Good morning!

Please, sign in, login into webassing, locate LectureMCQ_L4 (PY105) and answer question 1 (but ONLY Q1 !)

No labs today

No class on Monday

HW1P1

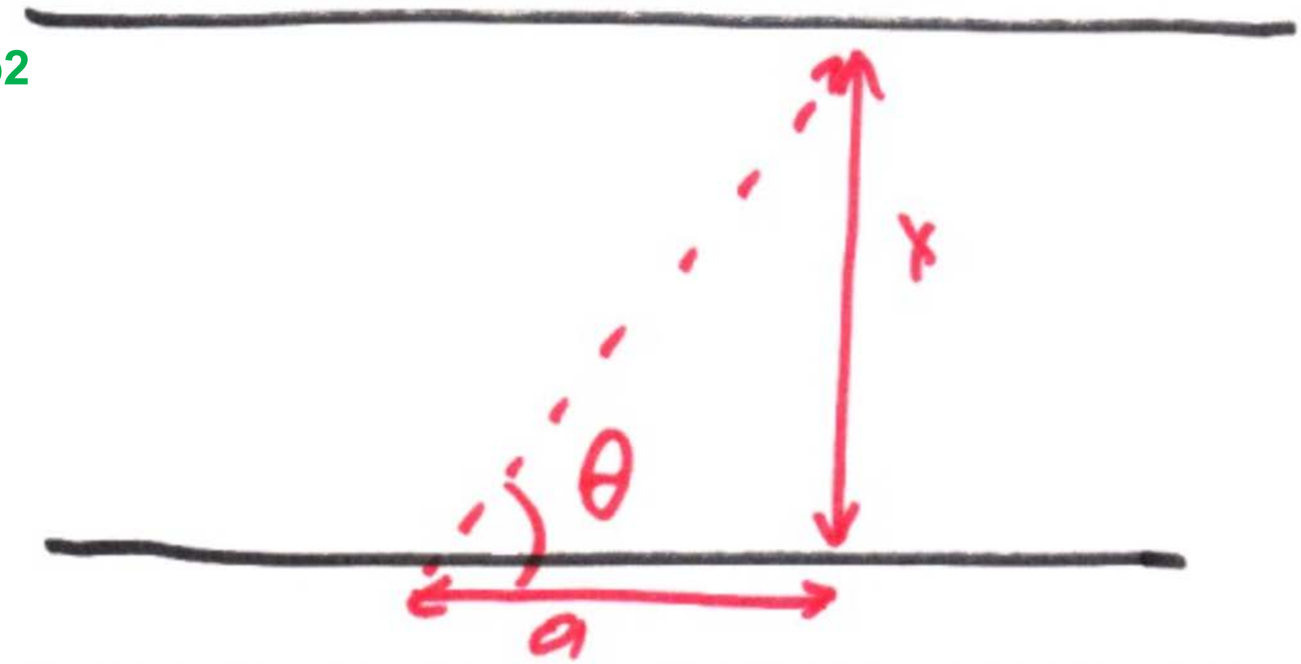
100.0%	33m	25
24.0%	16m	6
–	-	ND
–	-	NS
–	-	ND
–	-	NS
56.0%	66m	14
–	-	NS
–	-	ND
100.0%	346m	25
56.0%	116m	14
–	-	ND
–	-	NS
32.0%	-	8
20.0%	-	5
–	-	ND
36.0%	74m	9
–	-	NS
–	-	ND
100.0%	49m	25
100.0%	83m	25
–	-	NS
20.0%	44m	5
–	-	ND
–	-	NS
96.0%	65m	24
–	-	ND

–	-	NS
–	-	ND
28.0%	72m	7
40.0%	12m	10
20.0%	12m	5
48.0%	60m	12
–	47m	NS
–	-	ND
72.0%	55m	18
100.0%	76m	25
16.0%	-	4
–	-	NS
44.0%	51m	11
84.0%	56m	21
100.0%	29m	25
–	-	NS
72.0%	100m	18
–	-	NS
36.0%	68m	9
40.0%	89m	10

36.0%	36m	9
92.0%	74m	23
–	2m	NS
100.0%	108m	25
100.0%	-	25
–	-	ND
88.0%	69m	22
–	-	ND
100.0%	-	25
20.0%	137m	5
32.0%	30m	8
–	-	ND
60.0%	77m	15
32.0%	209m	8
28.0%	45m	7
–	-	NS
–	-	ND
28.0%	72m	7
40.0%	12m	10
20.0%	12m	5
48.0%	60m	12
–	47m	NS
–	-	ND
72.0%	55m	18
100.0%	76m	25
16.0%	-	4

96.0%	42m	24
20.0%	-	5
100.0%	123m	25
–	-	NS
28.0%	-	7
–	-	NS
–	-	ND
–	-	ND
20.0%	13m	5
–	-	ND
100.0%	-	25
72.0%	316m	18
84.0%	97m	21
–	-	ND
100.0%	57m	25
80.0%	-	20
–	-	ND
20.0%	-	5
72.0%	262m	18
–	-	ND
100.0%	63m	25
100.0%	51m	25
100.0%	197m	25
–	-	NS
20.0%	80m	5
–	-	NS

Lab2



More notes are on BB

2. Execute your experiment, provide the appropriate data and calculations, and present the result.

Measure a and θ

$$x = a \cdot \tan\theta$$

1) A small ball was released from rest from a window 4.9 m above the ground. The ball hits the ground 1 second later. Find the acceleration of the ball.

2) If the same ball was shot straight up with the same acceleration and the initial speed of 10 m/s, how high would it go?

Two balls of the *same size* are simultaneously dropped from the roof of a two story building.
One weighs *twice* as much as the other.
The time it takes to the heavy ball to reach the ground is:

(1) about half as long as for the lighter ball.

(2) about the same as long as for the lighter ball.

(3) about twice as much time as for lighter ball.

LectureMCQ L4 Q2

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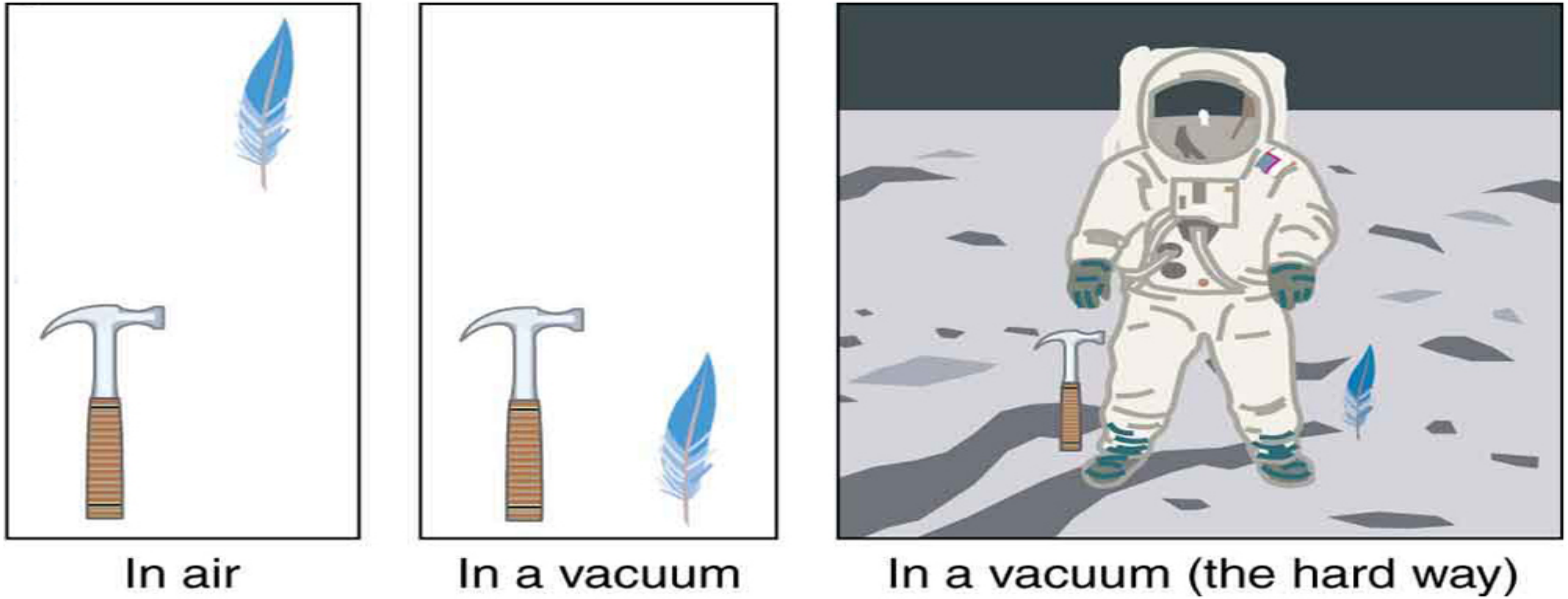
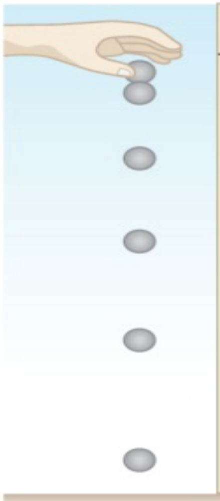
LectureMCQ L4 Q2

https://www.youtube.com/watch?v=Cxzo_Ct3Yf8 http://teachology.xyz/fpe.mov



A hammer and a feather will fall with the same constant acceleration if air resistance is considered negligible. This is a general characteristic of gravity not unique to Earth, as astronaut David R. Scott demonstrated on the Moon in 1971, where the acceleration due to gravity is only 1.67 m/s^2 .



y (m)	v (m/s)	t (s)
0	0	0
−0.049	−0.98	0.1
−0.196	−1.96	0.2
−0.441	−2.94	0.3
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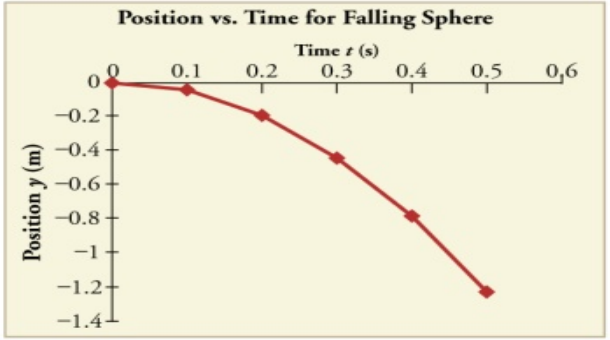
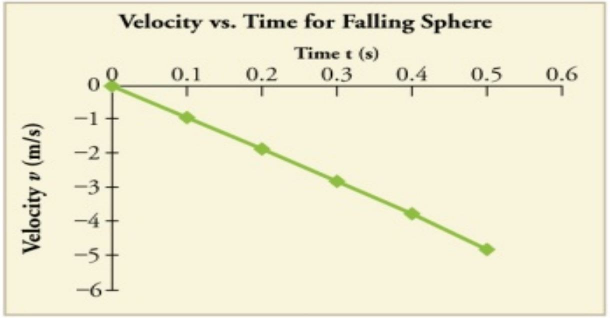
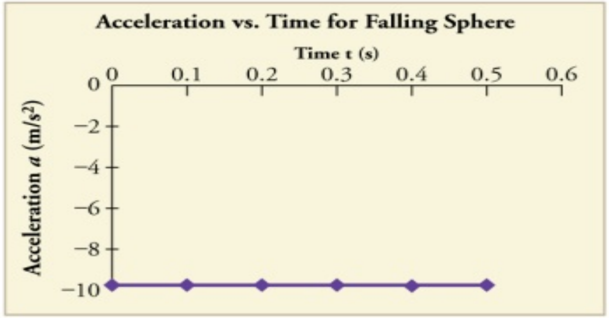
−1.225	−4.90	0.5



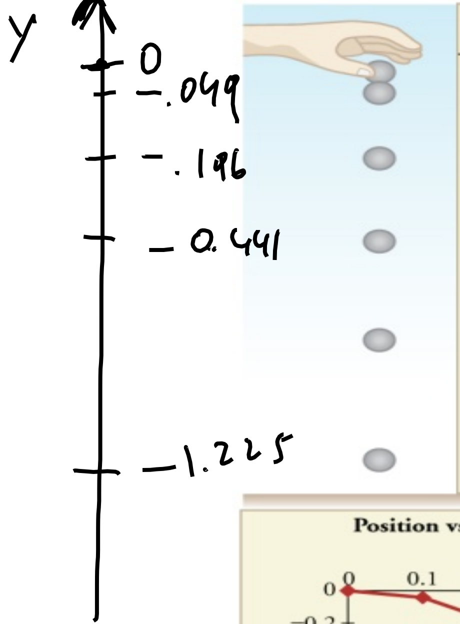




Something *very* important is missing in this picture.

<u>What is it?</u>

(Think of the assumptions made to take the measurements).



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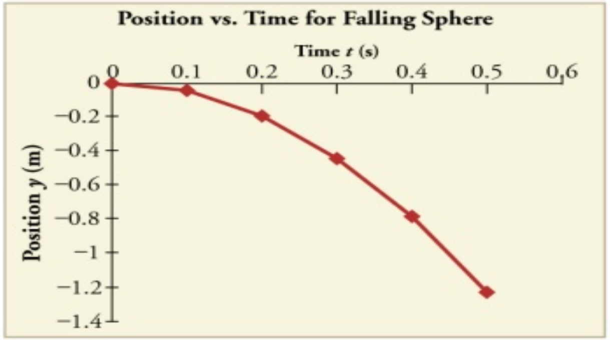

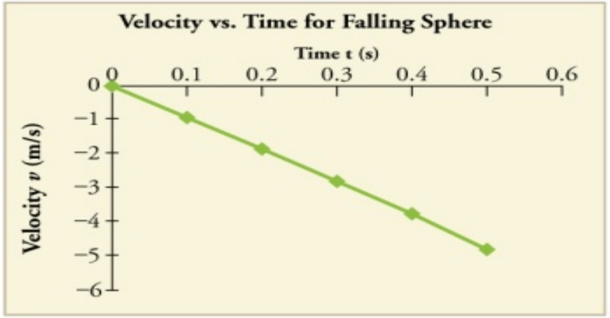

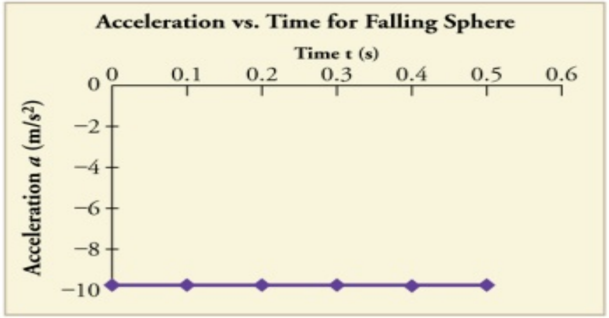

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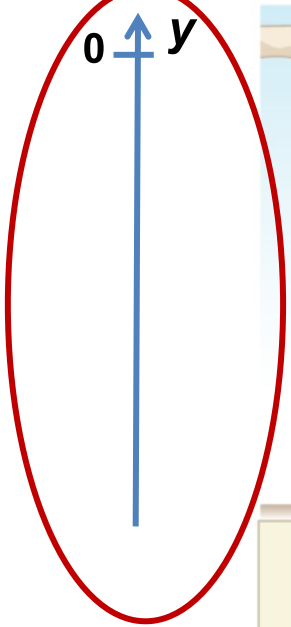

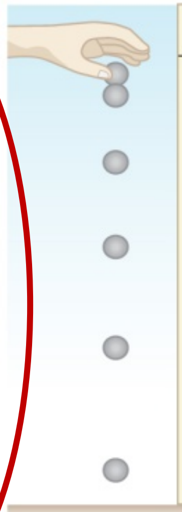

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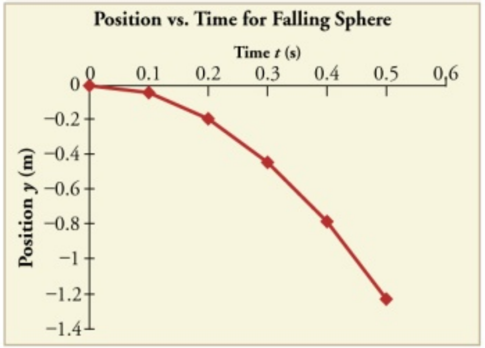

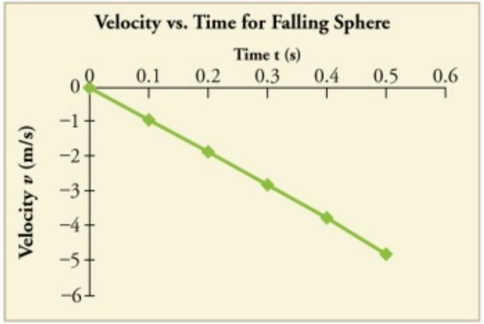

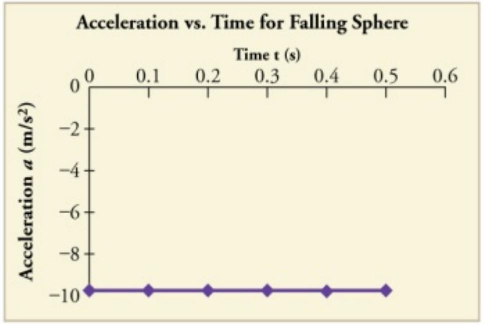

Positions and velocities of a metal ball released from rest when air resistance is negligible.

LectureMCQ L4 Q3

The acceleration of the ball points:

1. up
2. down
3. left
4. right
5. to Boston

Positions and velocities of a metal ball released from rest when air resistance is negligible.

LectureMCQ L4 Q3

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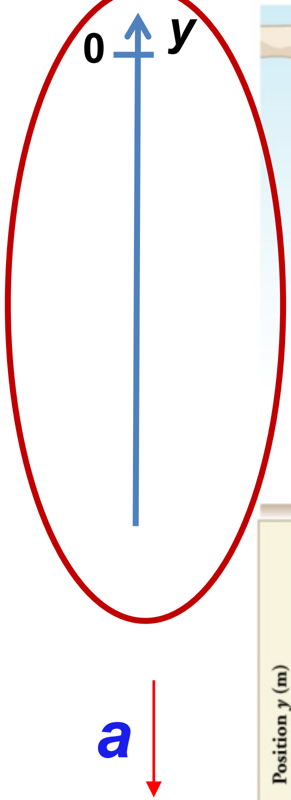
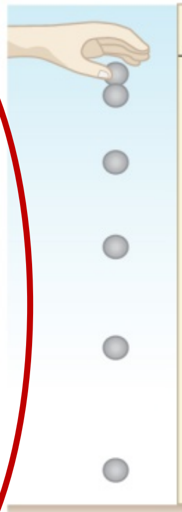
$V_0 = 0$

$|V|$

$V \neq 0$

a





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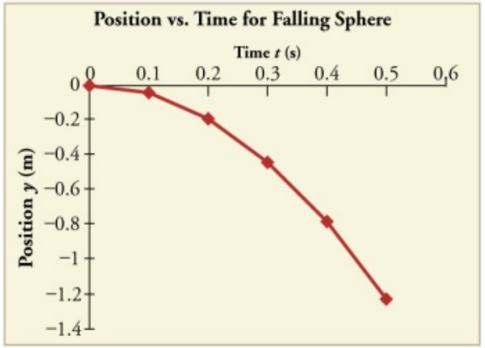
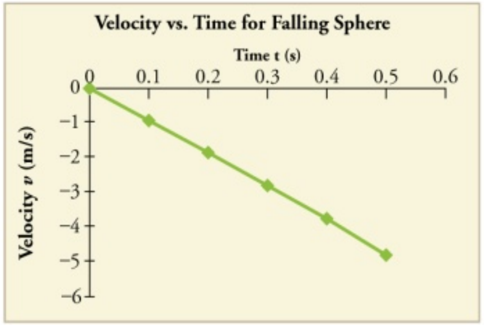
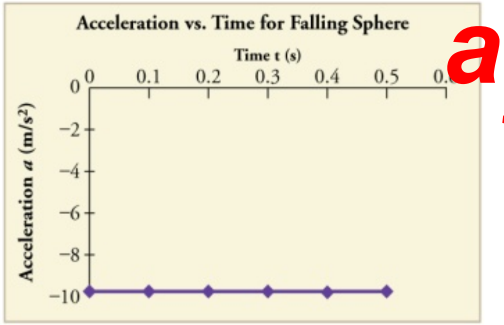


Positions and velocities of a metal ball released from rest when air resistance is negligible.

Acceleration is a constant and is equal to *gravitational acceleration.*

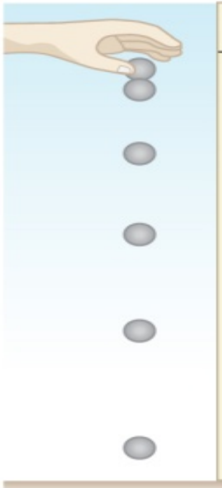




$$a_y = a = -\,g = -\,9.8\ m/s^2$$

$$g = |a| = 9.8\ m/s^2$$

Flip the axis



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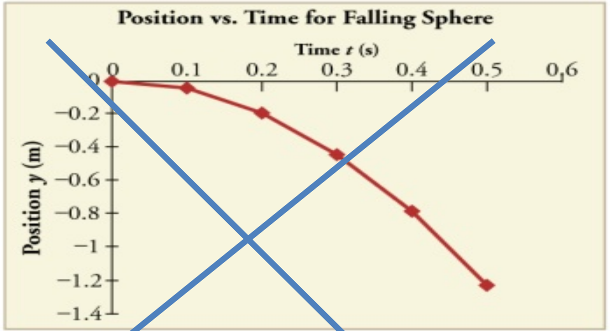
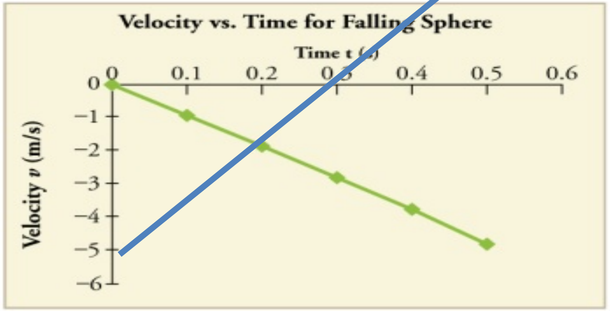
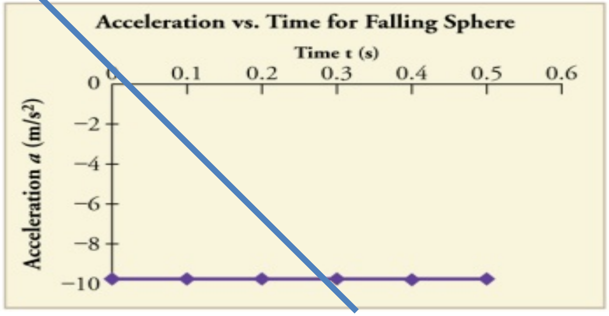






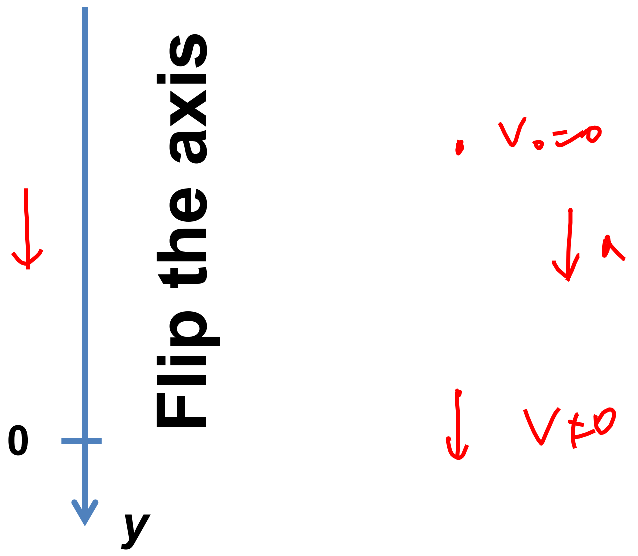
For y-axis pointing *down* ALL data will be different!

$g = |a| = 9.8\ m/s^2$

LectureMCQ_L4_ Q4

Now a = …

1. 0
2. g
3. $-g$
4. disappeared



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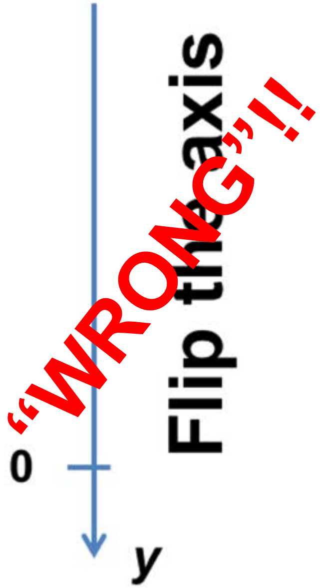

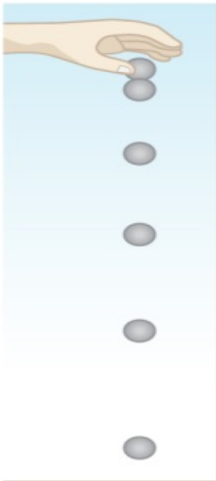

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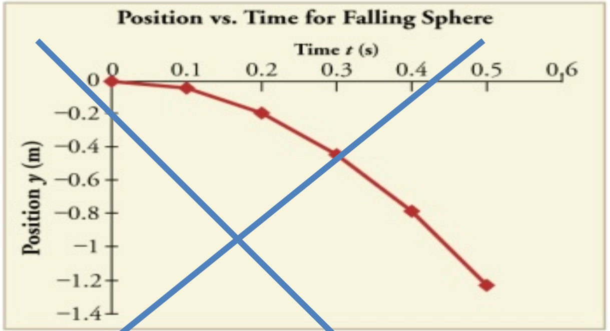
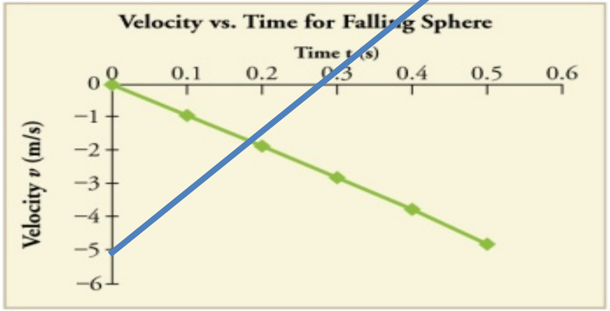
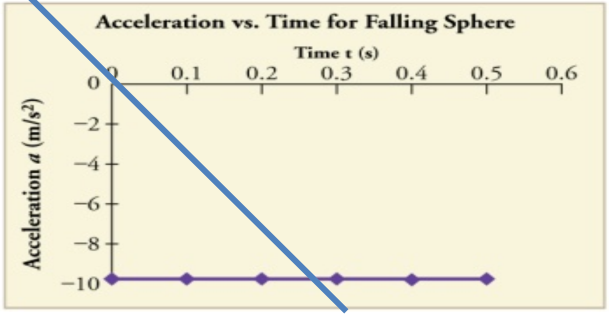




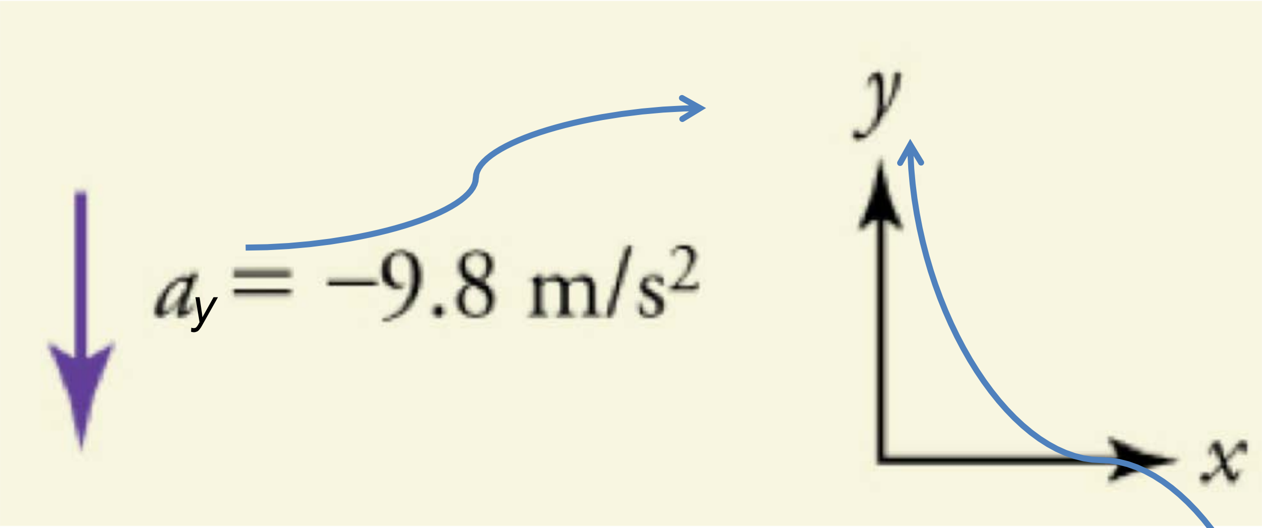


ALWAYS select positive y-direction UP!

Always point y-axis UP!

FREE FALL = MCA !

1-D motion



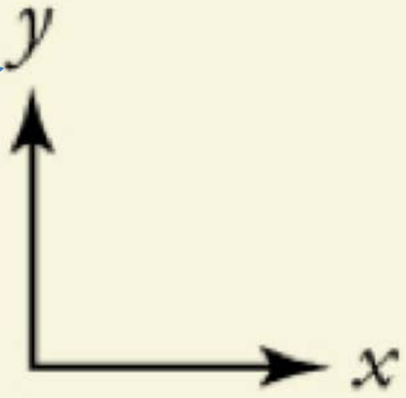
At the Earth's surface, $\vec{g}$, the acceleration due to gravity, equals 9.8 m/s^2 and is directed down.

$g = |a_y| = 9.8\ \mathrm{m/s^2} \sim 10\ \mathrm{m/s^2}$ => $a_y = -g$

y – axis points UP !

1-D motion

$$a_y = -9.8\ \text{m/s}^2$$



$$g = |a_y| = 9.8\ \text{m/s}^2$$

$$y = y_i + v_{iy}t + \frac{a_y t^2}{2} = y_0 + v_{oy}t - \frac{gt^2}{2}$$

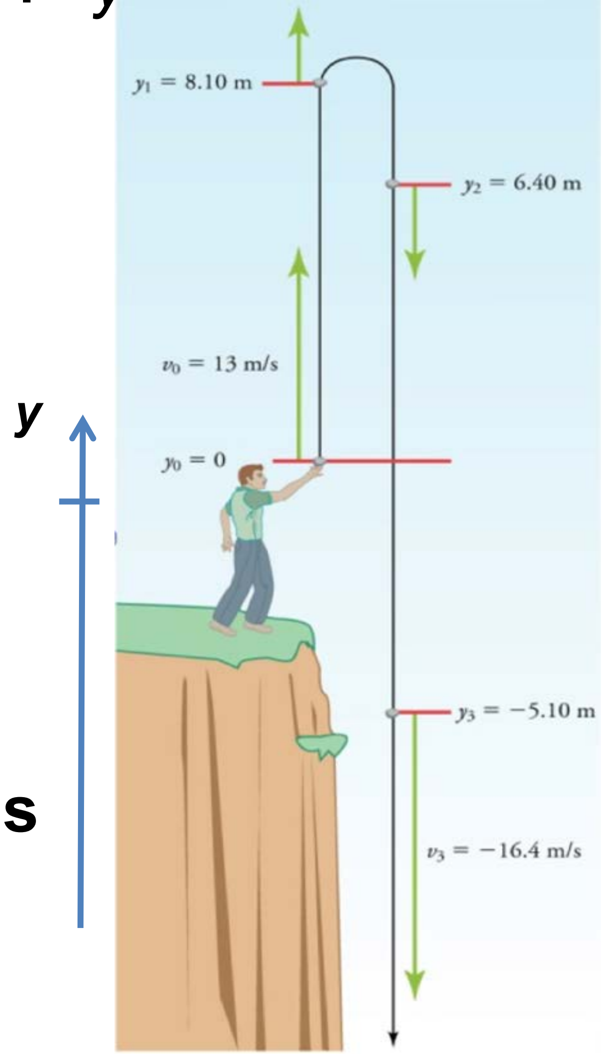
$$v_y = v_{iy} + a_y t = v_{0y} - gt$$

For *any* direction of y-axis

$$\boldsymbol{v_{y\,ave} = (v_{y\,0} + v_{y\,f})/2}$$

Only when y-axis points UP.

$$\boldsymbol{v_y^{\,2} = v_{oy}^{\,2} - 2\,g\,(y - y_o)}$$



A small ball was released from rest from a window 4.9 m above the ground. The ball hits the ground 1 second later. Find the acceleration of the ball.

$V_0 = 0 \text{ m/s}$

$X_i = 4.9 \text{ m}$

$\boxed{V = V_0 + a \cdot t}$

$X_f = 0 \text{ m}$

$\boxed{X = X_i + V_i \cdot t + \frac{1}{2} a t^2}$

MCA

$X = 0$, $X_i = 4.9$, $V_i = 0$, $t = 1 \text{ s}$

$0 = 4.9 + 0 \cdot 1 + \frac{1}{2} \cdot a \cdot 1^2$

$-4.9 \cdot 2 = a$

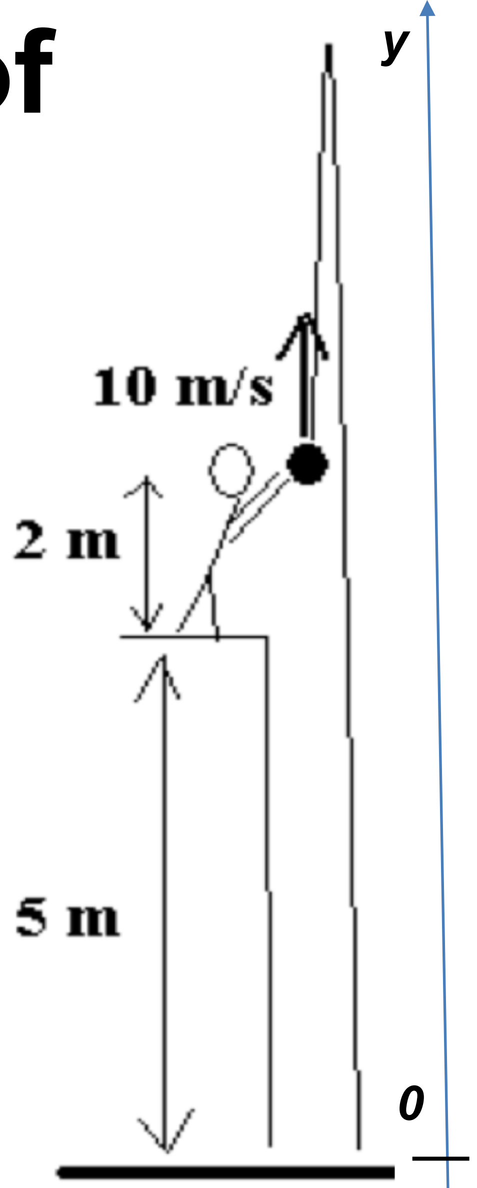
$\boxed{-9.8 = a}$

$a = -9.8 \text{ m/s}^2$

A man standing on the roof of a 5 m high barn shoots a ball straight upward with the initial speed of 10 m/s, releasing the ball when it is 2 m above the roof. How much time is needed for the ball to reach the highest point of the trajectory? Find: The height of the ball from the ground at its highest point; The total time the ball was flying; The total distance traveled by the ball; The total displacement traveled by the ball; The average speed of the ball over the total time the ball was in the air; The average velocity of the ball over the total time the ball was in the air; The speed of the ball just before it hits the ground.

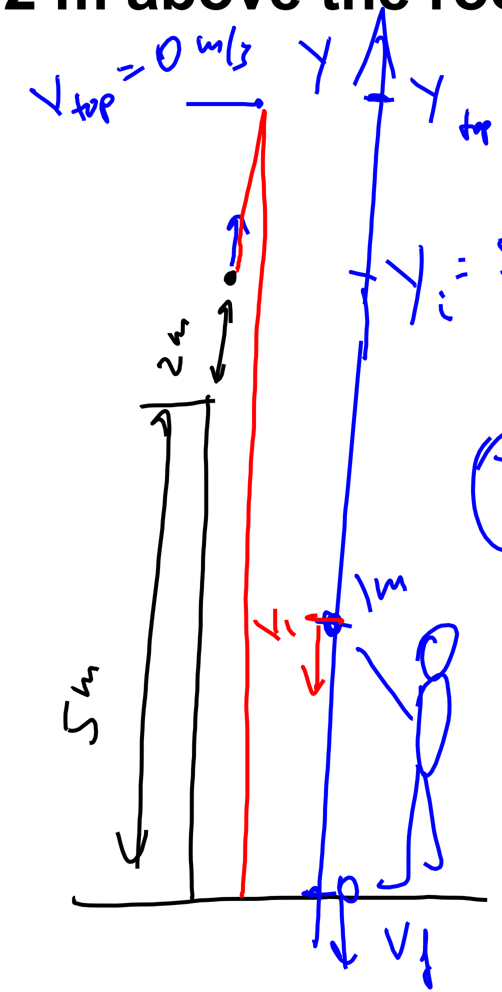
A man standing on the roof of a 5 m high barn shoots a ball straight upward with the initial speed of 10 m/s, releasing the ball when it is 2 m above the roof.

Find EVERYTHING!



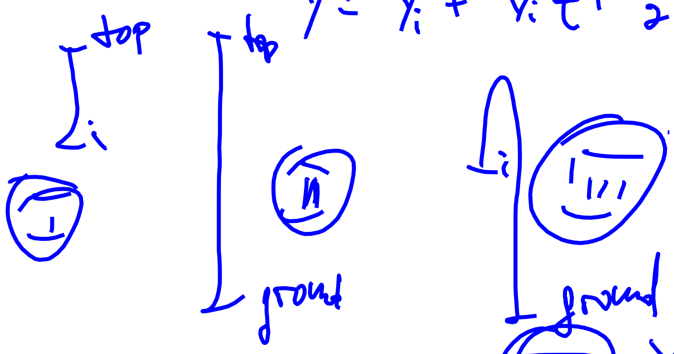
A man standing on the roof of a 5 m high barn shoots a ball straight upward with the initial speed of 10 m/s, releasing the ball when it is 2 m above the roof.

$v_i = 10\ m/s$



MCA: $v = v_i + a\cdot t$

$y = y_i + v_i t + \frac{1}{2} a t^2$ | $a = -10\ m/s^2$



I

$0 = 10 - 10\cdot t_{top}$

$y_{top} = 7 + 10t + \frac{-10\cdot t_{top}^2}{2}$

$t_{top} = 1s$; $y_{top} = 7 + 10 - \frac{10}{2} = 12m$

III

$v_f = 10 - 10\, t_{tot}$

$0 = 7 + 10 t_{tot} + \frac{1}{2} \frac{-10\cdot t_{tot}^2}{2}$

IV

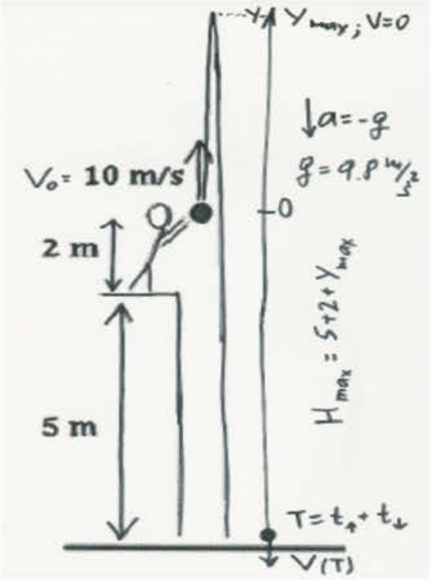
$v_1 = 10 - 10\cdot t_1$

$1 = 7 + 10\cdot t_1 + \frac{-10 t_1^2}{2}$

$v^2 = v_i^2 + 2\cdot a\cdot \Delta y$

$v_1^2 = 10^2 + 2\cdot(-10)\cdot(1-7)$

A man standing on the roof of 5 m high barn shoots a basketball straight upward with the initial speed of 10 m/s, releasing the ball when it is 2 m above the roof.



Try to find: (use $g = 10\ m/s^2$)

How much time is needed for the ball to reach the highest point of the trajectory?

$V = V - gt$ at Y_{max} $V = 0$ => $0 = 10 - 10 * t_{\uparrow}$ => $t_{\uparrow} = 1\ s$

The height of the ball from the ground at its highest point. $y = 10t - \frac{10t^2}{2} = 10t - 5t^2$

$Y_{max} = y(1) = 5\ m$

The total time the ball was flying. $T = t_{\uparrow} + t_{\downarrow} = 1 + t_{\downarrow}$

From the highest point to the ground is 12 m => $12 = \frac{10t_{\downarrow}{}^2}{2}$ => $t_{\downarrow} = \sqrt{2.4}\ s$

Another way: $-7 = 10T - \frac{10T^2}{2} = 10T - 5T^2$ => $T^2 - 2T - 1.4 = 0$ => $T = \frac{2 \pm \sqrt{4 + 4 * 1.4}}{2} = 1 + \sqrt{2.4}$

The total distance traveled by the ball. 5 + 12 = 17 m

The average speed of the ball over the total time the ball was in the air 17/T

The total displacement traveled by the ball -7 m

The average velocity of the ball over the total time the ball was in the air -7/T

The speed of the ball just before it hits the ground: velocity $V_f = V(T) = 10 - 10 * T$ speed $|10 - 10 * T|$

EXAMPLE : You are driving your car at 20 m/s when you see a deer in the road 60 m ahead. It takes you 1.0 seconds before you apply the brakes, but then the car slows down and comes to a stop.

Assuming the car's acceleration is constant what magnitude acceleration (at least) is required to avoid hitting the deer? ___________

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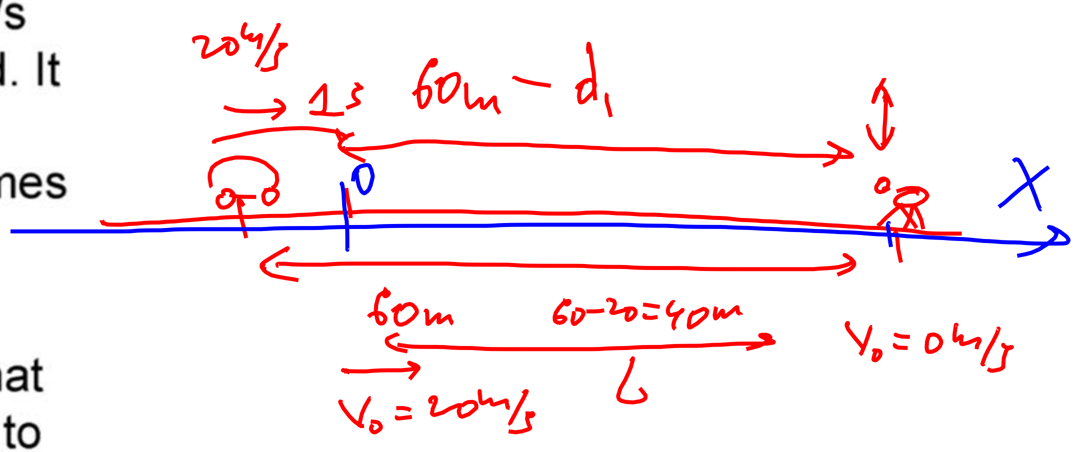


Assuming the car's acceleration is constant what magnitude acceleration (at least) is required to avoid hitting the deer? __________

(From: A. Duffy)

$$d_1 = \underbrace{\Delta x = v \cdot t}_{} = 20 \cdot 1 = 20\,m$$

② : MCA

$$v = v_i + a \cdot t$$
$$x = x_i + v_i t + \tfrac{1}{2} a t^2$$

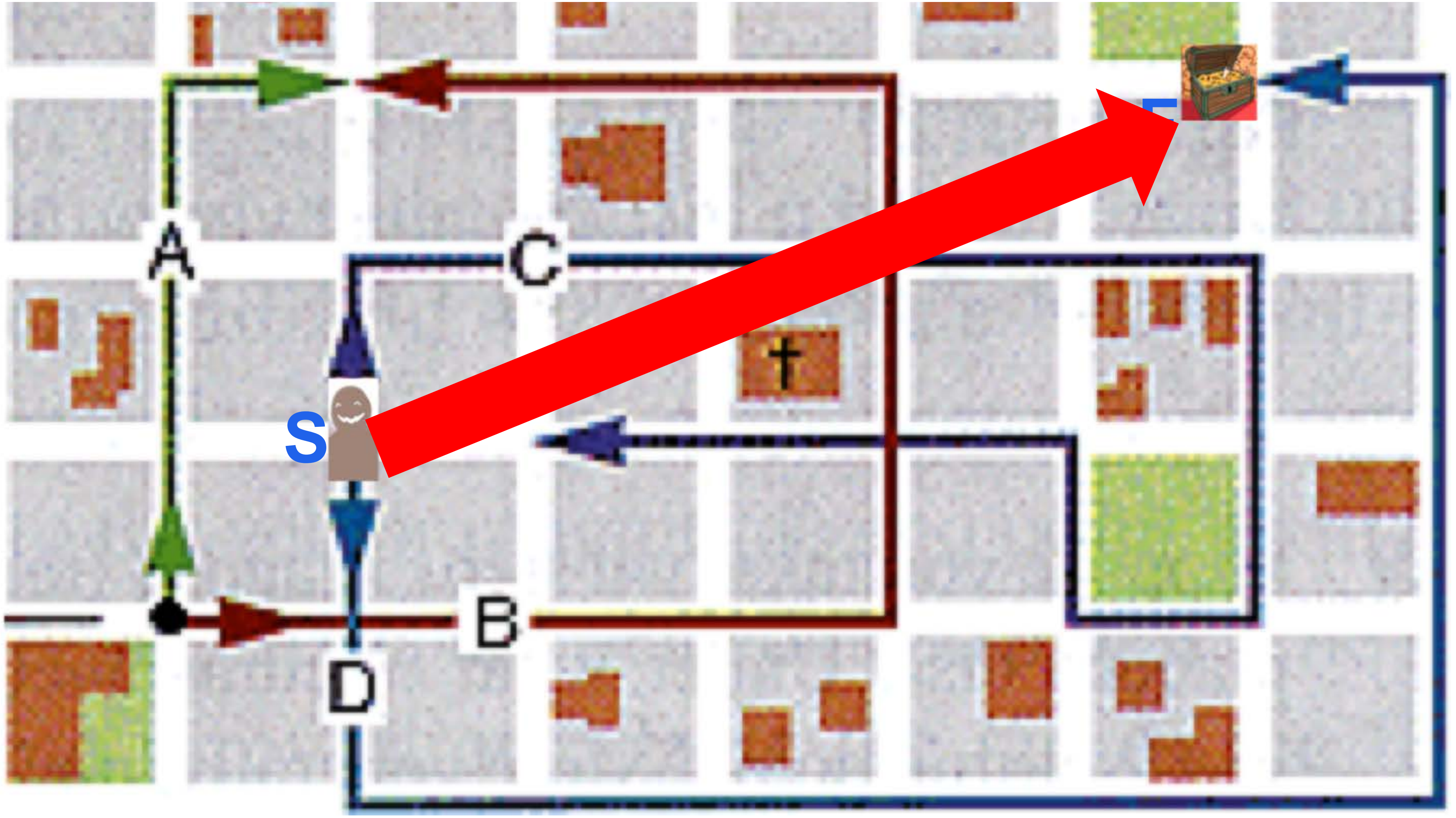
MCV

$$0 = 20 + a \cdot t$$
$$40 = 0 + 20 t + \tfrac{1}{2} a \cdot t^2$$

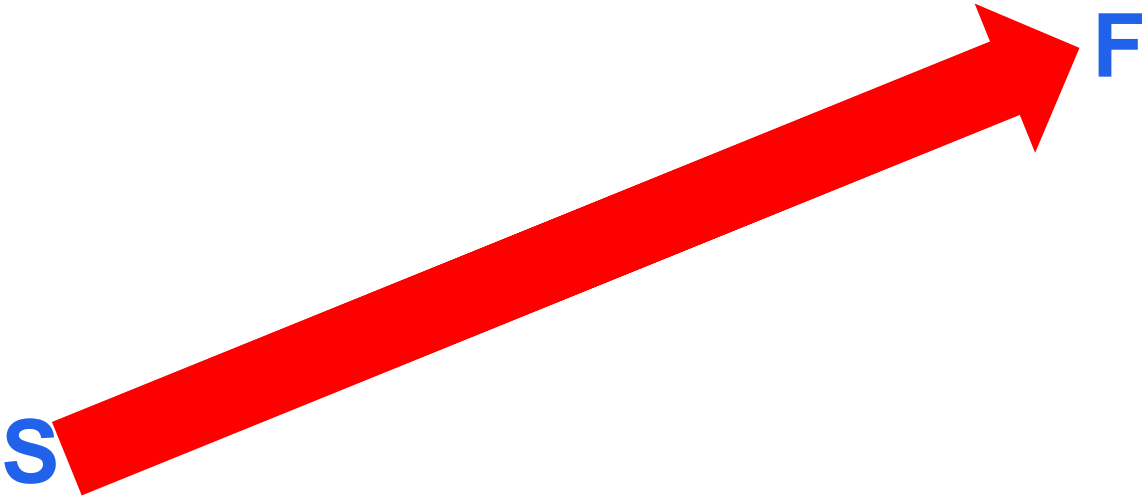
$$\Rightarrow v_f^2 = v_i^2 + 2 \cdot a \cdot \Delta x$$
$$0 = 20^2 + 2 \cdot a \cdot 40$$

$$a = -\frac{20^2}{2 \cdot 40} = -\frac{\cancel{400}}{\cancel{2} \cdot \cancel{40}} = -5\,m/s^2$$

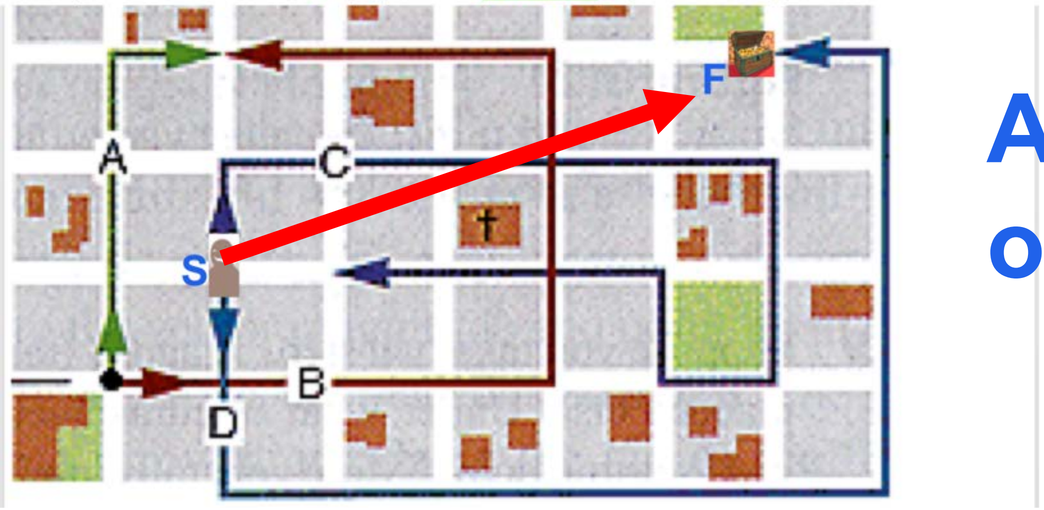
Displacement =: (c) an "arrow" pointing from S to F



Displacement =: (c) an "<u>arrow</u>" pointing from S to F



Displacement =: (c) an "arrow" pointing from S to F



A motion = combination of "arrows"!

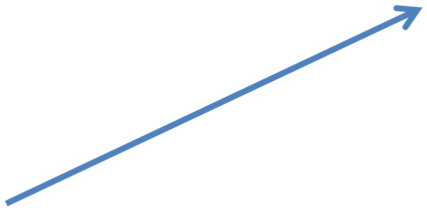
A new name

"arrows" = vector

Need to study the properties of *vectors*

Vectors

A vector is an arrow!



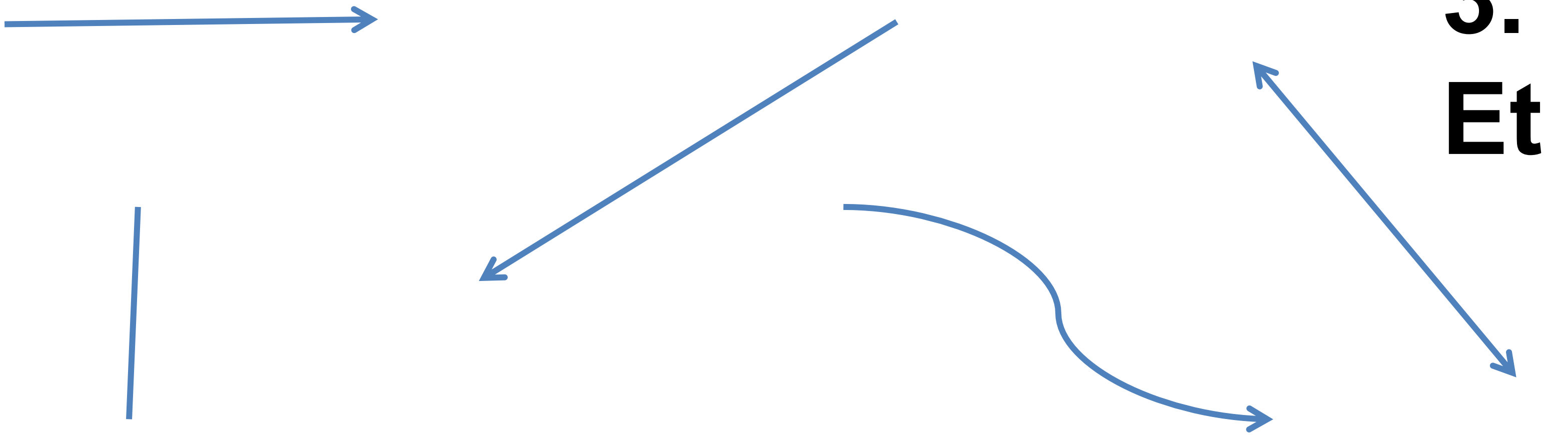
A vector is:

1) straight,
2) has magnitude (its length)
3) has direction (described by an arrowhead).

Vectors!

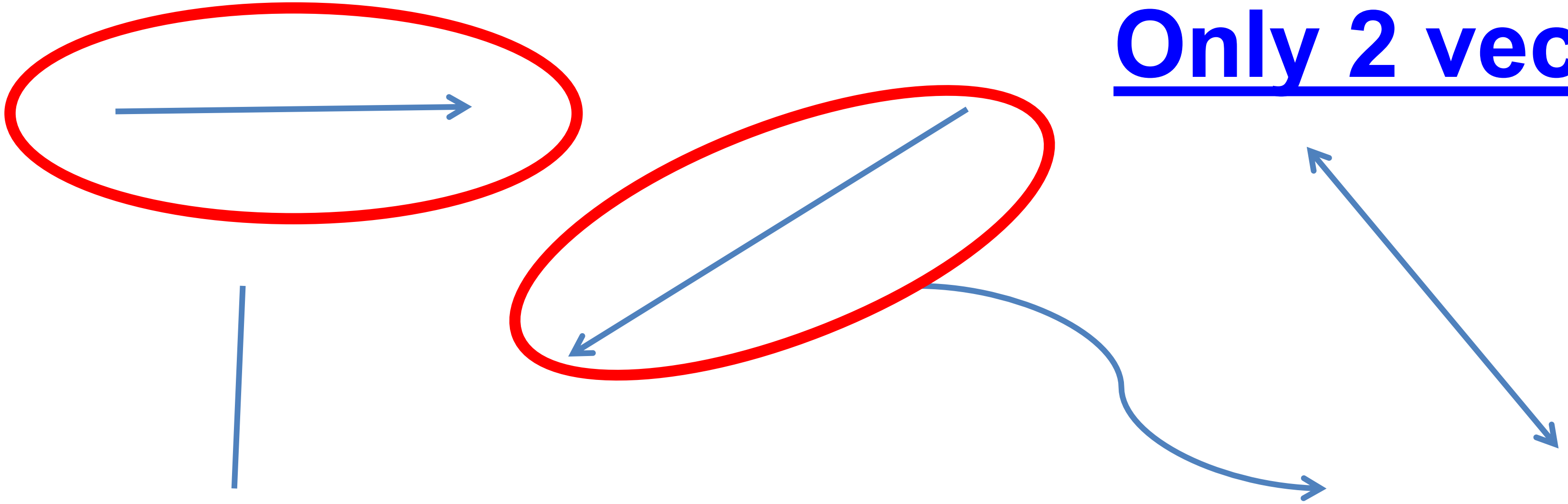
1. 1
2. 2
3. 3

Etc.



How many *vectors* do you see?

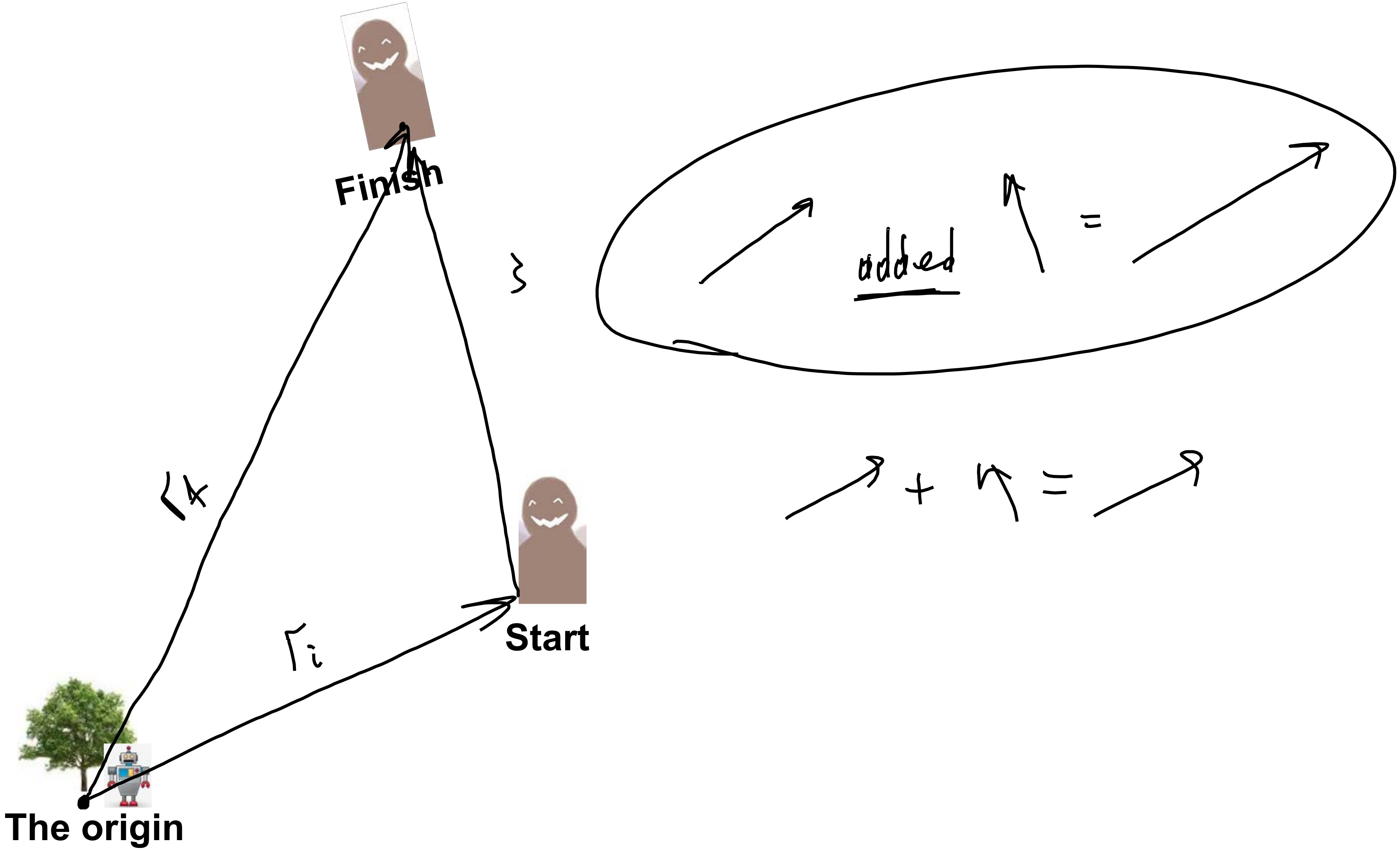
LectureMCQ_L4__Q5



Only 2 vectors

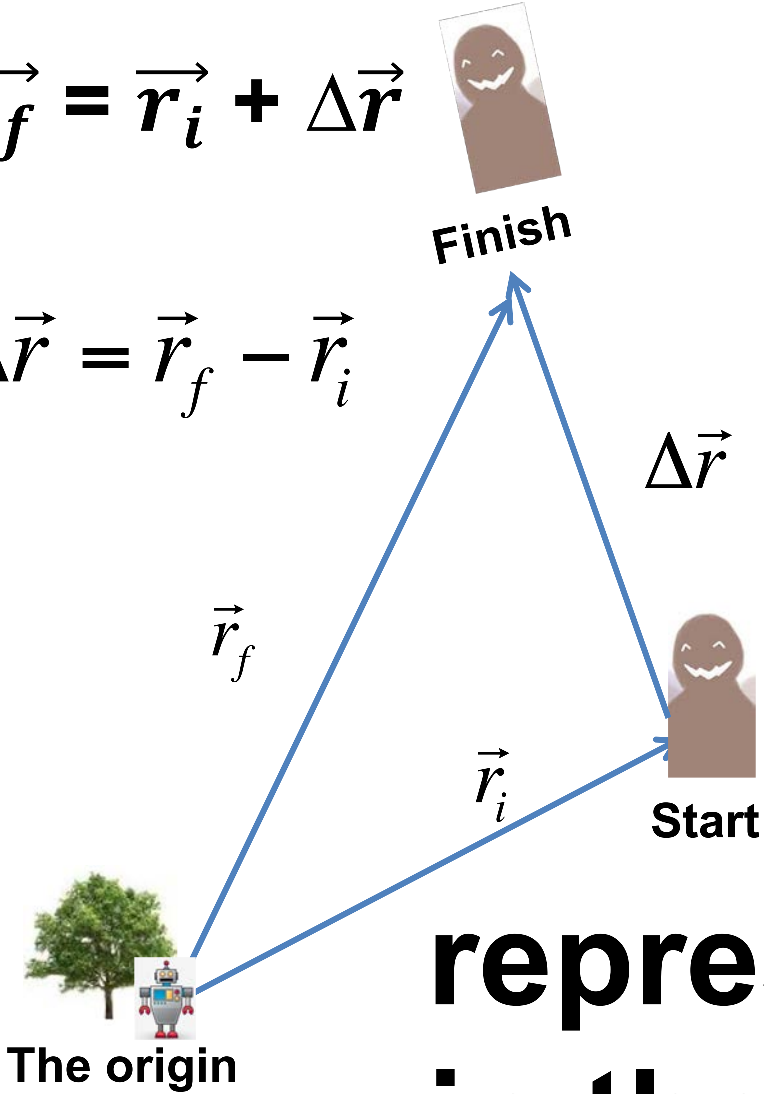
A vector is:

1) **straight,**
2) **has magnitude (its length)**
3) **has direction (described by an arrowhead).**


Finish
Start
The origin
r_f
r_i
added
=
+
=

$$\overrightarrow{r_f} = \overrightarrow{r_i} + \Delta\vec{r}$$

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$$



A *position vector* (arrow) connects the origin and position.

A *displacement* is a vector representing the change in the position vector.

Distance and Displacement

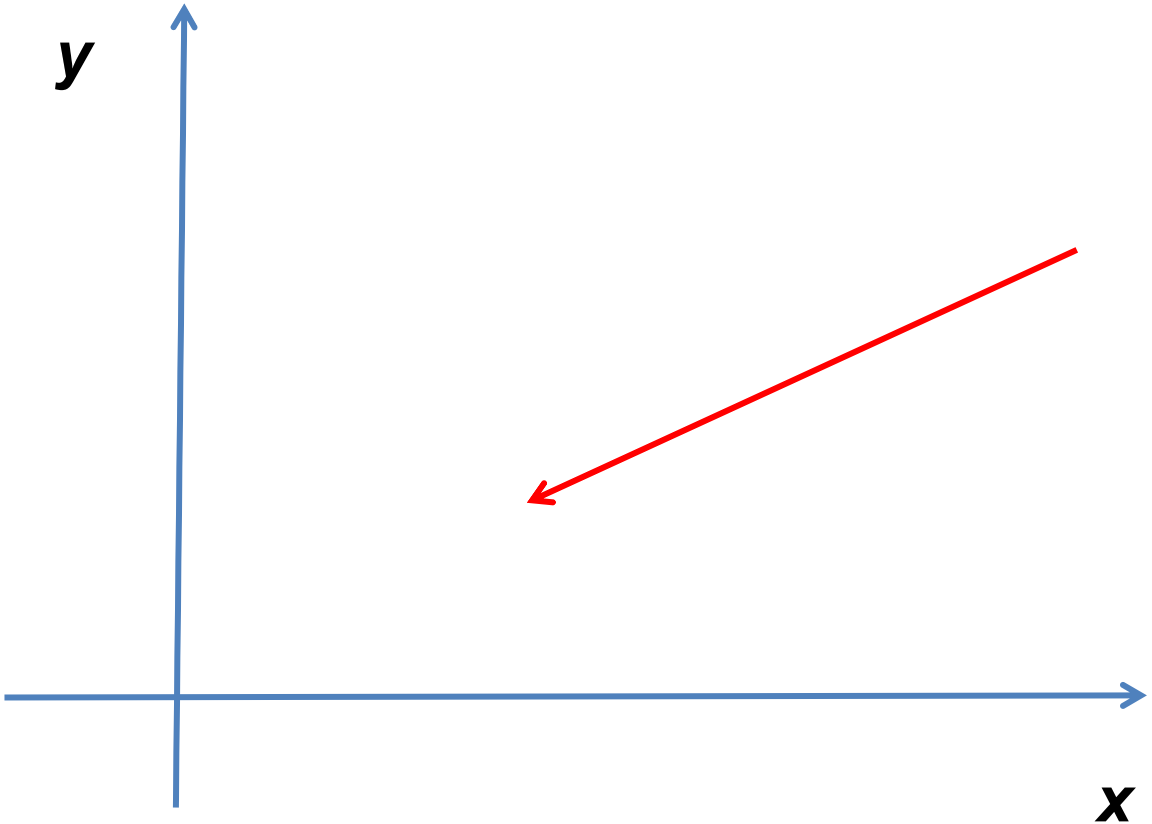
Distance is a *scalar* representing the length of the trajectory.
Displacement is a *vector* representing a change in position. Its magnitude is the straight-line distance between the start and end points, while its direction is the direction of the straight line from the start point to the end point. If you start at an initial position $\vec{r}_i$ and move to a final position $\vec{r}_f$, your displacement $\Delta\vec{r}$ is defined as: $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$

Or you can always write: $\boldsymbol{\overrightarrow{r_f}} = \boldsymbol{\overrightarrow{r_i}} + \Delta\boldsymbol{\vec{r}}$

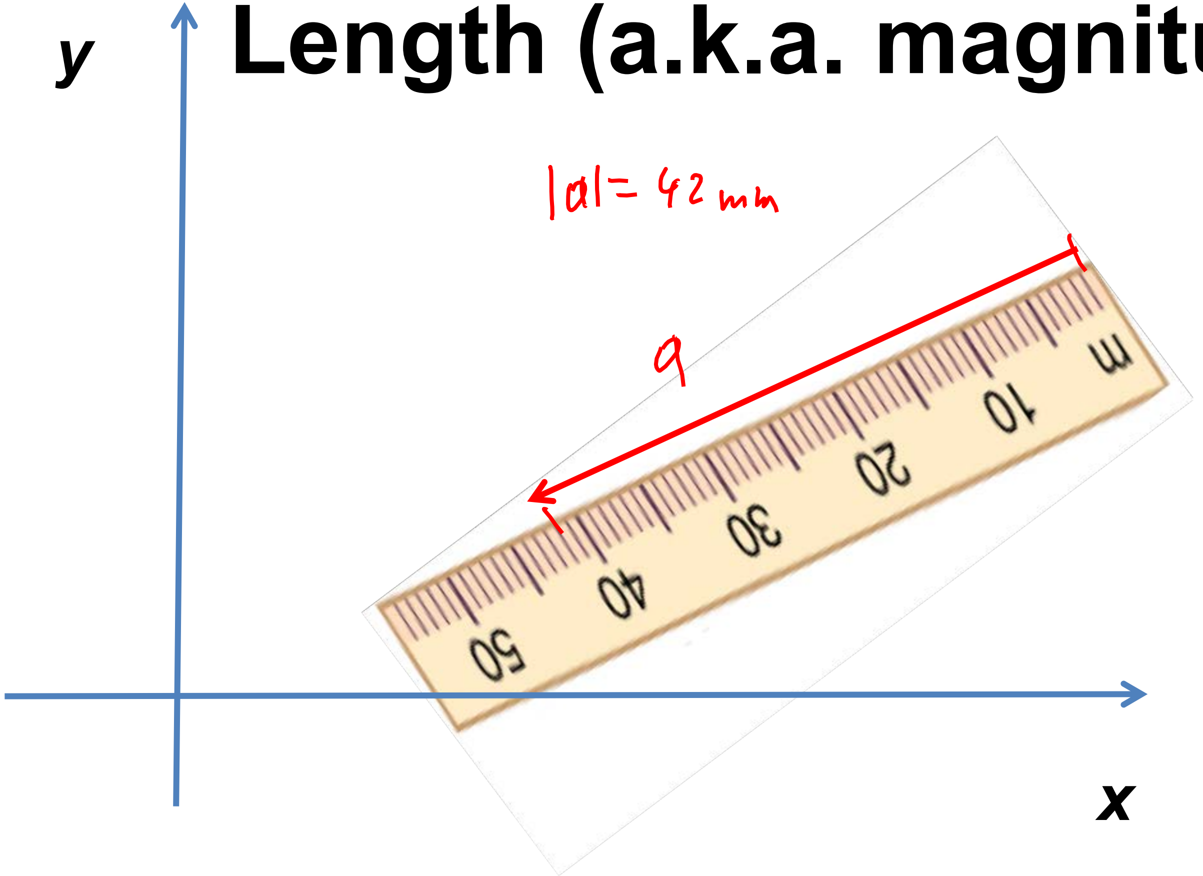
Remember (!!!) "change" is "final minus initial"

$\boxed{\Delta \;=\; \text{"Final"} - \text{"Initial"}}$

Math description of a vector



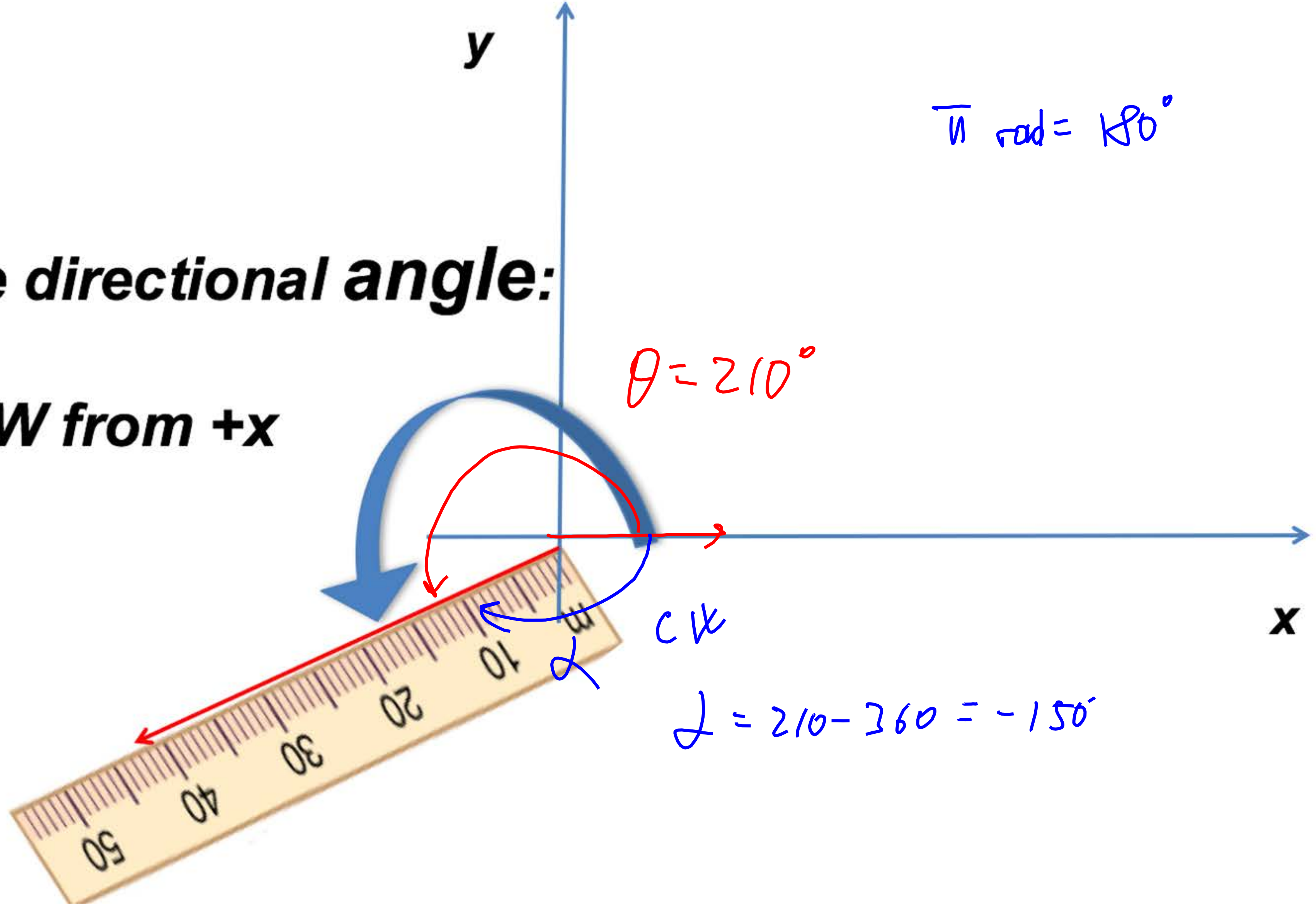
Length (a.k.a. magnitude)



The directional angle:

CCW from +x

π rad = 180°



$\alpha = 210 - 360 = -150°$

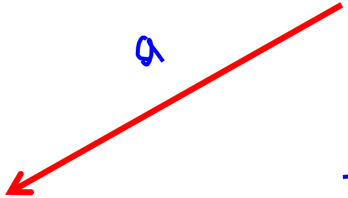
Math operations on vectors:

1. Multiplying a vector by a number

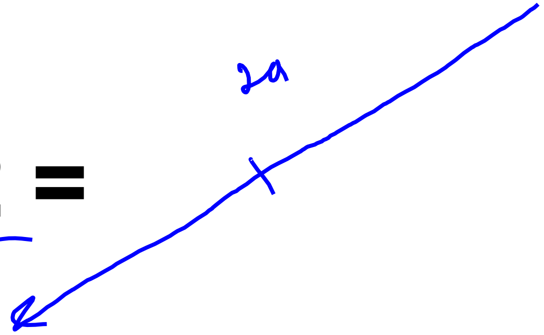
2. Adding two vectors

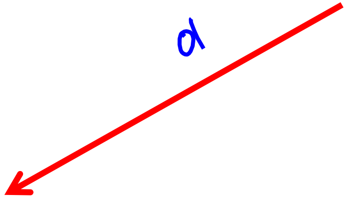
Math operations on vectors:

1. Multiplying a vector by a number

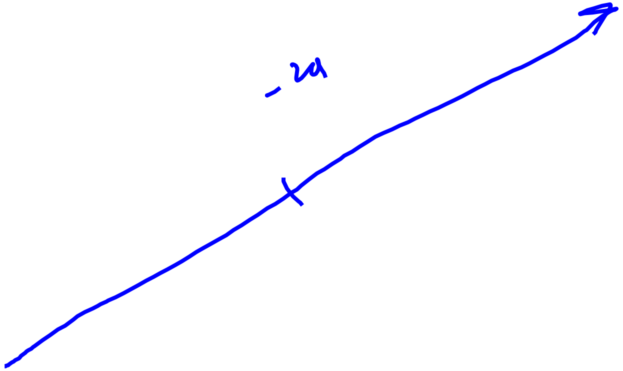


x 2 =





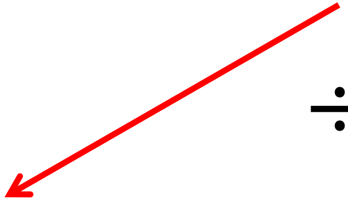
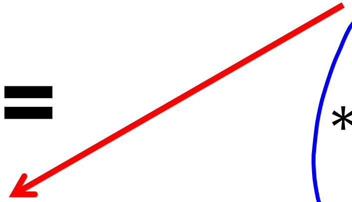
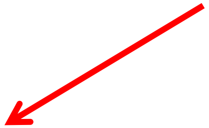
x (-2) =



Math operations on vectors:

We know now the rule for Multiplying a vector by a number.

What about *dividing* by a number?

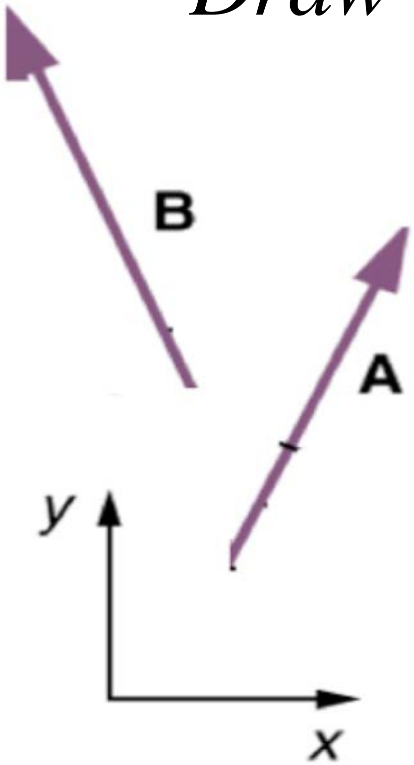
 $\div\ 2 =$  $* \ \frac{1}{2} =$ 

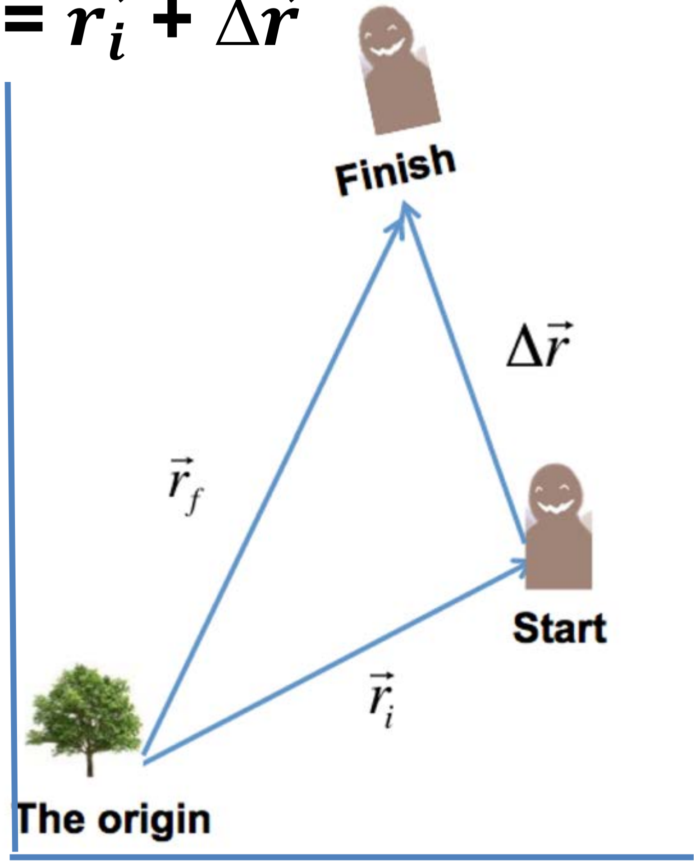
VECTOR ADDITION

$$\text{Draw} \quad \vec{A} + \vec{B} \quad (= \mathbf{A} + \mathbf{B})$$

(little arrows vs. bold font)

$$\overrightarrow{r_f} = \overrightarrow{r_i} + \Delta\vec{r}$$

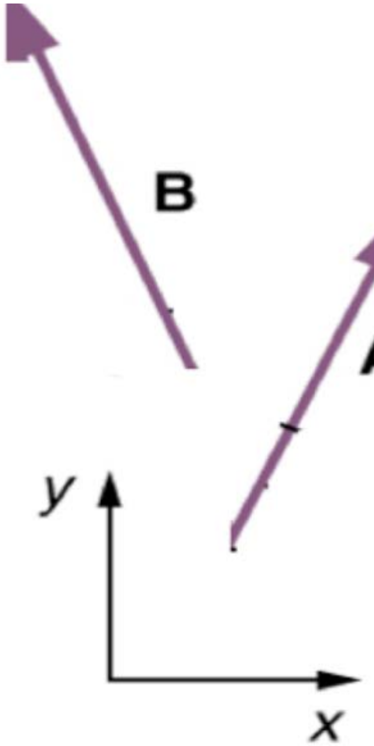




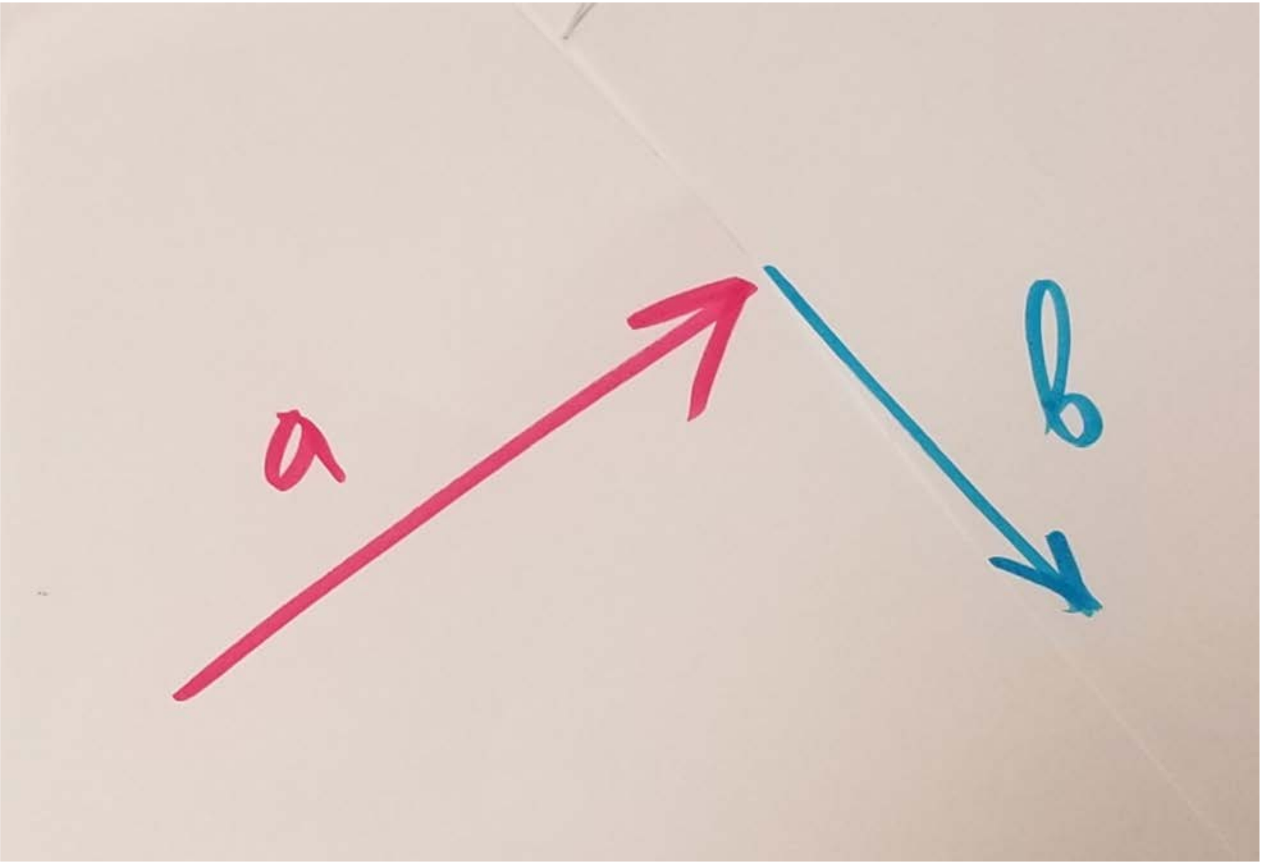
Two-step rule ("*tail-to-head*"): 1. "MOVE"; 2. "CONNECT"

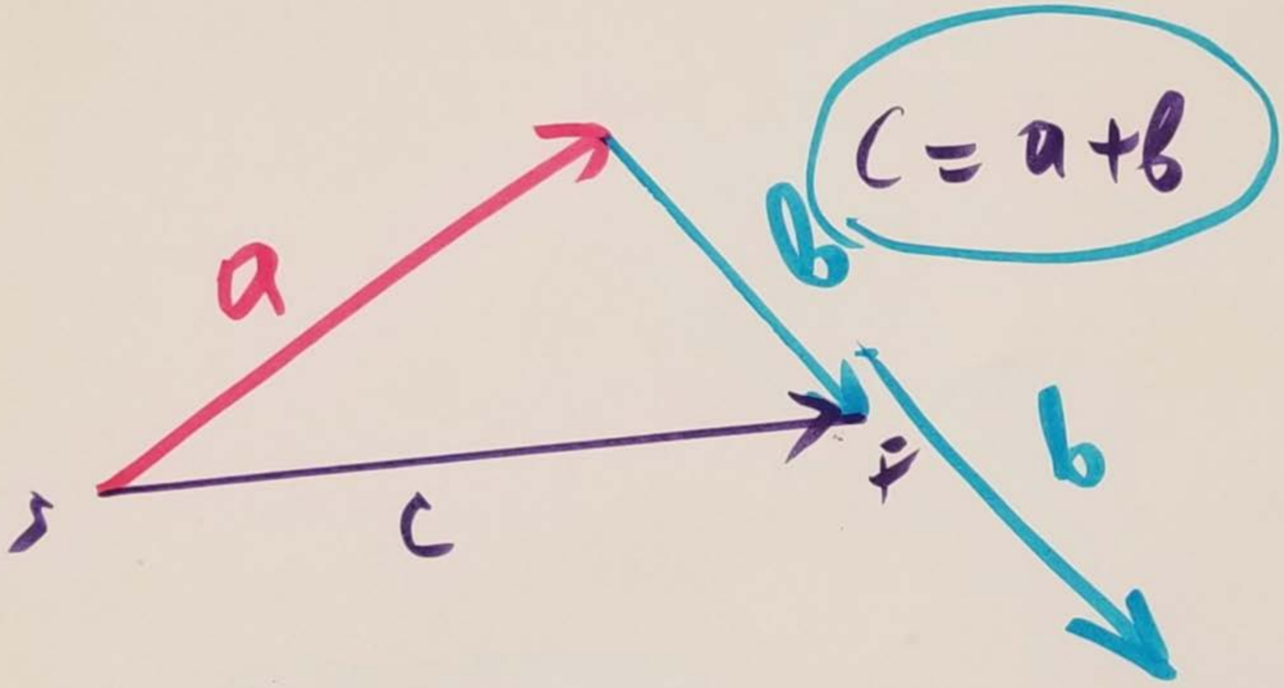
Apply the two-step rule ("*tail-to-head*"):

1. "MOVE"; 2. "CONNECT"



$a + b = ?$


a
b



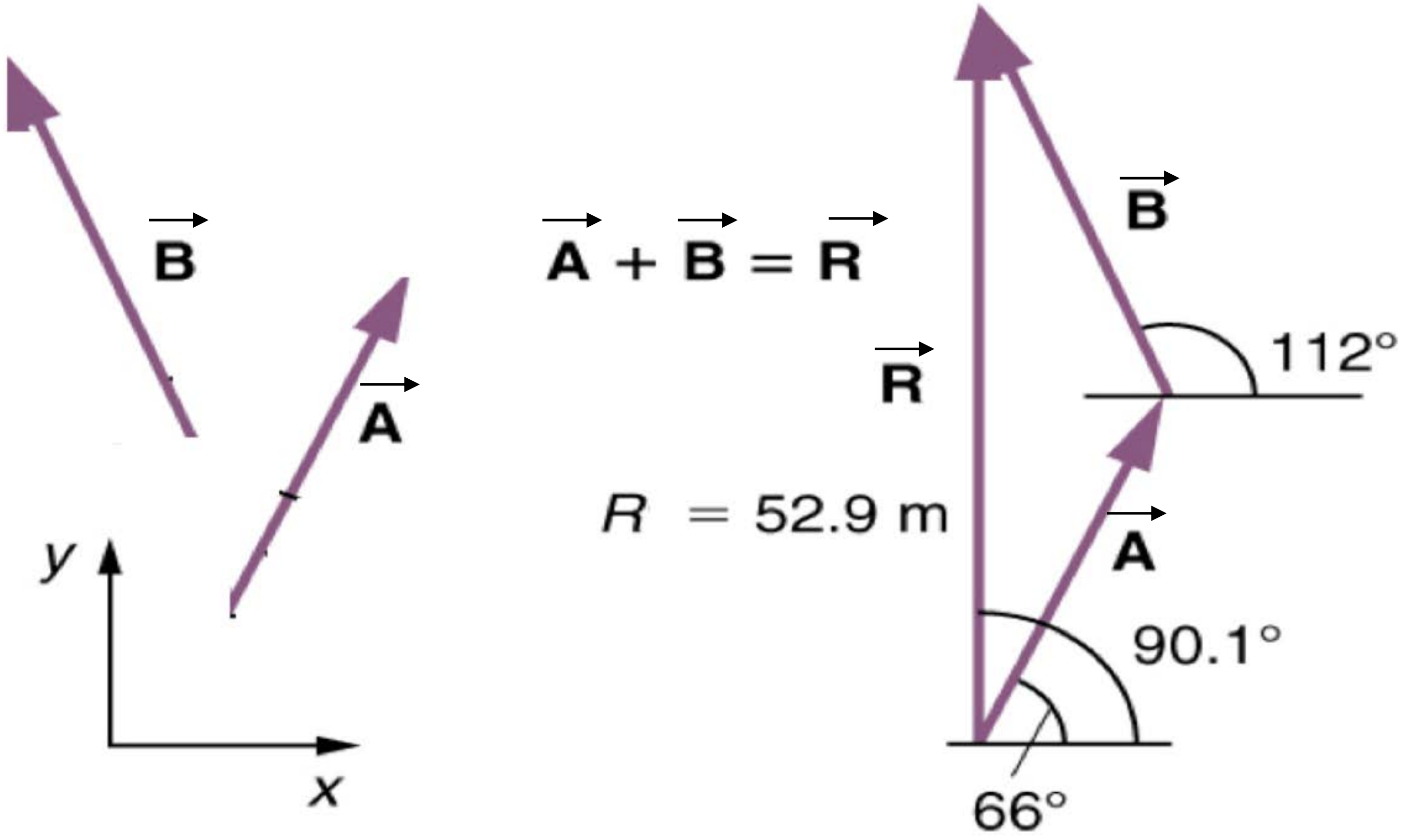
$|a| = 10$ cm

$|b| = 6$ cm

$|c| = \underline{12}$ cm

$|a| + |b| = 10 + 6 = \underline{16}$

VECTOR ADDITION



The "tail to head" rule!

<u>LectureMCQ L4 Q6</u>

"The magnitude of the sum of two vectors is always *<u>equal</u>* to the sum of the magnitudes of each of the original vectors."

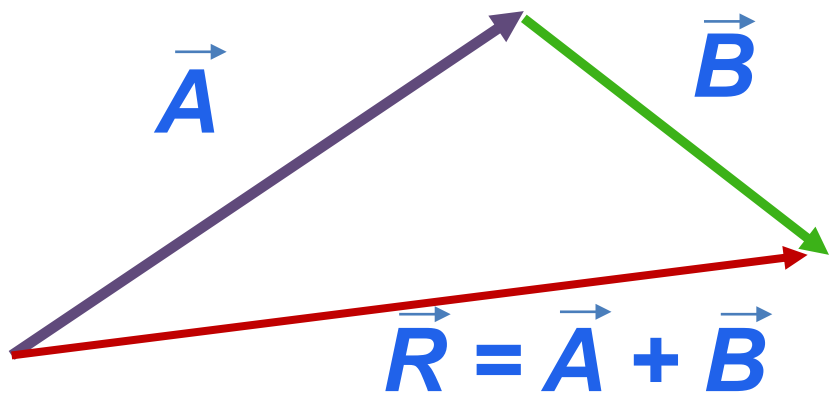
The statement above is …

1. **Correct**
2. **Wrong**
3. **Partially correct**
4. **Partially wrong**
5. **Depends on vectors**
6. **Does not have any meaning**
7. **Does not have any use**
8. **Blue**

Vector ADDITION

$$Draw \quad \vec{A} + \vec{B} \quad (= \boldsymbol{A} + \boldsymbol{B})$$

(little arrows vs. bold font)



LectureMCQ L4 Q6

Is this correct?

$$|\vec{R}| = |\vec{A}| + |\vec{B}|$$

1. Yes! 2. NO!

3. I don't know!

A 2-step rule ("*tail-to-head*"): 1. "MOVE"; 2. "CONNECT"

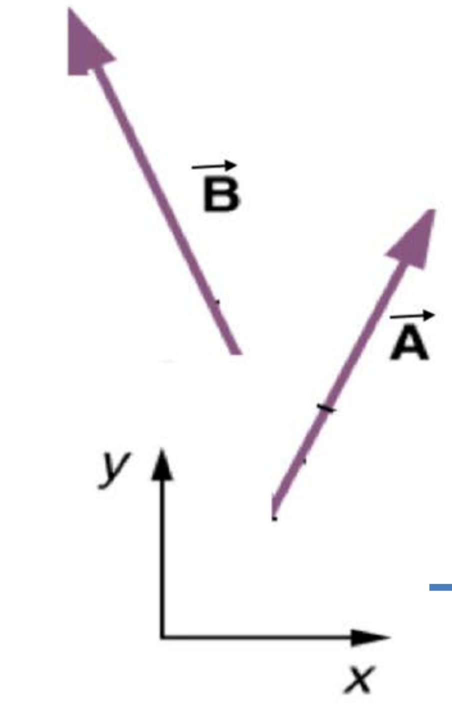
LectureMCQ L4 Q6

"The magnitude of the sum of two vectors is always *equal* to the sum of the magnitudes of each of the original vectors."

The statement above is …

1. **Correct**
2. **Wrong**
3. **Partially correct**
4. **Partially wrong**
5. **Depends on vectors**
6. **Does not have any meaning**
7. **Does not have any use**
8. **Blue**

VECTOR ADDITION The “tail to head” rule!

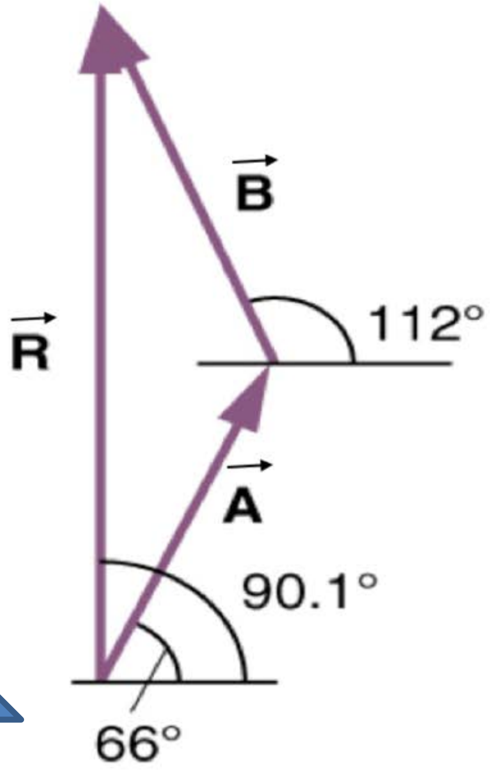


$$\vec{A}+\vec{B}=\vec{R}$$

$$|\vec{A}+\vec{B}|=|\vec{R}|$$

BUT

$$|\vec{A}|+|\vec{B}|\neq|\vec{R}|$$

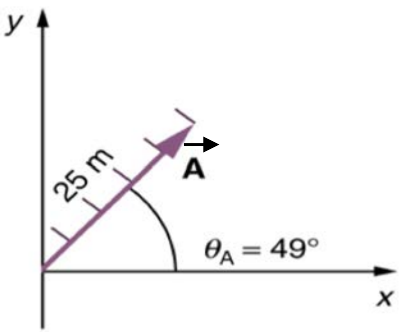


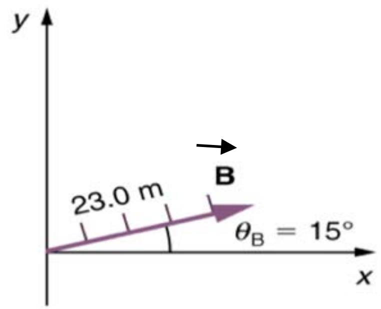
$$|\vec{A}|+|\vec{B}|\neq\left|\vec{A}+\vec{B}\right|$$

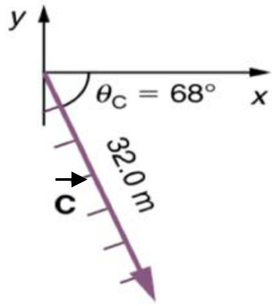
The magnitude of the sum of vectors is NOT equal to the sum of the magnitudes of vectors!

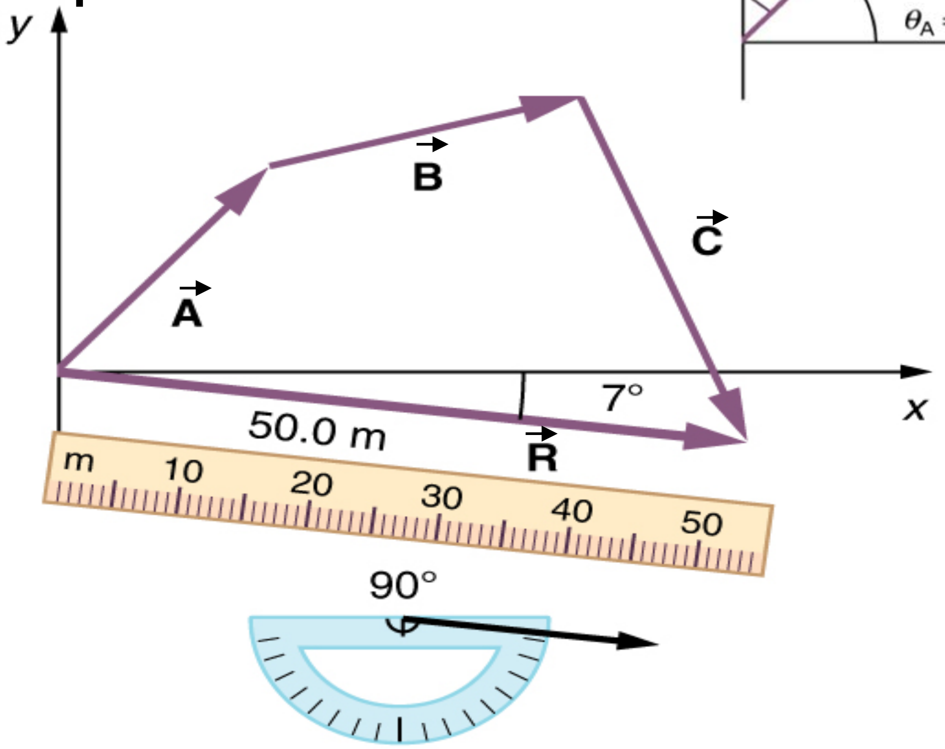
VECTOR ADDITION: MORE VECTORS

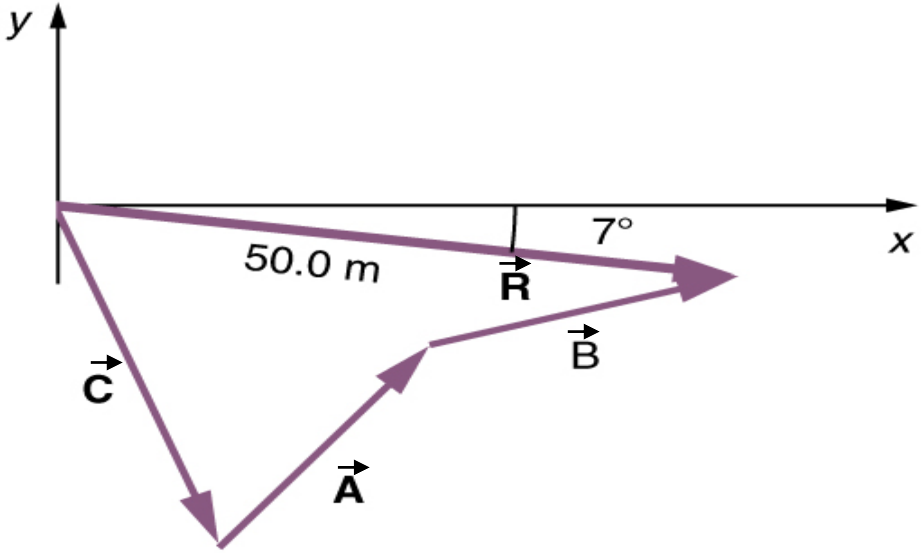
Use the "tail to head" rule for each step!









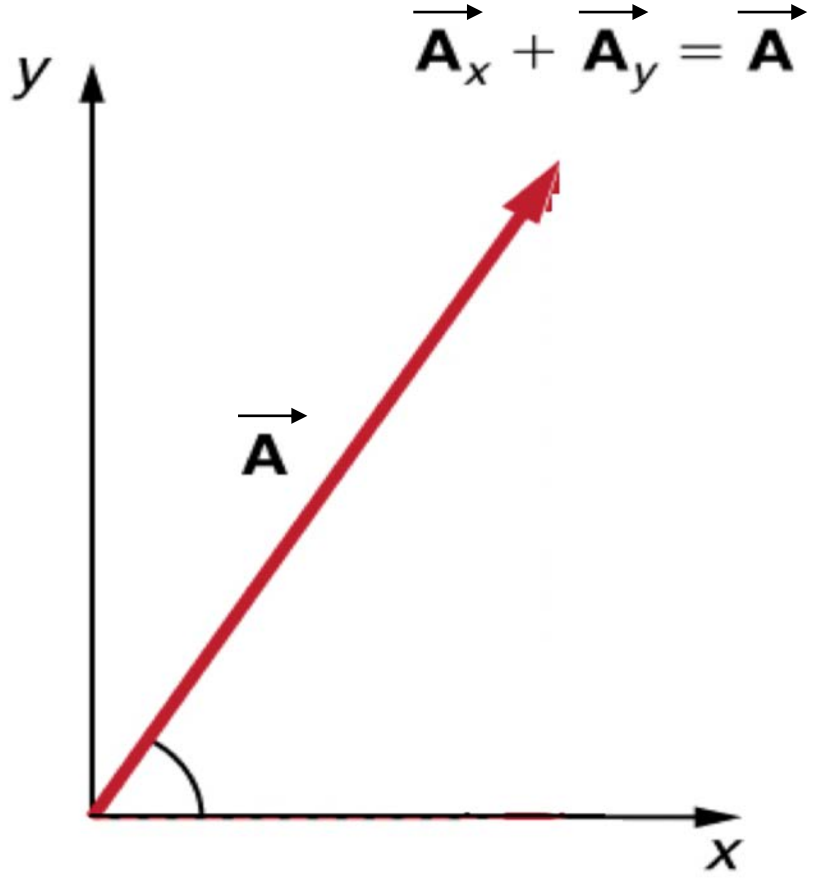


$$\vec{R} = \vec{A} + \vec{B} + \vec{C}$$

$$\vec{C} + \vec{A} + \vec{B} = \vec{R}$$

Vector and its components

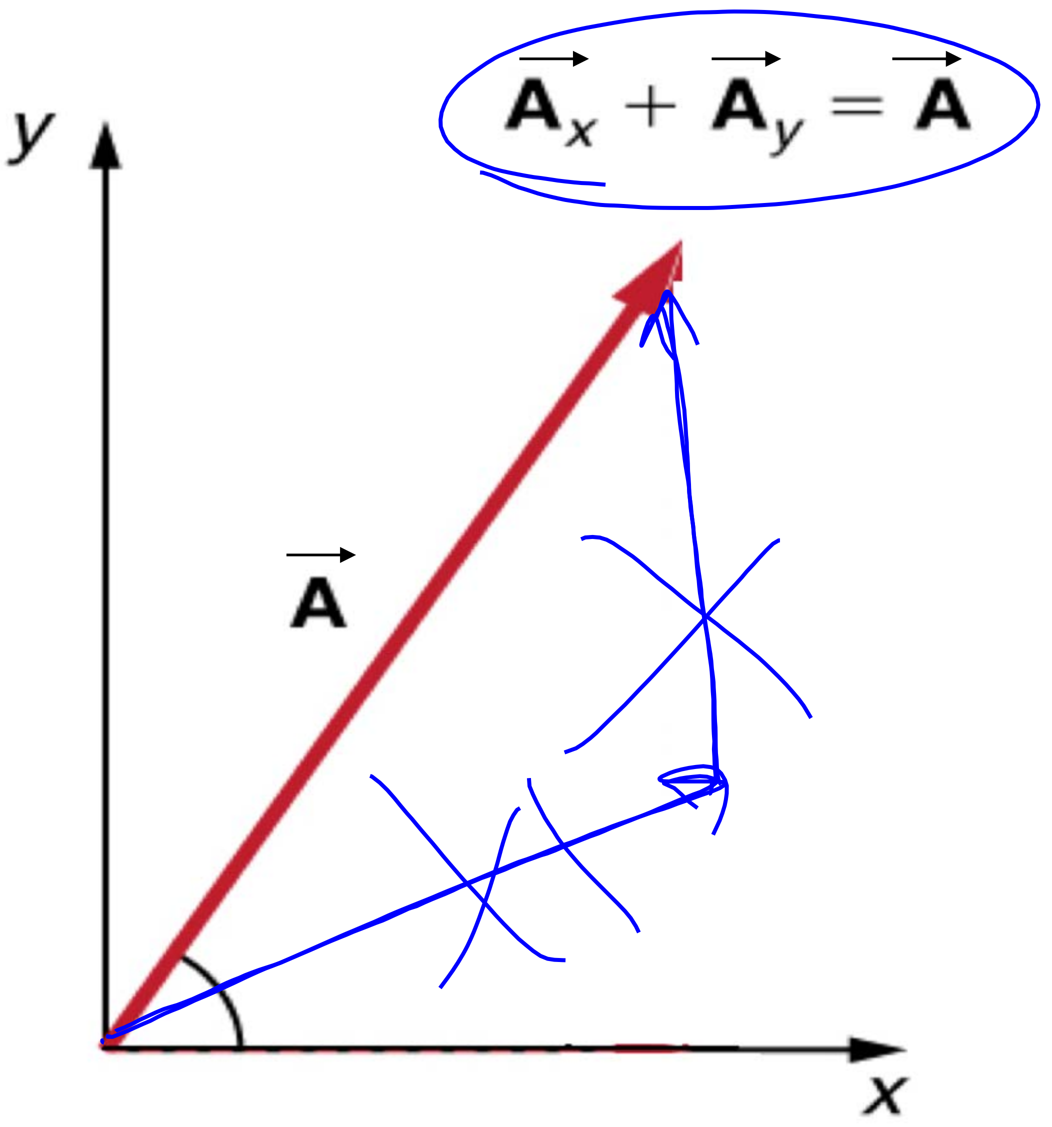
Components of vector $\vec{\mathbf{A}}$, are such ***vectors*** $\vec{\mathbf{A}}_x$ and $\vec{\mathbf{A}}_y$, which are (a) **parallel to *x* and *y* axes**, (b) **the *sum* of which is equal to vector** $\vec{\mathbf{A}}$.



Draw the components of *A*

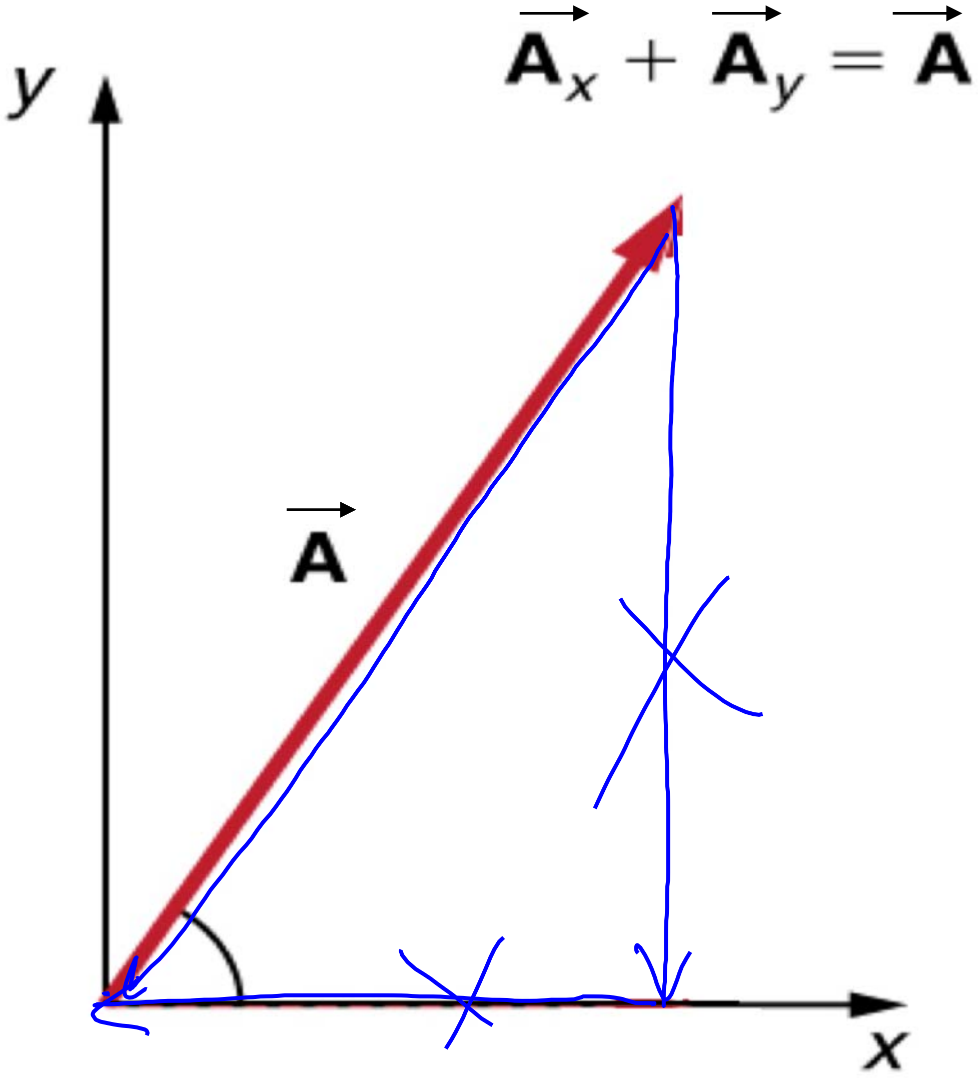
(trial 1)

Components of vector $\vec{\mathbf{A}}$, are such **vectors** $\vec{\mathbf{A}}_x$ and $\vec{\mathbf{A}}_y$, which are (a) **parallel to *x* and *y* axes**, (b) **the *sum* of which is equal to vector** $\vec{\mathbf{A}}$.

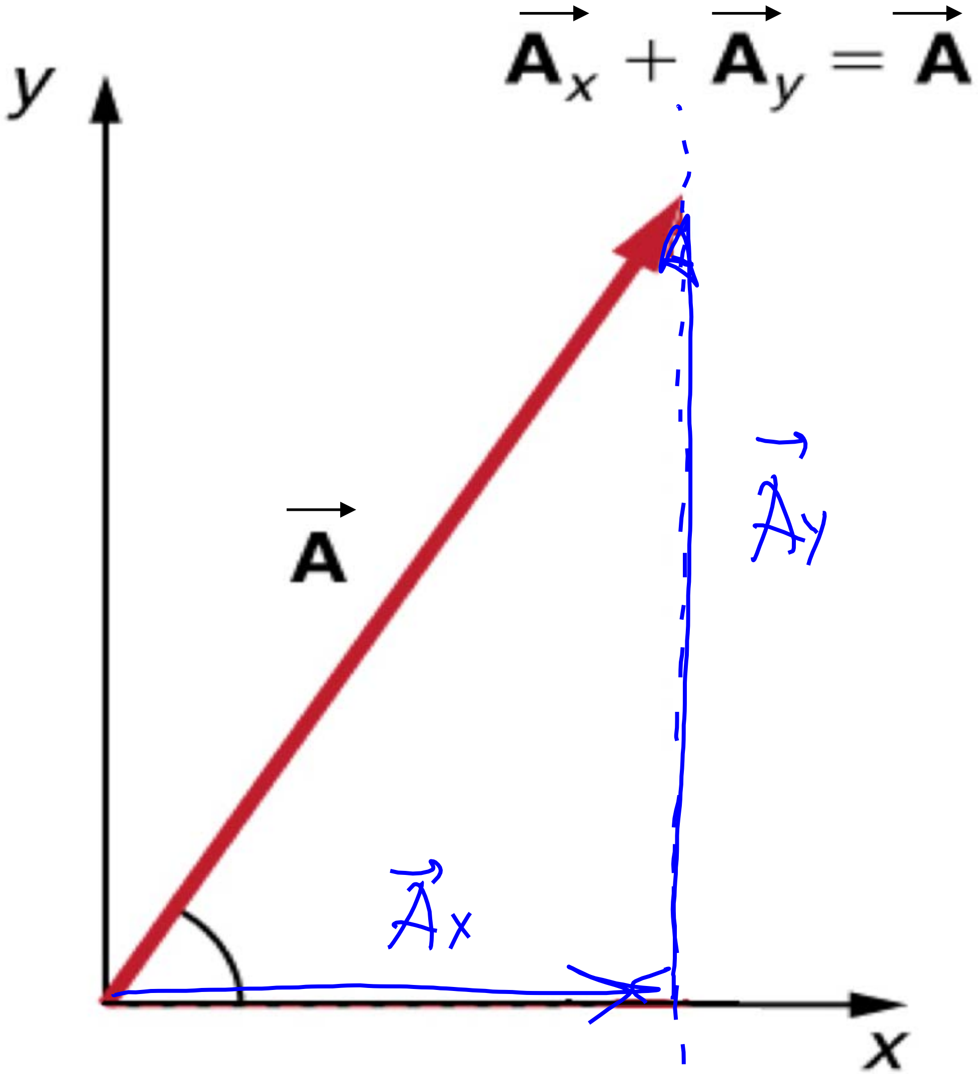


Draw the components of *A* *(trial 2)*

Components of vector **A** , are such **vectors** $\mathbf{A}_x$ and $\mathbf{A}_y$, which are (a) **parallel to *x* and *y* axes**, (b) **the *sum* of which is equal to vector** **A**.

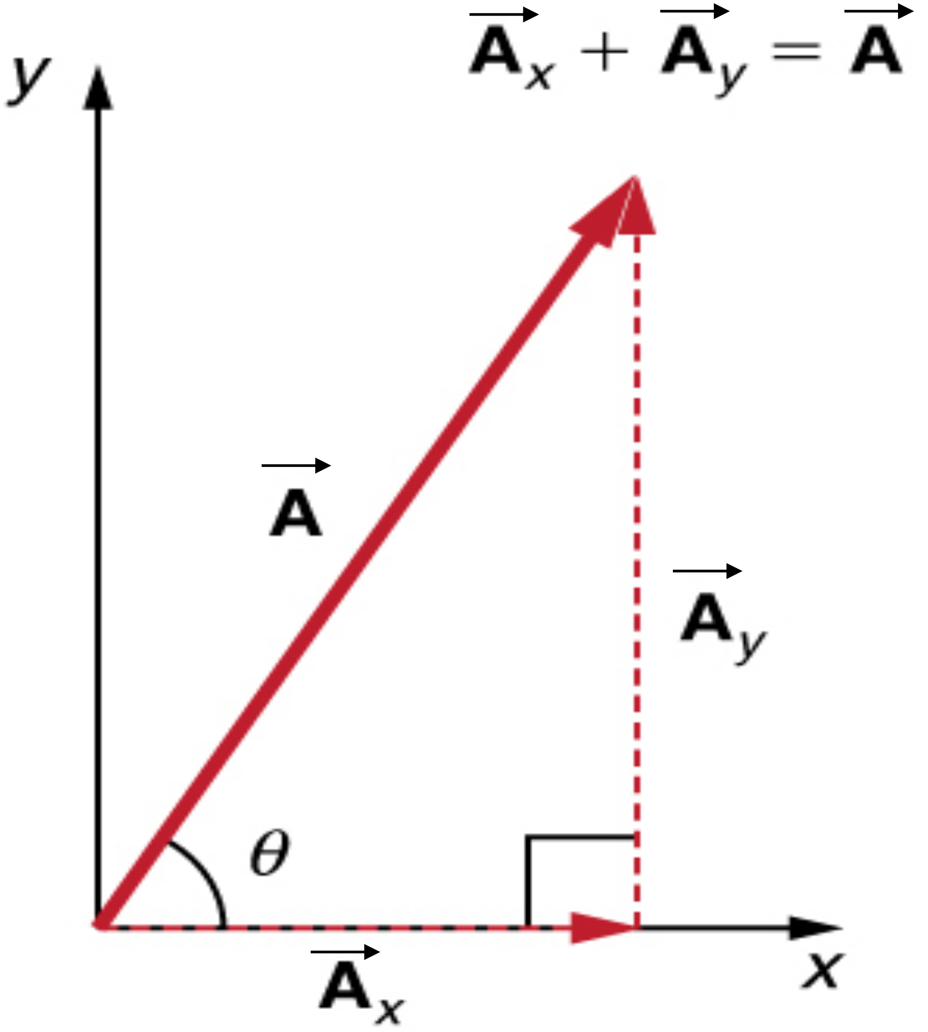


Draw the components of *A*

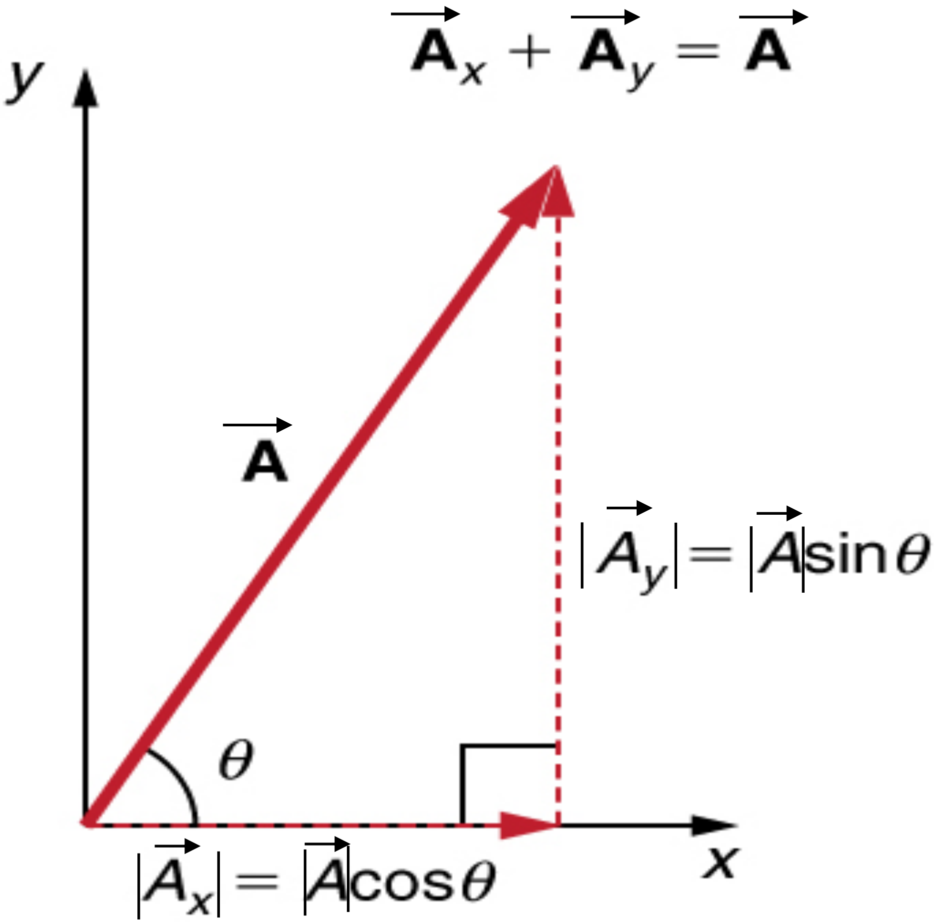


Vector $\vec{\mathbf{A}}$, with its tail at the origin of an *x*, *y*-coordinate system, is shown together with its *x*- and *y*-components, $\vec{\mathbf{A}}_x$ and $\vec{\mathbf{A}}_y$.

These three vectors *always* form a right triangle.



Keeping "hat arrows" And "absolute magnitude"

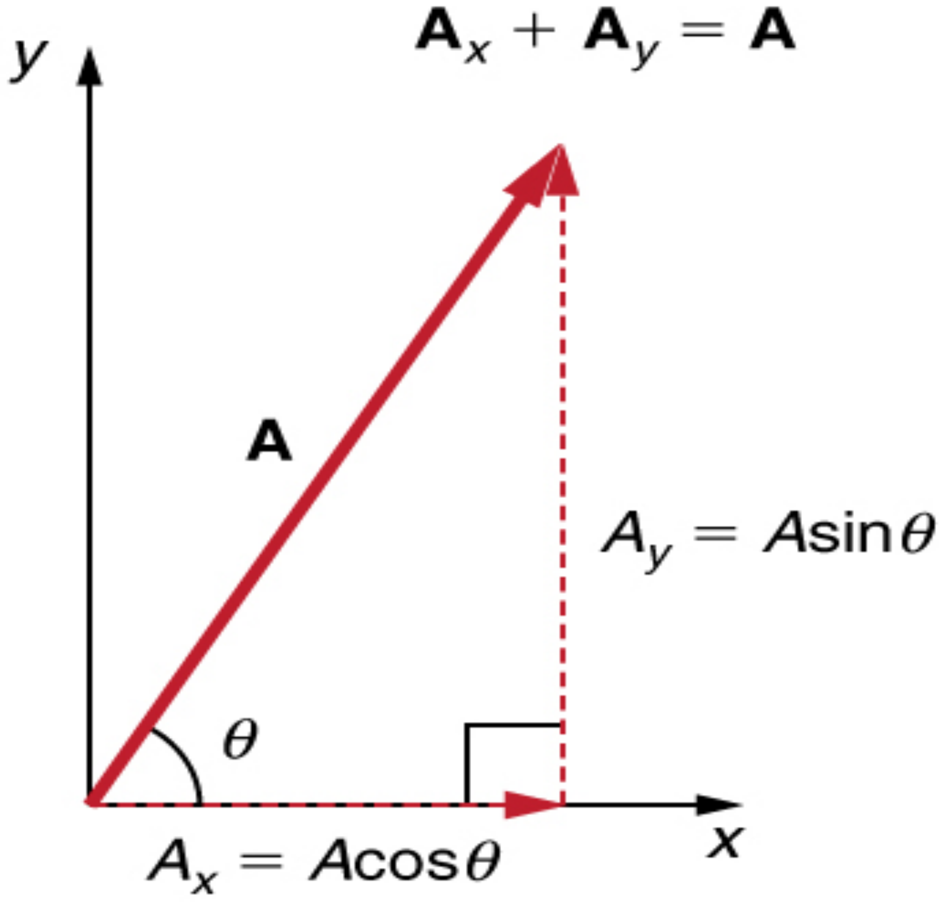


The magnitudes of the vector components $\vec{\mathbf{A}}_x$ and $\vec{\mathbf{A}}_y$ can be related to the resultant vector $\vec{\mathbf{A}}$ and the angle θ with trigonometric identities. In this example,

$|\vec{A}_x| = |\vec{A}|\cos\theta$ and

$|\vec{A}_y| = |\vec{A}|\sin\theta$.

Dropping ***"hat arrows" and "absolute magnitude"***



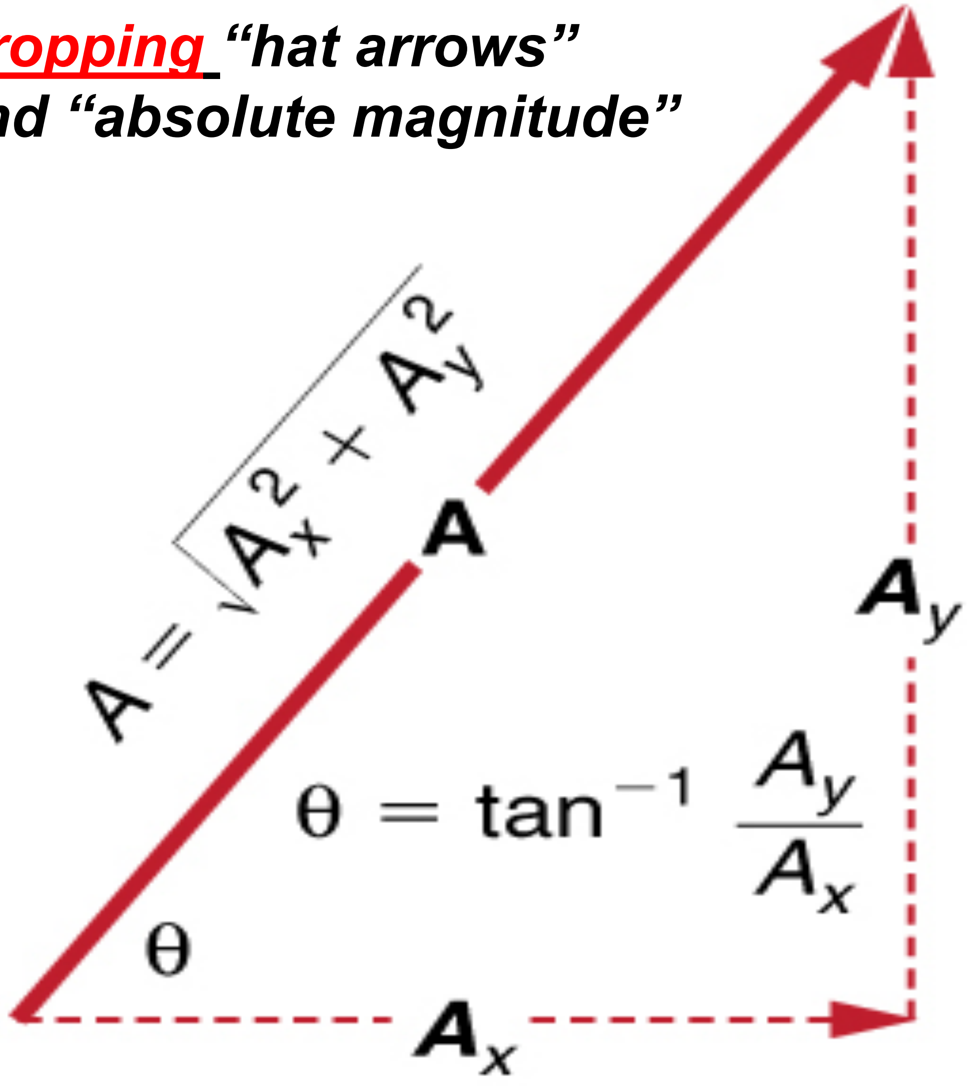
The magnitudes of the vector components $\mathbf{A}_x$ and $\mathbf{A}_y$ can be related to the resultant vector **A** and the angle θ with trigonometric identities. In this example,

$A_x = A \cos \theta$ and

$A_y = A \sin \theta$.

The magnitude and direction of the resultant vector can be determined once the magnitudes of horizontal and vertical components *Ax* and *Ay* have been determined.

***Dropping* "hat arrows" and "absolute magnitude"**



Note:* $\boldsymbol{\theta}$ *= tan^{-1} OR tan^{-1} +180 !

A *second* meaning of word "component".

A "component" = A "coordinate"

The x-component (x-coordinate) of a vector $\vec{A}$ is the number which is:

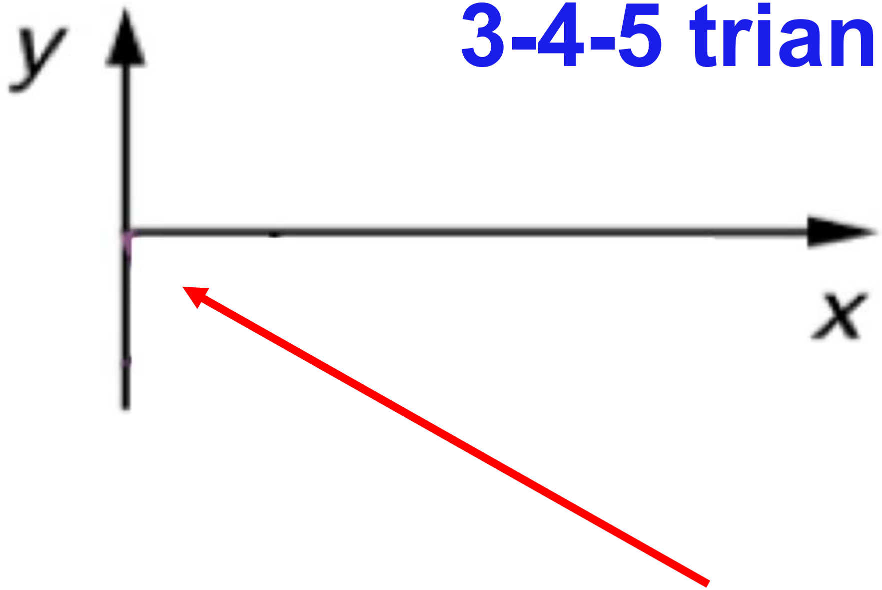
a) equal to the magnitude of its x-vector component, if it points *parallel* to the x-axis

b) equal to (-1)xthe magnitude of its x-vector component, if it points *opposite* to the x-axis

And the same definition for the y-component.

The x-component (x-coordinate) of a vector $\vec{A}$ is the number which is:
= to the magnitude of its x-vector component, if it points *parallel* to the x-axis
= to (-1)xthe magnitude of its x-vector component if it points *opposite* to the x-axis

The vector and its components form a 3-4-5 triangle. Find its components.

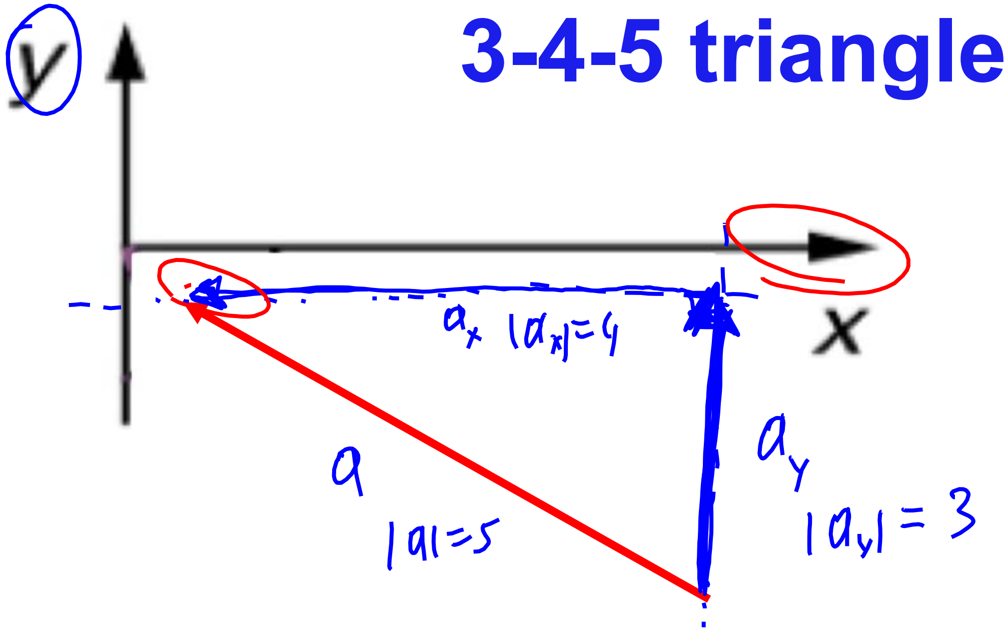


The *x*-component (*x*-coordinate) of a vector $\vec{A}$ is the number which is:

= to the magnitude of its *x*-vector component, if it points *parallel* to the *x*-axis

= to (-1)x the magnitude of its *x*-vector component if it points *opposite* to the *x*-axis

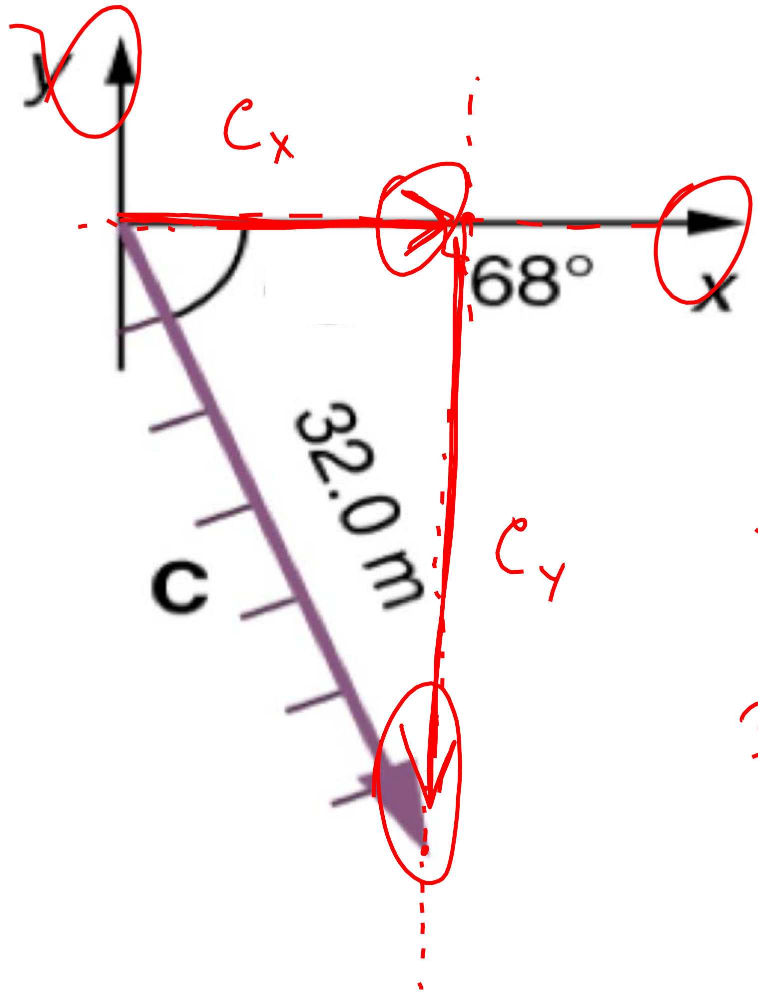
The vector and its components form a 3-4-5 triangle. Find its components.



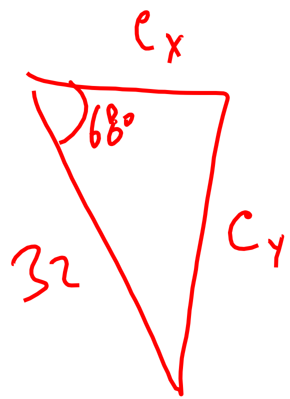
$a_x = -4$

$a_y = +3$

Using given magnitude and direction find the components of the vector.



$\vec{C_x} + \vec{C_y} = \vec{C}$



$|C_x| = 32 \cdot \cos 68$

$|C_y| = 32 \cdot \sin 68$

$C_x = 32 \cdot \cos 68$

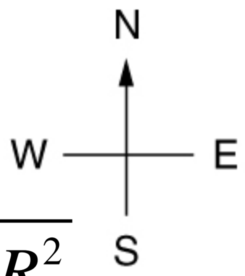
$C_y = -32 \cdot \sin 68$

VECTOR ADDITION FOR 2 VECTORS (JUST LEARNED)

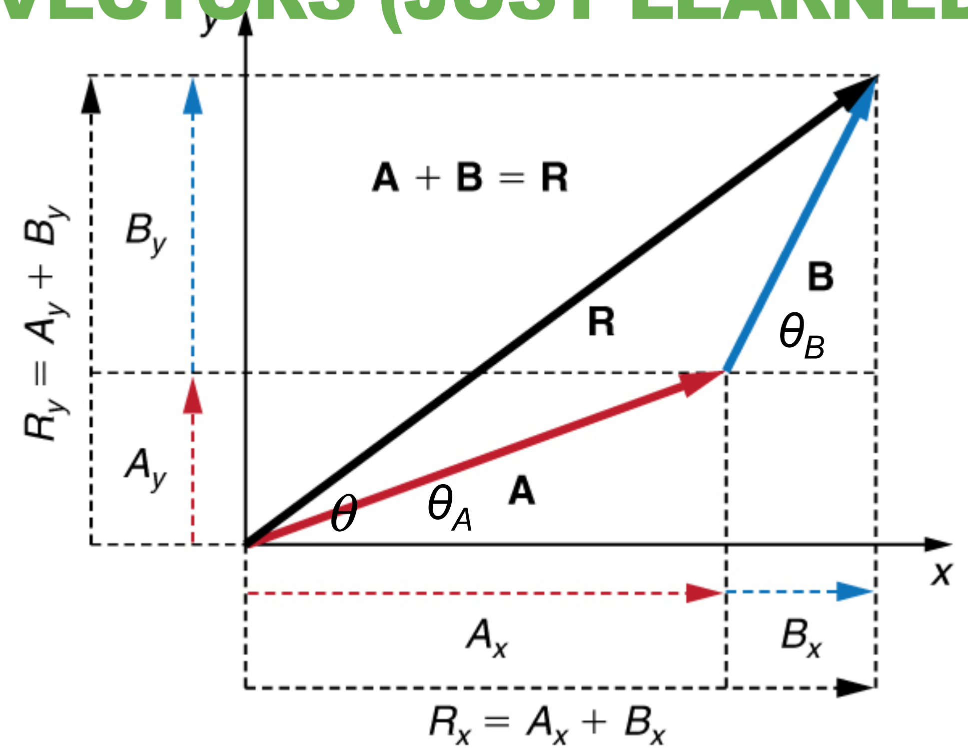
Adding two vectors algebraically

$A_x = A \cos \theta_A \quad A_y = A \sin \theta_A$

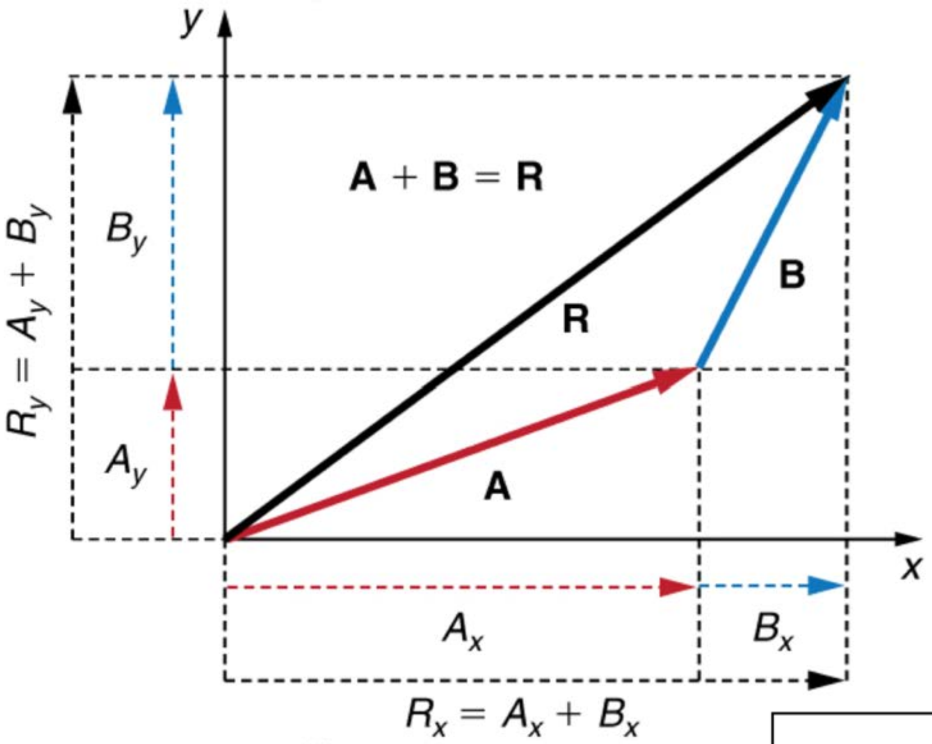
$B_x = \text{B} \cos \theta_B \quad B_y = \text{B} \sin \theta_B$.



$$\tan \theta = \frac{R_y}{R_x} \qquad R = \sqrt{R_x^2 + R_y^2}$$



To add vectors **A** and **B** , first determine the horizontal and vertical components of each vector. These are the dotted vectors $\mathbf{A}_x$, $\mathbf{A}_y$, $\mathbf{B}_x$ and $\mathbf{B}_y$ shown in the image.

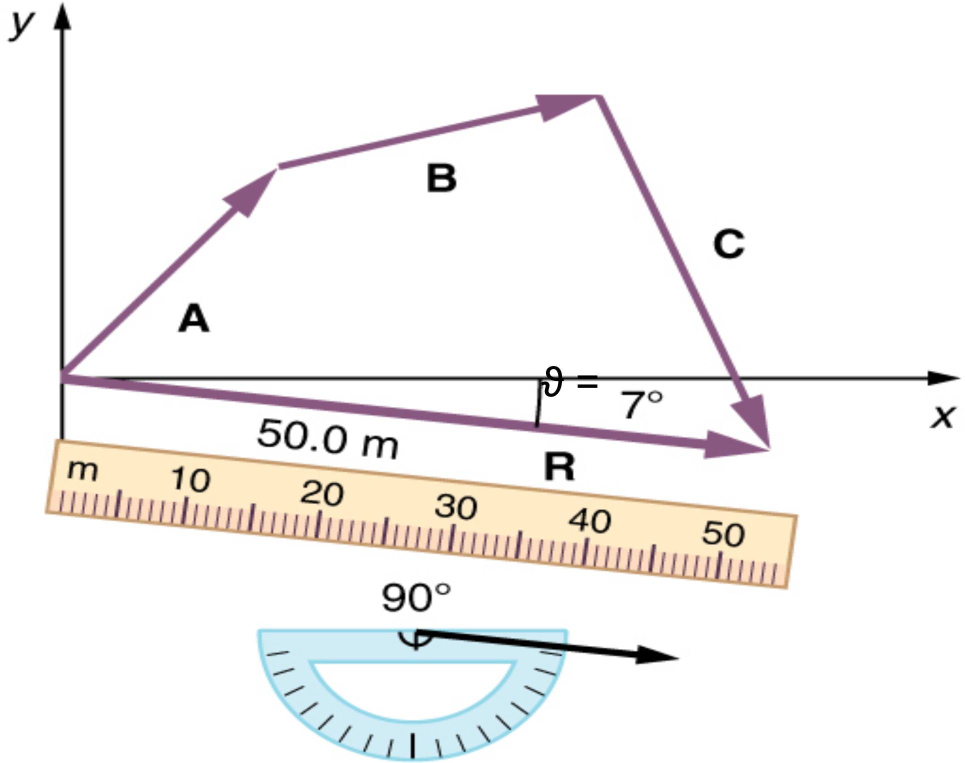


$$R = \sqrt{R_x^2 + R_y^2}$$

$$\tan\theta = \frac{R_y}{R_x}$$

Vector addition: the component method

$A_x =$	$A_y =$
$B_x =$	$B_y =$
$R_x = A_x + B_x =$	$R_y = A_y + B_y =$



$$\mathbf{R} = \mathbf{A} + \mathbf{B} + \mathbf{C}$$

means

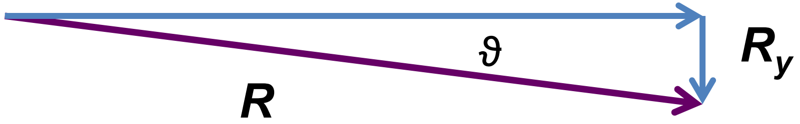
$$R_x = A_x + B_x + C_x$$

AND

$$R_y = A_y + B_y + C_y$$

AND

$$\mathbf{R} = \mathbf{R_x} + \mathbf{R_y}$$



$$|R| = \sqrt{(R_x)^2 + (R_y)^2} \qquad \tan\vartheta = \frac{|R_y|}{|R_x|}$$