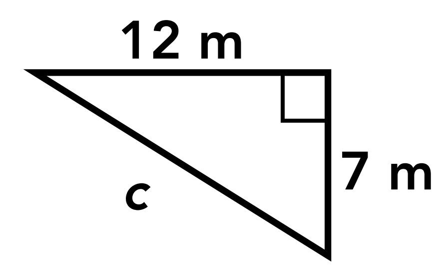
2D MOTION & VECTORS

Basics

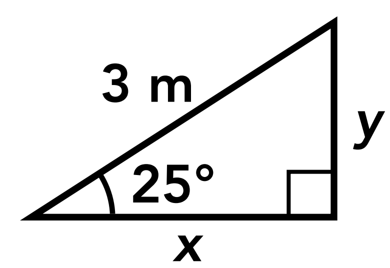
1. Which of these examples could be considered two-dimensional (2D) motion? (select all that apply)
   - A. A ball falling straight down
   - B. A soccer ball kicked upwards at an angle
   - C. A car driving on an inclined ramp
   - D. A car driving in a circle on a flat road

2. An object's components of motion in the x direction and the y direction are
   - A. always independent of each other
   - B. independent of each other, unless one of them is changing
   - C. never independent of each other in 2D motion
   - D. none of the above

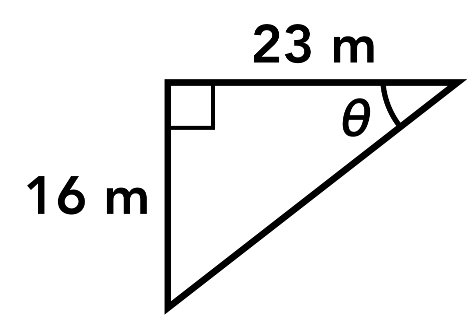
3. What is the length of side c in the triangle shown on the right?



4. What are the values of x and y in the triangle shown on the right?



5. What is the value of the reference angle θ in the triangle shown on the right?



6. If an object is dropped, what is its downwards acceleration while it's in free fall (ignoring air resistance)?

Vectors

7. A vector can be described using (select all that apply)
   - A. An arrow with a length and direction
   - B. A single value
   - C. A magnitude and an angle
   - D. Two components, each with a direction

8. Which of the following is always positive? (select all that apply)
   - A. The angle of a vector
   - B. The magnitude of a vector
   - C. The components of a vector
   - D. The reference angle of a vector

9. If vector $\vec{A}$ has a magnitude of 12 and vector $\vec{B}$ has a magnitude of 27, which of the following could be the possible magnitude of vector $\vec{C}$ if $\vec{C} = \vec{A} + \vec{B}$? (select all that apply)

   A 40
   B 30
   C 20
   D 10

10. A vector will have an ***x*** component of 0 if (select all that apply)

   A the vector is parallel to the ***y*** axis
   B the vector is parallel to the ***x*** axis
   C the vector has an angle of 0°
   D the vector has an angle of 90°

11. At what angle will a vector's ***x*** and ***y*** components have equal magnitude and sign (+/-)?

   A 0°
   B 45°
   C 135°
   D 180°

12. Vector ***v*** has an angle of 155°. At what other angle would the vector have the same ***x*** component? (select all that apply)

   A 25°
   B 65°
   C 205°
   D -155°

13. Vector ***v*** has an angle of 60°. If the vector rotates to an angle of 30°, the magnitude of the ***y*** component

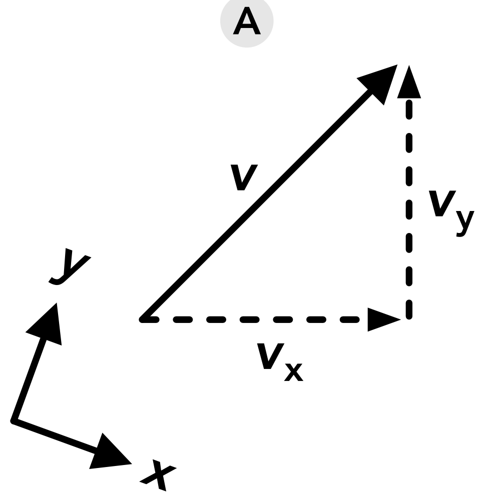
   A increases
   B decreases
   C stays the same
   D cannot be determined

14. Vector ***v*** has an angle of 120°. If the vector rotates to an angle of 170°, the magnitude of the ***x*** component

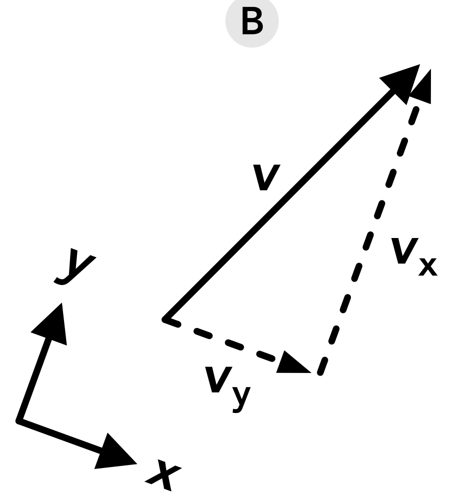
   A increases
   B decreases
   C stays the same
   D cannot be determined

15. Which of these shows the correct ***x*** and ***y*** components of the vector ***v*** based on the axes shown?

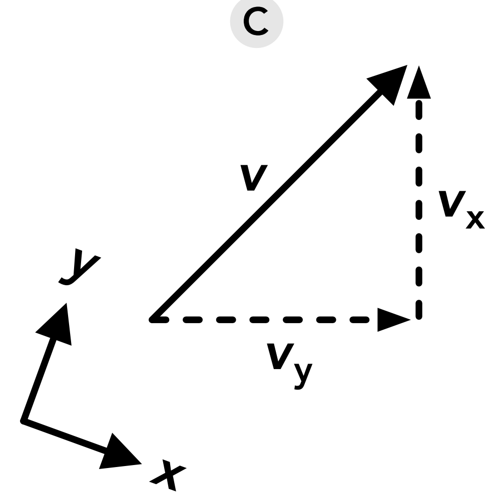
A



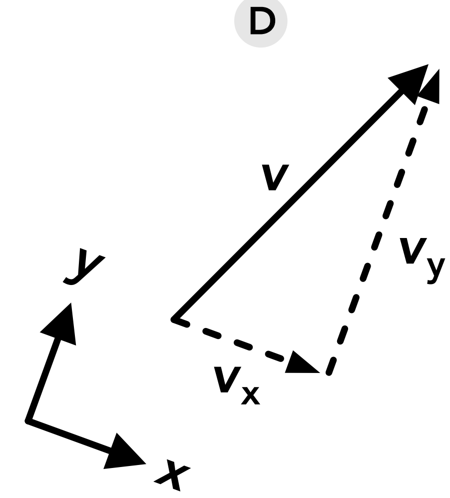
B



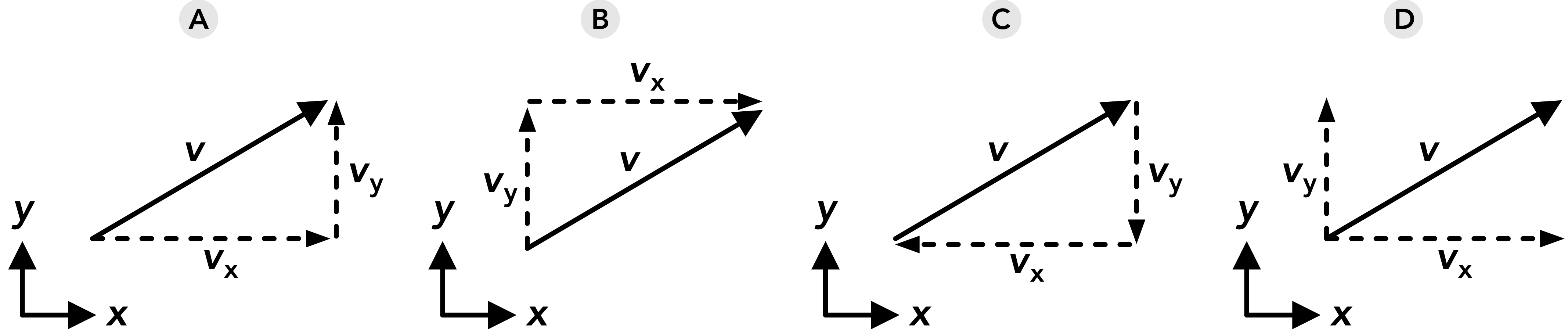
C



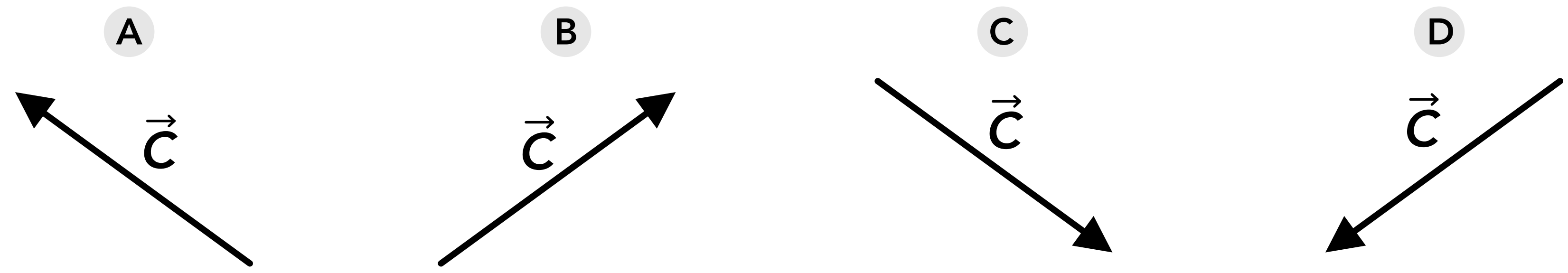
D

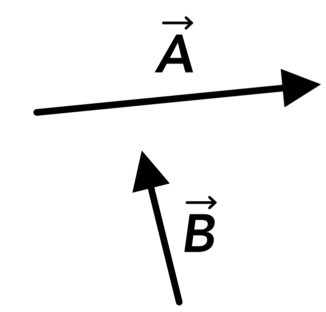


16. Which of the options shown is a correct way to draw the components of vector ***v***? (select all that apply)

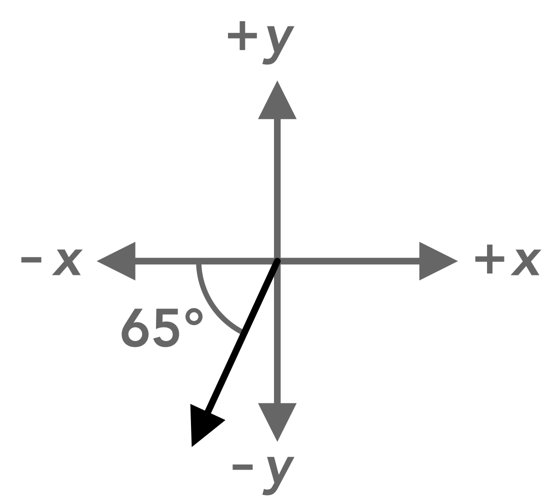


17. Which vector $\vec{C}$ represents the resultant vector of $\vec{A} + \vec{B}$ shown on the right?

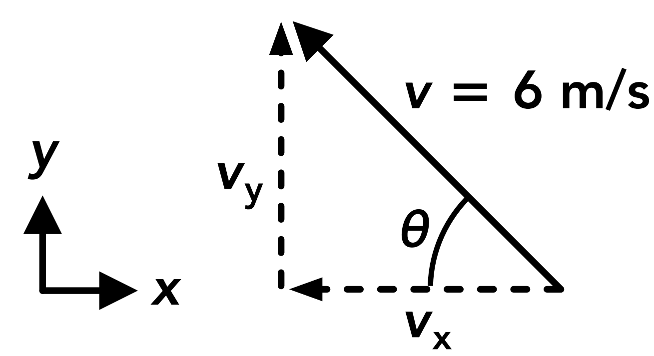




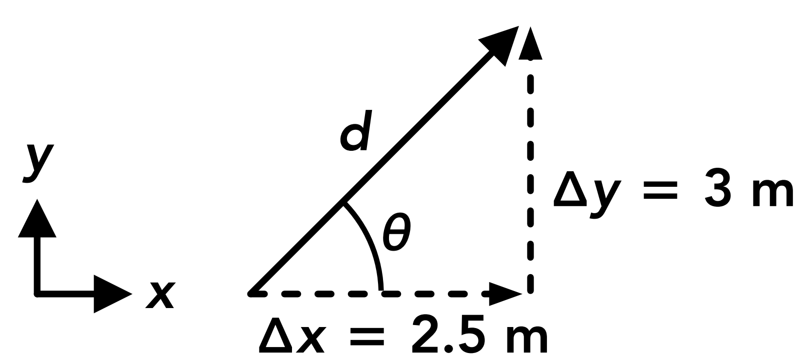
18. What is the angle of the vector shown on the right (using convention)?
What is the reference angle of the vector?



19. What are the values of the components v_x and v_y for the vector shown on the right if the reference angle θ is 40°?



20. What is the magnitude and angle of the vector shown on the right?



Position and displacement

21. A person is standing at a position with coordinates (7, 11) on a coordinate system where "right" is the positive ***x*** direction and "up" is the positive ***y*** direction. They walk 15 units to the right, then 6 units up, then 3 units to the left, then 2 units down. What are their new coordinates?

- A (25, 19)
- B (19, 15)
- C (-5, 7)
- D (20, 9)

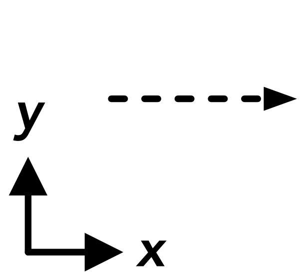
22. A person moves from coordinates (2 m, 3 m) to coordinates (-10 m, -9 m). What is the magnitude of their displacement?

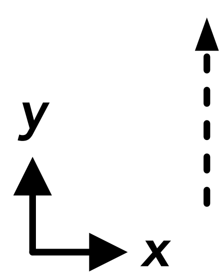
A -12 m
B 12 m
C -17 m
D 17 m

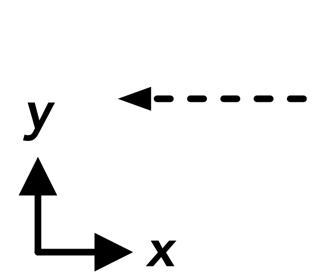
23. A person drives 1.5 km in the negative ***x*** direction and then drives 2.6 km in the positive ***y*** direction. What is the angle of their total displacement vector?

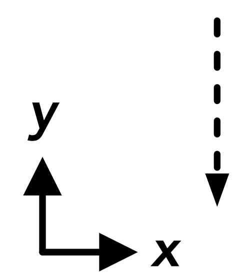
A -60°
B -120°
C 120°
D 60°

24. A person walks 25 m at an angle of 160°. What would be the direction of the ***x*** component of their displacement vector?

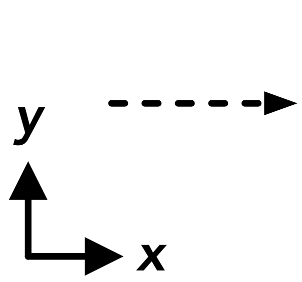
A


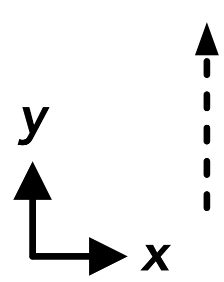
B


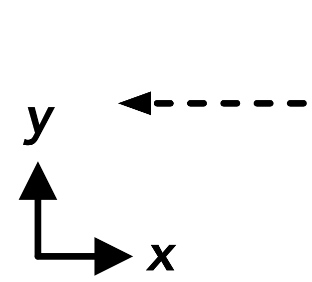
C


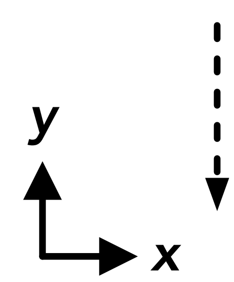
D


25. A person walks 18 m at an angle of -45°. What would be the direction of the ***y*** component of their displacement vector?

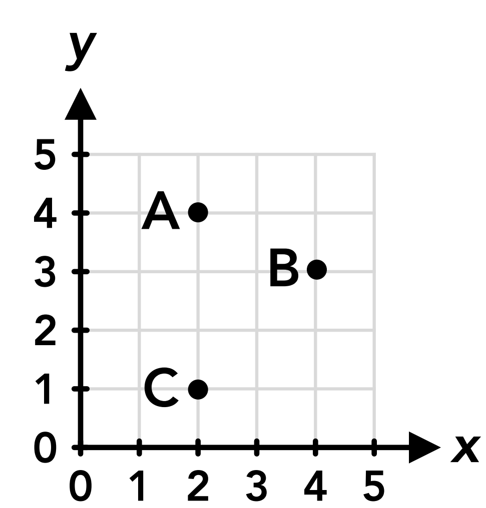
A


B


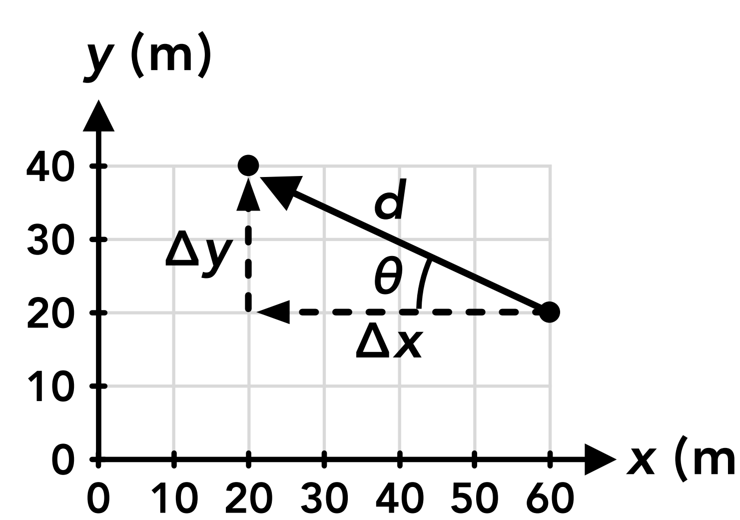
C


D


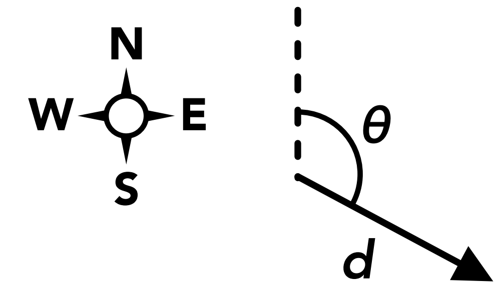
26. What are the coordinates of points A, B and C shown on the right?



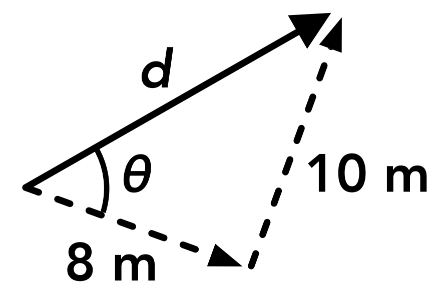
27. A person walks a displacement shown by the vector ***d*** on the right. What are the values of the ***x*** component, ***y*** component, magnitude ***d*** and reference angle ***θ*** of their displacement?



28. If you walk along the displacement vector ***d*** shown on the right, where ***d*** is 2 km and ***θ*** is 130° clockwise from due north, how far east and how far south did you walk?



29. Find the magnitude ***d*** and reference angle ***θ*** of the vector shown on the right.



30. Person A is at a position with coordinates (2, 3), person B is at coordinates (8, 6), and person C is at coordinates (4, 8). Is person C closer to person A or person B?

31. If you walk 2 km at an angle of 40°, and then walk 3 km at an angle of 10°, what is the magnitude and angle of your total displacement?

32. A person walks 45 m west, then walks 22 m north, and then walks 8 m east. What is the magnitude of their total displacement?

33. An ant walks 35 cm straight along the ground towards a wall and then walks 18 cm straight up the wall. What is the angle of the ant's total displacement relative to the ground?

Velocity

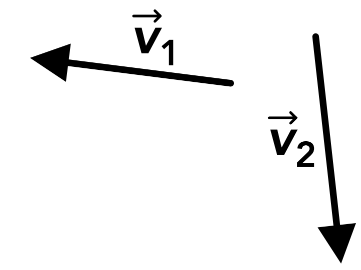
34. An instantaneous velocity vector
    - A Shows the path of an object's motion over a period of time
    - B Shows the distance an object travels over a period of time
    - C Shows the direction of motion at an instant in time
    - D Shows the instantaneous change in an object's velocity

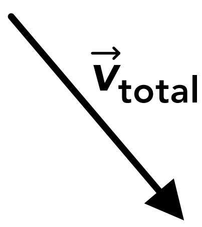
35. A car has a velocity vector ***v*** with an angle of 30°. If only the ***y*** component of its velocity is doubled, the car's new velocity vector will have
    - A the same magnitude and direction
    - B a larger magnitude and the same direction
    - C the same magnitude and a different direction
    - D a larger magnitude and a different direction

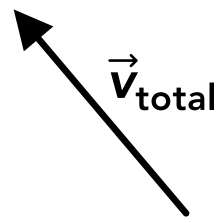
36. A biker is riding at 5 m/s at an angle of -50°. If the biker maintains their speed but turns so their velocity vector rotates to an angle of -80°, the magnitude of the ***x*** component of the velocity

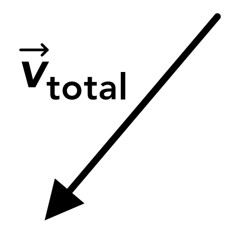
- A increases
- B decreases
- C stays the same
- D cannot be determined

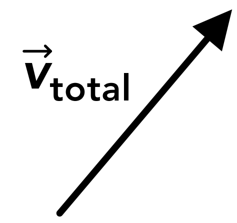
37. Which vector represents the resultant vector of $v_1 + v_2$ shown on the right?



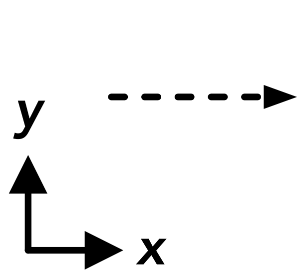
A


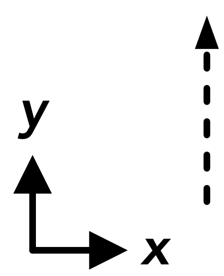
B


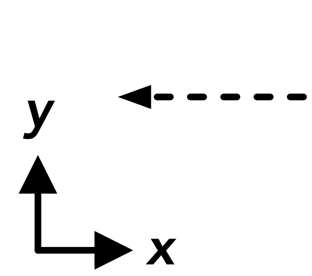
C


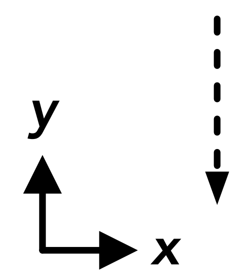
D


38. A boat is moving at 3 m/s at an angle of 190°. What is the direction of the ***y*** component of its velocity vector?

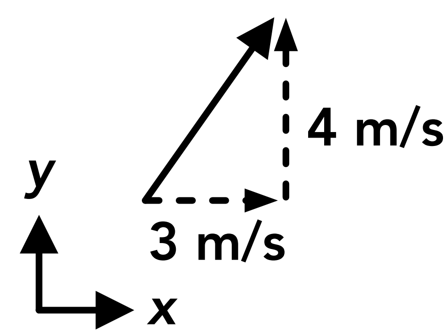
A


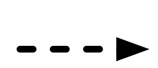
B


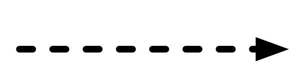
C


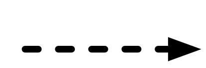
D


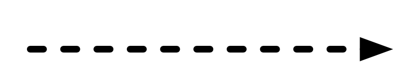
39. A runner has a velocity vector as shown on the right, and then a very strong wind causes their ***y*** velocity component to double. What is the new ***x*** component of their velocity?



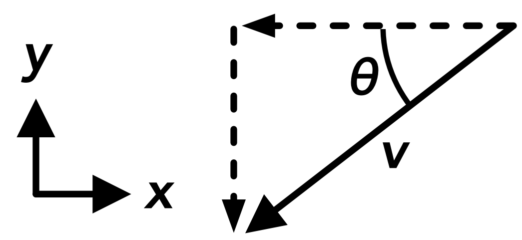
A

3 m/s

B

6 m/s

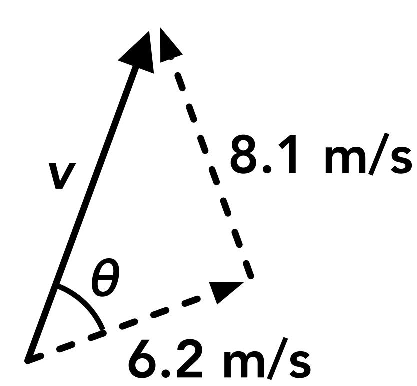
C

4 m/s

D

8 m/s

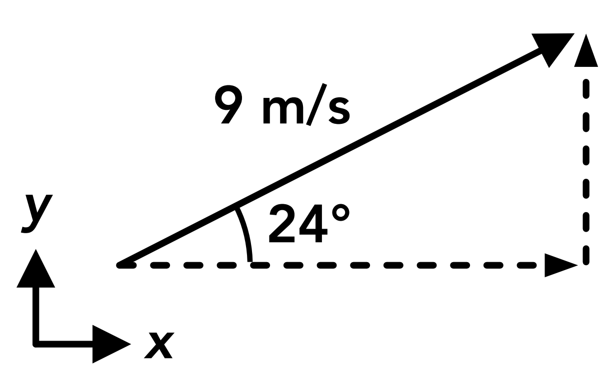
40. If the magnitude of the velocity shown on the right is 12.8 m/s, what is the velocity in the ***x*** and ***y*** directions if the reference angle ***θ*** is 36°?



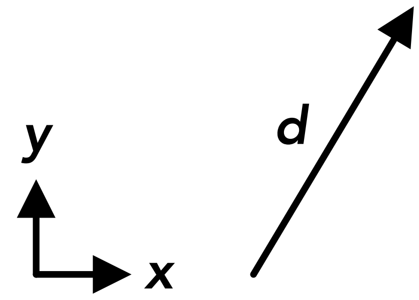
41. A car has a velocity vector with components shown on the right. Find the magnitude ***v*** and the reference angle ***θ*** of the velocity.



42. If an object has a constant velocity shown by the vector on the right, how far will it travel in the ***y*** direction over a period of 2.6 seconds?



43. If an object travels a displacement ***d*** of 42 m at an angle of 58° as shown in the vector on the right, what is its velocity in the ***x*** direction if it takes 8 seconds to travel that displacement?



44. A frisbee is flying horizontally relative to the ground at a constant 7 m/s and an angle of 38° as seen from above. How long will it take the frisbee to fly 32 m in the ***x*** direction?

45. A person walking at a constant velocity moves from a position with coordinates (9 m, 2 m) to coordinates (2 m, 5 m) in a period of 3 seconds. What is the magnitude and angle of the person's velocity?

46. An object has a velocity of 4 m/s at an angle of 100°. How far does the object travel in the ***y*** direction over a period of 12 seconds?

47. A person runs at a constant speed of 2 m/s from the bottom to the top of a ramp with a height of 2 m and an angle of 15° relative to the ground. How long does it take them to reach the top?

48. A boat can travel at a speed of 3.5 m/s through the water. If the boat points straight across a 62 m wide river but there is a sideways current of 1.5 m/s (parallel to the shore), how far does the boat move downstream by the time it reaches the other side?

49. A boat can travel at a speed of 3.5 m/s through the water. The driver wants to cross the river, and there is a sideways current of 1.5 m/s (parallel to the shore). If the driver wants to move straight across the river so that the boat's path is perpendicular to the shore (so the boat does not move downstream or upstream), what angle should the driver point the boat? Find the reference angle between the direction the boat is pointing and the starting shoreline.

Acceleration

50. Using a coordinate system where the postive ***x*** direction is to the right and the positive ***y*** direction is up, an object that is in free fall (ignoring air resistance) will have an acceleration vector with

   A a ***y*** component of 9.8 m/s²
   B a ***y*** component of -9.8 m/s²
   C an ***x*** component of 9.8 m/s²
   D an ***x*** component of -9.8 m/s²

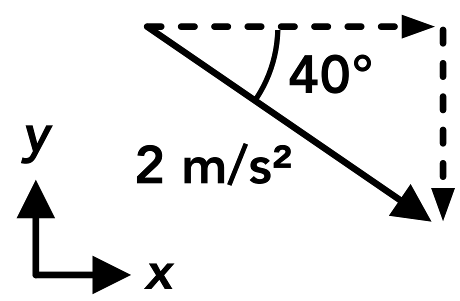
51. A book is sliding down an inclined ramp with an angle of θ relative to the ground. The magnitude of the book's acceleration parallel to the incline (ignoring friction) would be

A g
B $g\cos(\theta)$
C $g\sin(\theta)$
D $g\tan(\theta)$

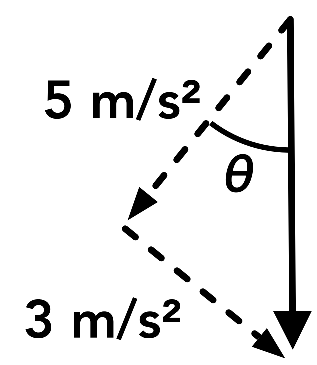
52. An object is sliding down an inclined ramp with no friction and an angle between 0° and 90°. The magnitude of the object's acceleration parallel to the incline is

A 9.8 m/s²
B 0 m/s²
C greater than 9.8 m/s²
D less than 9.8 m/s²

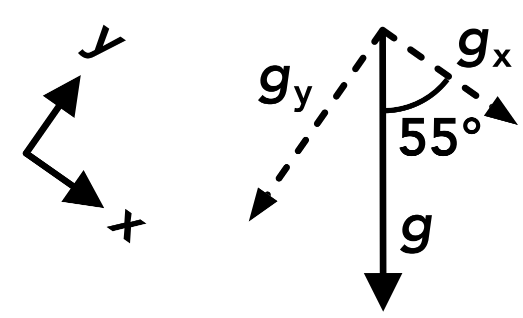
53. A car is speeding up and has an acceleration as shown by the vector on the right. What are the ***x*** and ***y*** components of the acceleration?



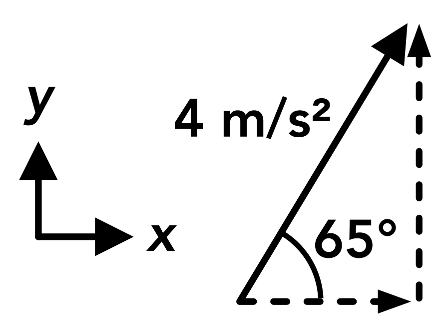
54. An object has an acceleration with components as shown on the right. What are the magnitude and reference angle θ of the acceleration?



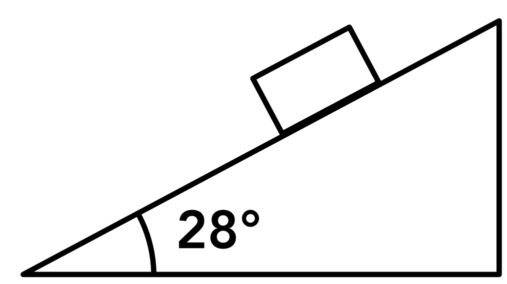
55. An object is in free fall with no air resistance and is accelerating at g. Using the coordinate system shown on the right, what are the values of the ***x*** and ***y*** components of g?



56. If a speed boat starts at rest and then experiences an acceleration as shown by the vector on the right, what will be its displacement in the ***x*** and ***y*** directions after a period of 6 seconds?



57. A box slides down a ramp with no friction as shown on the right. If the box starts from rest, what is the speed of the box (in the direction of its motion) after 3 seconds?



58. A textbook is released from rest and slides down a ramp with an angle of 35° relative to the ground. Ignoring friction, how far along the ramp does the textbook move in 0.5 seconds?

59. On an alien planet with a different amount of gravity than we have on Earth, a box is sitting on a ramp with no friction and an incline of 22° relative to the ground. The box is released from rest and travels 3 m along the incline in 2 seconds. What is the acceleration due to gravity on the alien planet? (What would be the value of [g])

Answers - Basics

1. Answer: B, C, D
   A) This would be one-dimensional motion in the vertical direction
   B) This would be two-dimensional motion because the ball moves in the horizontal and vertical directions
   C) This would be two-dimensional motion because the car moves in the horizontal and vertical directions
   D) This would be two-dimensional motion as seen from above because the car moves in two different horizontal directions as it drives in a circle (it does not drive in a straight line)

2. Answer: A
   An object's components of motion in the ***x*** direction and the ***y*** direction are always independent, one does not affect the other.

3. Answer: 13.9 m
   Side length ***c*** can be found using the Pythagorean theorem: $c = \sqrt{a^2 + b^2} = \sqrt{(12)^2 + (7)^2} = 13.9$

4. Answer: ***x*** = 2.7 m, ***y*** = 1.3 m
   $x = (3)\cos(25°) = 2.7 \text{ m}$
   $y = (3)\sin(25°) = 1.3 \text{ m}$

5. Answer: 34.8°
   $\theta = \tan^{-1}\left(\frac{16}{23}\right) = 34.8°$

6. Answer: 9.8 m/s²
   Any object in free fall has a downwards acceleration due to gravity of 9.8 m/s² (ignoring air resistance).

Answers - Vectors

7. Answer: A, C, D
   A) These fully describe a vector.
   B) A single value is not enough to describe a vector.
   C) These fully describe a vector.
   D) These fully describe a vector.

8. Answer: B, D
   A) The angle of a vector can be negative if it is described as clockwise from the positive ***x*** axis.
   B) Magnitude is always a positive value.
   C) Components can be negative if they point in the negative direction of their axis.
   D) A reference angle is always a positive value.

9. Answer: B, C
   When two vectors are added they form a resultant vector. The maximum magnitude of the resultant vector would be when the vectors point in the same direction and the resultant vector magnitude is the sum of the individual vector magnitudes. The minimum magnitude of the resultant vector would be when the the vectors point in opposite directions and the resultant vector magnitude is the difference between the individual vector magnitudes (one vector magnitude is subtracted from the other). In this problem, the minimum magnitude of $\vec{C}$ is: 27 - 12 = 15, and the maximum magnitude of $\vec{C}$ is: 27 + 12 = 39.

10. Answer: A, D
    A) The ***x*** component would be 0 and the ***y*** component would be equal to the vector's magnitude.
    B) The ***x*** component would equal the vector's magnitude and the ***y*** component would be 0.
    C) The ***x*** component would equal the vector's magnitude and the ***y*** component would be 0.
    D) The ***x*** component would be 0 and the ***y*** component would be equal to the vector's magnitude.

11. Answer: B
    A) The x component would be positive and equal to the vector's magnitude, the y component would be 0.
    B) The x and y components would be positive and equal in magnitude.
    C) The x and y components would be equal in magnitude but x would be negative and y would be positive.
    D) The x component would be negative and equal to the vector's magnitude, the y component would be 0.

12. Answer: C, D
    The x component of the vector would be: $v\cos(\theta)$, and $\cos(155°) = -0.91$
    A) cos(25°) = 0.91 (same magnitude but opposite sign).
    B) cos(65°) = 0.42 (different magnitude).
    C) cos(205°) = -0.91 (same magnitude and sign).
    D) cos(-155°) = -0.91 (same magnitude and sign).

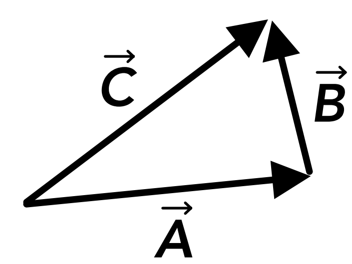
13. Answer: B
    The y component of the vector would be: $v\sin(\theta)$. sin(60°) = 0.87 and sin(30°) = 0.50 so the magnitude of the y component would decrease (it becomes shorter).

14. Answer: A
    The x component of the vector would be: $v\cos(\theta)$. cos(120°) = -0.50 and cos(170°) = -0.98, so the magnitude (which ignores the sign) of the x component would increase.

15. Answer: D
    A) The components are not parallel to the x and y axes shown.
    B) The components are parallel to the x and y axes shown but are not labeled correctly.
    C) The components are not parallel to the x and y axes shown.
    D) The components are parallel to the x and y axes shown and are labeled correctly.

16. Answer: A, B, D
    A) The components are parallel to their corresponding axes and are in the correct directions.
    B) The components are parallel to their corresponding axes and are in the correct directions.
    C) The components are parallel to their corresponding axes but are not in the correct directions.
    D) The components are parallel to their corresponding axes and are in the correct directions.

17. Answer: B
    The vectors can be drawn and added using the tip-to-tail method as seen on the right:



18. Answer: 245° or -115°, reference angle = 65°
    The angle is measured from the positive x axis, either counterclockwise (positive angles) or clockwise (negative angles). The reference angle is the smallest angle between the vector and the x axis and is always positive.

19. Answer: v_x = -4.6 m/s , v_y = 3.9 m/s
    Using the conventional angle: 180° - 40° = 140°
    $v_x = (6)\cos(140°) = -4.6$ m/s
    $v_y = (6)\sin(140°) = 3.9$ m/s

    Using the reference angle:
    $v_x = (6)\cos(40°) = 4.6$ m/s but it points in the negative direction so $v_x = -4.6$ m/s
    $v_y = (6)\sin(40°) = 3.9$ m/s and it points in the positive direction

20. Answer: d = 3.9 m, θ = 50.2°
    $$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(2.5)^2 + (3)^2}$$
    $$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{3}{2.5}\right)$$

Answers - Position and displacement

21. Answer: B
The x coordinate of their final position would be: 7 + 15 - 3 = 19.
The y coordinate of their final position would be: 11 + 6 - 2 = 15.

22. Answer: D
The x component of their displacement would be: $\Delta x = x_f - x_i$ = (-10) - (2) = -12 m.
The y component of their displacement would be: $\Delta y = y_f - y_i$ = (-9) - (3) = -12 m.

The magnitude of their displacement would be: $d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(-12)^2 + (-12)^2}$ = 17 m.

23. Answer: C
The x component of the displacement vector would be -1.5 km and the y component would be 2.6 km.

The reference angle between the vector and the x component would be: $\theta = \tan^{-1}\left(\frac{2.6}{1.5}\right) = 60°$

The conventional angle relative to the positive x axis would be: 180° - 60° = 120°.

24. Answer: C
The x component of the displacement vector would be: $(25)\cos(160°) = -23.5$ m so the x component would point in the negative x direction.

25. Answer: D
The y component of the displacement vector would be: $(18)\sin(-45°) = -12.7$ m so the y component would point in the negative y direction.

26. Answer: A = (2,4), B = (4,3), C = (2,1)
The coordinates list the position values of a point as (x, y).

27. Answer: Δx = -40 m, Δy = 20 m, d = 44.7 m, θ = 26.6 deg

$$\Delta x = x_f - x_i = (20) - (60)$$
$$\Delta y = y_f - y_i = (40) - (20)$$
$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(-40)^2 + (20)^2}$$
$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{20}{40}\right)$$

28. Answer: 1.5 km east, 1.3 km south
The reference angle between the east direction and the vector is: 130° - 90° = 40°
The eastward component of the displacement would be: $(2)\cos(40°) = 1.5$ km
The southward component of the displacement would be: $(2)\sin(40°) = 1.3$ km

29. Answer: d = 12.8 m, θ = 51.3 deg

$$d = \sqrt{(8)^2 + (10)^2}$$
$$\theta = \tan^{-1}\left(\frac{10}{8}\right)$$

30. Answer: Person C is closer to person B
The distance between person C and person A is: $\sqrt{(4 - 2)^2 + (8 - 3)^2} = 5.4$

The distance between person C and person B is: $\sqrt{(4 - 8)^2 + (8 - 6)^2} = 4.5$

31. Answer: 4.8 km at 22°

$\Delta x_1 = (2)\cos(40°) = 1.53$ km $\quad$ $\Delta y_1 = (2)\sin(40°) = 1.29$ km

$\Delta x_2 = (3)\cos(10°) = 2.95$ km $\quad$ $\Delta y_2 = (3)\sin(10°) = 0.52$ km

$\Delta x_{total} = (1.53) + (2.95) = 4.48$ km $\quad$ $\Delta y_{total} = (1.29) + (0.52) = 1.81$ km

$$d_{total} = \sqrt{(4.48)^2 + (1.81)^2} = 4.8 \text{ km}$$

$$\theta_{total} = \tan^{-1}\left(\frac{1.81}{4.48}\right) = 22°$$

32. Answer: 43.1 m

Using east as the positive ***x*** direction and north as the positive ***y*** direction:

$\Delta x = (-45) + (8) = -37$ m

$\Delta y = 22$ m

$$d_{total} = \sqrt{(-37)^2 + (22)^2} = 43.1 \text{ m}$$

33. Answer: 27.2°

The horizontal component of the total displacement would be 35 cm.

The vertical component of the total displacement would be 18 cm.

$$\theta = \tan^{-1}\left(\frac{18}{35}\right) = 27.2°$$

Answers - Velocity

34. Answer: C

A) A displacement vector may show the path of an object over a period of time if it moves in a straight line.

B) A displacement vector may show the distance an object travels if it moves in a straight line.

C) An instantaneous velocity vector shows the direction of motion at an instant in time.

D) An acceleration vector would show the change in an object's velocity.

35. Answer: D

The ***x*** component of the velocity vector will stay the same. The angle of the vector is given by: $\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

The magnitude of the vector is given by: $v = \sqrt{v_x^2 + v_y^2}$

If the ***y*** component is doubled, the magnitude of the vector will increase and the angle of the vector will change.

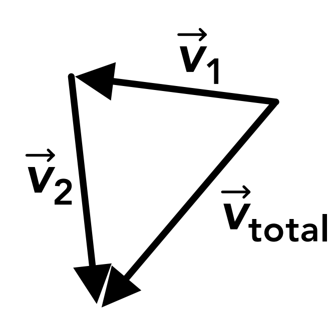
36. Answer: B

The ***x*** component of the first vector is: $(5)\cos(-50°) = 3.2$ m/s

The ***x*** component of the new vector is: $(5)\cos(-80°) = 0.9$ m/s

37. Answer: C

The vectors can be drawn and added using the tip-to-tail method:



38. Answer: D

The ***y*** component of the vector is: $(3)\sin(190°) = -0.52$ m/s

Since the ***y*** component has a negative value, it would point in the negative ***y*** direction.

39. Answer: A
The x and y components of the velocity are independent of each other, so the x component would not change.

40. Answer: v_x = -10.4 m/s , v_y = -7.5 m/s
Using the conventional angle: 180° + 36° = 216°
$v_x = (12.8)\cos(216°) = -10.4$ m/s
$v_y = (12.8)\sin(216°) = -7.5$ m/s

Using the reference angle:
$v_x = (12.8)\cos(36°) = 10.4$ m/s **but it points in the negative direction so** $v_x = -10.4$ m/s
$v_y = (12.8)\sin(36°) = 7.5$ m/s **but it points in the negative direction so** $v_y = -7.5$ m/s

41. Answer: v = 10.2 m/s, θ = 52.6°
$$v = \sqrt{(6.2)^2 + (8.1)^2}$$
$$\theta = \tan^{-1}\left(\frac{8.1}{6.2}\right)$$

42. Answer: 9.5 m
$$v_y = (9)\sin(24°) = 3.66 \text{ m/s}$$
The displacement of the object in the y direction would be: (3.66 m/s)(2.6 s) = 9.5 m

43. Answer: 2.8 m/s
The x component of the displacement vector is: $\Delta x = (42)\cos(58°) = 22.26$ m
The velocity in the x direction would be: (22.26 m) / (8 s) = 2.8 m/s

44. Answer: 5.8 s
The x component of the velocity vector is: $v_x = (7)\cos(38°) = 5.52$ m/s
The time it takes to travel 32 m is: (32 m) / (5.52 m/s) = 5.8 s

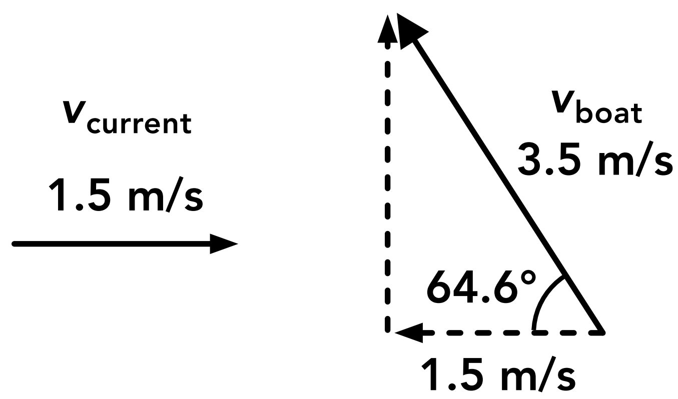
45. Answer: 2.5 m/s, 156.8°
$$\Delta x = (2) - (9) = -7 \text{ m} \qquad \Delta y = (5) - (2) = 3 \text{ m}$$
The magnitude of the displacement is: $d = \sqrt{(-7)^2 + (3)^2} = 7.62$ m
The reference angle of the displacement vector and velocity vector is: $\theta = \tan^{-1}\left(\frac{3}{7}\right) = 23.2°$
The conventional angle of the vectors is: 180° - 23.2° = 156.8°
The magnitude of their velocity is: (7.62 m) / (3 s) = 2.5 m/s

46. Answer: 47.3 m
The y component of the velocity vector is: $(4)\sin(100°) = 3.94$ m/s
The displacement in the y direction over a period of 12 seconds is: (3.94 m/s)(12 s) = 47.3 m

47. Answer: 3.9 s
The length of the ramp is: (2 m) / $\sin(15°) = 7.73$ m
The time it takes them to reach the top is: (7.73 m) / (2 m/s) = 3.8 s

48. Answer: 26.6 m
The component of the boat's velocity straight across the river is 3.5 m/s because the boat points straight across the river. The time it takes to cross the river only depends on that velocity component, so the time to cross the river is: (62 m) / (3.5 m/s) = 17.71 s. The displacement of the boat downstream is: (17.71 s)(1.5 m/s) = 26.6 m.

49. Answer: 64.6°
The boat must point at the angle where the component of its velocity through the water parallel to the current is 1.5 m/s in the opposite direction of the current, so that the total velocity vector of the boat only points straight across the river.



$$\theta = \cos^{-1}\left(\frac{1.5}{3.5}\right) = 64.6°$$

or

$$v^2 = v_x^2 + v_y^2$$
$$(3.5)^2 = (1.5)^2 + v_y^2$$
$$v_y = \sqrt{(3.5)^2 - (1.5)^2} = 3.16$$
$$\theta = \tan^{-1}\left(\frac{3.16}{1.5}\right) = 64.6°$$

Answers - Acceleration

50. Answer: B
An object in free fall will have an acceleration vector with a magnitude of 9.8 m/s² which points downwards (towards the ground). Since the positive y direction is up, the y component of the acceleration vector will have a value of -9.8 m/s².

51. Answer: C
If θ is the angle between the incline and the horizontal, the component of the acceleration due to gravity parallel to the incline is $g\sin(\theta)$.

52. Answer: D
If θ is the angle between the incline and the horizontal, the component of the acceleration due to gravity parallel to the incline is $g\sin(\theta)$, which will be less than g (9.8 m/s²) if θ is less than 90°.

53. Answer: a_x = 1.5 m/s², a_y = -1.3 m/s²
$$a_x = (2)\cos(-40°) = 1.5 \text{ m/s}^2$$
$$a_y = (2)\sin(-40°) = -1.3 \text{ m/s}^2$$

54. Answer: 5.8 m/s², 31.0°
$$a = \sqrt{(5)^2 + (3)^2}$$
$$\theta = \tan^{-1}\left(\frac{3}{5}\right)$$

55. Answer: g_x = 5.6 m/s², g_y = 8.0 m/s²
$$g_x = (9.8)\cos(55°)$$
$$g_y = (9.8)\sin(55°)$$

56. Answer: Δx = 30.4 m, Δy = 65.3 m
$$a_x = (4)\cos(65°) = 1.69 \text{ m/s}^2$$
$$a_y = (4)\sin(65°) = 3.63 \text{ m/s}^2$$
$$\Delta x = v_{xi}t + \frac{1}{2}a_x t^2 = (0)(6) + \frac{1}{2}(1.69)(6)^2 = 30.4 \text{ m}$$
$$\Delta y = v_{yi}t + \frac{1}{2}a_y t^2 = (0)(6) + \frac{1}{2}(3.63)(6)^2 = 65.3 \text{ m}$$

57. Answer: 13.8 m/s
The component of the acceleration of the box parallel to the ramp is: $(9.8)\sin(28°) = 4.6 \text{ m/s}^2$
The speed of the box after 3 seconds is: (4.6 m/s²)(3 s) = 13.8 m/s

58. Answer: 0.7 m
The component of the acceleration of the textbook parallel to the ramp is: $(9.8)\sin(35°) = 5.62\ \text{m/s}^2$
The displacement of the textbook after 0.5 seconds is:
$$\Delta x = v_i t + \frac{1}{2} a\, t^2 = (0)(0.5) + \frac{1}{2}(5.62)(0.5)^2 = 0.7\ \text{m}$$

59. Answer: 4 m/s²
The component of acceleration due to gravity parallel to the incline (the acceleration of the box) is:
$$\Delta x = v_i t + \frac{1}{2} a\, t^2 \qquad 3 = (0)(2) + \frac{1}{2} a (2)^2 \qquad a = 1.5\ \text{m/s}^2$$
Which is equal to the component of the acceleration due to gravity parallel to the incline: $g \sin(\theta)$

The value of g would be given by: $1.5\ \text{m/s}^2 = g \sin(22°)$ $\quad g = 4\ \text{m/s}^2$