

Name: _____

Dynamics Test

K/U	28	T/I	16	C	26	A	30
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A. True/False

Indicate whether the sentence or statement is true or false.

- _____ 1. The normal force \vec{F}_N that acts on an object is *always equal* in magnitude and opposite in direction to the gravitational force \vec{F}_G that is acting on it.
- _____ 2. *Friction always* acts against an object's motion relative to the contact surface.
- _____ 3. When forces acting on an object are in equilibrium, the object *can still be moving*.
- _____ 4. For an object sliding along a ramp, the force of kinetic friction acting on the object *increases* as the angle of inclination of the ramp increases.
- _____ 5. A car accelerates from rest when a traffic light turns green. A cup of coffee that was sitting on the dashboard of the car falls into the driver's lap. The driver could rightly argue that the cup's apparent motion *was due to its inertia*. It had a tendency to stay still and the car accelerated from beneath it.
- _____ 6. *The sum of all the forces* acting on a stationary object is the same as that acting on an object in uniform motion.
- _____ 7. For an object travelling with uniform circular motion, its acceleration is always directed *tangent to the circle*.
- _____ 8. When *a curve in the road is banked*, a component of the normal force contributes to the centripetal force.

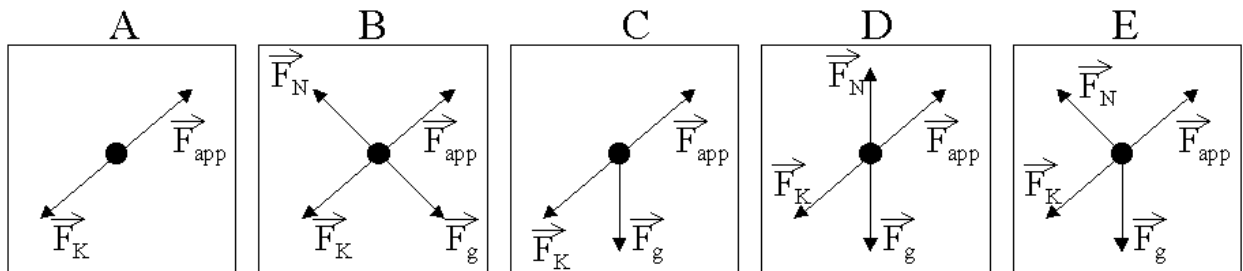
B. Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

9. When analyzing dynamics problems, free-body diagrams

- a. should always be used
- b. are more useful when analyzing horizontal forces than when analyzing vertical forces
- c. should include only the forces that are directly responsible for the acceleration
- d. should be used only when objects are accelerating
- e. only apply to objects in equilibrium

10. The free-body diagram of a block being pushed up a rough ramp is best represented by



- a. A
- b. B
- c. C
- d. D
- e. E

11. A 24-kg traffic light is suspended from the midpoint of a cable suspended between two poles. The angle between the cable and the pole is 80° at both poles. The net force acting on the traffic light has a value of

- a. zero
- b. 47 N
- c. 82 N
- d. 2.4×10^2 N
- e. 4.6×10^2 N

_____ 12. An elevator accelerates downward. What is the relationship between the gravitational force \vec{F}_g acting on the elevator and the tension \vec{F}_T in the cable that supports the elevator?

a. $|\vec{F}_g| = |\vec{F}_T|$

b. $|\vec{F}_g| > |\vec{F}_T|$

c. $|\vec{F}_g| < |\vec{F}_T|$

d. $|\vec{F}_g| \geq |\vec{F}_T|$

e. $|\vec{F}_g| \leq |\vec{F}_T|$

_____ 13. An object sits at rest on a ramp. As the angle of inclination of the ramp increases, the object suddenly begins to slide. Which of the following explanations best accounts for the object's movement?

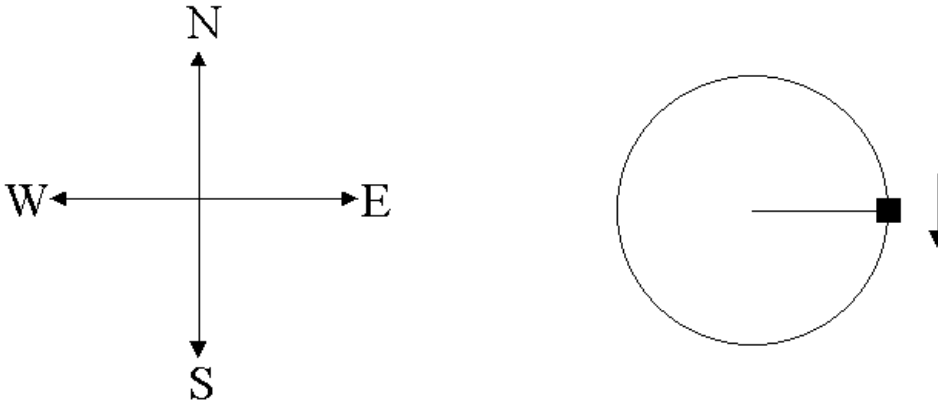
- a. The coefficient of static friction has decreased sufficiently.
- b. The force of gravity acting on the object has increased sufficiently.
- c. The component of gravity along the ramp has increased sufficiently.
- d. The friction has decreased sufficiently while the normal force has remained unchanged.
- e. The normal force has increased sufficiently.

_____ 14. A passenger on a Ferris wheel of diameter 22 m makes one complete revolution every 45 s. What is the passenger's centripetal acceleration?

- a. 19 m/s^2
- b. 13 m/s^2
- c. 0.43 m/s^2
- d. 0.21 m/s^2
- e. 0.068 m/s^2

_____ 15. The diagram below shows a rock on the end of a string being whirled around in a circle in the horizontal plane. The motion is viewed from above and the stone is rotating clockwise.

What are the directions associated with its instantaneous velocity and instantaneous acceleration, respectively?



- a. south, east
- b. east, west
- c. south, south
- d. west, west
- e. south, west

_____ 16. Imagine you are a passenger upside-down at the top of a vertical looping roller coaster. The centripetal force acting on you at this position

- a. is perhaps the least of anywhere in the loop
- b. is supplied at least partly by gravity
- c. is supplied partly by the seat of the roller coaster
- d. is directed vertically downward
- e. all of the above

C. Short Answer

17. Newton's third law talks about forces always acting in pairs with the two forces of any pair being equal in strength and opposite in direction. Does this imply a "balanced" force situation and, if so, how is it possible to ever accelerate anything?

18. Describe how “artificial” gravity can be produced on board an orbiting space station. Discuss the physics of the situation.

19. An object with a mass of 15 kg rests on a frictionless horizontal plane and is acted upon by a horizontal force of 30 N.

- (a) What is its acceleration?
- (b) How far will it move in 10 s?
- (c) What will be its velocity after 10 s?

20. If the coefficient of friction is 0.30, how much horizontal force is needed to pull a mass of 15 kg across a level board at a uniform velocity?

21. A 200 g ball on the end of a string is rotated in a horizontal circle of radius 10.0 m. The ball completes 10 rotations in 5.0 s. What is the centripetal force of the string on the ball?

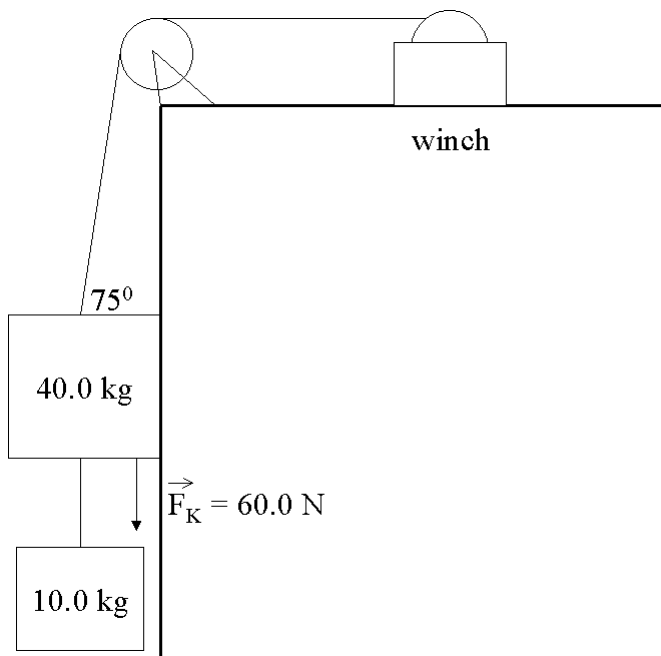
D. Problem Solving

22. An electric winch is used to raise a 40-kg package and a 10-kg package vertically up the side of a building as pictured in the diagram. There is a frictional force of 60 N acting between the wall and the 40-kg package. The angle the cable makes to the vertical is 15° . Include an appropriate free-body diagram for each of the following questions. (Assume two significant digits.)

(a) Calculate the force the winch must exert on the cable to slide the packages at a constant speed up the wall.

(b) If the packages are lowered with an acceleration 1.0 m/s^2 , what is the tension in the cable connecting the two packages?

(c) If the packages are raised with an acceleration of 1.0 m/s^2 , what is the tension in the rope connecting the two packages?

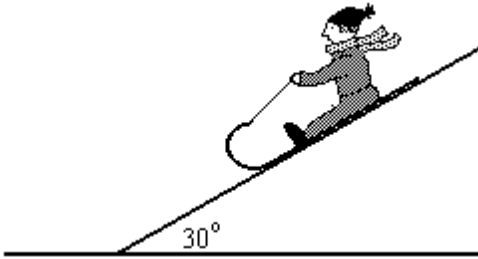


23. A passenger in an elevator has a mass of 100 kg. Calculate the force, in newtons, exerted on the passenger by the elevator, if the elevator is

- (a) at rest
- (b) moving with an upward acceleration of 30 cm/s^2
- (c) moving with a downward acceleration of 15 cm/s^2
- (d) moving upward with a uniform velocity of 15 cm/s^2
- (e) falling freely (the cable breaks).

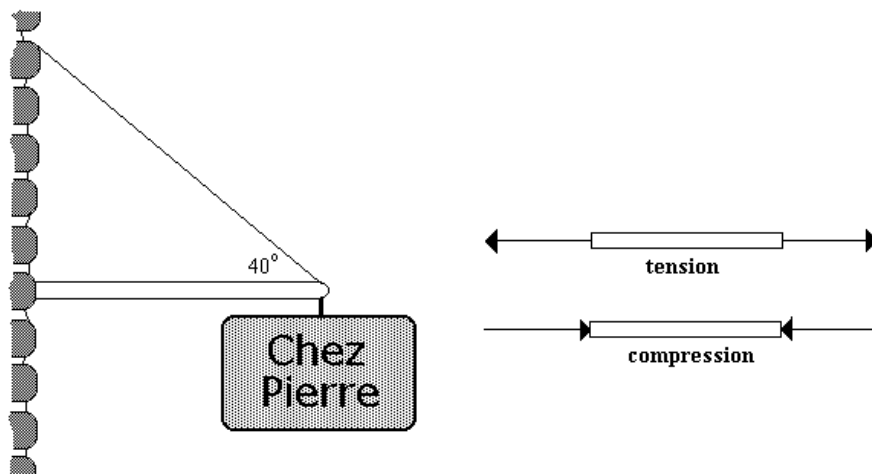
24. A boy on a toboggan is sliding down a snow-covered hillside. The boy and toboggan together have a mass of 50 kg, and the slope is at an angle of 30° to the horizontal. Find the boy's acceleration considering the following.

- (a) if there is no friction
- (b) if the coefficient of kinetic friction is 0.15



25. A pendulum of mass 1.0 kg is suspended from the roof of a car travelling on a level road. An observer in the car notices that the pendulum string makes an angle of 10° with the vertical. What is the acceleration of the car?

26. The sign for Pierre's restaurant has a mass of 82 kg. It is held out from the wall by a light horizontal steel rod, which supports no weight, and a wire at 40° to the horizontal, as illustrated. Find the tension in the wire and the compression in the steel rod.



27. An object of mass 3.0 kg is whirled around in a vertical circle of radius 1.3 m with a constant velocity of 6.0 m/s. Calculate the maximum and minimum tension in the string.

Answer Sheet

A. True/False

- | | |
|---------------------------------------|-------|
| 1. F, not always equal | 1 K/U |
| 2. T | 1 K/U |
| 3. T | 1 K/U |
| 4. F, decreases | 1 K/U |
| 5. T | 1 K/U |
| 6. T | 1 K/U |
| 7. F, toward the centre of the circle | 1 K/U |
| 8. T | 1 K/U |

B. Multiple Choice

- | | |
|------------|-------|
| 9. ANS: A | 1 K/U |
| 10. ANS: E | 1 K/U |
| 11. ANS: A | 1 K/U |
| 12. ANS: B | 1 K/U |
| 13. ANS: C | 1 K/U |
| 14. ANS: D | 1 K/U |
| 15. ANS: E | 1 K/U |
| 16. ANS: E | 1 K/U |

C. Short Answer

17. ANS: Newton's third law does not imply a "balanced" force situation. While it is true that the two forces of any pair are equal in strength and opposite in direction, these forces act on different objects. Object A exerts a force on object B resulting in object B exerting an equal force on object A. These forces don't act on the same object so they do not "balance" each other.

2 C 2 T

18. ANS: Artificial gravity can be produced by rotating the space station. Imagine the space station designed as a giant wheel that spins. For people on board, the fictitious centrifugal force would make them feel as though they were being pulled toward the outside of the wheel. "Up" would be toward the wheel's hub. What is actually happening is that the rim of the wheel is

pushing the people toward the hub as it overcomes their inertia to always move tangent to the wheel. The force upward from the rim of the wheel on people's feet would feel exactly the same as a downward pull by some gravitational attractor. The strength of the force is dictated by the wheel's radius and spin rate.

2 C	2 T
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19. ANS:

(a) Using Newton's Second Law,

$$\begin{aligned}\vec{a} &= \frac{\vec{F}_{\text{net}}}{m} = \frac{30 \text{ N}}{15 \text{ kg}} \\ &= 2.0 \text{ m/s}^2 \text{ in the direction of the applied horizontal force}\end{aligned}$$

(b) Since the acceleration is constant, the equations of uniformly accelerated motion may be used to describe its motion.

$$\begin{aligned}\Delta \vec{d} &= \vec{v}_1 \Delta t + \frac{1}{2} \vec{a} (\Delta t)^2 \\ &= (0 \text{ m/s})(10 \text{ s}) + \frac{1}{2} (2.0 \text{ m/s}^2)(10 \text{ s})^2 \\ &= 0 \text{ m} + 100 \text{ m} \\ &= 100 \text{ m in the direction of the applied horizontal force}\end{aligned}$$

(c)

$$\begin{aligned}\vec{v}_2 &= \vec{v}_1 + \vec{a} \Delta t \\ &= 0 \text{ m/s} + (2.0 \text{ m/s}^2)(10 \text{ s}) \\ &= 20 \text{ m/s in the direction of the applied horizontal force}\end{aligned}$$

3 K/U	3 C	1 T
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20. ANS:

$$\begin{aligned}\vec{F}_f &= \mu_k \vec{F}_N \\ &= \mu_k mg \\ &= 0.30(15 \text{ kg})(9.8 \text{ N/kg}) \\ &= 44 \text{ N}\end{aligned}$$

2 K/U	1 C
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21. ANS:

$$f = \frac{10}{5.0} = 2 \text{ Hz}$$

$$\begin{aligned} F_c &= 4\pi^2 m r f^2 \\ &= 4\pi^2 (0.200 \text{ kg})(10.0 \text{ m})(2.0 \text{ Hz})^2 \\ &= 316 \text{ N, or } 3.2 \times 10^2 \text{ N} \end{aligned}$$

2 K/U 1 C

D. Problem Solving

22. ANS:

(a) Consider the system of the packages: Free-body diagram:

$$\begin{array}{ll} F_T \sin 75^\circ & \text{acting up} \\ F_g & \text{acting down} \\ F_K & \text{acting down} \end{array}$$

At a constant speed, the acceleration and net force are both zero.

Using the sign convention that “up” is (–) and “down” is (+):

$$\begin{aligned} \vec{F}_{\text{net}} &= \vec{F}_T(\sin 75^\circ) + \vec{F}_g + \vec{F}_K \\ \vec{F}_T(\sin 75^\circ) &= -50 \text{ kg}(9.8 \text{ m/s}^2) - 6.0 \text{ N} \\ \vec{F}_T &= 5.7 \times 10^2 \text{ N} \end{aligned}$$

The force the winch must exert is $5.7 \times 10^2 \text{ N}$ [up].

(b) Consider the 10-kg package:

$$\begin{array}{ll} \text{Free-body diagram:} & F_T \quad \text{acting up} \\ & F_g \quad \text{acting down} \end{array}$$

$$\begin{aligned} \vec{F}_{\text{net}} &= \vec{F}_T + \vec{F}_g \\ \vec{F}_T &= \vec{F}_{\text{net}} - \vec{F}_g \\ &= m\vec{a} - m\vec{g} \\ &= 10.0 \text{ kg}(1.0 \text{ m/s}^2) - 10.0 \text{ kg}(9.8 \text{ N/kg}) \\ \vec{F}_T &= -88 \text{ N} \end{aligned}$$

The force of tension in the cable connecting the two packages is 88 N [up].

(c) Consider the 10-kg package:

Free-body diagram: F_T acting up
 F_g acting down

$$\begin{aligned}\vec{F}_{\text{net}} &= \vec{F}_T + \vec{F}_g \\ \vec{F}_T &= \vec{F}_{\text{net}} - \vec{F}_g \\ &= m\vec{a} - m\vec{g} \\ &= 10.0 \text{ kg}(-1.0 \text{ m/s}^2) - 10.0 \text{ kg}(9.8 \text{ N/kg}) \\ \vec{F}_T &= -108 \text{ N}\end{aligned}$$

The force of tension in the cable connecting the two packages is 108 N [up].

3 T 3 C 6 A

23. ANS:

(a)

at rest, $\vec{a} = 0$ and $\vec{F}_{\text{net}} = 0$

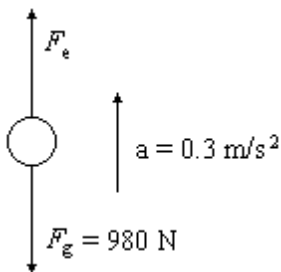
$$\begin{aligned}F_g &= mg \\ &= (100 \text{ kg})(9.8 \text{ N/kg}) \\ &= 980 \text{ N}\end{aligned}$$

$$\begin{aligned}\vec{F}_{\text{net}} &= \vec{F}_e + \vec{F}_g \\ 0 &= F_e - 980 \text{ N}\end{aligned}$$

$$F_e = +980 \text{ N}$$

$$\vec{F}_e = 980 \text{ N [up]}$$

(b)



$$\vec{F}_{\text{net}} = \vec{F}_e + \vec{F}_g = m\vec{a}$$

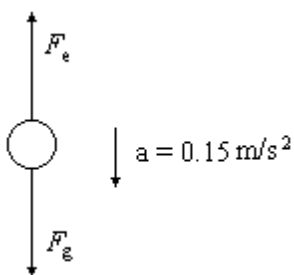
$$F_e - 980 \text{ N} = (100 \text{ kg})\left(0.30 \text{ m/s}^2\right)$$

$$F_e - 980 \text{ N} = 30 \text{ N}$$

$$F_e = 1010 \text{ N}$$

$$\vec{F}_e = 1010 \text{ N [up]}$$

(c)



$$\vec{F}_{\text{net}} = \vec{F}_e + \vec{F}_g = m\vec{a}$$

$$F_e - 980 \text{ N} = -15 \text{ N}$$

$$F_e = 965 \text{ N}$$

$$\vec{F}_e = 965 \text{ N [up]}$$

(d) If v is uniform,

$$a = 0, \vec{F}_{\text{net}} = 0$$

$\therefore F_e = 980 \text{ N [up]}$ as in (a).

(e) If falling freely, there is no force of the elevator on the passenger, as seen below.

$$\vec{F}_{\text{net}} = \vec{F}_e + \vec{F}_g = m\vec{a}$$

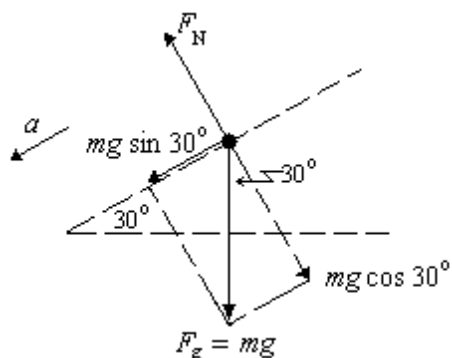
$$F_e - 980 \text{ N} = - (100 \text{ kg})\left(9.8 \text{ m/s}^2\right)$$

$$F_e = 0 \text{ N}$$

5 K/U	5 C	8 A
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24. ANS:

(a)



$$F = mg \sin 30^\circ \quad \text{But } F = ma$$

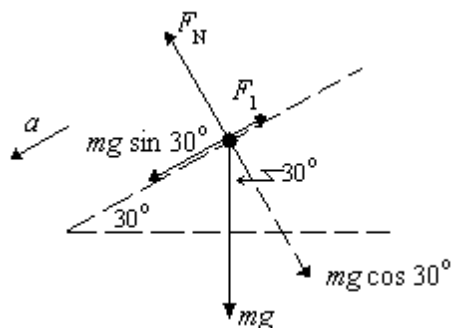
$$\therefore ma = mg \sin 30^\circ$$

$$\text{or } a = g \sin 30^\circ$$

$$= 9.8 \text{ m/s}^2 (0.50)$$

$$= 4.9 \text{ m/s}^2$$

(b)



$$\vec{F}_{\text{net}} = \vec{F}_{\text{down slope}} + \vec{F}_f$$

$$F_{\text{net}} = mg \sin 30^\circ - \mu_k F_N$$

$$\text{But } F_{\text{net}} = ma, \text{ and } F_N = mg \cos 30^\circ$$

$$\therefore ma = mg \sin 30^\circ - \mu_k mg \cos 30^\circ$$

$$\text{or } a = g \sin 30^\circ - \mu_k g \cos 30^\circ$$

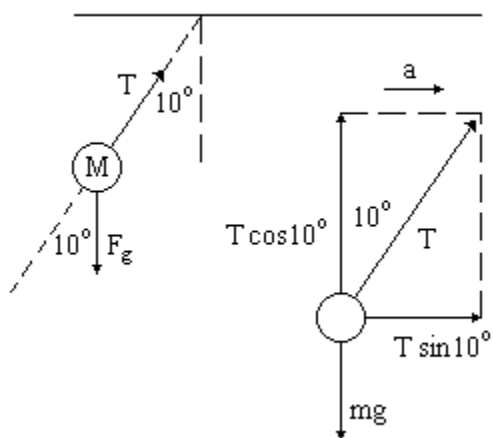
$$= \left(9.8 \text{ m/s}^2 \right) (0.500) - (0.15) \left(9.8 \text{ m/s}^2 \right) (0.866)$$

$$= 4.9 \text{ m/s}^2 - 1.3 \text{ m/s}^2$$

$$= 3.6 \text{ m/s}^2$$

2 T 4 C 5 A

25. ANS: Ball and car accelerating at same rate.



$$\vec{F}_{\text{net}} = \vec{T} + \vec{F}_g$$

Taking vertical components,

$$T \cos 10^\circ - mg = 0$$

$$\text{or } T \cos 10^\circ = mg \quad (1)$$

Taking horizontal components,

$$T \sin \theta = ma \quad (2)$$

Combining (1) and (2)

$$\frac{ma}{mg} = \frac{T \sin \theta}{T \cos \theta}$$

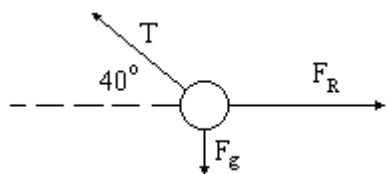
$$a = g \tan \theta$$

$$= 9.8 \tan 10^\circ$$

$$= 1.76 \text{ m/s}^2, \text{ or } 1.8 \text{ m/s}^2$$

2 T 2 C 4 A

26. ANS: Solution 1: Components



$$\begin{aligned}F_{\epsilon} &= mg \\ &= (82 \text{ kg})(9.8 \text{ N/kg}) \\ &= 804 \text{ N}\end{aligned}$$

Taking vertical components:

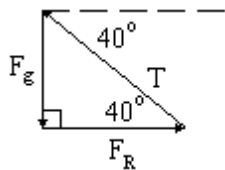
$$T \sin 40^{\circ} = 804 \text{ N}$$

$$T = 1251 \text{ N, or } 1.3 \times 10^3 \text{ N}$$

Taking horizontal components:

$$\begin{aligned}F_{\text{R}} &= T \cos 40^{\circ} \\ &= (1250 \text{ N})(\cos 40^{\circ}) \\ &= 958 \text{ N, or } 9.6 \times 10^2 \text{ N}\end{aligned}$$

Solution 2: Triangle of Forces



$$\sin 40^{\circ} = \frac{F_{\epsilon}}{T}$$

$$\sin 40^{\circ} = \frac{804 \text{ N}}{T}$$

$$T = 958 \text{ N}$$

$$\tan 40^{\circ} = \frac{F_{\epsilon}}{F_{\text{R}}}$$

$$= \frac{804 \text{ N}}{F_{\text{R}}}$$

$$F_{\text{R}} = 1250 \text{ N, or } 1.3 \times 10^3 \text{ N}$$

Thus the tension in the wire is $9.6 \times 10^2 \text{ N}$ and the compression in the rod is $1.3 \times 10^3 \text{ N}$.

2 T 2 C 3 A

27. ANS: Note the mass of the ball is immaterial.

At the top,

$$\vec{F}_c = \vec{F}_g + \vec{T}$$

$$\vec{T} = \vec{F}_c - \vec{F}_g$$

$$-\vec{T} = -\frac{mv^2}{R} + mg \text{ (up is positive)}$$

$$= \frac{-(3.0 \text{ kg})\left(6.0 \text{ m/s}^2\right)}{1.3 \text{ m}} + (3.0 \text{ kg})(9.8 \text{ N/kg})$$

$$-\vec{T} = -83.1 \text{ N} + 29.4 \text{ N}$$

$$\vec{T} = 53.7 \text{ N, or } 54 \text{ N}$$

At the bottom,

$$\vec{T} = \vec{F}_c - \vec{F}_g$$

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

$$= 83.1 \text{ N} + 29.4 \text{ N}$$

$$= 112.5 \text{ N, or } 1.1 \times 10^2 \text{ N}$$

2 T	2 C	4 A
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