The next four questions pertain to the situation described below.

A toy car is moving along the x axis. A plot of its position versus time is shown in the figure to the right.

1) Which of the following statements is true ?

a. The magnitude of the acceleration of the toy car is smaller at t=4 s than at t = 7 s.
b. The magnitude of the acceleration of the toy car is the same at t=4 s as it is at t = 7 s.
c. The magnitude of the acceleration of the toy car is larger at t=4 s than at t = 7 s.

2) The change in the velocity of the toy car between t = 7 s and t = 8 s is

a. Positive
b. Zero
c. Negative

3) What is the average velocity of the toy car between t = 0 s and t = 3 s ?

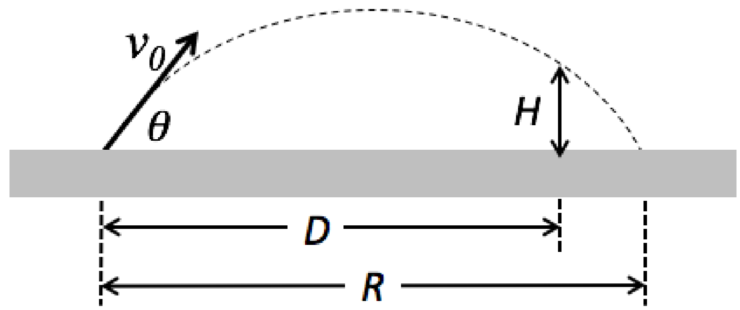
a. V_{ave} = 2 m/s
b. V_{ave} = 1 m/s
c. V_{ave} = 0 m/s
d. V_{ave} = -1 m/s
e. V_{ave} = -2 m/s

4) At t = 0 s, the velocity of the toy car is 4 m/s. Assuming that the acceleration of toy car between $t = 0$ s and t = 3 s is constant, what is value of this acceleration?

a. a_{0-3} = -1.33 m/s^2
b. a_{0-3} = 2.67 m/s^2
c. a_{0-3} = -2.67 m/s^2
d. a_{0-3} = 1.33 m/s^2
e. a_{0-3} = 0 m/s^2

The next three questions pertain to the situation described below.

Suppose the Illinois football team wins a game against Northwestern by kicking a field goal. The ball starts at rest on the ground a horizontal distance $D = 35$ m from the goal and is kicked toward the goal in such a way that its initial angle with the ground is $\theta = 30^\circ$ and its initial speed is $v_0 = 23.74$ m/s. Neglect air resistance.



5) What is the speed of the ball when it reaches its maximum height?

a. $v_0 sin(\theta)$
b. v_0
c. $v_0 cos(\theta)$

6) How high above the ground is the ball when it reaches the goal?

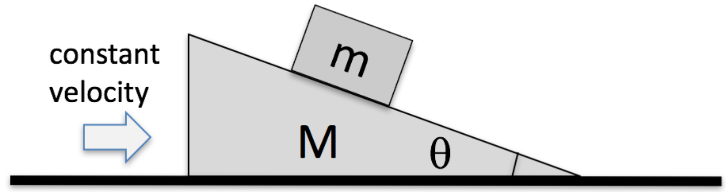
a. H = 6.8 m
b. H = 20.2 m
c. H = 14.4 m
d. H = 6 m
e. H = 19.2 m

7) Suppose the horizontal distance that the ball travels in the air before landing on the ground is R in the above scenario. If the initial speed of the ball is doubled but the initial angle is unchanged, what is the new horizontal distance that ball will travel in the air before landing on the ground ?

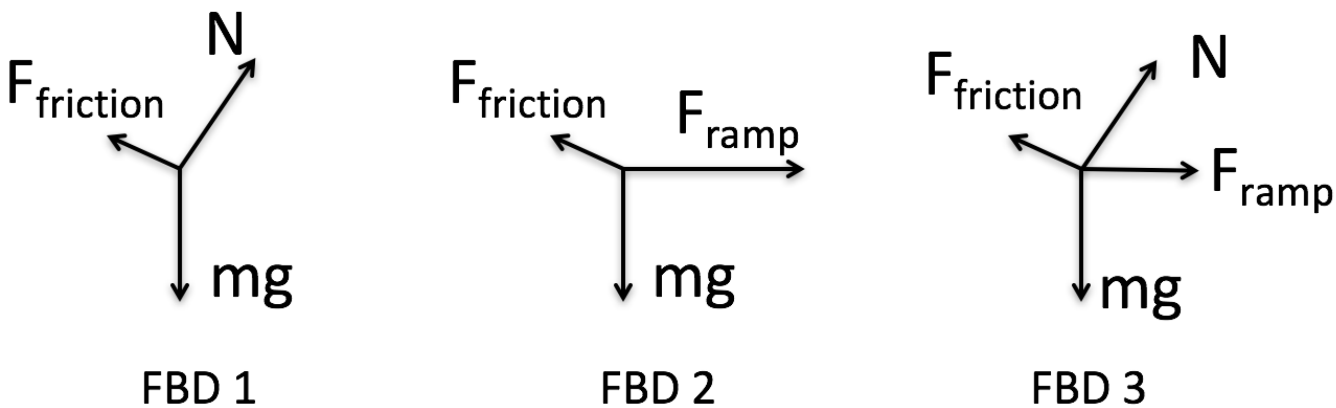
a. 2R
b. 4R
c. $\sqrt{2}$R

The next three questions pertain to the situation described below.

A box of mass mass m sits on the inclined surface of a ramp and does not slide on the ramp. The ramp has mass M and makes an angle θ with respect to the horizontal floor. The ramp-box combination slides across the floor in the +x direction with constant velocity V.



8) Which of the following is the correct free body diagram for the box?



a. FBD 1
b. FBD 2
c. FBD 3

9) The total force exerted on the box **by the ramp**

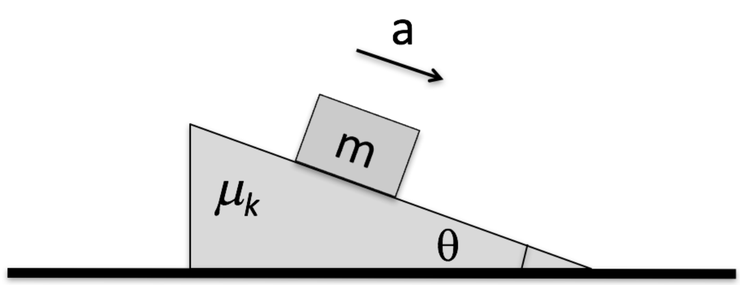
a. points vertically upward.
b. is parallel to the surface of the box
c. points horizontally to the right.

10) Suppose the magnitude of the frictional force acting on the box in the above scenario is f_V. If the ramp and box were moving with a bigger constant velocity in the +x direction, the magnitude of the frictional force needed to keep the box from sliding on the ramp would be

a. f_V
b. Bigger than f_V
c. Smaller than f_V

The next two questions pertain to the situation described below.

A box of mass m = 15 kg slides down a ramp with acceleration a = 3.5 m/s^2. The ramp makes an angle $\theta = 35^{\circ}$with respect to the horizontal floor and does not move.



11) What is the magnitude of the total force acting on the box ?

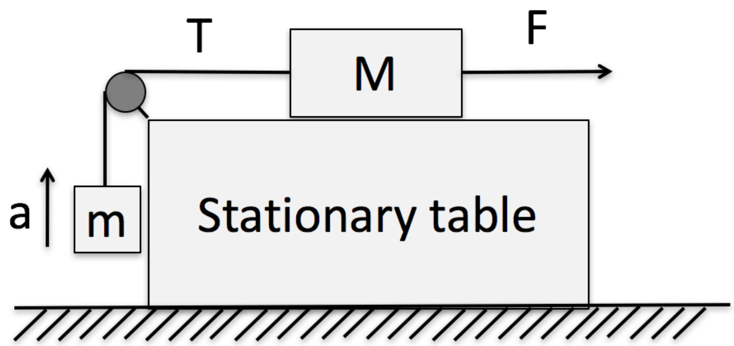
a. $ma\ cos(\theta)$
b. ma
c. $ma\ sin(\theta)$

12) What is the coefficient of kinetic friction between the box and the ramp ?

a. μ_k = 0.22
b. μ_k = 1.14
c. μ_k = 0.26
d. μ_k = 0.93
e. μ_k = 0.7

The next two questions pertain to the situation described below.

A box with mass $M = 17$ kg is free to slide on top of a frictionless horizontal table and is attached by a massless string and pulley to a hanging weight of mass $m = 12$ kg. A constant horizontal force F is applied to the box in the direction away from the pulley, as shown in the figure. The weight is observed to move upward with a constant acceleration $a = 1.9$ m/s^2.



13) How does the magnitude of the tension in the string T compares to the magnitude of the applied force F?

a. $F > T$
b. $F = T$
c. $F < T$

14) What is the magnitude of the applied force F ?

a. F = 55.1 N
b. F = 32.3 N
c. F = 22.8 N
d. F = 140.5 N
e. F = 172.8 N

The next two questions pertain to the situation described below.

Bicyclists are competing on a circular track of radius R = 58 meters. Assume the surface of the track is horizontal. A bicyclist whose mass is m = 58 kg completes 12 full laps around the track in 240 seconds. The mass of her bicycle is M = 7 kg.

15) Assuming the speed of the bicyclist is constant, what is the magnitude of the total force exerted on her during the ride ?

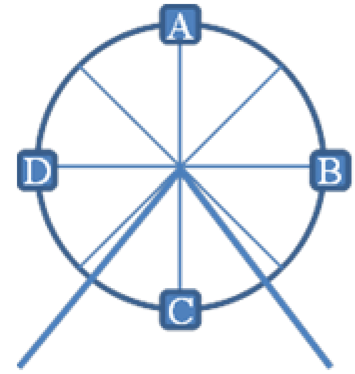
a. F = 372.1 N
b. F = 83 N
c. F = 332 N
d. F = 0 N
e. F = 658.8 N

16) What is the direction of the total force exerted on the track by the bicycle?

a. Pointing toward the center of the track and upward.
b. Pointing away from the center of the track and downward.
c. Horizontal, away from the center of the track.
d. Horizontal, toward the center of the track.
e. It is zero.

The next two questions pertain to the situation described below.

A Ferris wheel has a radius R and is turning counter-clockwise at a constant angular velocity ω. A student of mass m is sitting in the car labeled B.



17) At the instant shown, what is the magnitude of the force that the seat exerts on the student ?

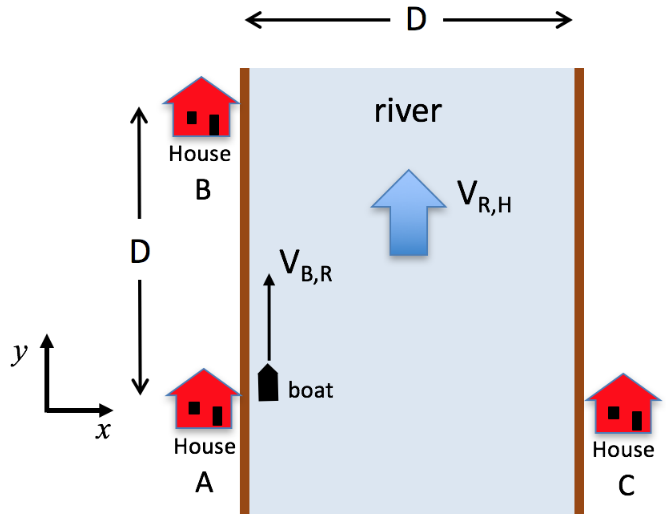
a. $F_{seat,student} = \sqrt{(mg)^2 + (m\omega^2 R)^2}$
b. $F_{seat,student} = mg - m\omega^2 R$
c. $F_{seat,student} = mg + m\omega^2 R$
d. $F_{seat,student} = mg$
e. $F_{seat,student} = m\omega^2 R$

18) At the instant shown, what is the magnitude of the total force on the student ?

a. $F_{total} = mg$
b. $F_{total} = m\omega^2 R$
c. $F_{total} = 0$

The next three questions pertain to the situation described below.

The houses, A, B , and C, are located on a river as shown. House B is on the same side of the river as House A, and is a distance $D = 600$ m away. House C is directly across the river from House A, and is also a distance $D = 600$ m away. The river flows in the +y direction with speed $V_{R,H} = 1.1$ m/s relative to the houses. Your boat can move with maximum velocity of $V_{B,R} = 3.3$ m/s relative to the water of the river.



19) What is Δt_{AB}, the shortest time in which you can drive your boat from House A to House B ?

a. $\Delta t_{AB} = 272.7$ s
b. $\Delta t_{AB} = 136.4$ s
c. $\Delta t_{AB} = 192.8$ s
d. $\Delta t_{AB} = 181.8$ s
e. $\Delta t_{AB} = 545.5$ s

20) What is Δt_{BA}, the shortest time in which you can drive your boat from House B to House A ?

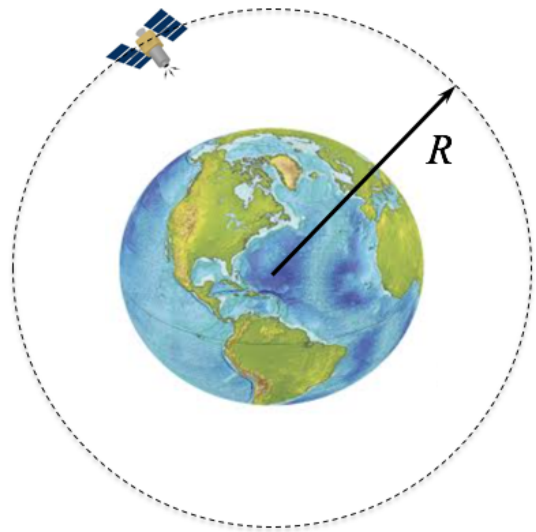
a. $\Delta t_{BA} = 272.7$ s
b. $\Delta t_{BA} = 136.4$ s
c. $\Delta t_{BA} = 192.8$ s
d. $\Delta t_{BA} = 181.8$ s
e. $\Delta t_{BA} = 545.5$ s

21) What is Δt_{AC}, the shortest time in which you can drive your boat from House A to House C ?

a. $\Delta t_{AC} = 136.4$ s
b. $\Delta t_{AC} = 272.7$ s
c. $\Delta t_{AC} = 181.8$ s
d. $\Delta t_{AC} = 545.5$ s
e. $\Delta t_{AC} = 192.8$ s

The next three questions pertain to the situation described below.

A satellite of mass M_S = 325 kg is in a circular orbit of radius R around the Earth, which has a mass M_{Earth}. The satellite completes 6 orbits per day.



22) What is the angular velocity of the satellite, ω, as it orbits the Earth ?

a. ω = 6.9 $\times 10^{-5}$ rad/s
b. ω = 7.3 $\times 10^{-5}$ rad/s
c. ω = 43.6 $\times 10^{-5}$ rad/s

23) Which of the following expression gives the radius of the satellite's orbit ?

a. $R = (GM_{Earth}M_S/\omega^2)^{1/3}$
b. $R = (GM_{Earth}/\omega)^{1/2}$
c. $R = (GM_{Earth}M_S/\omega)^{1/2}$
d. $R = (GM_{Earth}/\omega^2)^{1/3}$
e. $R = (\omega/M_S g)^{1/2}$

24) Many communication satellites have a period of about 24 hours so that they can stay above more or less the same spot on the earth. Satellites of the Global Positioning System (GPS) have a period that is about 12 hours. Which satellites are closest to the Earth?

a. Satellites with a period of 12 hours are closer than satellites with a period of 24 hours.
b. Satellites with a period of 24 hours are closer than satellites with a period of 12 hours.
c. We can't answer this question without knowing the mass of the satellites.