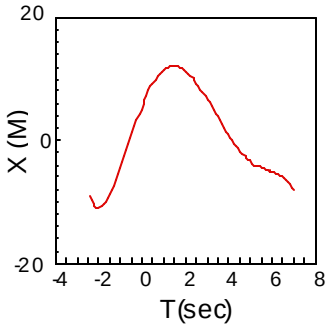
1. Consider a parachutist with his chute open descending from a plane. His terminal velocity is given by $v = C\sqrt{\frac{mg}{b}}$, where m is his mass and b is the coefficient for the air resistance force. Suddenly, the chute develops a hole which changes b, which represents the air resistance of the chute, to half its original value. The terminal velocity of the parachutist:

A. increases by a factor of 2.
B. increases by a factor of $\sqrt{2}$.
C. remains the same.
D. decreases by a factor of $\sqrt{2}$.
E. decreases by a factor of 2.

2. The figure shows the position versus time for a particle. At what time does the magnitude of the velocity have the largest value?

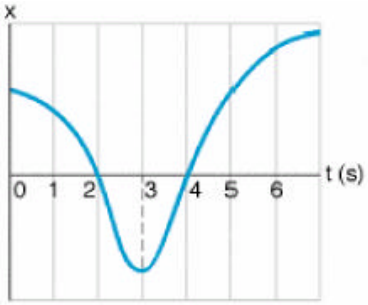


A. -2 sec
B. 0 sec
C. 2 sec
D. 6 sec
E. Impossible to tell from the above graph

3. A rocket takes off from rest under the power of its rocket motor. The rocket motor is sufficiently powerful that the rocket has an upward acceleration of 10g (98 m/s^2). After 5 sec the rocket motor instantaneously burns out and only the downward acceleration of gravity acts on the rocket. At what time, after the motor burns out, does the rocket reach its maximum height?

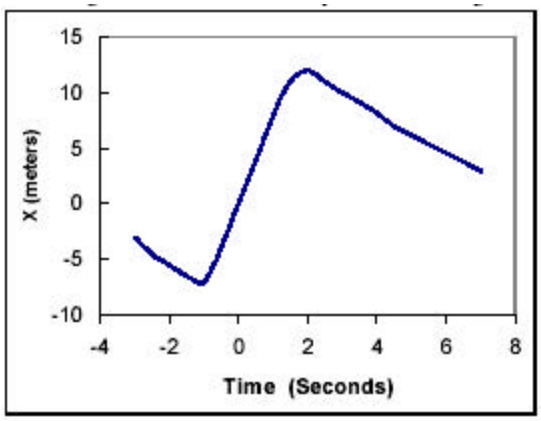
A. 0 sec
B. 5 sec
C. 25 sec
D. 50 sec
E. 75 sec

4. The figure pertains to an armadillo that scampers left (direction of decreasing x) and right along an x axis. Of the choices given below, near what time is its velocity zero?



A. 0 s
B. 1 s
C. 2 s
D. 3 s
E. 5 s

5. The figure shows the position versus time for a particle. At which of the following times does the magnitude of the velocity have the largest value?

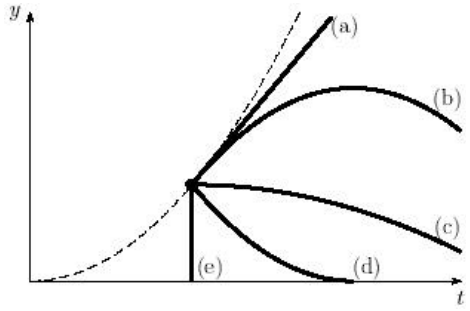


A. -2 sec
B. 0 sec
C. 2 sec
D. 4 sec
E. 6 sec

6. A penny is accidentally allowed to drop from rest from the observation deck of the Empire State Building, a height of 1,050 feet (320 meters) above the ground. Without air resistance to slow it, how fast would the penny be traveling when it hit the ground?

A. 19.6 m/s (43.8 mi/hr)
B. 56.0 m/s (125 mi/hr)
C. 64.1 m/s (143 mi/hr)
D. 79.2 m/s (177 mi/hr)
E. 101.4 m/s (227 mi/hr)

7. Immediately after a successful liftoff, the space shuttle moves straight upward with constant acceleration. In the figure below, the dashed curve shows the shuttle's height *y* as a function of time *t*. At the instant indicated by the dot, the booster rockets burn out and detach from the shuttle. Which solid curve best represents the height of the boosters as a function of time?



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

8. A particle starts from the origin at t = 0 with a velocity of $+4.0\hat{j}$ m/s and moves in the xy plane with a constant acceleration of $(6.0\hat{i} + 4.0\hat{j})$ m/s^2. At the instant the x coordinate of the particle is 27 m, what is the value of its y coordinate?

A. 35 m
B. 30 m
C. 26 m
D. 18 m
E. 12 m

9. If $\mathbf{a} = 28\mathbf{i} + 11\mathbf{j}$ and $\mathbf{b} = 4\mathbf{i} - 3\mathbf{j}$, what is the magnitude of the vector $\mathbf{a} - \mathbf{b}$?

A. 27.8
B. 33.0
C. 38.0
D. 25.3
E. 40.0

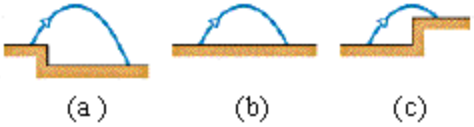
10. A proton initially velocity $\mathbf{v} = 4.0\mathbf{i} - 2.0\mathbf{j} + 3.0\mathbf{k}$ and then 4.0 s later has velocity $v = -2.0\mathbf{i} - 2.0\mathbf{j} + 5.0\mathbf{k}$ (in meters per second). In unit vector notation, what is the average acceleration $\mathbf{a}_{avg}$ over the 4.0 s?

A. $(-1.5\mathbf{i} + 0.50\mathbf{k})$ m/s^2
B. $(0.5\mathbf{i} + -1.0\mathbf{j} + 2.0\mathbf{k})$ m/s^2
C. $(-6.0\mathbf{i} + 2.0\mathbf{k})$ m/s^2
D. $(1.5\mathbf{i} - 0.50\mathbf{k})$ m/s^2
E. $(4.0\mathbf{i} - 2.0\mathbf{j} + 3.0\mathbf{k})$ m/s^2

11. Let vector **A** = 2 **i** + 2 **j** + 2 **k**, and vector **B** = **i** - **j** + **k**. What is the angle between **A** and **B**?

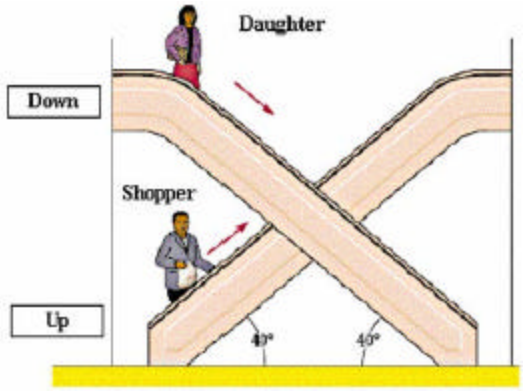
A. 19.5 degrees
B. 45 degrees
C. 70.5 degrees
D. 86.8 degrees
E. 90 degrees

12. The figure shows three situations in which identical projectiles are launched from the ground (at the same levels) at identical initial speeds and angles. The projectiles do not land on the same terrain, however. Which of the following statements regarding the final speeds of the particles is true?



A. a is greatest, then b and finally c.
B. c is greatest, then b and finally a.
C. a is greatest and b and c are equal.
D. c is greatest and a and b are equal.
E. they are all equal.

13. In a large department store. A shopper is standing on the "up" escalator, which is traveling at an angle of 40° above the horizontal and at a speed of 0.8 m/s. He passes his daughter, who is standing on the identical, adjacent "down" escalator. Find the magnitude of the velocity of the shopper relative to his daughter.



A. 0.51 m/s
B. 0.61 m/s
C. 0.8 m/s
D. 1.02 m/s
E. 1.22 m/s

14. A roadrunner moves in a line with velocity $v = (3.0t^2 + 2.0t + 1.0)$ ft/s, where t is measured in seconds. What is the instantaneous acceleration at time $t = 4.0$ s?

A. 10 ft/s^2
B. 20 ft/s^2
C. 24 ft/s^2
D. 26 ft/s^2
E. 57 ft/s^2

15. In 1940, Emanuel Zacchini flew as a human cannonball, setting a distance record that remains unbroken. The magnitude of his initial velocity was 24.2 m/s at an angle $\theta = 31.2°$ above the horizontal. In this problem, neglect the height of the mouth of the cannon off the ground and assume the ground is perfectly level. Also, neglect air resistance. Find the record distance that Emanuel flew.

A. 30.9 m
B. 53.0 m
C. 64.3 m
D. 71.2 m
E. 173 m

16. A ball rolls horizontally off the edge of a tabletop that is 1.5 m high. It strikes the floor at a point 1.52 m horizontally away from the edge of the table. Neglecting air resistance, what was its speed at the instant it left the table?

A. 0.34 m/s
B. 1.5 m/s
C. 2.75 m/s
D. 5.3 m/s
E. 9.8 m/s

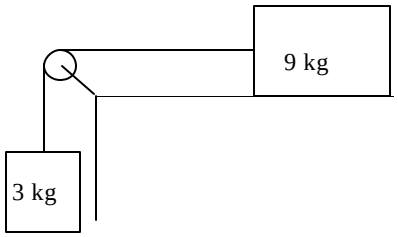
17. A bullet shot horizontally from a gun:

A. never strikes the ground.
B. travels in a straight line.
C. strikes the ground much later than one dropped vertically from the same point at the same instant.
D. strikes the ground at approximately the same time as one dropped vertically from the same point at the same instant.
E. strikes the ground much sooner than one dropped vertically from the same point at the same instant.

18. A stone is thrown horizontally from the top of a 20 m high hill. It strikes the ground at an angle of 45°. With what speed was it thrown?

A. 14 m/s
B. 20 m/s
C. 28 m/s
D. 32 m/s
E. 40 m/s

19. A 9 kg block on a frictionless table is connected by a light massless cord through a frictionless pulley to a 3 kg mass hanging over the edge of the table as shown. The blocks are free to accelerate. What is the tension in the cord?



A. 29.4 N
B. 68.6 N
C. 22.0 N
D. 98.0 N
E. 9.8 N

20. A block slides down a frictionless plane that makes an angle of 30° with the horizontal. The acceleration of the block is:

A. zero
B. 4.90 m/s^2
C. 5.66 m/s^2
D. 8.49 m/s^2
E. 9.80 m/s^2