{m}} = \frac{2\pi r}{t} = 2\pi r f$$

$$f = \frac{\sqrt{\frac{FR}{m}}}{2\pi r} = \frac{1}{2\pi} \sqrt{\frac{F}{mR}} = 9000 \text{ rpm}$$

52. A space station in the form of a large wheel, 120 m in diameter, rotates to provide an "artificial gravity" of 3.00 m/s^2 for persons located at the outer rim. Find the rotational frequency of the wheel (in revolutions per minute) that will produce this effect.

ANS: 2.14 rpm

PTS: 3 DIF: Challenging

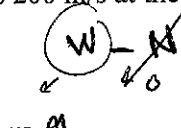
$$a_c = \frac{v^2}{R}, 3 = \frac{v^2}{\frac{120}{2}}, v = \sqrt{180}, v = \frac{2\pi R}{t}$$

$$t = \frac{2\pi R}{v} = 285, f = \frac{1}{t} \times 60 \text{ rpm}$$

53. An airplane pilot experiences weightlessness as she passes over the top of a loop-the-loop maneuver. If her speed is 200 m/s at the time, find the radius of the loop.

ANS: 4 080 m

PTS: 2 DIF: Average



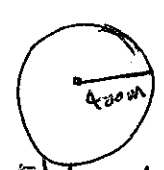
$$W = \frac{mv^2}{R}, mg = \frac{mv^2}{R}, R = \frac{v^2}{g}$$

$$R = \frac{(200)^2}{9.8} \text{ m} = 4081 \text{ m}$$

54. A race car starts from rest on a circular track of radius 400 m. Its speed increases at the constant rate of 0.500 m/s^2 . At the point where the magnitudes of the radial and tangential accelerations are equal, determine (a) the speed of the race car, and (b) the elapsed time.

ANS: 14.1 m/s, 28.3 s

PTS: 2 DIF: Average



$$a_r = 0.5 \text{ m/s}^2, a_t = a_r$$


$$0.5 = \frac{v^2}{R}, v = \sqrt{0.5R} = 14.1 \text{ m/s}$$

$$v = v_0 + at \rightarrow 14.1 = 0 + (0.5)t, t = \frac{14.1}{0.5} \text{ s}$$

55. A small dense object is suspended from the rear view mirror in a car by a lightweight fiber. As the car is accelerating at 1.90 m/s^2 , what angle does the string make with the vertical?

ANS: 11.0 degrees

PTS: 2 DIF: Average



$$T \cos \theta = mg \rightarrow (2)$$

$$T \sin \theta = ma \rightarrow (1)$$

$$\frac{(1)}{(2)} = \tan \theta = \frac{a}{g}$$

$$\theta = \tan^{-1} \left(\frac{a}{g} \right) = \tan^{-1} \left(\frac{1.9}{9.8} \right)$$

arctan $\theta = 11^\circ$