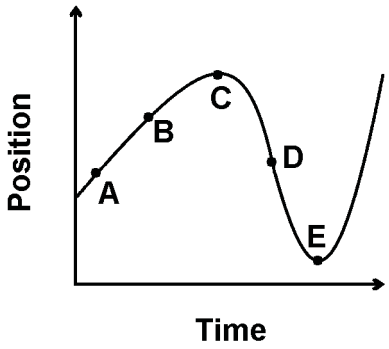
Base your answers to questions **1** through **3** on the position versus time graph below which shows the motion of a particle on a straight line.




1. At which of the labeled points is the magnitude of the velocity greatest?
   (A) *A* (D) *D*
   (B) *B* (E) *E*
   (C) *C*

2. At which of the labeled points is the velocity zero?
   (A) *B* only (D) *C* and *D*
   (B) *E* only (E) *C* and *E*
   (C) *D* only

3. At which of the labeled points is the magnitude of the acceleration greatest?
   (A) *A* (D) *D*
   (B) *B* (E) *E*
   (C) *C*

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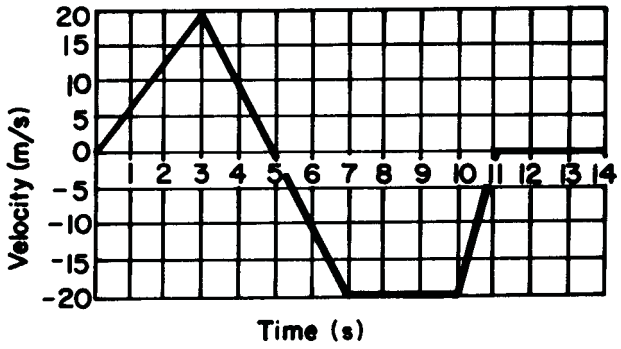
Base your answers to questions **4** and **5** on the graph below which shows the velocity *versus* time for an object moving in a straight line.




4. At what time after $t = 0$ does the object again pass through its initial position?
   (A) 3 s (D) 9 s
   (B) 5 s (E) 10 s
   (C) 7 s

5. During which interval does the particle have the same average acceleration as 12 s < $t$ < 14 s?
   (A) 9 s < $t$ < 11 s (D) 3 s < $t$ < 7 s
   (B) 2 s < $t$ < 5 s (E) 5 s < $t$ < 11 s
   (C) 0 s < $t$ < 3 s

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6. A motorist driving at 50 m/s applies the brakes so that the car decelerates at a rate of 2 m/s$^2$. The time for the car to stop is closest to
   (A) 5 s (D) 25 s
   (B) 10 s (E) 50 s
   (C) 13 s

7. A ball is thrown straight up with an initial velocity of 14 m/s. The maximum height attained by the ball is closest to
   (A) 0.7 m (D) 20 m
   (B) 1.4 m (E) 30 m
   (C) 10 m

8. A car is traveling along a straight road with a velocity of 10 m/s. It begins to accelerate uniformly at time $t = 0$ and covers a distance of 300 m in 5 s. What is the magnitude of the acceleration?
   (A) 10 m/s$^2$ (D) 24 m/s$^2$
   (B) 12 m/s$^2$ (E) 60 m/s$^2$
   (C) 20 m/s$^2$

9. A car is traveling with a velocity of 5 m/s along a straight road. Another car starting at rest 250 m behind it begins to accelerate uniformly. What is the magnitude of its acceleration if it catches the first car after 10 seconds?
   (A) 0.5 $m/s^2$
   (B) 1 $m/s^2$
   (C) 2 $m/s^2$
   (D) 2.5 $m/s^2$
   (E) 6 $m/s^2$

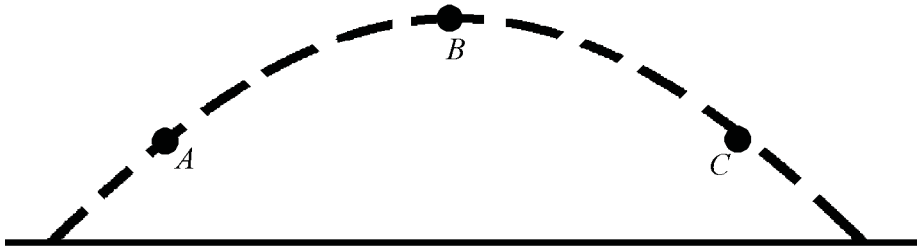
10. An object is thrown off a cliff with an initial upward velocity of 15 m/s. It strikes the ground with a downward velocity of 25 m/s. If air resistance is negligible, the height of the cliff is most nearly
   (A) 10 m
   (B) 20 m
   (C) 30 m
   (D) 40 m
   (E) 50 m

11. A cannon fires a projectile with an initial speed $v$ at an angle $\theta$ above the horizon. At what time does the projectile hit the ground?
   (A) $\frac{2v\cos\theta}{g}$
   (B) $\frac{v\cos\theta}{g}$
   (C) $\frac{2v\sin\theta}{g}$
   (D) $\frac{v\sin\theta}{g}$
   (E) $\frac{v\sin^2\theta}{g}$

12. A cannon fires a projectile with an initial speed $v$ at an angle $\theta$ above the horizon. What is the maximum height reached by the projectile?
   (A) $\frac{2v^2\sin^2\theta}{g}$
   (B) $\frac{v^2\sin^2\theta}{2g}$
   (C) $\frac{2v^2\cos\theta\sin\theta}{g}$
   (D) $\frac{v^2\cos\theta\sin\theta}{g}$
   (E) $\frac{v^2\cos^2\theta}{g}$

Base your answers to questions **13** through **17** on the following information.

A cannonball is fired and follows the parabolic path shown below. Air resistance is negligible. Point *B* is the highest point on the path and points *A* and *C* are at the same height.




13. How do the speeds of the cannonball at the there points compare?
    (A) $v_A < v_B < v_C$ (B) $v_C < v_B < v_A$ (C) $v_B < v_A < v_C$ (D) $v_A < v_B = v_C$ (E) $v_B < v_A = v_C$

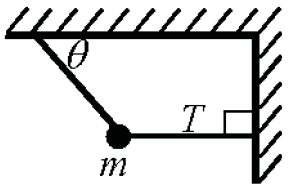
14. How do the accelerations of the ball at the three points compare?
    (A) $a_A < a_B < a_C$ (B) $a_B < a_A < a_C$ (C) $a_A = a_B = a_C$ (D) $a_A = a_B < a_C$ (E) $a_B < a_A = a_C$

15. Which of the following best describes the direction of the acceleration of the ball at point *C*?
    (A) to the right
    (B) down and to the right
    (C) down
    (D) up and to the right
    (E) up and to the left

16. Which of the following best describes the direction of the velocity of the cannonball at point *B*?
    (A) to the right
    (B) up and to the right
    (C) down and to the right
    (D) up
    (E) down

17. Which of the following best describes the direction of the net force on the ball at point *A*?
    (A) up and to the right
    (B) to the right
    (C) down and to the right
    (D) down
    (E) There is no net force on the cannonball at point *A*

18.



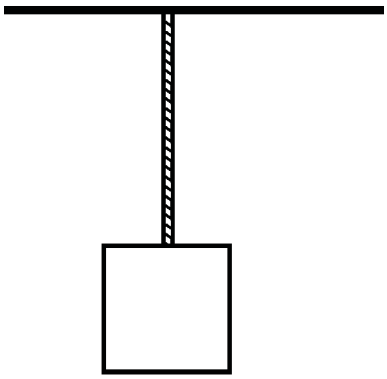

Two massless strings of equal length are used to suspend a ball as shown above. If the tension in the first string is *T,* what is the tension in the second string?

(A) $T\sin\theta$
(B) $T\cos\theta$
(C) $\frac{T}{\cos\theta}$
(D) $mg - T$
(E) $mg - T\sin\theta$

19. A box of mass 50 kg is held by two identical, vertical, and massless ropes. What is the tension in each string?

(A) 50 N
(B) 250 N
(C) 500 N
(D) 300 N
(E) 100 N

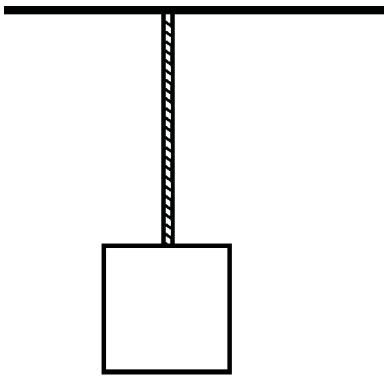
20.



A uniform rope of weighing 30 N hangs from a ceiling as shown above. A box of weight 50 N hangs from the rope. What is the tension in the rope?

(A) 50 N throughout the rope.
(B) 65 N throughout the rope.
(C) 80 N throughout the rope.
(D) It varies from 50 N at the bottom of the rope to 80 N at the top.
(E) It varies from 80 N at the bottom of the rope to 50 N at the top.

21.

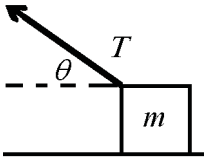


A uniform rope of weight 60 N hangs from a ceiling as shown above. A box of weight 90 N hangs from the rope. What is the ratio of the tension at the top of the rope to the tension at the bottom?

(A) $\frac{2}{5}$
(B) $\frac{2}{3}$
(C) 1
(D) $\frac{3}{2}$
(E) $\frac{5}{3}$

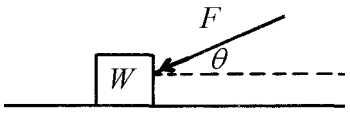
22. A ball of mass $m$ hangs vertically from a massless string experiencing a tension $T$. What force is required to pull the ball out to an angle $\theta$ from the vertical?
(A) $mg \sin \theta$
(B) $mg \cos \theta$
(C) $mg \tan \theta$
(D) $2mg \tan \theta$
(E) $mg/\cos \theta$

23. Base your answer to the following question on the diagram below which shows a box of mass $m$ being pulled across a rough horizontal floor by a force of magnitude $T$ at an angle . The coefficient of friction between the box and the floor is $\mu$.




The normal force on the box has magnitude
(A) $mg + T\sin \theta$
(B) $mg - T\sin \theta$
(C) $mg + T\cos \theta$
(D) $mg - T\cos \theta$
(E) $mg$

24.




A block of weight $W$ is pushed along a horizontal surface at constant speed $v$ by a forces $F$ that acts at an angle $\theta$. What is the magnitude of the normal force on the block?
(A) $W - F\cos \theta$
(B) $W - F\sin \theta$
(C) $W$
(D) $W + F\sin \theta$
(E) $W + F\cos \theta$

25. An object that was formerly in a state of equilibrium is no longer is such a state. Which of the following does NOT describe this situation?
(A) A rock initially at rest begins to slide down an inclined plane.
(B) A ball held in a stationary hand is dropped from a height.
(C) An object decelerates along a plane and comes to be at rest.
(D) A box at rest on the floor is placed on a shelf.
(E) A car traveling north at constant velocity turns left.

26. Which of the following are necessary for an object to be in translational equilibrium

I. Net velocity = 0 m/s
II. Net acceleration = 0 m/s$^2$
III. Net force = 0 N

(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III