1. (8 points) As an employee at the Texas Aggie Material Corporation, you are testing a 2.00-m long spring by pushing a block to the right in order to compress the spring. A sensor determines that the position of the block is $x(t) = (2.00 \text{ m}) - (0.800 \text{ m/s}^2)t^2 + (0.100 \text{ m/s}^4)t^4$ where t is in seconds. Assuming you start pushing the block at $t = 0$, what is the magnitude of the acceleration of the block at the instant the spring reaches maximum compression?

   The concepts necessary to solve this problem correctly: Finding kinematic equations through derivatives or integrals, verbal constraints into mathematical language (maximum compression at $v(t) = 0$).

   (A) 0.00 m/s^2

   (B) 0.200 m/s^2

   (C) 1.60 m/s^2

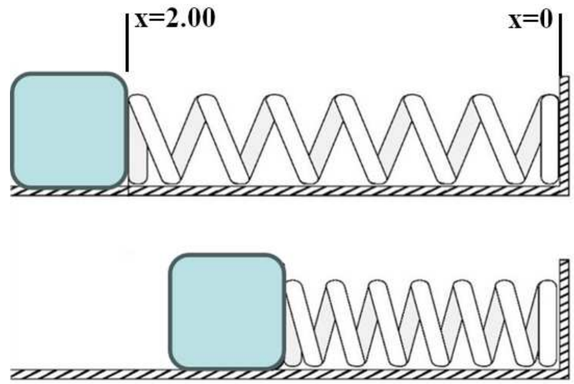
   (D) 3.20 m/s^2

   (E) 6.40 m/s^2

   (F) 0.800 m/s^2

   (G) 2.400 m/s^2

   (H) 4.800 m/s^2



   Points Per Response:
   A:
   B:
   C: 4
   D: 8
   E:
   F:
   G:
   H:

2. (2 points) In the previous problem, what was the direction of the acceleration at the instant the spring reaches maximum compression?

   The concepts necessary to solve this problem correctly: Direction of vector components based on coordinate axes definition.

   (A) Left

   (B) Right

   Points Per Response:
   A: 2
   B:

3. (8 points) Car A's velocity is represented by the graph on the left while Car B's velocity is represented by the graph on the right. Assuming the cars started from the same position, how far apart are the cars at $t = 40$ s? (Note the labels on the two axes are slightly different.)

The concepts necessary to solve this problem correctly: Graphical derivatives and integrals, finding kinematic equations through derivatives or integrals.

(A) 400 m

(B) 450 m

(C) 475 m

(D) 350 m

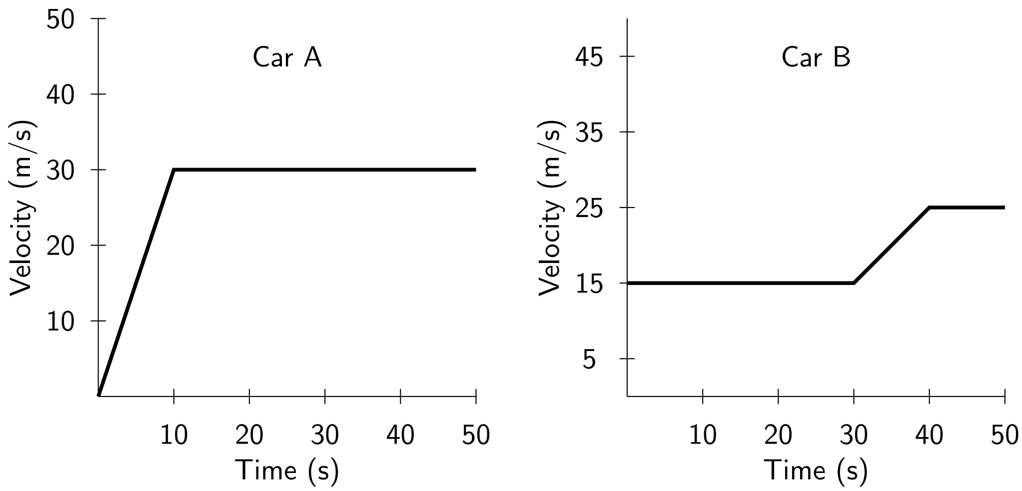
(E) 325 m

(F) 375 m

(G) 425 m

Points Per Response:

A: 8
B: 6
C: 5
D:
E:
F:
G:



4. (8 points) Ball A is projected vertically upwards at 30.0 m/s from a point P and 2.5 seconds later, Ball B is also launched vertically upwards from P at 30.0 m/s. How long after Ball B was launched did the balls collide?

The concepts necessary to solve this problem correctly: Using constant acceleration kinematic equations, verbal constraints into mathematical language ($y_A(t) = y_B(t)$).

(A) 1.81 s

(B) 4.31 s

(C) 3.91 s

(D) 6.41 s

(E) 0.894 s

(F) 3.39 s

Points Per Response:

A: 8
B: 6
C:
D:
E:
F:

5. (6 points) Vector $\vec{A}$ has a magnitude of 3.00 and is oriented 20.0 degrees south of west. Vector $\vec{B}$ has a magnitude of 4.00 and is oriented 30 degrees west of north. Both vectors are shown in the figure below. What is the magnitude of Vector $\vec{C}$ where $\vec{C} = 5\vec{A} - 3\vec{B}$?

The concepts necessary to solve this problem correctly: Vector Addition, correct use of trig functions.

(A) 17.5

(B) 11.7

(C) 20.8

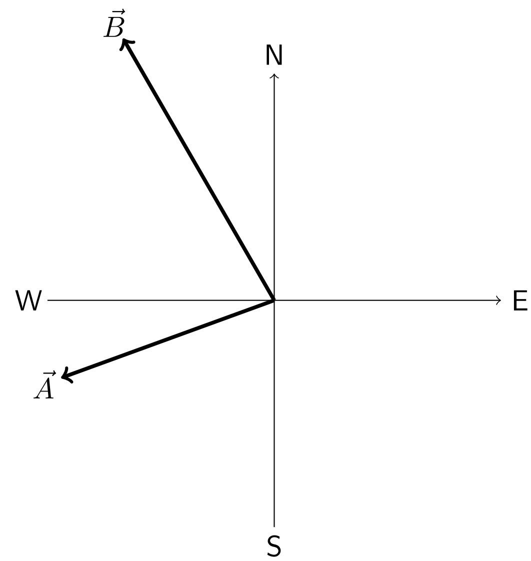
(D) 3.00

(E) 14.8

(F) 7.57

Points Per Response:

A: 6
B: 3
C: 4
D:
E:
F:



6. (8 points) An engineering student develops a tennis ball launching cannon. The cannon can fire a tennis ball at 30.0° and 35.0 m/s. If the launch platform is 10.0 m above where the ball lands at point B, how long does it take for the ball to reach point B?

The concepts necessary to solve this problem correctly: Projectile Motion

(A) 4.07 s

(B) 0.501 s

(C) 6.50 s

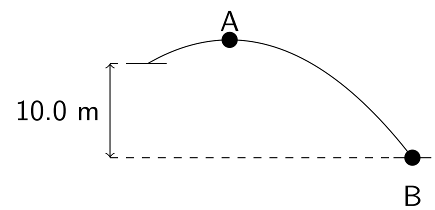
(D) 0.314 s

(E) 1.91 s

(F) 2.71 s

(G) 7.16 s

(H) 5.22 s



Points Per Response:
A: 8
B: 6
C: 6
D: 4
E:
F:
G:
H:

7. (8 points) In the previous problem, how far did the ball travel horizontally in the time it took to reach the maximum height, shown as point A?

The concepts necessary to solve this problem correctly: Projectile Motion

(A) 54.1 m

(B) 61.7 m

(C) 69.3 m

(D) 78.4 m

(E) 86.8 m

(F) 72.9 m

Points Per Response:
A: 8
B: 6
C: 4
D:
E:
F:

8. (6 points) A person in a rowboat aims directly across (east) a swiftly moving river at a dock on the other side. The river is 130 m across and the rowboat can travel 6.00 m/s in still water. If the river flows at a speed of 2.50 m/s south, by how much will the rowboat miss the dock?

The concepts necessary to solve this problem correctly: Relative velocity

(A) 54.2 m

(B) 0.00 m

(C) 312 m

(D) 50.0 m

(E) 211 m

(F) 18.5 m

(G) 83.3 m

(H) 151 m

Points Per Response:

A: 6
B:
C: 3
D: 2
E:
F:
G:
H:

9. (8 points) An object is in circular motion with a radius of $R = 5.00$ m and its speed is defined by the function $|\vec{v}(t)| = 8t^2 - 50$ (in m/s). What is the magnitude of the acceleration at $t = 3.00$ s?

The concepts necessary to solve this problem correctly: Definition of radial and tangential acceleration, recognition of component directions in circular motion.

(A) 48.0 m/s^2

(B) 96.8 m/s^2

(C) 108 m/s^2

(D) 145 m/s^2

(E) 77.3 m/s^2

(F) 175.3 m/s^2

(G) 59.6 m/s^2

Points Per Response:

A: 4
B: 3
C: 8
D: 5
E:
F:
G:

10. (4 points) Two identical balls are thrown at the same time with the same initial speed v_0. Ball A is thrown 60° above the horizontal and Ball B is thrown at 30° above the horizontal. If the ground is level, which ball is traveling with a greater speed the instant it contacts the ground?

    The concepts necessary to solve this problem correctly: Projectile Motion

    (A) Ball A

    (B) Ball B

    (C) Both balls will have the same speed when they hit

    (D) It is impossible to tell with the information given

    Points Per Response:
    A:
    B:
    C: 4
    D:

11. (4 points) You have two vectors $\vec{A}$ and $\vec{B}$. Which of the following statements is **FALSE** about the cross product (also called the vector product) of these two vectors?

    The concepts necessary to solve this problem correctly: Dot and Cross Products

    (A) The maximum magnitude of the cross product will occur when $\vec{A}$ and $\vec{B}$ are perpendicular.

    (B) The direction of the resulting vector must be perpendicular to both $\vec{A}$ and $\vec{B}$.

    (C) The magnitude of the cross product can be positive, negative or zero.

    (D) Reversing the order of the cross product reverses the direction of the resulting vector ($\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$).

    Points Per Response:
    A:
    B:
    C: 4
    D:

12. (8 points) You know that the magnitude of two vectors are given as $|\vec{A}| = 10.0$ and $|\vec{B}| = 15.0$. You also know that the magnitude of the cross product between those vectors is $|\vec{A} \times \vec{B}| = 100$. What is the dot product between these two vectors?

The concepts necessary to solve this problem correctly: Dot and Cross Products

(A) $+112$ only

(B) Could be either $+112$ or -112

(C) $+41.8$ only

(D) Could be either $+41.8$ or -41.8

(E) -50.8 only

(F) Could be either $+50.8$ or -50.8

(G) -94.8 only

(H) Could be either $+94.8$ or -94.8

Points Per Response:
A: 6
B: 8
C: 2
D: 3
E:
F:
G:
H:

13. (6 points) A residential HVAC unit needs to be able to move about 11,500 cubic inches per second of cold air through a house. What is this in cubic meters per hour?

The concepts necessary to solve this problem correctly: Unit conversions $(1 \text{ in}^3 = (2.54 \text{ cm})^3)$.

(A) 678

(B) 1,050,000

(C) 96,700

(D) 3,310

Points Per Response:
A: 6
B: 2
C:
D:

14. (4 points) An object represented by the small solid circle is moving in a circular path in the xy-plane as shown by the dashed line below. The object is moving clockwise and its speed is decreasing. Based on the position of the object in the picture, what direction does the acceleration vector point?

The concepts necessary to solve this problem correctly: Recognition of component directions in circular motion.

(A) In the positive x-direction

(B) In the positive y-direction

(C) In the negative x-direction

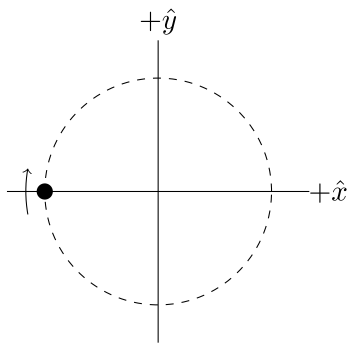
(D) In the negative y-direction

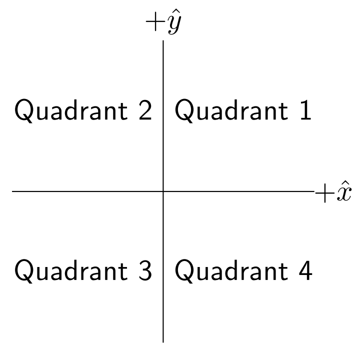
(E) Somewhere in Quadrant 1

(F) Somewhere in Quadrant 2

(G) Somewhere in Quadrant 3

(H) Somewhere in Quadrant 4





Points Per Response:

A: 1
B:
C:
D: 1
E:
F:
G:
H: 4

15. (4 points) The diagram below shows an object moving with constant acceleration from time t_1 to t_2 to t_3, etc. Each position is spaced by an equal amount of time Δt. Which graph of v_x vs t best represents the motion shown in the diagram?

The concepts necessary to solve this problem correctly: Relating functions to graphical representation, direction of vector components based on coordinate axes definition.

(A) Graph i

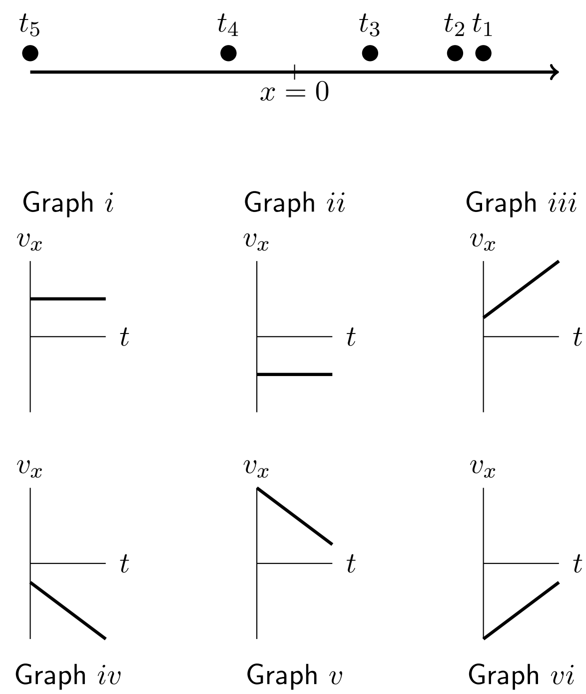
(B) Graph ii

(C) Graph iii

(D) Graph iv

(E) Graph v

(F) Graph vi



Points Per Response:
A:
B:
C: 1
D: 4
E: 2
F:

16. (8 points) At the dog park your dog leaves your side and runs with the following three displacement vectors: 3.00 m at 50 degrees west of south, 5.00 m at 35 degrees south of east and finally 4.00 m at 40 degrees north of east. What displacement vector is needed for your dog to return to your side?

The concepts necessary to solve this problem correctly: Vector Addition, Definition of displacement.

(A) $+4.86\hat{x}$-$2.23\hat{y}$

(B) -$4.86\hat{x}+2.23\hat{y}$

(C) $+9.09\hat{x}+7.74\hat{y}$

(D) -$9.09\hat{x}$-$7.74\hat{y}$

(E) -$5.23\hat{x}+2.59\hat{y}$

(F) $+5.23\hat{x}$-$2.59\hat{y}$

(G) $+2.61\hat{x}$-$5.10\hat{y}$

(H) -$2.61\hat{x}+5.10\hat{y}$

Points Per Response:

A: 6
B: 8
C:
D: 2
E: 6
F: 4
G:
H: