Last time   1-d kinematics

$$\cancel{(x-x_0)} \quad x - x_0 = \int_{t_0}^{t} v\,dt$$

$$v - v_0 = \int_{t_0}^{t} a\,dt$$

Always true

$$v = v_0 + at$$

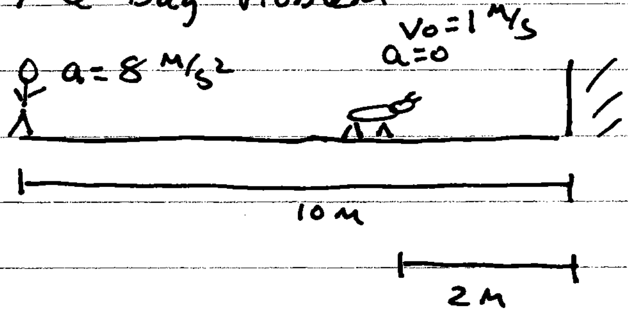
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$

$$x = x_0 + \left(\frac{v + v_0}{2}\right)t$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

True for a const

The bug Problem



Bug to wall in time t_{bug}

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad \underbrace{x - x_0}_{2} = \underbrace{v_0}_{1} t + \tfrac{1}{2}\underbrace{\cancel{a}}_{0} t^2$$

$$t_{bug} = 2\,s$$

Person to wall in time t_{person}

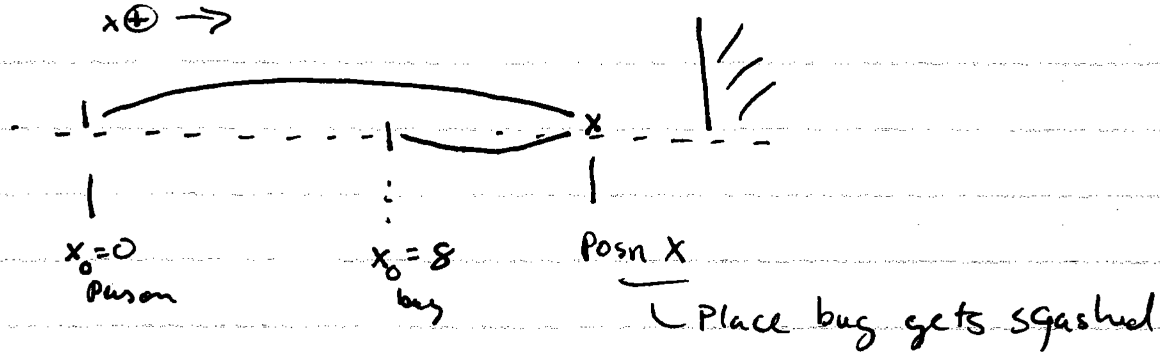
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad 10\,m = \tfrac{1}{2}(8)t^2$$

$$t_{person} = 1.6\,s$$

because $t_{person} < t_{bug}$ — The bug dies

Want to put a little wreath :)

Where and When does bug get Squashed?



Person

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$x = \frac{8}{2}t^2$

2 eqns
2 unknowns (t, x)
solve
Simultaneously

Bug $x = x_0 + v_0 t + \frac{1}{2}at^2$

$x = 8 + 1t + 0$ $\quad x = 8 + t$

$8+t = \frac{8}{2}t^2$

$0 = t^2 - \frac{2}{8}t - 2$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad \frac{\frac{2}{8} \pm \sqrt{\left(\frac{2}{8}\right)^2 + 4(2)}}{2}$$

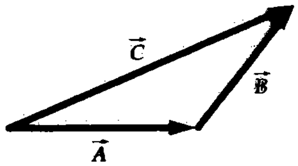
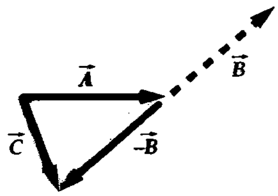
.25 $\quad$ 2.84

$t = 1.54\ s$ or $t = -1.3\ s$ Which is Correct?

$x = 8 + t = 8 + 1.54 = 9.54\ m$

Table 3-1

Properties of Vectors

Property	Explanation	Figure	Component representation
Equality	$\vec{A} = \vec{B}$ if $\lvert\vec{A}\rvert = \lvert\vec{B}\rvert$ and their directions are the same		$A_x = B_x$ $A_y = B_y$ $A_z = B_z$
Addition	$\vec{C} = \vec{A} + \vec{B}$		$C_x = A_x + B_x$ $C_y = A_y + B_y$ $C_z = A_z + B_z$
Negative of a vector	$\vec{A} = -\vec{B}$ if $\lvert\vec{B}\rvert = \lvert\vec{A}\rvert$ and their directions are opposite		$A_x = -B_x$ $A_y = -B_y$ $A_z = -B_z$
Subtraction	$\vec{C} = \vec{A} - \vec{B}$		$C_x = A_x - B_x$ $C_y = A_y - B_y$ $C_z = A_z - B_z$
Multiplication by a scalar	$\vec{B} = s\vec{A}$ has magnitude $\lvert\vec{B}\rvert = s\lvert\vec{A}\rvert$ and has the same direction as $\vec{A}$ if s is positive or $-\vec{A}$ if s is negative		$B_x = sA_x$ $B_y = sA_y$ $B_z = sA_z$

demo Mb-16 Monkey + cannon

demo Mb-24 Howitzer and Tunnel

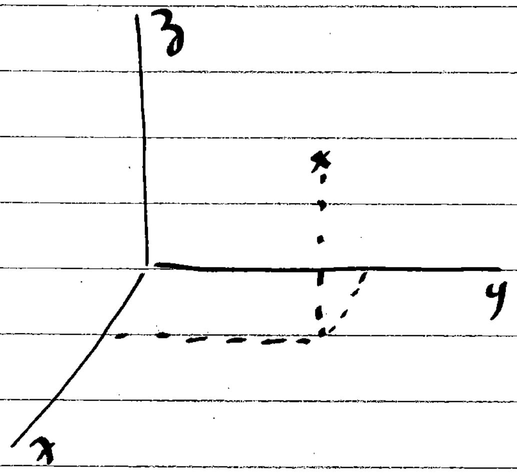
Temperature   Scalar ⇐ #

1-d Motion

(Sign)(Scalar) ← #

Multidimensional Motion

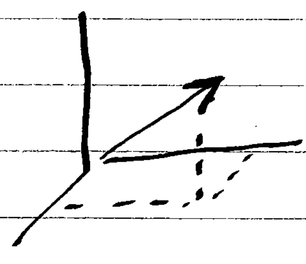
Position



⇒ 3 #'s

Velocity → magnitude + direction

Think of an arrow



Again 3 #'s
can specify
a Magnitude
+
~~and~~ ~~a~~ direction

Vectors – Lesson 1

Vectors : Made up of 3 components or #'s

Have Magnitude and direction

All vectors w/ same direction and Magnitude are equivalent regardless of placement

Picture as an Arrow

$\vec{A} = \nearrow$

$-\vec{A} = \swarrow$ same magnitude, opposite direction

Magnitude of $\vec{A} = |\vec{A}|$

$|a\vec{A}| = |a||\vec{A}|$ in direction of $\vec{A}$

mult vector by constant just scales magnitude

Vector Addition

geometrical

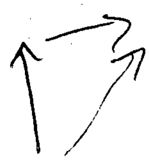
$\vec{A} + \vec{B} = ?$ B

Head to tail Addition

A ↑ B

Boat

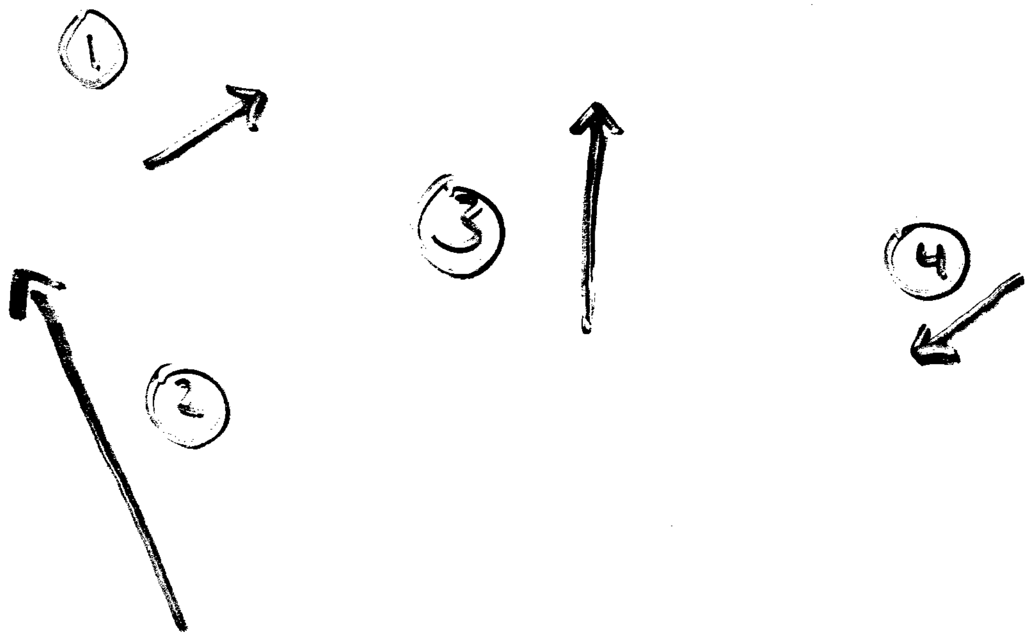
3 student demo



PRS

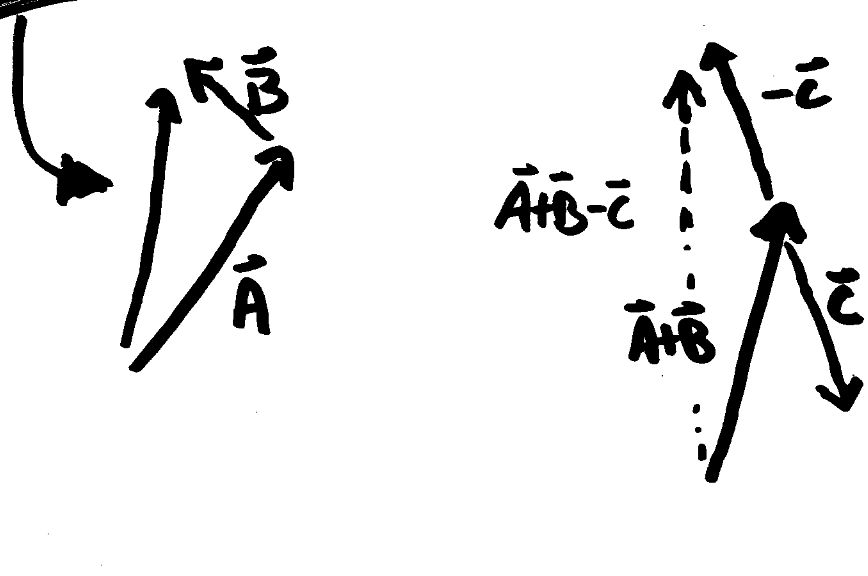
Which vector best Represents

$$\vec{A} + \vec{B} - \vec{C} \quad ?$$



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

$\vec{A} + \vec{B} + (-\vec{C})$

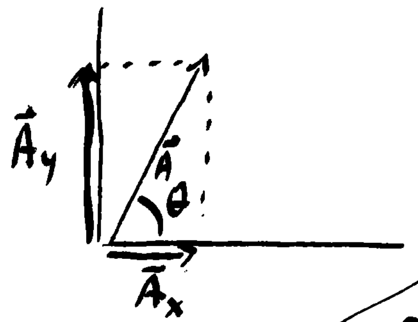


Answer is 2

Addition of vectors : Analytical

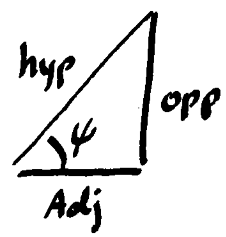
Any vector can be broken up into component

~~Which components you choose depends on the problem~~



$$\frac{|\vec{A}_x|}{|\vec{A}|} = \sin\theta$$

recall



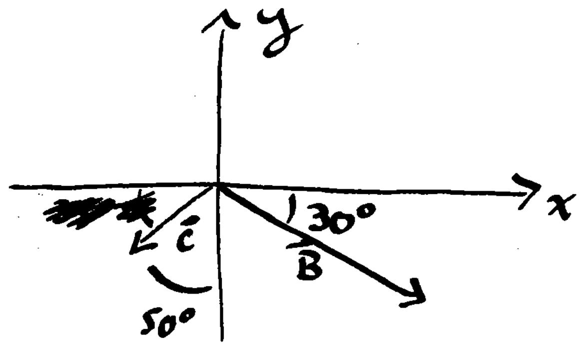
$$\frac{opp}{hyp} = \sin\psi$$

$$\frac{Adj}{hyp} = \cos\psi$$

$$|\vec{A}_x| = |\vec{A}| \sin\theta$$

$$|\vec{A}_y| = |\vec{A}| \cos\theta$$

Example



what is vector sum of $\vec{B}$ and $\vec{C}$

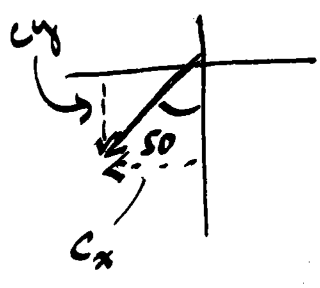
$$\vec{B} + \vec{C} = \vec{R}$$

?

"resolve" $\vec{C}$ into components

$$C_x = -|\vec{C}| \sin 50$$

$$C_y = -|\vec{C}| \cos 50$$



$$B_x = |\vec{B}| \cos 30$$

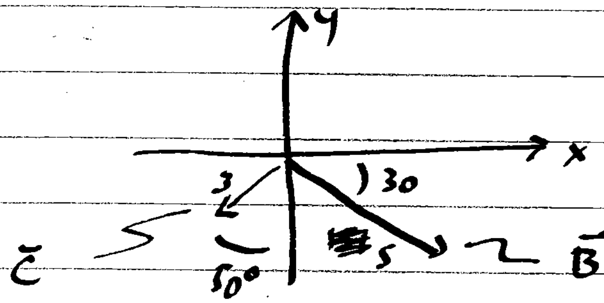
$$B_y = |\vec{B}| \sin 30$$

More on vectors later

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

$\vec{B}$ = vector w/ Magn. 5 30° from +x axis in -y direction

$\vec{C}$ = vector w/ Magn. 3 50° from -y axis in -x direction



resolve $\vec{B}$ into components (create 1d parts from 2d quantity)

$B_x = |\vec{B}| \cos 30$

$B_y = -|\vec{B}| \sin 30$

resolve $\vec{C}$ into components

$C_x = -|\vec{C}| \sin 50$

$C_y = -|\vec{C}| \cos 50$

$R_x = \Sigma$ of x components of vectors in sum

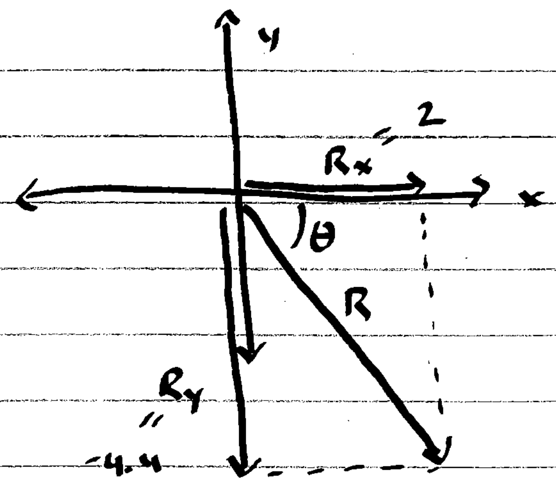
$R_x = |\vec{B}| \cos 30 - |\vec{C}| \sin 50$

$R_x = 5 \cos 30 - 3 \sin 50 = 2$

$R_y = \Sigma$ of y component of vectors in sum

$R_y = -|\vec{B}| \sin 30 - |\vec{C}| \cos 50$

$= -5 \sin 30 - 3 \cos 50 = -4.4$



$|\vec{R}|^2 = R_x^2 + R_y^2 = 23.4 \qquad |\vec{R}| = 4.8$

$\tan\theta = \dfrac{|R_y|}{|R_x|} = \dfrac{4.4}{2} \Rightarrow \theta = 65.6^\circ$

down from +x axis
in -y direction

or clockwise from x-axis