Extra Practice 1

Due: 2:00pm on Wednesday, February 10, 2016

You will receive no credit for items you complete after the assignment is due. Grading Policy

Converting between Different Units

Unit conversion problems can seem tedious and unnecessary at times. However, different systems of units are used in different parts of the world, so when dealing with international transactions, documents, software, etc., unit conversions are often necessary.

Here is a simple example. The inhabitants of a small island begin exporting beautiful cloth made from a rare plant that grows only on their island. Seeing how popular the small quantity that they export has been, they steadily raise their prices. A clothing maker from New York, thinking that he can save money by "cutting out the middleman," decides to travel to the small island and buy the cloth himself. Ignorant of the local custom of offering strangers outrageous prices and then negotiating down, the clothing maker accepts (much to everyone's surpise) the initial price of 400 $\mathrm{tepizes/m^2}$. The price of this cloth in New York is 120 $\mathrm{dollars/yard^2}$.

Part A

If the clothing maker bought 500 $\mathrm{m^2}$ of this fabric, how much money did he lose? Use $1\ \mathrm{tepiz} = 0.625\ \mathrm{dollar}$ and $0.9144\ \mathrm{m} = 1\ \mathrm{yard}$.

Express your answer in dollars using two significant figures.

Hint 1. How to approach the problem

To find how much money the clothing maker loses, you must find how much money he spent and how much he would have spent in New York. Furthermore, since the problem asks how much he lost in dollars, you need to determine both in dollars. This will require unit conversions.

Hint 2. Find how much he paid

If the clothing maker bought 500 $\mathrm{m^2}$ at a cost of 400 $\mathrm{tepizes/m^2}$, then simple multiplication will give how much he spent in tepizes. Once you've found that, convert to dollars. How much did the clothing maker spend in dollars?

Express your answer in dollars to three significant figures.

Hint 1. Find how much he paid in $\mathrm{tepizes}$

If the clothing maker bought 500 $\mathrm{m^2}$ at a cost of 400 $\mathrm{tepizes/m^2}$, then how much did he pay in total, in $\mathrm{tepizes}$?

Express your answer in $\mathrm{tepizes}$.

ANSWER:

2.00×10^5 $\mathrm{tepizes}$

Correct

ANSWER:

1.25×10^5 $\mathrm{dollars}$

Incorrect; Try Again; 2 attempts remaining

Hint 3. Find the price in New York

You know that the price of the fabric in New York is 120 $\mathrm{dollars/yard^2}$. Thus, you need only to find the number of square yards that the clothing maker purchased and then multiply to find the price in New York. What would it have cost him to buy the fabric in New York?

Express your answer in dollars to three significant figures.

Hint 1. Determine how much cloth he bought in yard^2

You are given that $0.9144 \mathrm{~m} = 1 \mathrm{~yard}$. Squaring both sides, you would get that $0.8361 \mathrm{~m}^2 = 1 \mathrm{~yard}^2$. How much is $500 \mathrm{~m}^2$?

Express your answer in yard^2 **to three significant figures.**

ANSWER:

598 yard^2

ANSWER:

7.18×10^4 $\mathrm{dollars}$

ANSWER:

5.3×10^4 $\mathrm{dollars}$

All attempts used; correct answer displayed

Still think that unit conversion isn't important?

Here is a widely publicized, true story about how failing to convert units resulted in a huge loss. In 1998, the Mars Climate Orbiter probe crashed into the surface of Mars, instead of entering orbit. The resulting inquiry revealed that NASA navigators had been making minor course corrections in SI units, whereas the software written by the probe's makers implicitly used British units. In the United States, most scientists use SI units, whereas most engineers use the British, or Imperial, system of units. (Interestingly, British units are *not* used in Britain.) For these two groups to be able to communicate to one another, unit conversions are necessary.

The unit of force in the SI system is the newton (N), which is defined in terms of basic SI units as $1\ \mathrm{N} = 1\ \mathrm{kg \cdot m/s^2}$. The unit of force in the British system is the pound (lb), which is defined in terms of the slug (British unit of mass), foot (ft), and second (s) as $1\ \mathrm{lb} = 1\ \mathrm{slug \cdot ft/s^2}$.

Part B

Find the value of 15.0 N in pounds. Use the conversions $1\ \mathrm{slug} = 14.59\ \mathrm{kg}$ and $1\ \mathrm{ft} = 0.3048\ \mathrm{m}$.

Express your answer in pounds to three significant figures.

Hint 1. How to approach the problem

When doing a unit conversion, you should begin by comparing the units you are starting with and the units you need to finish with. In this problem, we have the following:

Starting units	Final units
$\frac{\mathrm{kg \cdot m}}{\mathrm{s^2}}$	$\frac{\mathrm{slug \cdot ft}}{\mathrm{s^2}}$

Notice that both have seconds squared in the denominator. You will only have to change the units in the numerator. Match up the units that measure the same quantity (e.g., kilograms and slugs both measure mass). Once you've done this, create a fraction (e.g., $1\ \mathrm{hour}/60\ \mathrm{minutes}$) based on conversion factors such that the old unit is canceled out of the expression and the new unit appears in the position (i.e., numerator or denominator) of the old unit. In this problem, there are two pairs within the starting and final units that must be converted in this way (i.e., kilograms/slugs and meters/feet).

Hint 2. Calculate the first conversion

The first step is to eliminate kilograms from the expression for newtons in favor of slugs. What is the value of 15 $\mathrm{kg \cdot m/s^2}$ in $\mathrm{slug \cdot m/s^2}$?

Express your answer in slug-meters per second squared to four significant figures.

ANSWER:

1.028

ANSWER:

15.0 N = 3.37 lb

Correct

Thus, if the NASA navigators believed that they were entering a force value of 15 N (3.37 lb), they were actually entering a value nearly four and a half times higher, 15 lb. Though these errors were only in tiny course corrections, they added up during the trip of many millions of kilometers.

In the end, the blame for the loss of the 125-million-dollar probe was placed on the lack of communication between people at NASA that allowed the units mismatch to go unnoticed. Nonetheless, this story makes apparent how important it is to carefully label the units used to measure a number.

Consistency of Units

In physics, every physical quantity is measured with respect to a *unit*. Time is measured in seconds, length is measured in meters, and mass is measured in kilograms. Knowing the units of physical quantities will help you solve problems in physics.

Part A

Gravity causes objects to be attracted to one another. This attraction keeps our feet firmly planted on the ground and causes the moon to orbit the earth. The force of gravitational attraction is represented by the equation

$$F = \frac{Gm_1m_2}{r^2},$$

where F is the magnitude of the gravitational attraction on either body, m_1 and m_2 are the masses of the bodies, r is the distance between them, and G is the gravitational constant. In SI units, the units of force are $\mathrm{kg \cdot m/s^2}$, the units of mass are kg, and the units of distance are m. For this equation to have consistent units, the units of G must be which of the following?

Hint 1. How to approach the problem

To solve this problem, we start with the equation

$$F = \frac{Gm_1m_2}{r^2}.$$

For each symbol whose units we know, we replace the symbol with those units. For example, we replace m_1 with kg. We now solve this equation for G.

ANSWER:

- ○ $\frac{\mathrm{kg}^3}{\mathrm{m \cdot s}^2}$
- ○ $\frac{\mathrm{kg \cdot s}^2}{\mathrm{m}^3}$
- ◉ $\frac{\mathrm{m}^3}{\mathrm{kg \cdot s}^2}$
- ○ $\frac{\mathrm{m}}{\mathrm{kg \cdot s}^2}$

Correct

Part B

One consequence of Einstein's theory of special relativity is that mass is a form of energy. This mass-energy relationship is perhaps the most famous of all physics equations:

$$E = mc^2,$$

where m is mass, c is the speed of the light, and E is the energy. In SI units, the units of speed are $\mathrm{m/s}$. For the preceding equation to have consistent units (the same units on both sides of the equation), the units of E must be which of the following?

Hint 1. How to approach the problem

To solve this problem, we start with the equation

$$E = mc^2.$$

For each symbol whose units we know, we replace the symbol with those units. For example, we replace m with kg. We now solve this equation for E.

ANSWER:

- ○ $\frac{\mathrm{kg \cdot m}}{\mathrm{s}}$
- ◉ $\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^2}}$
- ○ $\frac{\mathrm{kg \cdot s^2}}{\mathrm{m^2}}$
- ○ $\frac{\mathrm{kg \cdot m^2}}{\mathrm{s}}$

Correct

To solve the types of problems typified by these examples, we start with the given equation. For each symbol whose units we know, we replace the symbol with those units. For example, we replace m with kg. We now solve this equation for the units of the unknown variable.

Dimensions of Physical Quantities

Learning Goal:

To introduce the idea of physical dimensions and to learn how to find them.

Physical quantities are generally not purely numerical: They have a particular *dimension* or combination of dimensions associated with them. Thus, your height is not 74, but rather 74 inches, often expressed as 6 feet 2 inches. Although feet and inches are different *units* they have the same *dimension--length*.

Part A

In classical mechanics there are three base dimensions. Length is one of them. What are the other two?

Hint 1. MKS system

The current system of units is called the International System (abbreviated SI from the French Système International). In the past this system was called the mks system for its base units: meter, kilogram, and second. What are the dimensions of these quantities?

ANSWER:

- ○ acceleration and mass
- ○ acceleration and time
- ○ acceleration and charge
- ◉ mass and time
- ○ mass and charge
- ○ time and charge

Correct

There are three dimensions used in mechanics: length (l), mass (m), and time (t). A combination of these three dimensions suffices to express any physical quantity, because when a new physical quantity is needed (e.g., velocity), it always obeys an equation that permits it to be expressed in terms of the units used for these three dimensions. One then derives a unit to measure the new physical quantity from that equation, and often its unit is given a special name. Such new dimensions are called derived dimensions and the units they are measured in are called derived units.

For example, area A has derived dimensions $[A] = l^2$. (Note that "dimensions of variable x" is symbolized as $[x]$.) You can find these dimensions by looking at the formula for the area of a square $A = s^2$, where s is the length of a side of the square. Clearly $[s] = l$. Plugging this into the equation gives $[A] = [s]^2 = l^2$.

Part B

Find the dimensions $[V]$ of volume.

Express your answer as powers of length (l), mass (m), and time (t).

Hint 1. Equation for volume

You have likely learned many formulas for the volume of various shapes in geometry. Any of these equations will give you the dimensions for volume. You can find the dimensions most easily from the volume of a cube $V = e^3$, where e is the length of the edge of the cube.

ANSWER:

$[V]$ = l^3

Correct

Part C

Find the dimensions $[v]$ of speed.

Express your answer as powers of length (l), mass (m), and time (t).

Hint 1. Equation for speed

Speed v is defined in terms of distance d and time t as

$$v = \frac{d}{t}.$$

Therefore, $[v] = [d]/[t]$.

Hint 2. Familiar units for speed

You are probably accustomed to hearing speeds in miles per hour (or possibly kilometers per hour). Think about the dimensions for miles and hours. If you divide the dimensions for miles by the dimensions for hours, you will have the dimensions for speed.

ANSWER:

$[v]$ = $\frac{l}{t}$

Correct

The dimensions of a quantity are not changed by addition or subtraction of another quantity with the same dimensions. This means that Δv, which comes from subtracting two speeds, has the same dimensions as speed.

It does not make physical sense to add or subtract two quanitites that have different dimensions, like length plus time. You *can* add quantities that have different units, like miles per hour and kilometers per hour, as long as you convert both quantities to the same set of units before you actually compute the sum. You can use this rule to check your answers to any physics problem you work. If the answer involves the sum or difference of two quantities with different dimensions, then it must be incorrect.

This rule also ensures that the dimensions of any physical quantity will *never* involve sums or differences of the base dimensions. (As in the preceeding example, $\mathrm{l} + \mathrm{t}$ is not a valid dimension for a physical quantitiy.) A valid dimension will only involve the product or ratio of powers of the base dimensions (e.g. $\mathrm{m}^{2/3}\mathrm{l}^2\mathrm{t}^{-2}$).

Part D

Find the dimensions $[a]$ of acceleration.

Express your answer as powers of length (l), mass (m), and time (t).

Hint 1. Equation for acceleration

In physics, acceleration a is defined as the change in velocity in a certain time. This is shown by the equation $a = \Delta v / \Delta t$. The Δ is a symbol that means "the change in."

ANSWER:

$[a]$ = $\frac{l}{t^2}$

Correct

Converting Units: The Magic of 1

Learning Goal:

To learn how to change units of physical quantities.

Quantities with physical dimensions like length or time must be measured with respect to a *unit*, a standard for quantities with this dimension. For example, length can be measured in units of meters or feet, time in seconds or years, and velocity in meters per second.

When solving problems in physics, it is necessary to use a consistent system of units such as the International System (abbreviated SI, for the French Système International) or the more cumbersome English system. In the SI system, which is the preferred system in physics, mass is measured in kilograms, time in seconds, and length in meters. The necessity of using consistent units in a problem often forces you to convert some units from the given system into the system that you want to use for the problem.

The key to unit conversion is to multiply (or divide) by a ratio of different units that equals one. This works because multiplying any quantity by one doesn't change it. To illustrate with length, if you know that $1 \text{ inch} = 2.54 \text{ cm}$, you can write

$$1 = \frac{2.54 \text{ cm}}{1 \text{ inch}}.$$

To convert inches to centimeters, you can multiply the number of inches times this fraction (since it equals one), cancel the inch unit in the denominator with the inch unit in the given length, and come up with a value for the length in centimeters. To convert centimeters to inches, you can divide by this ratio and cancel the centimeters.

For all parts, notice that the units are already written after the answer box; don't try to write them in your answer also.

Part A

How many centimeters are there in a length 50.4 inches ?

Express your answer in centimeters to three significant figures.

ANSWER:

128 cm

Correct

Sometimes you will need to change units twice to get the final unit that you want. Suppose that you know how to convert from centimeters to inches and from inches to feet. By doing both, in order, you can convert from centimeters to feet.

Part B

Suppose that a particular artillery piece has a range R = 9040 yards . Find its range in miles. Use the facts that $1\ \mathrm{mile} = 5280\ \mathrm{ft}$ and 3\; {\rm ft} = 1\; {\rm yard}.

Express your answer in miles to three significant figures.

Hint 1. Convert yards to feet

The first step in this problem is to convert from yards to feet, because you know how to then convert feet into miles. Convert 9040 {\rm \rm yards} into feet. Use

\large{1 = \frac {3\; \rm{ft}}{1\; \rm{yard}}}.

Express your answer in feet to three significant figures.

ANSWER:

2.71×10^4 \rm ft

ANSWER:

9040 {\rm \rm yards} = 5.14 \rm miles

Correct

Often speed is given in miles per hour (\rm mph), but in physics you will almost always work in SI units. Therefore, you must convert \rm mph to meters per second (\rm m/s).

Part C

What is the speed of a car going v = 1.000 \; \rm mph in SI units? Notice that you will need to change from miles to meters and from hours to seconds. You can do each conversion separately. Use the facts that 1\; {\rm mile} = 1609\; {\rm m} and 1\; {\rm hour} = 3600\; {\rm s}.

Express your answer in meters per second to four significant figures.

Hint 1. Convert miles to meters

In converting 1.000\; \rm mph into meters per second, you will need to multiply by

\large{1 = \frac{1609\; \rm m}{1\; \rm mile}}.

When you do this, the miles will cancel to leave you with a value in meters per hour. You can then finish the conversion. What is v=1.000 \; \rm mph in meters per hour?

Express your answer in meters per hour to four significant figures.

ANSWER:

\texttip{v}{v} = 1609 \rm m/hour

Hint 2. Convert hours to seconds

Which of the following would you multiply 1609\; \rm m/hours by to convert it into meters per second (\rm m/s)?

ANSWER:

- ○ 3600\; \rm s
- ○ 1\; \rm hour
- ○ \large{\frac{3600\;\rm s}{1\; \rm hour}}
- ◉ \large{\frac{1\; \rm hour}{3600\;\rm s}}

ANSWER:

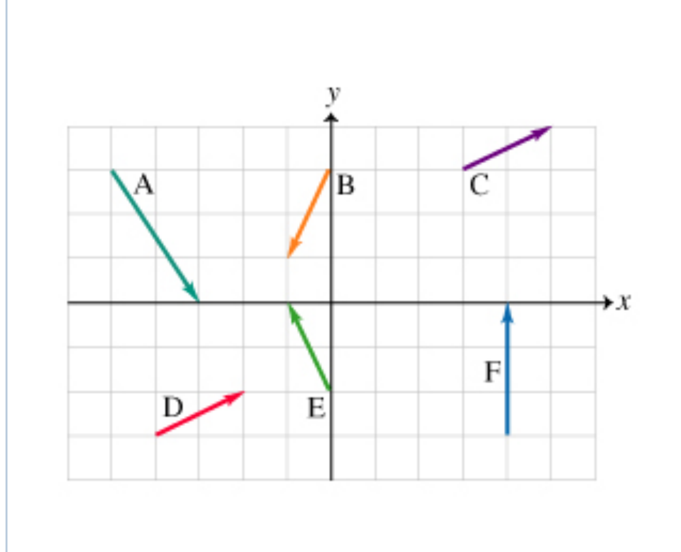
\texttip{v}{v} = 0.4469 \rm m/s

Correct

Notice that by equating the two values for \texttip{v}{v}, you get 1.000 \; {\rm mph} = 0.4469\; {\rm m/s}. It might be valuable to remember this, as you may frequently need to convert from miles per hour into more useful SI units. By remembering this relationship in the future, you can reduce this task to a single conversion.

Adding and Subtracting Vectors Conceptual Question

Six vectors (A to F) have the magnitudes and directions indicated in the figure.



Part A

Which two vectors, when added, will have the largest (positive) *x* component?

Hint 1. Largest *x* component

The two vectors with the largest *x* components will, when combined, give the resultant with the largest *x* component. Keep in mind that positive *x* components are larger than negative *x* components.

ANSWER:

- ○ C and E
- ○ E and F
- ○ A and F
- ◉ C and D
- ○ B and D

Correct

Part B

Which two vectors, when added, will have the largest (positive) *y* component?

Hint 1. Largest *y* component

The two vectors with the largest *y* components will, when combined, give the resultant with the largest *y* component. Keep in mind that positive *y* components are larger than negative *y* components.

ANSWER:

- C and D
- A and F
- E and F
- A and B
- E and D

Correct

Part C

Which two vectors, when *subtracted* (i.e., when one vector is subtracted from the other), will have the largest magnitude?

Hint 1. Subtracting vectors

To subtract two vectors, add a vector with the same magnitude but opposite direction of one of the vectors to the other vector.

ANSWER:

- A and F
- A and E
- D and B
- C and D
- E and F

Correct

Adding Scalar Multiples of Vectors Graphically

Draw the vectors indicated. You may use any extra (unlabeled) vectors that are helpful; but, keep in mind that the unlabeled vectors should be deleted before submitting your answer.

Part A

Draw the vector \vec{C} = \vec{A}+2\vec{B}.

The length and orientation of the vector will be graded. The location of the vector is not important.

Hint 1. How to approach the problem

You can add the vectors graphically or using components, but a graphical approach will be the simplest. It may help to draw the vector $2\vec{B}$ first.

Hint 2. Draw $2\vec{B}$

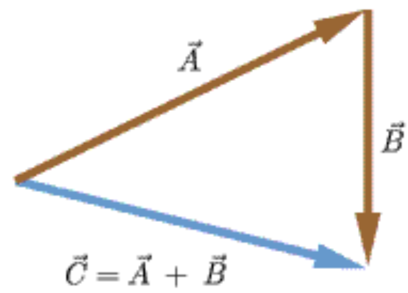
Draw the vector $\vec{B}_{\rm scaled} = 2\vec{B}$.

The length and orientation of the vector will be graded. The location of the vector is not important.

ANSWER:

Hint 3. Adding vectors graphically

To add two vectors, slide one vector (without rotating it) until its tip coincides with the tail of the second vector. The sum of the two vectors is the vector that goes from the tail of the first vector to the tip of the second:



ANSWER:

Correct

Now use the same technique to answer the next two parts.

Part B

Draw the vector \vec{C} = 1.5\vec{A}-3\vec{B}.

The length and orientation of the vector will be graded. The location of the vector is not important.

Hint 1. Find 1.5\vec{A} and -3\vec{B}

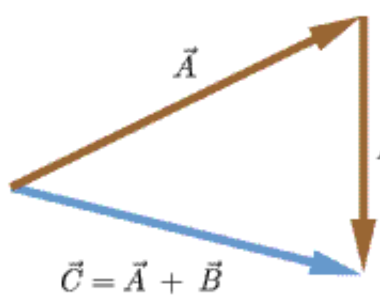
Draw the vectors $\vec{A}_{\rm scaled} = 1.5\vec{A}$ and $\vec{B}_{\rm scaled} = -3\vec{B}$. Recall that multiplying a vector by a negative number reverses its direction.

The length and orientation of the vectors will be graded. The locations of the vectors are not important.

ANSWER:

Hint 2. Adding vectors graphically

To add two vectors, slide one vector (without rotating it) until its tip coincides with the tail of the second vector. The sum of the two vectors is the vector that goes from the tail of the first vector to the tip of the second:



ANSWER:

Correct

Part C

Draw the vector $\vec{C} = 0.5\vec{A}+2\vec{B}$.

The length and orientation of the vector will be graded. The location of the vector is not important.

Hint 1. Find $0.5\vec{A}$ and $2\vec{B}$

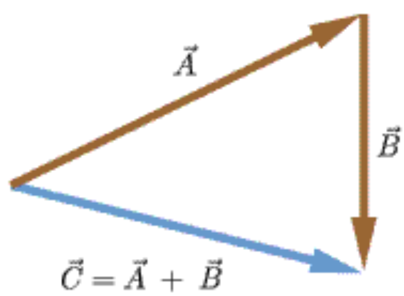
Draw the vectors $\vec{A}_{\rm scaled} = 0.5\vec{A}$ and $\vec{B}_{\rm scaled} = 2\vec{B}$.

The length and orientation of the vectors will be graded. The locations of the vectors are not important.

ANSWER:

Hint 2. Adding vectors graphically

To add two vectors, slide one vector (without rotating it) until its tip coincides with the tail of the second vector. The sum of the two vectors is the vector that goes from the tail of the first vector to the tip of the second:

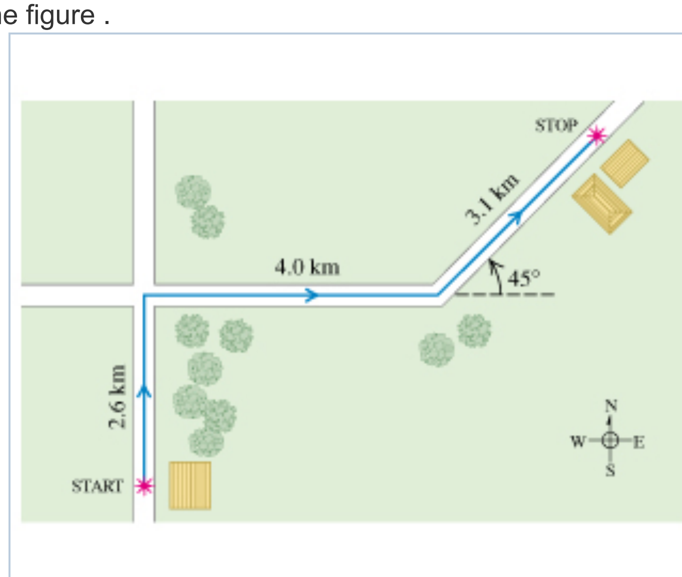


ANSWER:

Correct

Exercise 1.25

A postal employee drives a delivery truck along the route shown in the figure .



Part A

Determine the magnitude of the resultant displacement by drawing a scale diagram.

Express your answer using two significant figures.

ANSWER:

7.8 {\rm km}

Correct

Part B

Determine the direction of the resultant displacement.

Express your answer using two significant figures.

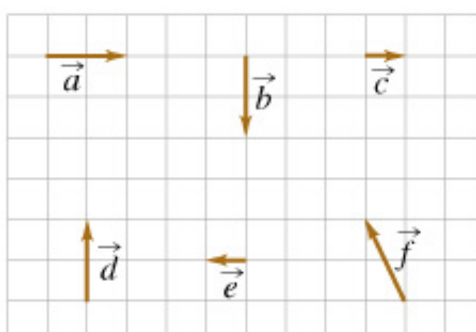
ANSWER:

38 {}^{\circ} North of East

Correct

Vector Addition Ranking Task

Six vectors (\texttip{\vec{a}}{a_vec} through \texttip{\vec{f}}{f_vec}) have the magnitudes and directions indicated in the figure.



Part A

Rank the vector combinations on the basis of their magnitude.

Rank from largest to smallest. To rank items as equivalent, overlap them.

Hint 1. Adding vectors graphically

To add two vectors together, imagine sliding one vector (without rotating it) until its tail coincides with the tip of the second vector. The sum of the two vectors, termed the *resultant* vector \texttip{\vec{R}}{R_vec}, is the vector that goes from the tail of the first vector to the tip of the second vector. The magnitude of the resultant, $|\vec R|$, is determined by the sum of the squares of its x and y components, that is,

$$|\vec R| = \sqrt {R_x^2 + R_y^2}.$$

ANSWER:

Correct

Part B

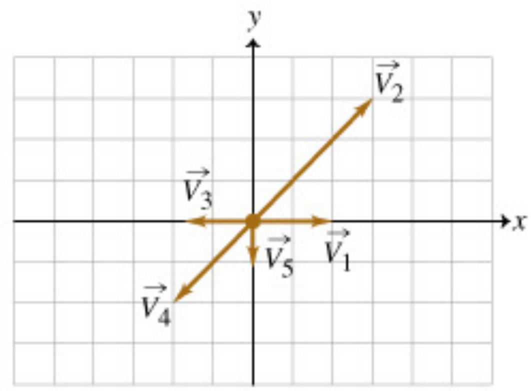
Rank the vector combinations on the basis of their angle, measured counterclockwise from the positive x axis. Vectors parallel to the positive x axis have an angle of 0° . All angle measures fall between 0° and 360°.

Rank from largest to smallest. To rank items as equivalent, overlap them.

Hint 1. Angle of a vector

The angle of a vector $\angle \vec V$ is to be measured counterclockwise from the *x* axis, with the *x* axis as 0°. The following vectors are at the angles listed and are shown on the graph below.

- $\angle \vec V_1 = 0^\circ$
- $\angle \vec V_2 = 45^\circ$
- $\angle \vec V_3 = 180^\circ$
- $\angle \vec V_4 = 225^\circ$
- $\angle \vec V_5 = 270^\circ$



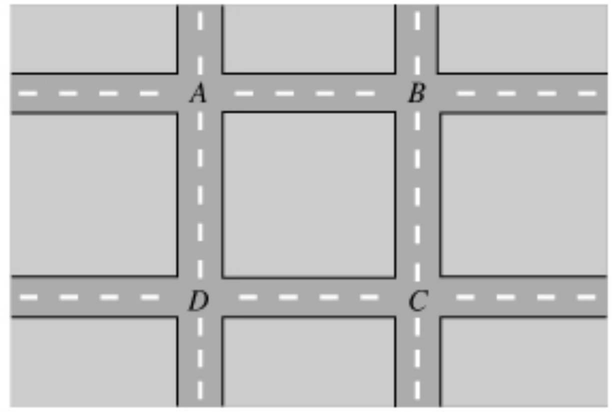
Notice that the magnitude of the vector is irrelevant when determining its angle

ANSWER:

Correct

Vector Magnitude and Direction Conceptual Question

A man out walking his dog makes one complete pass around a perfectly square city block. He starts at point A and walks clockwise around the block.



Let \texttip{\vec{r}_{\rm AB}}{r_AB_vec} be the displacement vector from A to B, \texttip{\vec{r}_{\rm BC}}{r_BC_vec} be the displacement vector from B to C, etc.

Part A

Which of the following vectors is equal to \texttip{\vec{r}_{\rm AB}}{r_AB_vec}?

Hint 1. Determining a vector

Recall that \texttip{\vec{r}_{\rm AB}}{r_AB_vec} is a vector representing the displacement of the man and his dog as they walk from point A to point B. This vector has a magnitude equal to one block and a direction along the positive *x* axis.

Hint 2. Equal vectors

Two vectors are equal if they have the same *magnitude* and the same *direction*.

ANSWER:

- \texttip{\vec{r}_{\rm BC}}{r_BC_vec} only
- \texttip{\vec{r}_{\rm CD}}{r_CD_vec} only
- \texttip{\vec{r}_{\rm DA}}{r_DA_vec} only
- All of the above
- None of the above

Correct

Recall that, for vectors to be equal, they must have the same *magnitude* and *direction*.

Part B

Which of the following vectors is equal to -\vec r_{AB}?

ANSWER:

- \texttip{\vec{r}_{\rm BC}}{r_BC_vec} only
- \texttip{\vec{r}_{\rm CD}}{r_CD_vec} only
- \texttip{\vec{r}_{\rm DA}}{r_DA_vec} only
- All of the above
- None of the above

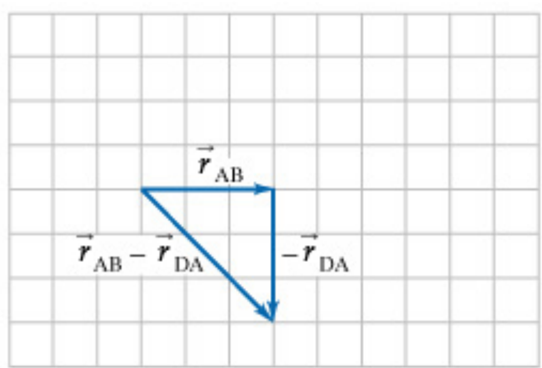
Correct

Part C

Which of the following vectors is equal to \vec r_{AB}-\vec r_{DA}?

Hint 1. Determining the difference of two vectors

\vec r_{AB}-\vec r_{DA} can be determined by adding the vector \texttip{\vec{r}_{\rm AB}}{r_AB_vec} to the vector pointing opposite to \texttip{\vec{r}_{\rm DA}}{r_DA_vec}. Thus \vec r_{AB}-\vec r_{DA} looks like this:



Carefully perform the vector addition in each of the options and compare the resultant vectors to the one shown above.

ANSWER:

- -(\vec r_{CD}+\vec r_{DA}) only
- \vec r_{AB}+\vec r_{BC} only
- \vec r_{BC}-\vec r_{CD} only
- All of the above
- None of the above

Correct

± Vector Addition

Consider the following three vectors:

\vec{A} = (2, -1, 1),
\vec{B} = (3, 0, 5),
and
\vec{C} = (1, 4, -2).
Calculate the following combinations. Express your answers as ordered triplets [e.g., (9, 4, -2)].

Part A

Hint 1. How to add vectors

Add vectors by adding the *x* components, *y* components, and *z* components individually.

ANSWER:

\vec{A} + \vec{B} = 5,-1,6

Correct

Part B

ANSWER:

\vec{B} + \vec{C} = 4,4,3

Correct

Part C

ANSWER:

\vec{A} + \vec{B} + \vec{C} = 6,3,4

Correct

Part D

Hint 1. Remember the order of precedence

3\vec{A} means multiply the vector \texttip{\vec{A}}{A_vec} by the constant 3, which you can do by multiplying each component by 3 separately. Follow normal rules of mathematical precedence; that is, multiply before adding vectors.

ANSWER:

3\vec{A} + 2\vec{C} = 8,5,-1

Correct

Part E

ANSWER:

2\vec{A} + 3\vec{B} + \vec{C} = 14,2,15

Correct

Part F

ANSWER:

2\vec{A} + 3(\vec{B} + \vec{C}) = 16,10,11

Correct

± Vector Addition and Subtraction

In general it is best to conceptualize vectors as arrows in space, and then to make calculations with them using their components. (You must first specify a coordinate system in order to find the components of each arrow.) This problem gives you some practice with the components.

Let vectors \vec{A} = (1, 0, -3), \vec{B} = (-2, 5, 1), and \vec{C} = (3, 1, 1). Calculate the following, and express your answers as ordered triplets of values separated by commas.

Part A

ANSWER:

\vec{A} - \vec{B} = 3,-5,-4

Correct

Part B

ANSWER:

\vec{B}-\vec{C} = -5,4,0

Correct

Part C

ANSWER:

- \vec{A} + \vec{B} - \vec{C} = -6,4,3

Correct

Part D

ANSWER:

3\vec{A} -2\vec{C} = -3,-2,-11

Correct

Part E

ANSWER:

- 2\vec{A} +3\vec{B} -\vec{C} = -11,14,8

Correct

Part F

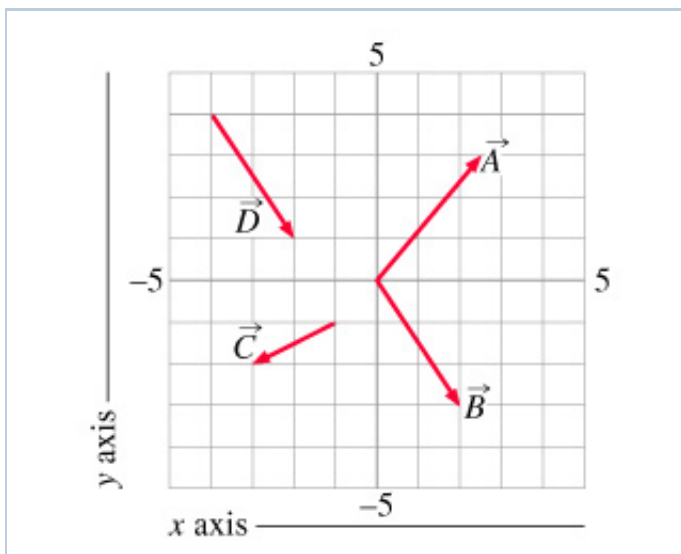
ANSWER:

2\vec{A} - 3(\vec{B} -\vec{C}) = 17,-12,-6

Correct

Components of Vectors

Shown is a 10 by 10 grid, with coordinate axes *x* and *y*
.
The grid runs from -5 to 5 on both axes. Drawn on this grid are four vectors, labeled \texttip{\vec{A}}{A_vec} through \texttip{\vec{D}}{D_vec}. This problem will ask you various questions about these vectors. All answers should be in decimal notation, unless otherwise specified.



Part A

What is the *x* component of \texttip{\vec{A}}{A_vec}?

Express your answer to two significant figures.

Hint 1. How to derive the component

A component of a vector is its length (but with appropriate sign) along a particular coordinate axis, the axes being specfied in advance. You are asked for the component of \texttip{\vec{A}}{A_vec} that lies along the *x* axis, which is horizontal in this problem. Imagine two lines perpendicular to the *x* axis running from the head (end with the arrow) and tail of \texttip{\vec{A}}{A_vec} down to the *x* axis. The length of the *x* axis between the points where these lines intersect is the *x* component of \texttip{\vec{A}}{A_vec}. In this problem, the *x* component is the *x* coordinate at which the perpendicular from the head of the vector hits the *x* axis (because the tail of the vector is at the origin).

ANSWER:

\texttip{A_{\mit x}}{A_x} = 2.5

Correct

Part B

What is the *y* component of \texttip{\vec{A}}{A_vec}?

Express your answer to the nearest integer.

ANSWER:

\texttip{A_{\mit y}}{A_y} = 3

Correct

Part C

What is the *y* component of \texttip{\vec{B}}{B_vec}?

Express your answer to the nearest integer.

Hint 1. Consider the direction

Don't forget the sign.

ANSWER:

\texttip{B_{\mit y}}{B_y} = -3

Correct

Part D

What is the \texttip{x}{x} component of \texttip{\vec{C}}{C_vec}?

Express your answer to the nearest integer.

Hint 1. How to find the start and end points of the vector components

A vector is defined only by its magnitude and direction. The starting point of the vector is of no consequence to its definition. Therefore, you need to somehow eliminate the starting point from your answer. You can run two perpendiculars to the *x* axis, one from the head (end with the arrow) of \texttip{\vec{C}}{C_vec}, and another to the tail, with the *x* component being the difference between *x* coordinates of head and tail (negative if the tail is to the right of the head). Another way is to imagine bringing the tail of \texttip{\vec{C}}{C_vec} to the origin, and then using the same procedure you used before to find the components of \texttip{\vec{A}}{A_vec} and \texttip{\vec{B}}{B_vec}. This is equivalent to the previous method, but it might be easier to visualize.

ANSWER:

\texttip{C_{\mit x}}{C_x} = -2

Correct

The following questions will ask you to give both components of vectors using the ordered pairs method. In this method, the *x* component is written first, followed by a comma, and then the *y* component. For example, the components of \texttip{\vec{A}}{A_vec} would be written 2.5,3 in ordered pair notation.

The answers below are all integers, so estimate the components to the nearest whole number.

Part E

In ordered pair notation, write down the components of vector \texttip{\vec{B}}{B_vec}.

Express your answers to the nearest integer.

ANSWER:

\texttip{B_{\mit x}}{B_x}, \texttip{B_{\mit y}}{B_y} = 2,-3

Correct

Part F

In ordered pair notation, write down the components of vector \texttip{\vec{D}}{D_vec}.

Express your answers to the nearest integer.

ANSWER:

\texttip{D_{\mit x}}{D_x}, \texttip{D_{\mit y}}{D_y} = 2,-3

Correct

Part G

What is true about \texttip{\vec{B}}{B_vec} and \texttip{\vec{D}}{D_vec}? Choose from the pulldown list below.

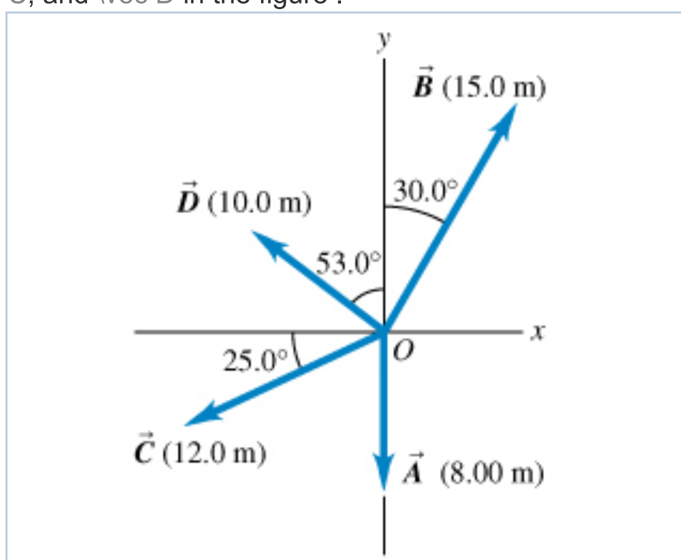
ANSWER:

- ○ They have different components and are not the same vectors.
- ○ They have the same components but are not the same vectors.
- ◉ They are the same vectors.
- ○

Correct

Exercise 1.27

Compute the *x*- and *y*-components of the vectors \vec A, \vec B, \vec C, and \vec D in the figure .



Part A

Enter your answers numerically separated by a comma.

ANSWER:

A_x, A_y = 0,-8.00 {\rm m}

Correct

Part B

Enter your answers numerically separated by a comma.

ANSWER:

B_x, B_y = 7.50,13.0 {\rm m}

Correct

Part C

Enter your answers numerically separated by a comma.

ANSWER:

C_x, C_y = -10.9,-5.07 {\rm m}

Correct

Part D

Enter your answers numerically separated by a comma.

ANSWER:

D_x, D_y = -7.99,6.02 {\rm m}

Correct

Exercise 1.29

Vector $\vec A$ has y-component A_y = +17.0 ${\rm m}$. $\vec A$ makes an angle of 26.0 ${\rm ^\circ}$ counterclockwise from the $+y$-axis.

Part A

What is the x-component of $\vec A$?

Express your answer with the appropriate units.

ANSWER:

A_x = -8.29 ${\rm m}$

Correct

Part B

What is the magnitude of $\vec A$?

Express your answer with the appropriate units.

ANSWER:

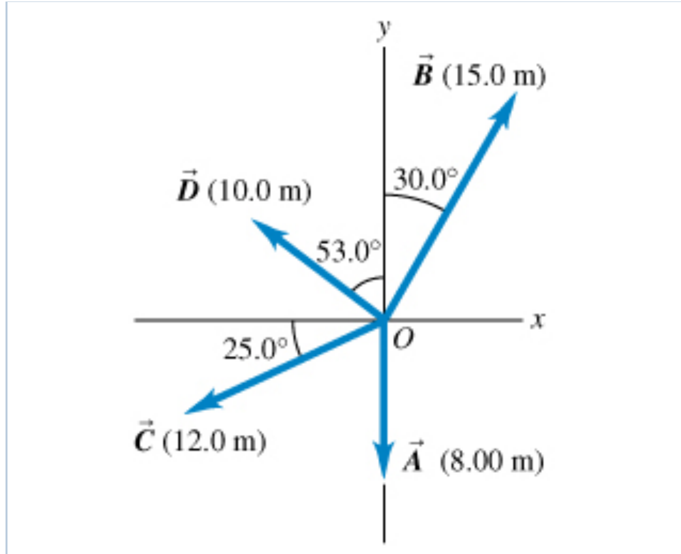
A = 18.9 ${\rm m}$

Correct

Exercise 1.31

Part A

For the vectors $\vec A$ and $\vec B$ in the figure , use the method of components to find the magnitude of the vector sum $\vec A+\vec B$.



ANSWER:

9.01 {\rm m}

Correct

Part B

Find the direction of the vector sum \vec A+\vec B.

Express your answer as counterclockwise angle from *x*-axis to the vector.

ANSWER:

33.6 {}^{\circ}

Correct

Part C

Find the magnitude of the vector sum \vec B+\vec A.

ANSWER:

9.01 {\rm m}

Correct

Part D

Find the direction of the vector sum \vec B+\vec A.

Express your answer as counterclockwise angle from *x*-axis to the vector.

ANSWER:

33.6 {}^{\circ}

Correct

Part E

Find the magnitude of the vector difference \vec A - \vec B.

ANSWER:

22.3 {\rm m}

Correct

Part F

Find the direction of the vector difference \vec A - \vec B.

Express your answer as counterclockwise angle from *x*-axis to the vector.

ANSWER:

250 {}^{\circ}

Correct

Part G

Find the magnitude of the vector difference \vec B - \vec A.

ANSWER:

22.3 {\rm m}

Correct

Part H

Find the direction of the vector difference $\vec B - \vec A$.

Express your answer as counterclockwise angle from *x*-axis to the vector.

ANSWER:

$70.3 {}^{\circ}$

Correct

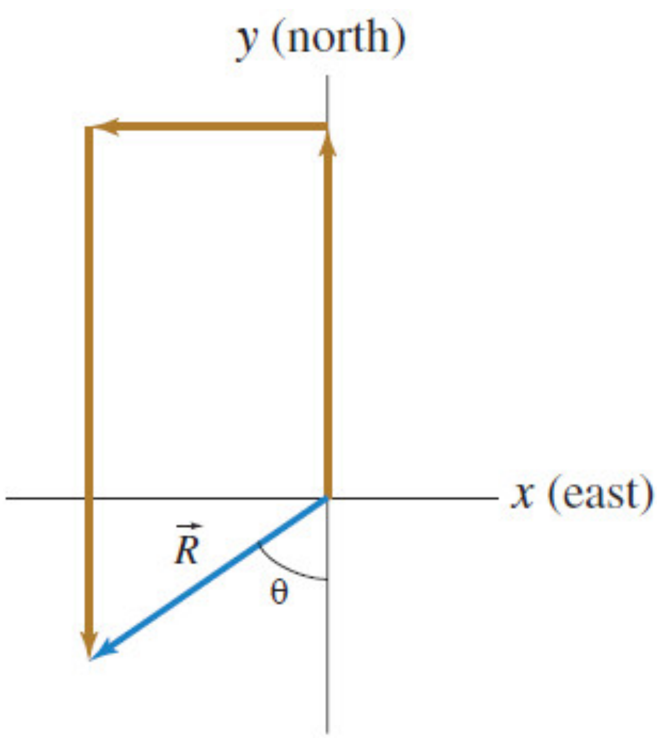
Exercise 1.33

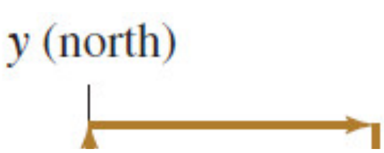
A disoriented physics professor drives $3.45 {\rm \; km}$ north, then $2.50 {\rm \; km}$ west, and then $1.70 {\rm \; km}$ south.

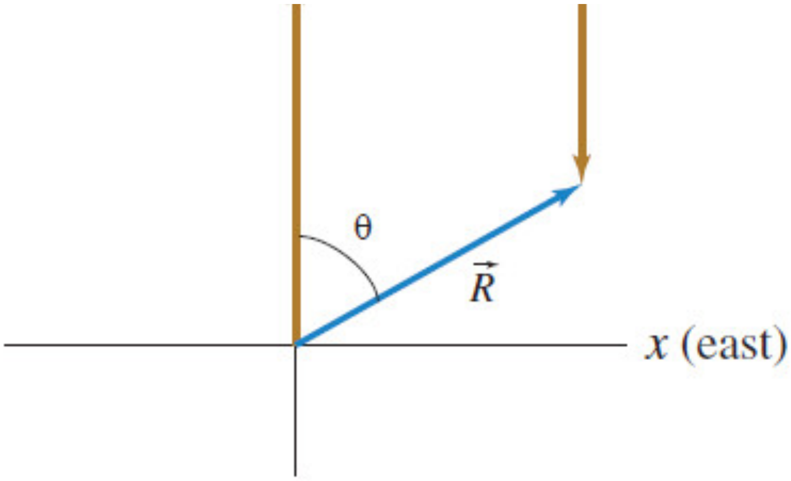
Part A

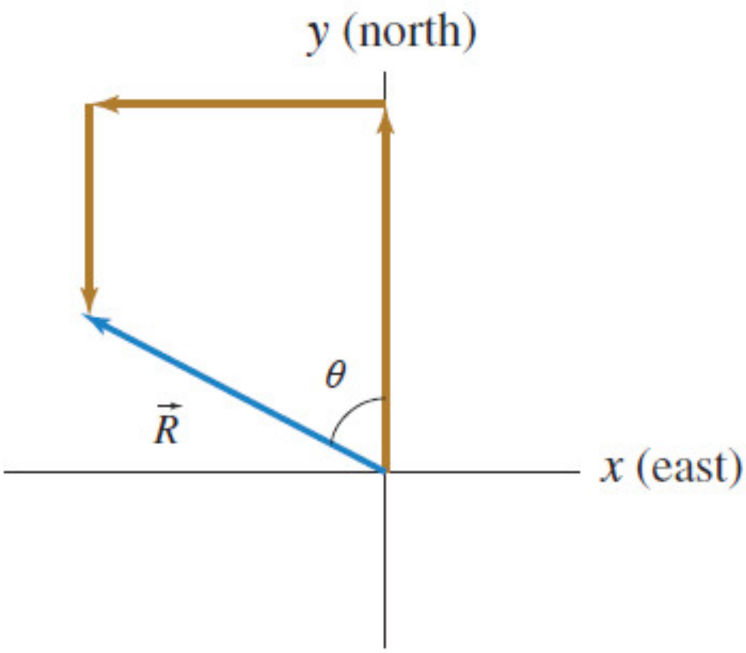
Select the correct vector-addition diagram (roughly to scale) of the resultant displacement.

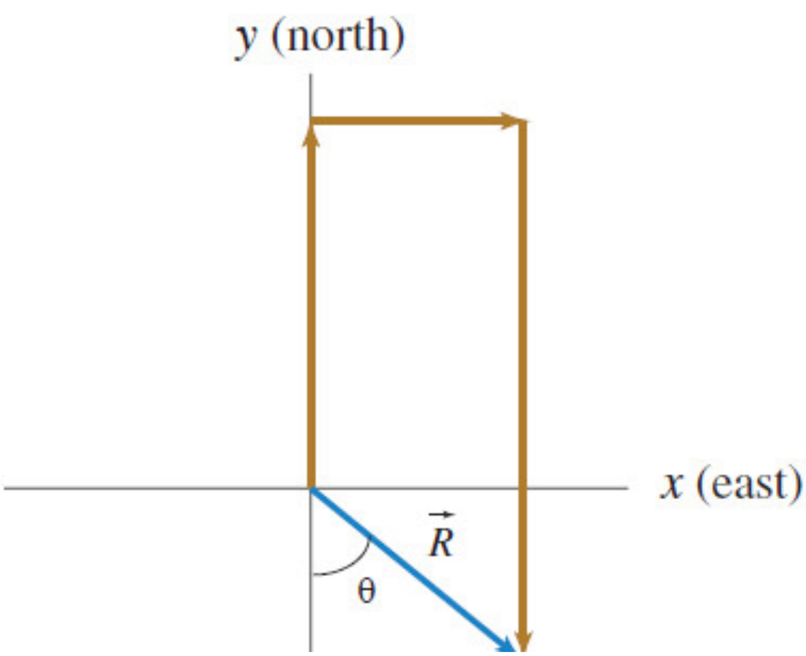
ANSWER:






θ
$\vec{R}$
x (east)


y (north)
θ
$\vec{R}$
x (east)


y (north)
x (east)
$\vec{R}$
θ

Correct

Part B

Find the magnitude of the resultant displacement, using the method of components.

Express your answer with the appropriate units.

ANSWER:

$R =$ 3.05 ${\rm km}$

Correct

Part C

Find the direction of the resultant displacement.

ANSWER:

$\theta =$ 55.0 $^\circ$ west of north

Correct

Part D

Show that the resultant displacement found from your diagram is in qualitative agreement with the result you obtained by using the method of components.

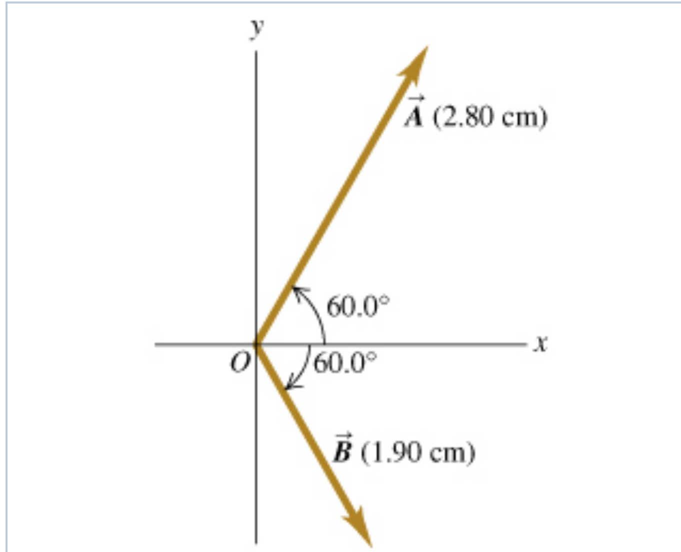
ANSWER:

- ○ From the method of components, $R_x < 0$ and $R_y < 0$, so $\vec{R}$ is in the 3rd quadrant. This agrees with the vector addition diagram.
- ○ From the method of components, $R_x > 0$ and $R_y > 0$, so $\vec{R}$ is in the 1st quadrant. This agrees with the vector addition diagram.
- ○ From the method of components, $R_x > 0$ and $R_y < 0$, so $\vec{R}$ is in the 4th quadrant. This agrees with the vector addition diagram.
- ◉ From the method of components, $R_x < 0$ and $R_y > 0$, so $\vec{R}$ is in the 2nd quadrant. This agrees with the vector addition diagram.

Correct

Exercise 1.35

Vector \vec A is 2.80 {\rm cm} long and is 60.0^\circ above the *x*-axis in the first quadrant. Vector \vec B is 1.90 {\rm cm} long and is 60.0^\circ below the *x*-axis in the fourth quadrant (the figure
).



Part A

Use components to find the magnitude of \vec A+\vec B.

ANSWER:

2.48 {\rm cm}

Correct

Part B

Use components to find the direction of \vec A+\vec B.

ANSWER:

18.3 {}^{\circ} counterclockwise from *x*-axis

Correct

Part C

Sketch the vector addition {\vec C} = {\vec A } + {\vec B}.

Draw the vector with it's tail at the dot. The orientation of your vector will be graded. The exact length of your vector will be graded.

ANSWER:

Correct

Part D

Use components to find the magnitude of \vec A - \vec B.

ANSWER:

4.10 {\rm cm}

Correct

Part E

Use components to find the direction of \vec A - \vec B.

ANSWER:

83.7 {}^{\circ} counterclockwise from *x*-axis

Correct

Part F

Sketch the vector subtraction {\vec C} = {\vec A } - {\vec B}.

Draw the vector with it's tail at the dot. The orientation of your vector will be graded. The exact length of your vector will be graded.

ANSWER:

Correct

Part G

Use components to find the magnitude of \vec B - \vec A.

ANSWER:

4.10 {\rm cm}

Correct

Part H

Use components to find the direction of \vec B - \vec A.

ANSWER:

264 ^{\circ} counterclockwise from *x*-axis

Correct

Part I

Sketch the vector subtraction {\vec C} = {\vec B } - {\vec A}.

Draw the vector with it's tail at the dot. The orientation of your vector will be graded. The exact length of your vector will be graded.

ANSWER:

Correct

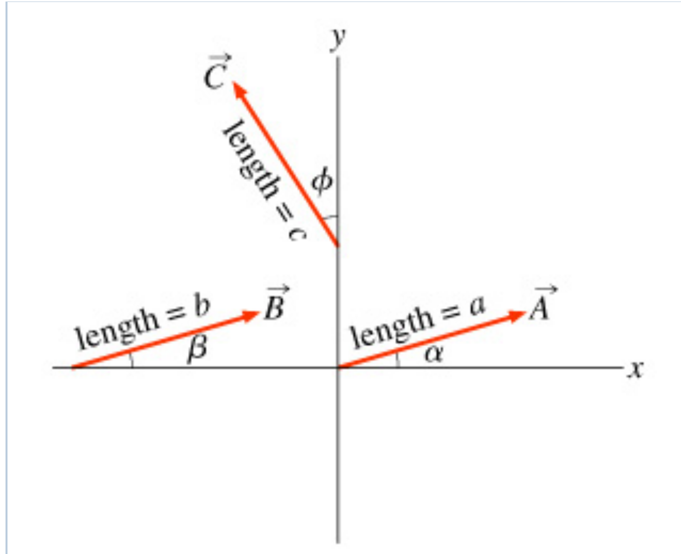
± Resolving Vector Components with Trigonometry

Often a vector is specified by a magnitude and a direction; for example, a rope with tension \texttip{\vec{T}}{T_vec} exerts a force of magnitude \texttip{T}{T} in a direction 35^\circ north of east. This is a good way to think of vectors; however, to calculate results with vectors, it is best to select a coordinate system and manipulate the components of the vectors in that coordinate system.

Part A

Find the components of the vector \texttip{\vec{A}}{A_vec} with length \texttip{a}{a} = 1.00 and angle \alpha=10.0 {\rm ^\circ} with respect to the *x* axis as shown in .

Enter the *x* component followed by the *y* component, separated by a comma.



You did not open hints for this part.

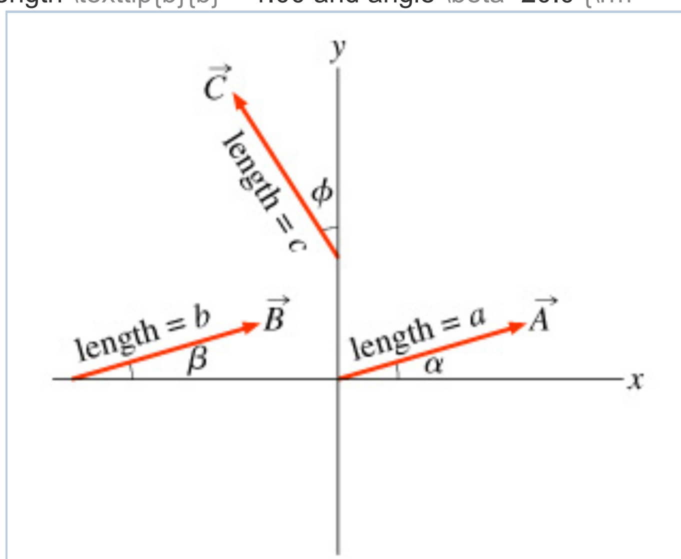
ANSWER:

\texttip{\vec{A}}{A_vec} =

Part B

Find the components of the vector \texttip{\vec{B}}{B_vec} with length \texttip{b}{b} = 1.00 and angle \beta=20.0 {\rm ^{\circ}} with respect to the *x* axis as shown in .

Enter the *x* component followed by the *y* component, separated by a comma.



You did not open hints for this part.

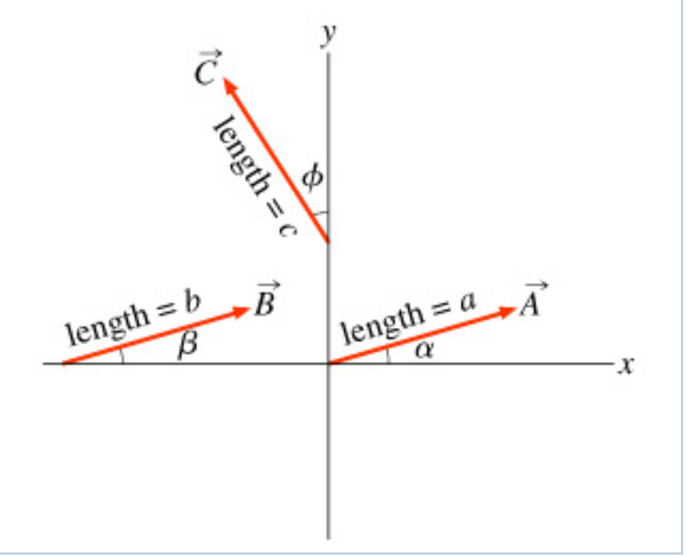
ANSWER:

\texttip{\vec{B}}{B_vec} =

Part C

Find the components of the vector \texttip{\vec{C}}{C_vec} with length \texttip{c}{c} = 1.00 and angle \phi = 35.0 {\rm ^{\circ}} as shown in .

Enter the *x* component followed by the *y* component, separated by a comma.



You did not open hints for this part.

ANSWER:

\texttip{\vec{C}}{C_vec} =

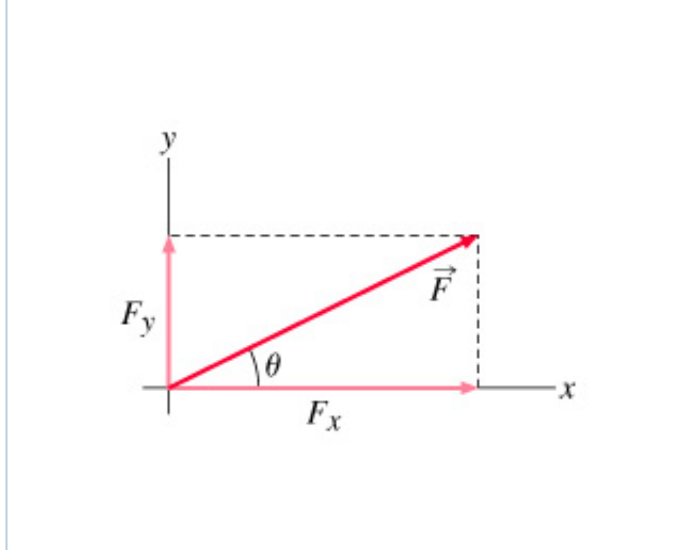
Vector Components--Review

Learning Goal:

To introduce you to vectors and the use of sine and cosine for a triangle when resolving components.

Vectors are an important part of the language of science, mathematics, and engineering. They are used to discuss multivariable calculus, electrical circuits with oscillating currents, stress and strain in structures and materials, and flows of atmospheres and fluids, and they have many other applications. Resolving a vector into components is a precursor to computing things with or about a vector quantity. Because position, velocity, acceleration, force, momentum, and angular momentum are all vector quantities, resolving vectors into components is *the most important skill* required in a mechanics course.

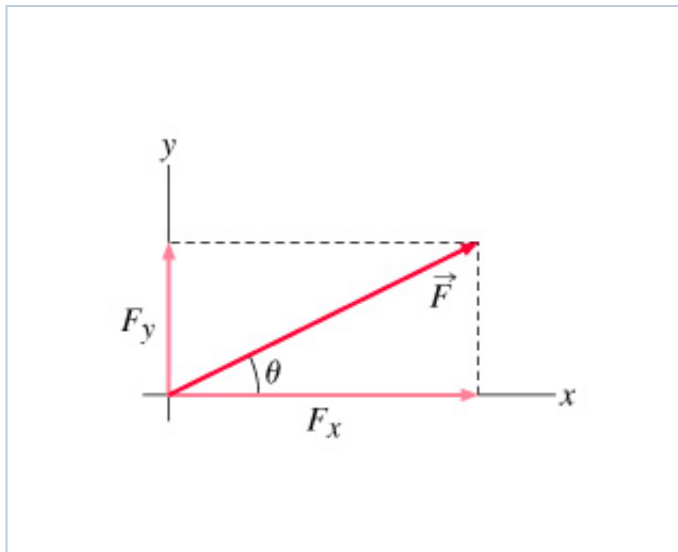
shows the components of \texttip{\vec{F}}{F_vec}, \texttip{F_{\mit x}}{F_x} and \texttip{F_{\mit y}}{F_y}, along the *x* and *y* axes of the coordinate system, respectively. The components of a vector depend on the coordinate system's orientation, the key being the angle between the vector and the coordinate axes, often designated \texttip{\theta }{theta}.



Part A

shows the standard way of measuring the angle. \texttip{\theta }{theta} is measured *to* the vector *from* the *x* axis, and counterclockwise is positive.

Express \texttip{F_{\mit x}}{F_x} and \texttip{F_{\mit y}}{F_y} in terms of the length of the vector \texttip{F}{F} and the angle \texttip{\theta }{theta}, with the components separated by a comma.



ANSWER:

\texttip{F_{\mit x}}{F_x}, \texttip{F_{\mit y}}{F_y} = \abs{F}{\cos}{\theta},\abs{F}{\sin}{\theta}

Correct

In principle, you can determine the components of *any* vector with these expressions. If \texttip{\vec{F}}{F_vec} lies in one of the other quadrants of the plane, \texttip{\theta }{theta} will be an angle larger than 90 degrees (or \pi/2 in radians) and \cos(\theta) and \sin(\theta) will have the appropriate signs and values.

Unfortunately this way of representing \texttip{\vec{F}}{F_vec}, though mathematically correct, leads to equations that must be simplified using trig identities such as

\sin(180^\circ + \phi) = -\sin(\phi)

and

\cos(90^\circ + \phi) = -\sin(\phi).

These must be used to reduce all trig functions present in your equations to either \sin(\phi) or \cos(\phi). Unless you perform this followup step flawlessly, you will fail to recoginze that

\sin(180^\circ + \phi) + \cos(270^\circ - \phi) = 0,

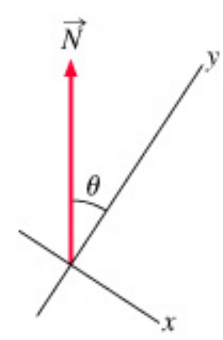
and your equations will not simplify so that you can progress further toward a solution. Therefore, it is best to express all components in terms of either \sin(\phi) or \cos(\phi), with \texttip{\phi }{phi} between 0 and 90 degrees (or 0 and \pi/2 in radians), and determine the signs of the trig functions by knowing in which quadrant the vector lies.

Part B

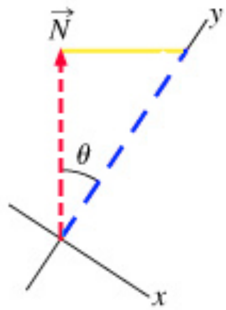
When you resolve a vector \texttip{\vec{F}}{F_vec} into components, the components *must have the form* \vert \vec{F}\vert\cos(\theta) or \vert\vec{F}\vert\sin(\theta). The signs depend on which quadrant the vector lies in, and there will be one component with \sin(\theta) and the other with \cos(\theta).

In real problems the optimal coordinate system is often rotated so that the *x* axis is not horizontal. Furthermore, most vectors will not lie in the first quadrant. To assign the sine and cosine correctly for vectors at arbitrary angles, you must figure out which angle is \texttip{\theta }{theta} and then properly reorient the definitional triangle.
As an example, consider the vector \texttip{\vec{N}}{N_vec} shown in labeled "tilted axes," where you know the angle \texttip{\theta }{theta} between \texttip{\vec{N}}{N_vec} and the *y* axis.

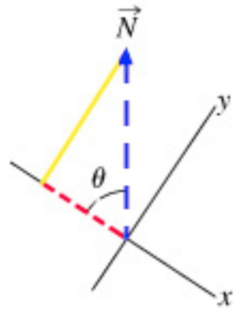
Which of the various ways of orienting the definitional triangle must be used to resolve \texttip{\vec{N}}{N_vec} into components in the tilted coordinate system shown? (In the figures, the hypotenuse is blue (long dashes), the side adjacent to \texttip{\theta }{theta} is red (short dashes), and the side opposite is yellow (solid).)



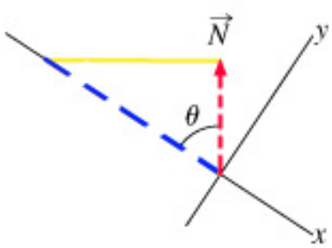
Tilted Axes



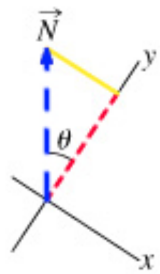
(1)



(2)



(3)



(4)

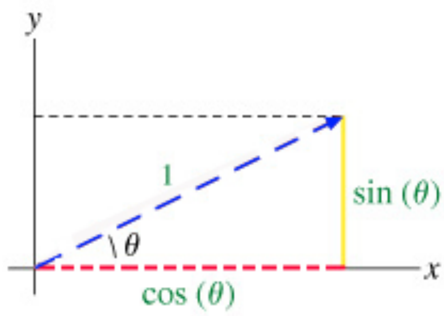
Indicate the number of the figure with the correct orientation.

Hint 1. Recommended procedure for resolving a vector into components

First figure out the sines and cosines of \texttip{\theta }{theta}, then figure out the signs from the quadrant the vector is in and write in the signs.

Hint 2. Finding the trigonometric functions

Sine and cosine are defined according to the following convention, with the key lengths shown in green: The hypotenuse (blue long dashes) has unit length, the side adjacent (red short dashes) to \texttip{\theta }{theta} has length \cos(\theta), and the side opposite (yellow solid) has length \sin(\theta).



ANSWER:

- ○ 1
- ○ 2
- ○ 3
- ◉ 4

Correct

Part C

Choose the correct procedure for determining the components of a vector in a given coordinate system from this list:

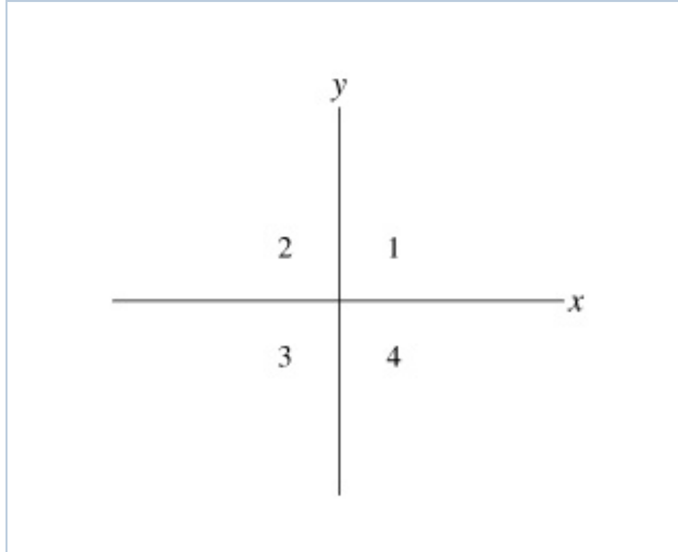
ANSWER:

- ○ Align the adjacent side of a right triangle with the vector and the hypotenuse along a coordinate direction with \theta as the included angle.
- ◉ Align the hypotenuse of a right triangle with the vector and an adjacent side along a coordinate direction with \theta as the included angle.
- ○ Align the opposite side of a right triangle with the vector and the hypotenuse along a coordinate direction with \theta as the included angle.
- ○ Align the hypotenuse of a right triangle with the vector and the opposite side along a coordinate direction with \theta as the included angle.

Correct

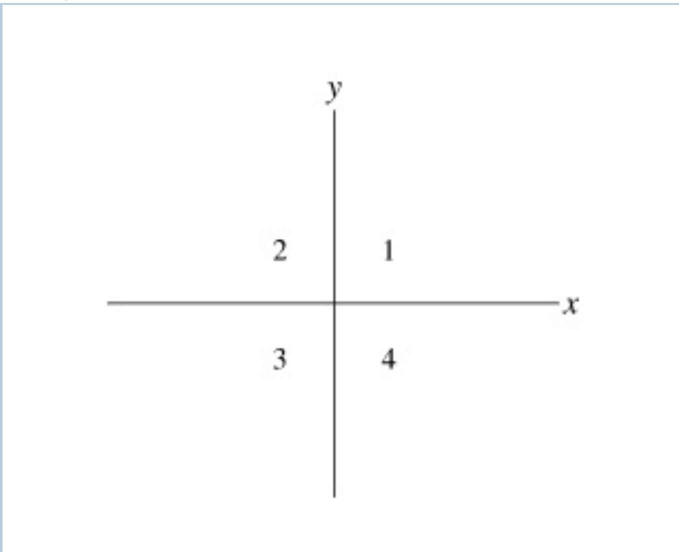
Part D

The space around a coordinate system is conventionally divided into four numbered *quadrants* depending on the signs of the *x* and *y* coordinates . Consider the following conditions:



A. x > 0, y > 0
B. x > 0, y < 0
C. x < 0, y > 0
D. x < 0, y < 0

Which of these lettered conditions are true in which the numbered quadrants shown in ?



Write the answer in the following way: If A were true in the third quadrant, B in the second, C in the first, and D in the fourth, enter "`3, 2, 1, 4`" as your response.

ANSWER:

1,4,2,3

Correct

Part E

Now find the components \texttip{N_{\mit x}}{N_x} and \texttip{N_{\mit y}}{N_y} of \texttip{\vec{N}}{N_vec} in the tilted coordinate system of **Part B**.

Express your answer in terms of the length of the vector \texttip{N}{N} and the angle \texttip{\theta }{theta}, with the components separated by a comma.

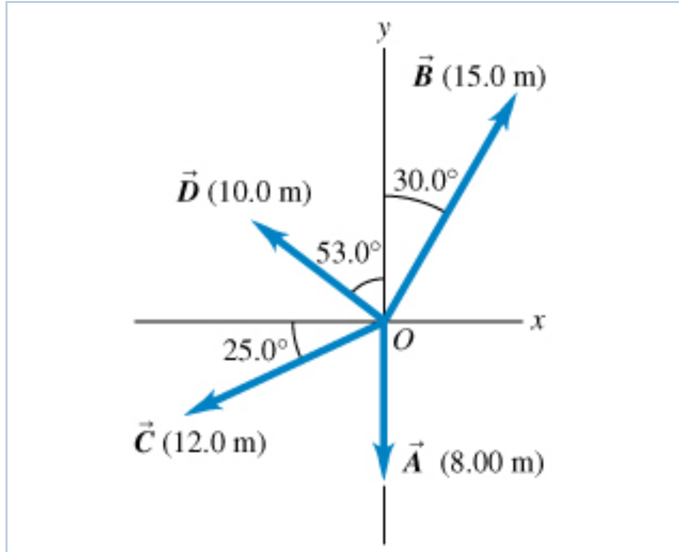
ANSWER:

\texttip{N_{\mit x}}{N_x}, \texttip{N_{\mit y}}{N_y} = -N {\sin}\left({\theta}\right),N {\cos}\left({\theta}\right)

Answer Requested

Exercise 1.37

Write each vector in the figure in terms of the unit vectors \hat i and \hat j.



Part A

ANSWER:

\vec A = -8 \hat{j}

Correct

Part B

ANSWER:

\vec B = 7.5 \hat{i}+7.5 \sqrt{3}\hat{j}

Correct

Part C

ANSWER:

\vec C = -10.88 \hat{i}-5.07 \hat{j}

Correct

Part D

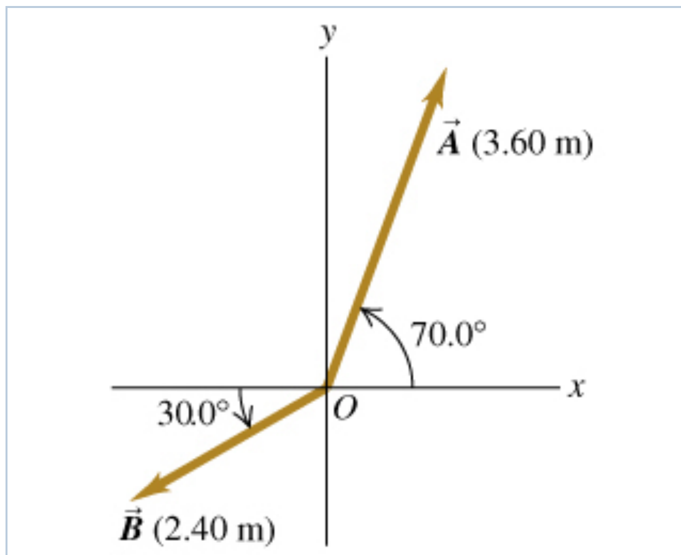
ANSWER:

\vec D =

Exercise 1.39

Part A

Write the vector \vec A in the figure in terms of the unit vectors \hat i and \hat j .



ANSWER:

\vec A = 1.23 \hat{i}+3.38 \hat{j}

Correct

Part B

Write the vector \vec B in the figure in terms of the unit vectors \hat i and \hat j .

ANSWER:

$\vec B$ =

Part C

Use unit vectors to express the vector $\vec C$, where $\vec{C}= 3.00\vec{A} - 4.00\vec{B}$.

ANSWER:

$\vec C$ =

Part D

Find the magnitude of $\vec C$.

ANSWER:

$\_\_\_\_\_$ ${\rm m}$

Part E

Find the direction of $\vec C$.

ANSWER:

$\_\_\_\_\_$ $^\circ$ counterclockwise from +*x*-axis

Exercise 1.41

Given two vectors $\vec A = - 2.00 \hat i + 3.00 \hat j + 6.00 \hat k$ and $\vec B = 4.00 \hat i + 2.00 \hat j - 3.00 \hat k$, do the following.

Part A

Find the magnitude of the vector $\vec A$.

ANSWER:

$|\vec A|$ = 7.00

Correct

Part B

Find the magnitude of the vector \vec B.

ANSWER:

|\vec B| = 5.39

Correct

Part C

Write an expression for the vector difference \vec A - \vec B.

Enter your answers numerically separated by commas.

ANSWER:

x,y,z = -6.00,1.00,9.00

Correct

Part D

Find the magnitude of the vector difference \vec A - \vec B.

ANSWER:

|\vec A - \vec B| = 10.9

Correct

Part E

Is this the same as the magnitude of \vec B - \vec A?

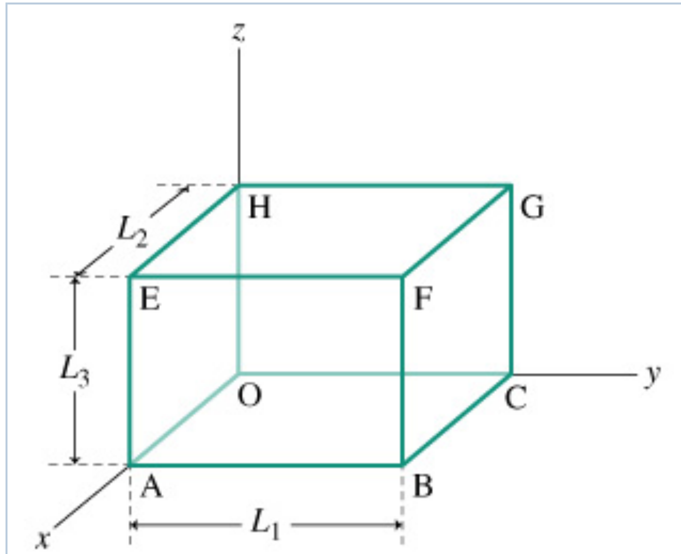
ANSWER:

- yes
- no

Correct

Vectors in a Unit Cell

In nature, substances often possess a crystalline structure. The basic component of a crystal is the unit cell, such as the rectangular parallelpiped illustrated.



In the questions that follow express your answers in terms of the unit vectors \texttip{\hat{i}}{i_unit}, \texttip{\hat{j}}{j_unit}, and \texttip{\hat{k}}{k_unit}, that is, a vector with components \texttip{V_{\mit x}}{V_x}, \texttip{V_{\mit y}}{V_y}, and \texttip{V_{\mit z}}{V_z} in the *x*, *y*, and *z* directions, respectively, is written V_x\hat i + V_y\hat j + V_z\hat k.

Part A

What is the vector \texttip{\vec{V}_{\rm CO}}{V_CO_vec} from point C to point O?

You did not open hints for this part.

ANSWER:

\texttip{\vec{V}_{\rm CO}}{V_CO_vec} =

Part B

What is the vector \texttip{\vec{V}_{\rm OE}}{V_OE_vec} from point O to point E?

ANSWER:

\texttip{\vec{V}_{\rm OE}}{V_OE_vec} =

Part C

What is the vector \texttip{\vec{V}_{\rm OF}}{V_OF_vec} from point O to point F?

ANSWER:

\texttip{\vec{V}_{\rm OF}}{V_OF_vec} =

Part D

What is the vector from A to B, \texttip{\vec{V}_{\rm AB}}{V_AB_vec}?

ANSWER:

\texttip{\vec{V}_{\rm AB}}{V_AB_vec} =

Part E

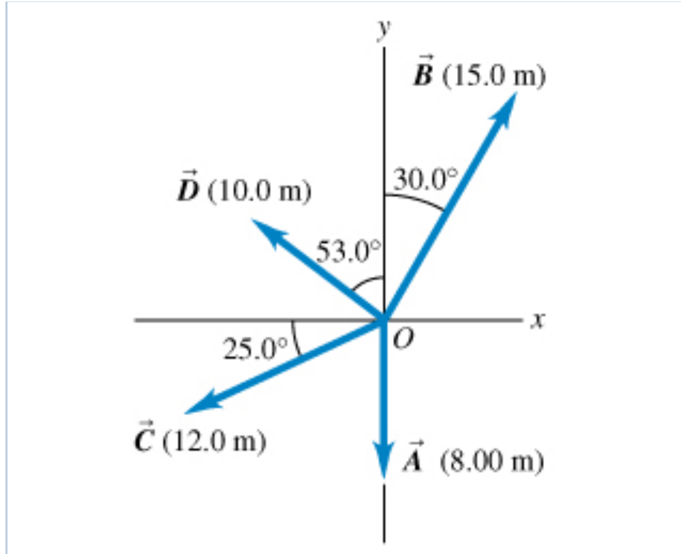
What is the vector \texttip{\vec{V}_{\rm BE}}{V_BE_vec} from point B to point E?

ANSWER:

\texttip{\vec{V}_{\rm BE}}{V_BE_vec} =

Exercise 1.43

For the vectors \vec A, \vec B, and \vec C in the figure , find the scalar products.



Part A

ANSWER:

\vec A\cdot \vec B =

Part B

ANSWER:

\vec B\cdot \vec C =

Part C

ANSWER:

\vec A\cdot\vec C =

Exercise 1.45

Find the angle between each of the following pairs of vectors \vec{A} = A_{x}\hat{ i } + A_{y}\hat{ j } and \vec{B} = B_x\hat{i} + B_y\hat{j}.

Part A

$A_{x_{1}}$= -2.00, $A_{y_{1}}$= 7.40; $B_{x_{1}}$= 2.70, $B_{y_{1}}$= -3.30.

ANSWER:

156 $^\circ$

Correct

Part B

$A_{x_{2}}$= 2.00, $A_{y_{2}}$= 6.00; $B_{x_{2}}$= 12.0, $B_{y_{2}}$= 5.40.

ANSWER:

$^\circ$

Part C

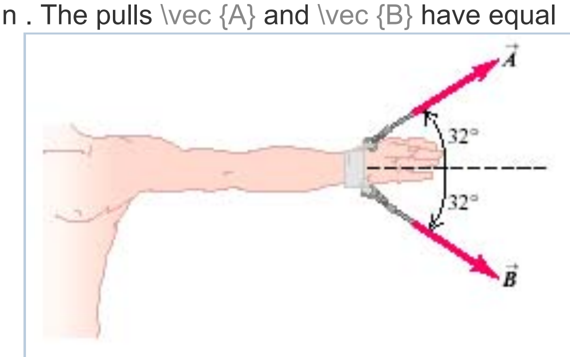
$A_{x_{3}}$ = -4.00, $A_{y_{3}}$ = 2.00; $B_{x_{3}}$ = 7.00, $B_{y_{3}}$ = 14.00.

ANSWER:

$^\circ$

Problem 1.63

A patient with a dislocated shoulder is put into a traction apparatus as shown in . The pulls $\vec {A}$ and $\vec {B}$ have equal magnitudes and must combine to produce an outward traction force of 11.5 ${\rm \; N}$ on the patient's arm.



Part A

How large should these pulls be?

Express your answer with the appropriate units.

ANSWER:

F = 6.78 {\rm N}

Answer Requested

Problem 1.65

You leave the airport in College Station and fly 26.0 {\rm \; km} in a direction 34.0^\circ south of east. You then fly 46.0 \rm km due north.

Part A

How far must you then fly to reach a private landing strip that is 32.0 \rm km due west of the College Station airport?

Express your answer with the appropriate units.

ANSWER:

R =

Part B

In what direction?

ANSWER:

\theta = ^\circ south of west

Problem 1.71

A patient in therapy has a forearm that weighs 23.0 {\rm N} and that lifts a 112.0-{\rm N} weight. These two forces have direction vertically downward. The only other significant forces on his forearm come from the biceps muscle (which acts perpendicularly to the forearm) and the force at the elbow. If the biceps produces a pull of 232 {\rm N} when the forearm is raised 43 ^\circ above the horizontal, find the magnitude and direction of the force that the elbow exerts on the forearm. (The sum of the elbow force and the biceps force must balance the weight of the arm and the weight it is carrying, so their vector sum must be 135.0 {\rm N} , upward.)

Part A

Express your answer using two significant figures.

ANSWER:

F = 169.7 \rm N

Incorrect; Try Again; 5 attempts remaining

Part B

Express your answer using two significant figures.

ANSWER:

\theta = ^\circ below the horizontal

Problem 1.69

You are lost at night in a large, open field. Your GPS tell you that you are 122.0 \rm m from your truck, in a direction 58.0^\circ east of south. You walk 74.0 {\rm \; m} due west along a ditch.

Part A

How much farther must you walk to reach your truck?

Express your answer with the appropriate units.

ANSWER:

R =

Part B

In what direction?

ANSWER:

\theta = ^\circ north of west

Problem 1.83

The scalar product of vectors \vec A and \vec B is +42.0 {\rm m^2} . Vector \vec A has magnitude 5.00 {\rm m} and direction 28.0 ^\circ west of south.

Part A

If vector \vec B has direction 39.0 ^\circ south of east, what is the magnitude of \vec B?

Express your answer with the appropriate units.

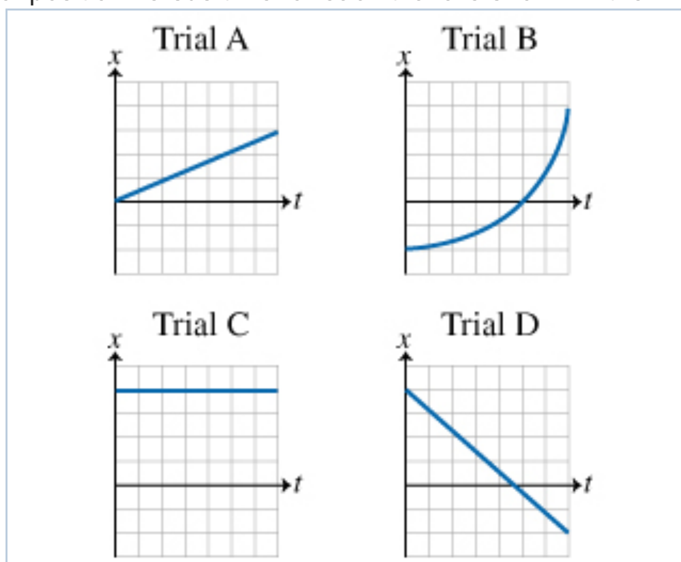
ANSWER:

B = 44.0 {\rm m}

Answer Requested

Velocity from Graphs of Position versus Time

An object moves along the *x* axis during four separate trials. Graphs of position versus time for each trial are shown in the figure.



Part A

During which trial or trials is the object's velocity not constant?

Check all that apply.

You did not open hints for this part.

ANSWER:

- ☐ Trial A
- ☐ Trial B
- ☐ Trial C
- ☐ Trial D

Part B

During which trial or trials is the magnitude of the average velocity the largest?

Check all that apply.

You did not open hints for this part.

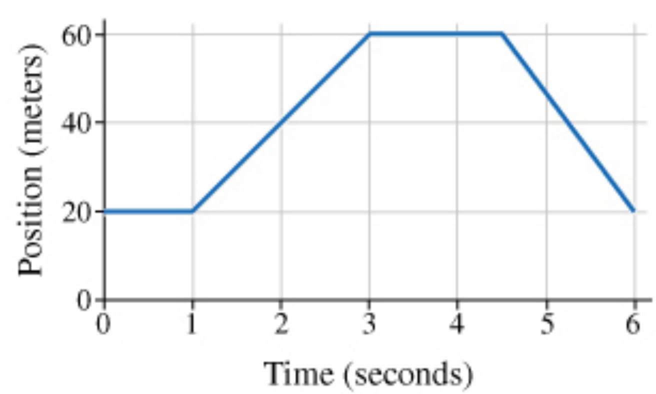
ANSWER:

- ☐ Trial A
- ☐ Trial B
- ☐ Trial C
- ☐ Trial D

± Average Velocity from a Position vs. Time Graph

Learning Goal:

To learn to read a graph of position versus time and to calculate average velocity.



In this problem you will determine the average velocity of a moving object from the graph of its position x(t) as a function of time \texttip{t}{t}. A traveling object might move at different speeds and in different directions during an interval of time, but if we ask at what *constant* velocity the object would have to travel to achieve the same displacement over the given time interval, that is what we call the object's *average velocity*. We will use the notation v_{\rm ave}[t_1, t_2] to indicate average velocity over the time interval from \texttip{t_{\rm 1}}{t_1} to \texttip{t_{\rm 2}}{t_2}. For instance, v_{\rm ave}[1, 3] is the average velocity over the time interval from t=1 to t=3.

Part A

Consulting the graph shown in the figure, find the object's average velocity over the time interval from 0 to 1 second.

Answer to the nearest integer.

You did not open hints for this part.

ANSWER:

v_{\rm ave}[0, 1] = \rm m/s

Part B

Find the average velocity over the time interval from 1 to 3 seconds.

Express your answer in meters per second to the nearest integer.

You did not open hints for this part.

ANSWER:

v_{\rm ave}[1, 3] = \rm m/s

Part C

Now find v_{\rm ave}[0,3].

Give your answer to three significant figures.

You did not open hints for this part.

ANSWER:

v_{\rm ave}[0, 3] = \rm m/s

Part D

Find the average velocity over the time interval from 3 to 6 seconds.

Express your answer to three significant figures.

You did not open hints for this part.

ANSWER:

v_{\rm ave}[3.0, 6.0] = \rm m/s

Part E

Finally, find the average velocity over the whole time interval shown in the graph.

Express your answer to three significant figures.

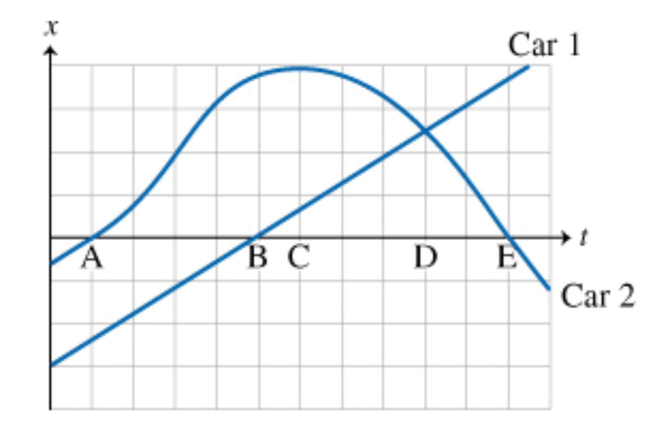
You did not open hints for this part.

ANSWER:

v_{\rm ave}[0.0, 6.0] = \rm m/s

Analyzing Position versus Time Graphs: Conceptual Question

Two cars travel on the parallel lanes of a two-lane road. The cars' motions are represented by the position versus time graph shown in the figure. Answer the questions using the times from the graph indicated by letters.



Part A

At which of the times do the two cars pass each other?

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- None
- Cannot be determined

Part B

This question will be shown after you complete previous question(s).

Part C

At which of the lettered times, if any, does car #1 momentarily stop?

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- none
- cannot be determined

Part D

At which of the lettered times, if any, does car #2 momentarily stop?

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- none
- cannot be determined

Part E

At which of the lettered times are the cars moving with nearly identical velocity?

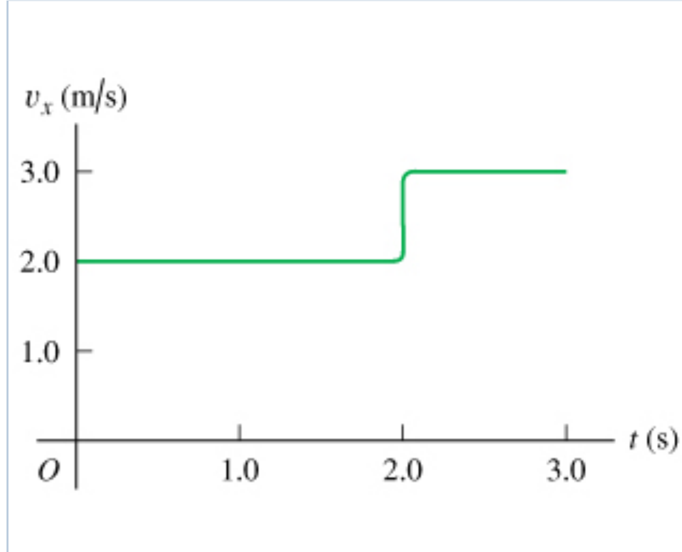
You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- None
- Cannot be determined

Exercise 2.9

A ball moves in a straight line (the *x*-axis). The graph in the figure shows this ball's velocity as a function of time.



Part A

What are the ball's average velocity during the first 2.9 {\rm s} ?

Express your answer using two significant figures.

ANSWER:

v_{\rm av} = {\rm m/s }

Part B

What are the ball's average speed during the first 2.9 {\rm s} ?

Express your answer using two significant figures.

ANSWER:

s_{\rm av} = {\rm m/s }

Part C

Suppose that the ball moved in such a way that the graph segment after 2.0 {\rm s} was -3.0 {\rm{ m/s}} instead of +3.0 {\rm{ m/s}}. Find the ball's and average velocity during the first 2.9 {\rm s} in this case.

Express your answer using two significant figures.

ANSWER:

v_{\rm av} = [ ] {\rm m/s }

Part D

Suppose that the ball moved in such a way that the graph segment after 2.0 {\rm s} was -3.0 {\rm{ m/s}} instead of +3.0 {\rm{ m/s}}. Find the ball's average speed during the first 2.9 {\rm s} in this case.

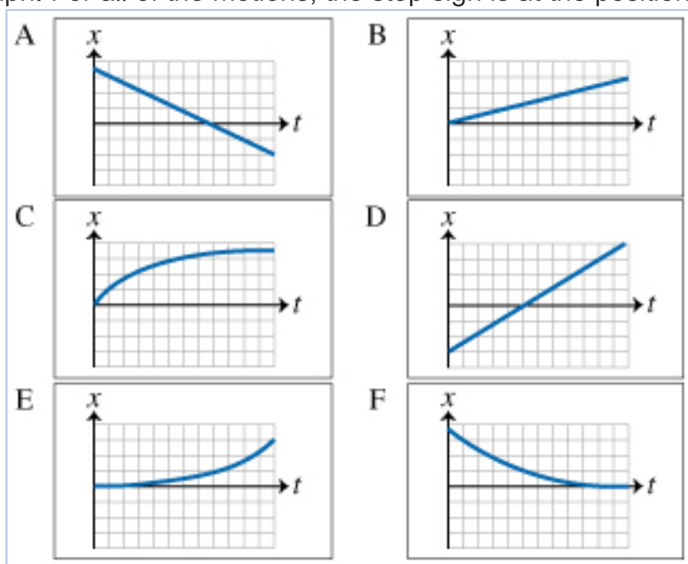
Express your answer using two significant figures.

ANSWER:

s_{\rm av} = [ ] {\rm m/s }

Position versus Time Graphs Conceptual Question

The motions described in each of the questions take place at an intersection on a two-lane road with a stop sign in each direction. For each motion, select the correct position versus time graph. For all of the motions, the stop sign is at the position x=0, and east is the positive *x* direction.



Part A

A driver ignores the stop sign and continues driving east at constant speed.

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- F

Part B

A driver ignores the stop sign and continues driving west at constant speed.

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- F

Part C

A driver, traveling west, slows and stops at the stop sign.

You did not open hints for this part.

ANSWER:

- A
- B
- C
- D
- E
- F

Part D

A driver, after stopping at the stop sign, accelerates to the east.

You did not open hints for this part.

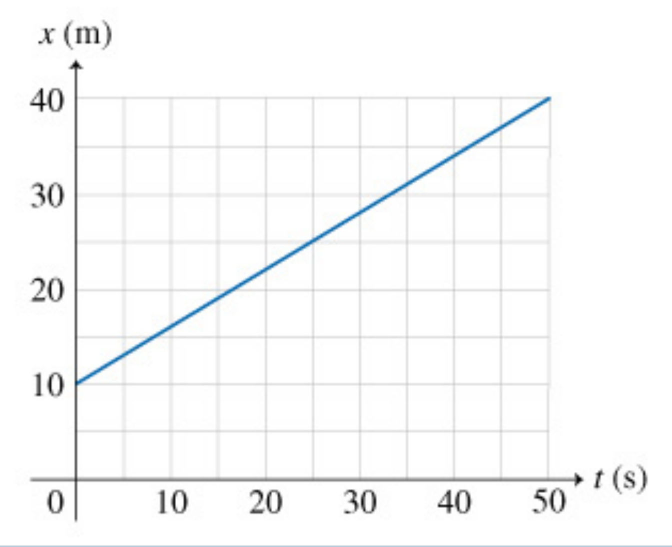
ANSWER:

- A
- B
- C
- D
- E
- F

What x vs. t Graphs Can Tell You

To describe the motion of a particle along a straight line, it is often convenient to draw a graph representing the position of the particle at different times. This type of graph is usually referred to as an *x vs. t graph.* To draw such a graph, choose an axis system in which time \texttip{t}{t} is plotted on the horizontal axis and position \texttip{x}{x} on the vertical axis. Then, indicate the values of \texttip{x}{x} at various times \texttip{t}{t}. Mathematically, this corresponds to plotting the variable \texttip{x}{x} as a function of \texttip{t}{t}. An example of a graph of position as a function of time for a particle traveling along a straight line is shown below. Note that an x vs. t graph like this does *not* represent the path of the particle in space.

Now let's study the graph shown in the figure in more detail. Refer to this graph to answer Parts A, B, and C.



Part A

What is the total distance \texttip{\Delta x}{Deltax} traveled by the particle?

Express your answer in meters.

You did not open hints for this part.

ANSWER:

\texttip{\Delta x}{Deltax} = \rm m

Part B

What is the average velocity \texttip{v_{\rm av}}{v_av} of the particle over the time interval \Delta t=50.0\;\rm s ?

Express your answer in meters per second.

You did not open hints for this part.

ANSWER:

\texttip{v_{\rm av}}{v_av} = \rm m/s

Part C

What is the instantaneous velocity \texttip{v}{v} of the particle at t=10.0\;\rm s?

Express your answer in meters per second.

You did not open hints for this part.

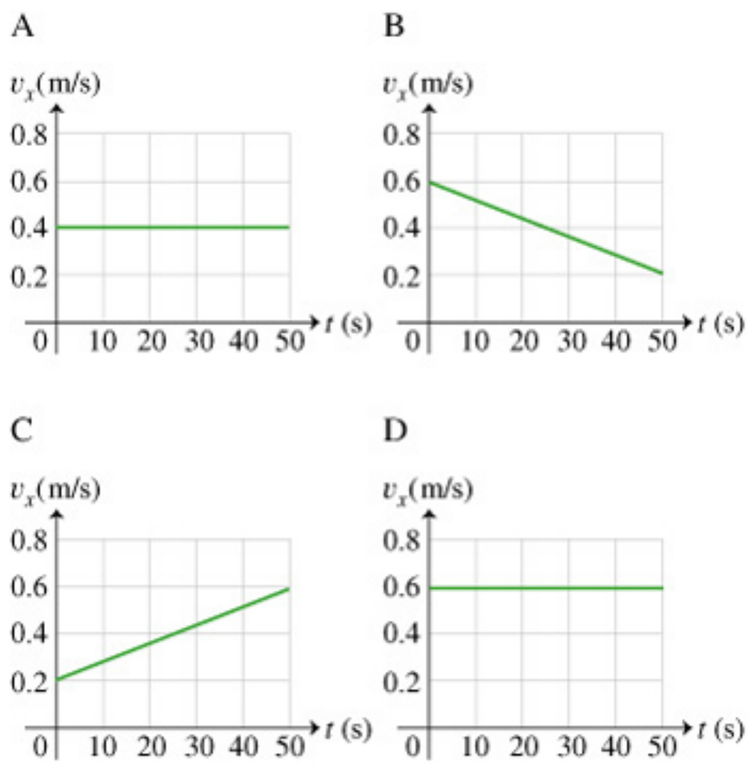
ANSWER:

\texttip{v}{v} = \rm m/s

Another common graphical representation of motion along a straight line is the *v vs. t graph*, that is, the graph of (instantaneous) velocity as a function of time. In this graph, time \texttip{t}{t} is plotted on the horizontal axis and velocity \texttip{v}{v} on the vertical axis. Note that by definition, velocity and acceleration are vector quantities. In straight-line motion, however, these vectors have only one nonzero component in the direction of motion. Thus, in this problem, we will call \texttip{v}{v} the velocity and \texttip{a}{a} the acceleration, even though they are really the components of the velocity and acceleration vectors in the direction of motion.

Part D

Which of the graphs shown is the correct v vs. t plot for the motion described in the previous parts?



You did not open hints for this part.

ANSWER:

- Graph A
- Graph B
- Graph C
- Graph D

Part E

This question will be shown after you complete previous question(s).

Direction of Velocity and Acceleration Vector Quantities Conceptual Question

For each of the motions described below, determine the algebraic sign (+, -, or 0) of the velocity and acceleration of the object at the time specified. For all of the motions, the positive *y* axis is upward.

Part A

An elevator is moving downward when someone presses the emergency stop button. The elevator comes to rest a short time later. Give the signs for the velocity and the acceleration of the elevator after the button has been pressed but before the elevator has stopped.

Enter the correct sign for the elevator's velocity and the correct sign for the elevator's acceleration, separated by a comma. For example, if you think that the velocity is positive and the acceleration is negative, then you would enter `+,-` . If you think that both are zero, then you would enter `0,0` .

You did not open hints for this part.

ANSWER:

Part B

A child throws a baseball directly upward. What are the signs of the velocity and acceleration of the ball immediately after the ball leaves the child's hand?

Enter the correct sign for the baseball's velocity and the correct sign for the baseball's acceleration, separated by a comma. For example, if you think that the velocity is positive and the acceleration is negative, then you would enter `+,-` . If you think that both are zero, then you would enter `0,0` .

You did not open hints for this part.

ANSWER:

Part C

A child throws a baseball directly upward. What are the signs of the velocity and acceleration of the ball at the very top of the ball's motion (i.e., the point of maximum height)?

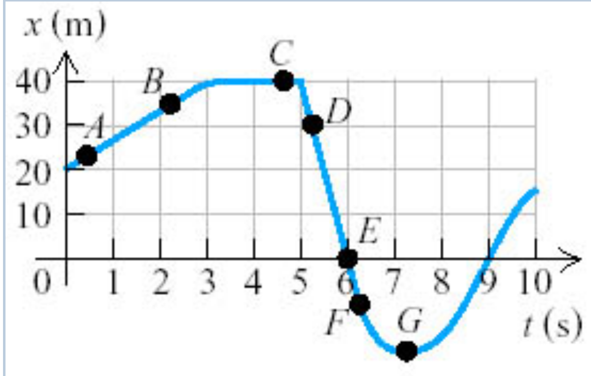
Enter the correct sign for the baseball's velocity and the correct sign for the baseball's acceleration, separated by a comma. For example, if you think that the velocity is positive and the acceleration is negative, then you would enter `+,-` . If you think that both are zero, then you would enter `0,0` .

You did not open hints for this part.

ANSWER:

Exercise 2.11

A test car travels in a straight line along the \texttip{x}{x} axis. The graph in the figure shows the car's position \texttip{x}{x} as a function of time.



Part A

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{A}{A}.

ANSWER:

v_{Ax} = {\rm m/s}

Part B

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{B}{B}.

ANSWER:

v_{Bx} = {\rm m/s}

Part C

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{C}{C}.

ANSWER:

v_{Cx} =		{\rm m/s}

Part D

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{D}{D}.

ANSWER:

v_{Dx} =		{\rm m/s}

Part E

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{E}{E}.

ANSWER:

v_{Ex} =		{\rm m/s}

Part F

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{F}{F}.

ANSWER:

v_{Fx} =		{\rm m/s}

Part G

Find the \texttip{x}{x} component of instantaneous velocity at point \texttip{G}{G}.

ANSWER:

v_{Gx} =		{\rm m/s}

Exercise 2.15

A turtle crawls along a straight line, which we will call the *x*-axis with the positive direction to the right. The equation for the turtle's position as a function of time is x(t)=50.0\;{\rm cm}+(2.00\;{\rm cm/s})\,t-(0.0625\;{\rm cm/s^2})\,t^2.

Part A

Find the turtle's initial velocity.

ANSWER:

v_{\rm x} = [ ] {\rm cm/s}

Part B

Find the turtle's initial position.

ANSWER:

x = [ ] {\rm cm}

Part C

Find the turtle's initial acceleration.

ANSWER:

a_{\rm x} = [ ] {\rm cm/s^2}

Part D

This question will be shown after you complete previous question(s).

Part E

This question will be shown after you complete previous question(s).

Part F

This question will be shown after you complete previous question(s).

Part G

This question will be shown after you complete previous question(s).

Part H

This question will be shown after you complete previous question(s).

Part I

This question will be shown after you complete previous question(s).

Part J

This question will be shown after you complete previous question(s).

Part K

This question will be shown after you complete previous question(s).

Part L

This question will be shown after you complete previous question(s).

Part M

This question will be shown after you complete previous question(s).

Part N

This question will be shown after you complete previous question(s).

Part O

This question will be shown after you complete previous question(s).

Part P

This question will be shown after you complete previous question(s).

Part Q

This question will be shown after you complete previous question(s).

Exercise 2.17

A car's velocity as a function of time is given by $v_{x}(t)= \alpha + \beta t^{2}$, where $\alpha=3.00\;{\rm m}/{\rm s}$ and $\beta=0.100\; {\rm m}/{\rm s}^{3}$.

Part A

Calculate the average acceleration for the time interval $t=0$ to $t=5.00\;{\rm s}$.

ANSWER:

$a_{\rm ave}$ = ______ ${\rm m/s^2}$

Part B

Calculate the instantaneous acceleration for $t = 0$.

ANSWER:

a = ______ ${\rm m/s^2}$

Part C

Calculate the instantaneous acceleration for $t = 5.00$ s.

ANSWER:

a = [ ] {\rm m/s^2}

Part D

This question will be shown after you complete previous question(s).

Part E

This question will be shown after you complete previous question(s).

Score Summary:

Your score on this assignment is 47.6%.
You received 95.17 out of a possible total of 200 points.