$x_2 - x_1 = \Delta x$ = change in x from $x = x_1$ to $x = x_2$

dx = tiny change in x

$x_2 - x_1 = \Delta x = \int_{x=x_1}^{x=x_2} dx$ = sum of many tiny changes of x, from $x = x_1$ to $x = x_2$.

Calculus rules for differentials: (not exhaustive)

$d(kx) = k\,dx$ if k constant

$d(x \pm y) = dx \pm dy$

$d(xy) = (dx)(y) + (x)(dy)$

$d(x/y) = ((dx)(y) - (x)(dy))/y^2$

$d(x^2) = 2x\,dx$

$d(x^n) = n x^{n-1}\,dx$

Calculus rules for integrals: (not exhaustive)

$\int_{x=a}^{x=b} dx = b - a$ $\int_{x=a}^{x=b} k\,dx = k(b-a)$ if k constant

$$\int_{x=a}^{x=b} \underbrace{x\,dx}_{} = \int_{x^2=a^2}^{x^2=b^2} \frac{1}{2} d(x^2) = \frac{1}{2}(b^2 - a^2)$$

$x\,dx = \frac{1}{2}(2x\,dx) = \frac{1}{2} d(x^2)$

$\vec{r}$ = position $\quad \vec{v}$ = velocity $\quad \vec{a}$ = acceleration

$\vec{v} = \dfrac{d\vec{r}}{dt}$ & $\vec{a} = \dfrac{d\vec{v}}{dt}$ (always, by definition)

<u>If $\vec{a}$ is constant, then also:</u>

$$\vec{v} - \vec{v}_0 = \Delta\vec{v} = \int_{\vec{v}_0}^{\vec{v}} d\vec{v} = \int_0^t \vec{a}\,dt \underset{\uparrow}{=} \vec{a}\,t$$

using $\vec{a}$ constant

$$\boxed{\vec{v} = \vec{v}_0 + \vec{a}\,t}$$

$$\vec{r} - \vec{r}_0 = \Delta\vec{r} = \int_{\vec{r}_0}^{\vec{r}} d\vec{r} = \int_0^t \vec{v}\,dt = \int_0^t (\vec{v}_0 + \vec{a}t)\,dt$$

$$\vec{r} - \vec{r}_0 = \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2 \qquad \boxed{\vec{r} = \vec{r}_0 + \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2}$$

$$v_x^2 - v_{x0}^2 = \Delta(v_x^2) = \int_{v_{x0}^2}^{v_x^2} d(v_x^2) = \int_{v_{x0}}^{v_x} 2v_x\,dv_x$$

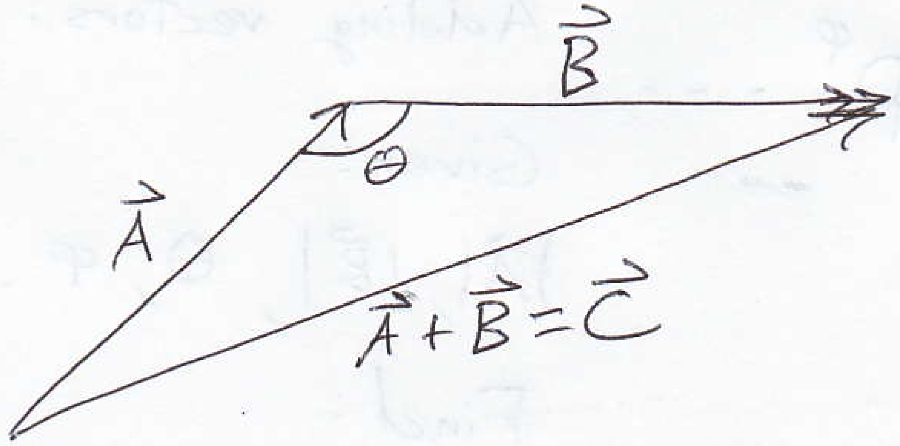
$$v_x^2 - v_{x0}^2 = \int_0^t 2\left(\frac{dr_x}{dt}\right)(a_x\,dt) = \int_{r_{x0}}^{r_x} 2a_x\,dr_x$$

$$v_x^2 - v_{x0}^2 \underset{\uparrow}{=} 2a_x\,\Delta r_x \qquad \boxed{v_x^2 = v_{x0}^2 + 2a_x(r_x - r_{x0})}$$

using $\vec{a}$ constant

Similarly, $\quad \boxed{v_y^2 = v_{y0}^2 + 2a_y(r_y - r_{y0})}$

Vector addition example:

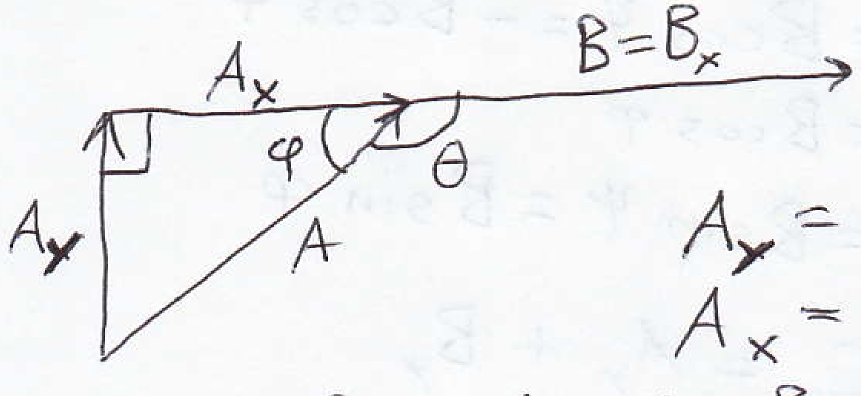


Given A, B, θ, Find C.

Method 1: Law of Cosines:

$$C = \sqrt{A^2+B^2-2AB\cos\theta}$$

Method 2: components:



$$\varphi = 180^\circ - \theta$$

$$A_y = A\sin\varphi = A\sin\theta$$

$$A_x = A\cos\varphi = -A\cos\theta$$

$$C_x = A_x + B_x = -A\cos\theta + B$$

$$C_y = A_y + B_y = A\sin\theta + 0$$

$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(-A\cos\theta + B)^2 + (A\sin\theta)^2}$$

(same as other answer)