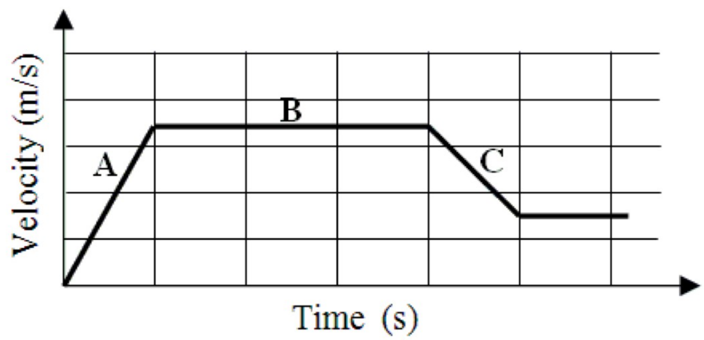
**1.** In which one of the following situations does the car have a westward acceleration?
A) The car travels westward at constant speed.
B) The car travels eastward and speeds up.
C) The car travels westward and slows down.
D) The car travels eastward and slows down.
E) The car starts from rest and moves toward the east.

east(+), initial velocity $= +v_0$, final velocity $= +v$
Slows down, $v_0 > v$
Acceleration $= \frac{v - v_0}{t}$ is negative (west)

**2.** An eagle is flying due east at 8.9 m/s carrying a gopher in its talons. The gopher manages to break free at a height of 12 m. What is the magnitude of the gopher's velocity as it reaches the ground? Note: effects of air resistance are not included in this calculation.
A) 22 m/s
B) 18 m/s
C) 11 m/s
D) 9.8 m/s
E) 8.9 m/s

$$v_x = v_{0x} = 8.9\text{m/s}$$
$$v_y^2 = v_{0y}^2 - 2gy = 0 - 2(9.8\text{m/s}^2)(\text{-}12\text{m})$$
$$v_y^2 = 235\text{m}^2/\text{s}^2$$
$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(8.9)^2 + 235}\ \text{m/s} = 18\,\text{m/s}$$




$$a_A = \frac{\Delta v_A}{t} = 3.5\text{m/s}^2$$
$$a_C = \frac{\Delta v_B}{t} = 2.0\text{m/s}^2$$
$a_A > a_C$, therefore, $F_A > F_B$

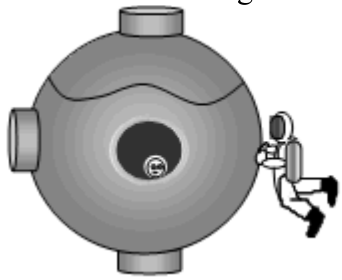
**3.** The figure shows the velocity versus time curve for a car traveling along a straight line. Which of the following statements is false?
A) No net force acts on the car during interval **B**.
B) Net forces act on the car during intervals **A** and **C**.
C) Opposing forces may be acting on the car during interval **B**.
D) Opposing forces may be acting on the car during interval **C**.
E) The magnitude of the net force acting during interval **A** is less than that during **C**.

A horse pulls a cart along a flat road. Consider the following four forces that arise in this situation.
(*1*) force of the horse pulling on the cart
(*2*) force of the cart pulling on the horse
(*3*) force of the horse pushing on the road
(*4*) force of the road pushing on the horse

**4.** Which two forces form an "action-reaction" pair that obeys Newton's third law?
A) *1* and *4*
B) *1* and *3*
C) *2* and *4*
D) *3* and *4*
E) *2* and *3*

(1 & 2) and (3 & 4) are "action-reaction" pairs

A 70.0-kg astronaut pushes to the left on a spacecraft with a force $\vec{F}$ in "gravity-free" space. The spacecraft has a total mass of $1.0 \times 10^4$ kg. During the push, the astronaut accelerates to the right with an acceleration of 0.36 m/s$^2$.



**5.** Which one of the following statements concerning this situation is true?
A) The spacecraft does not move, but the astronaut moves to the right with a constant speed.
B) The astronaut stops moving after he stops pushing on the spacecraft.
C) The force exerted on the astronaut is larger than the force exerted on the spacecraft.
D) The force exerted on the spacecraft is larger than the force exerted on the astronaut.
E) The velocity of the astronaut increases while he is pushing on the spacecraft.

**6.** For the spacecraft in the previous problem, determine the magnitude of the acceleration of the spacecraft.
A) 51.4 m/s$^2$
B) 0.36 m/s$^2$
C) $2.5 \times 10^{-3}$ m/s$^2$
D) $7.0 \times 10^{-3}$ m/s$^2$
E) $3.97 \times 10^{-4}$ m/s$^2$

$$F_A = m_A a_A = 70\text{ kg}\,(0.36\text{ m/s}^2) = 25\text{ N}$$
$$\text{Newton's 3rd law: } F_S = F_A = 25\text{ N} = m_S a_S$$
$$a_S = 25\text{ N}\big/\left(1\times10^4\text{ N}\right) = 2.5\times10^{-3}\text{ m/s}^2$$

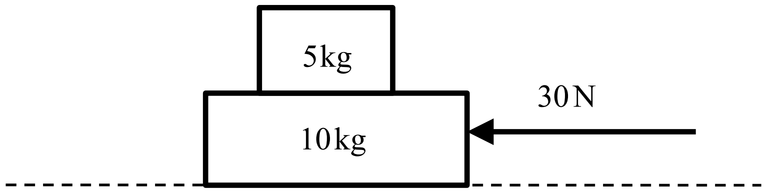
**7.** A pitcher delivers a fastball with a velocity of 43 m/s to the south. The batter hits the ball and gives it a velocity of 51 m/s to the north. What was the average acceleration of the ball during the 1.0 ms when it was in contact with the bat?
A) $4.3 \times 10^4$ m/s$^2$, south
B) $5.1 \times 10^4$ m/s$^2$, north
C) $9.4 \times 10^4$ m/s$^2$, north
D) $2.2 \times 10^3$ m/s$^2$, south
E) $7.0 \times 10^3$ m/s$^2$, north

$$\text{North}(+).\ v_0 = -43\text{m/s},\ v = +51\text{m/s}$$
$$a = (v - v_0)/t = 94\text{m/s}/(1\times10^{-3}\text{s}) = +9.4\times10^4\text{m/s}^2$$

**8.** The minimum takeoff speed for a certain airplane is 75 m/s. What minimum acceleration is required if the plane must leave a runway of length 1050 m? Assume the plane starts from rest at one end of the runway.
A) 1.5 m/s$^2$
B) 3.0 m/s$^2$
C) 4.5 m/s$^2$
D) 6.0 m/s$^2$
E) 2.7 m/s$^2$

$$v^2 = v_0^2 - 2ax;\quad a = \frac{v^2}{2x} = \frac{(75\text{m/s})^2}{2(1050\text{m})} = 2.7\text{m/s}^2$$

Two blocks rest on a horizontal *frictionless* surface as shown. The surface between the top and bottom blocks is roughened so that there is no slipping between the two blocks. A 30-N force is applied to the bottom block as suggested in the figure.




**9.** What is the acceleration of the "two block" system?
A) 1 m/s$^2$
B) 2 m/s$^2$
C) 3 m/s$^2$
D) 6 m/s$^2$
E) 15 m/s$^2$

$$a = \frac{F}{m} = \frac{30\text{ N}}{15\text{ kg}} = 2\text{ m/s}^2$$

**10.** What is the force of static friction between the top and bottom blocks of the previous problem?
A) zero newtons
B) 10 N
C) 20 N
D) 25 N
E) 30 N

$$f = ma = (5\text{ kg})\,(2\text{ m/s}^2) = 10\text{ N}$$

**11.** What is the minimum coefficient of static friction necessary to keep the top block from slipping on the bottom block of the previous problem?
A) 0.05
B) 0.10
C) 0.20
D) 0.30
E) 0.40

$$f^{\max} = \mu F_{\perp} = \mu W = \mu m g$$
$$\mu = \frac{f^{\max}}{mg} = \frac{10\text{N}}{5\text{ kg}(9.8\text{m/s}^2)} = 0.2$$

**12.** A ball is thrown vertically upward from the surface of the earth. Consider the following quantities:
**(1) the speed of the ball; (2) the velocity of the ball; (3) the acceleration of the ball.**
Which of these is (are) zero when the ball has reached the maximum height?
A) 1 and 2 only
B) 1 and 3 only
C) 1 only
D) 2 only
E) 1, 2, and 3

$$v = 0,\ \mathbf{v} = 0,\ a = -9.8\text{ m/s}^2$$

**13.** Two point masses *m* and *M* are separated by a distance *d*. If the separation *d* remains fixed and the masses are increased to the values 3*m* and 3*M* respectively, how does the gravitational force between them change?
A) The force will be one-third as great.
B) The force will be one-ninth as great.
C) The force will be three times as great.
D) The force will be nine times as great.
E) It is impossible to determine without knowing the numerical values of *m*, *M*, and *d*.

$$F_G = G\frac{m_1 m_2}{r^2}$$

$$F_G' = G\frac{m_1' m_2'}{r^2} = G\frac{(3m_1)(3m_2)}{r^2}$$

$$= 9G\frac{m_1 m_2}{r^2} = 9F_G$$

**14.** A rock is dropped from rest from a height *h* above the ground. It falls and hits the ground with a speed of 11 m/s. From what height should the rock be dropped so that its speed on hitting the ground is 22 m/s? Neglect air resistance.
A) 1.4*h*
B) 2.0*h*
C) 3.0*h*
D) 4.0*h*
E) 0.71*h*

$$v^2 = v_0^2 - 2g(-h) \Rightarrow h = \frac{v^2}{2g}$$

$$h' = \frac{v'^2}{2g} = \frac{(2v)^2}{2g} = 4\left[\frac{v^2}{2g}\right] = 4h$$

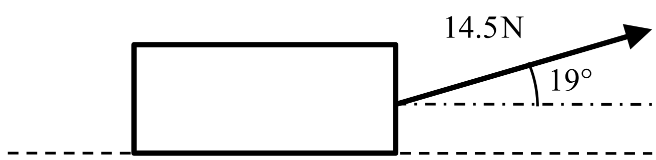
**15.** A rock is suspended from a string; and it moves downward at constant speed. Which one of the following statements is true concerning the tension in the string *if air resistance is not ignored?*
A) The tension is zero newtons.
B) The tension points downward.
C) The tension is equal to the weight of the rock.
D) The tension is less than the weight of the rock.
E) The tension is greater than the weight of the rock.

net force = 0; constant speed & direction

$$\sum \mathbf{F} = \mathbf{T} + \mathbf{W} + \mathbf{f} = +T + (-W) + f = 0$$

$T = W - f$, therefore, $T < W$

**16.** An apple crate with a weight of 225 N accelerates along a *frictionless* surface as the crate is pulled with a force of 14.5 N at an angle of 19°, as shown in the drawing. What is the horizontal acceleration of the crate?



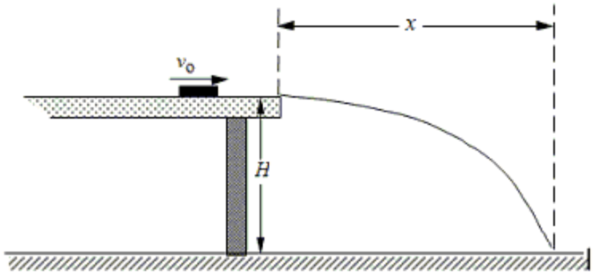

A) 1.40 m/s$^2$
B) 0.427 m/s$^2$
C) 1.29 m/s$^2$
D) 0.597 m/s$^2$
E) 0.644 m/s$^2$

$$W = mg \Rightarrow m = \frac{W}{g} = 22.5 \text{ kg}$$

$$F_x = F\cos 19° = 13.7 \text{ N}$$

$$a_x = \frac{F_x}{m} = \frac{13.7 \text{ N}}{22.5 \text{ kg}} = 0.597 \text{ m/s}^2$$

**17.** A puck slides across a smooth, level tabletop at height $H$ at a constant speed $v_0$. It slides off the edge of the table and hits the floor a distance $x$ away as shown in the figure.




$$y = v_{0y}t - \tfrac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2H}{g}}$$

$$v_{0x} = v_0; \quad x = v_0 t = v_0\sqrt{\frac{2H}{g}}$$

(Hint:find the time to hit the ground)

What is the relationship between the distances $x$ and $H$?

A) $x = v_0\sqrt{\dfrac{2H}{g}}$

B) $x = \dfrac{v_0^2}{2gH}$

C) $x = \dfrac{v_0^2}{gH}$

D) $H = v_0\sqrt{\dfrac{2x}{g}}$

E) $x = v_0\dfrac{H}{g}$

**18.** A net force of 25 N is applied for 5.7 s to a 12-kg box initially at rest. What is the speed of the box at the end of the 5.7-s interval?

A) 1.8 m/s
B) 12 m/s
C) 3.0 m/s
D) 7.5 m/s
E) 30 m/s

$$v = v_0 + at; \quad a = \frac{F}{m} = \frac{25\ \text{N}}{12\ \text{kg}} = 2.1\ \text{m/s}^2$$
$$= (2.1\ \text{m/s}^2)(5.7\ \text{s}) = 12\ \text{m/s}$$

**19.** A spaceship is observed traveling in the positive $x$ direction with a speed of 150 m/s when it begins accelerating at a constant rate. The spaceship is observed 25 s later traveling with an instantaneous velocity of 1500 m/s at an angle of 55° above the $+x$ axis. What was the magnitude of the acceleration of the spaceship during the 25 seconds?

A) 1.5 m/s$^2$
B) 7.3 m/s$^2$
C) 28 m/s$^2$
D) 48 m/s$^2$
E) 57 m/s$^2$

$$v_x = (1500\ \text{m/s})\cos 55° = 860\ \text{m/s}; \ a_x = \frac{v_x - v_{0x}}{t} = \frac{(860-150)\ \text{m/s}}{25\ \text{s}} = 28.4\ \text{m/s}^2$$
$$v_y = (1500\ \text{m/s})\sin 55° = 1230\ \text{m/s}; \ a_y = \frac{v_y}{t} = \frac{1230\ \text{m/s}}{25\ \text{s}} = 49.2\ \text{m/s}^2$$
$$a = \sqrt{a_x^2 + a_y^2} = \sqrt{(28.4)^2 + (49.2)^2}\text{m/s}^2 = 57\ \text{m/s}^2$$

20. In a tug-of-war, each man on a 5-man team pulls with an average force of 500 N. What is the tension in the center of the rope?

A) zero newtons
B) 100 N
C) 500 N
D) 2500 N
E) 5000 N