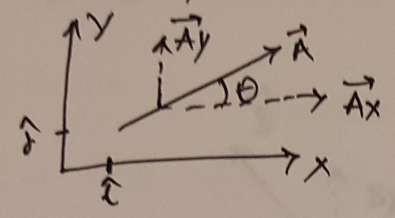
Vectors and coordinate systems (Knight textbook 3rd chapter)

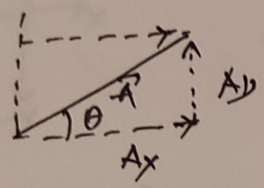
Vectors: Both magnitude and direction

Unit vector: Vector of unit length. Unit vectors in the direction of x, y axes in 2D Cartesian coordinate system are $\hat{i}, \hat{j}$



$$\vec{A} = \vec{A_x} + \vec{A_y} = A_x \hat{i} + A_y \hat{j}$$

Magnitude of vector $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$

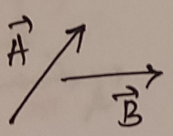


$$\sin\theta = \frac{A_y}{|\vec{A}|} \; ; \; \cos\theta = \frac{A_x}{|\vec{A}|} \Rightarrow \tan\theta = \frac{A_y}{A_x}$$

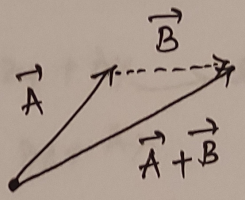
$$\sqrt{A_x^2 + A_y^2} = |\vec{A}|$$

- Sign of A_x is +ve if $\vec{A_x}$ points +ve x direction, negative if $\vec{A_x}$ points -ve x. Similar for A_y

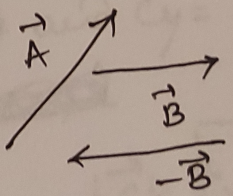
Vector Addition

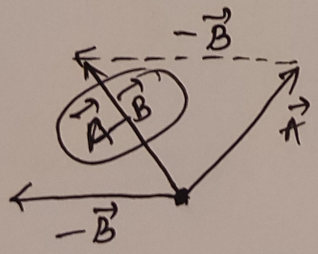


written as



Subtraction is Addition with negative sign

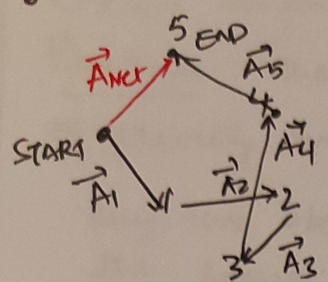




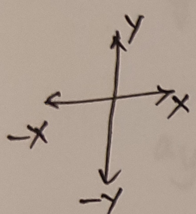
Multiplication $\vec{A} \cdot \vec{B}$ = Dot Product of $\vec{A}$ and $\vec{B}$ $= |\vec{A}||\vec{B}|\cos\theta$

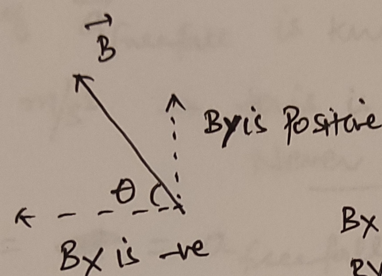
$\vec{A} \times \vec{B}$ = Cross product of $\vec{A}$ and $\vec{B}$ $= |\vec{A}||\vec{B}|\sin\theta\, \hat{n}$

$\hat{n}$ is unit vector perpendicular to the plane determined by $\vec{A}, \vec{B}$



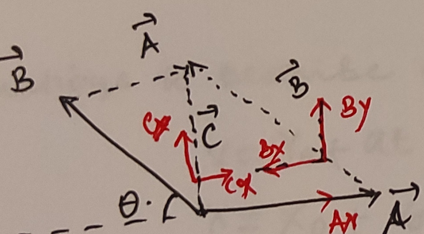
$$\vec{A}_{NET} = \vec{A}_1 + \vec{A}_2 + \vec{A}_3 + \vec{A}_4 + \vec{A}_5$$





$B_x = -|B| \cos\theta$

$B_y = |B| \sin\theta$



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

$C_y = B_y + A_y$ → here $A_y = 0$ No y component

$C_x = B_x + A_x$

$C_x = -|B| \cos\theta + |A|$ and $C_y = |B| \sin\theta$

[illegible]

[illegible]

$\therefore |\vec{C}| = \sqrt{(C_x)^2 + (C_y)^2}$

Slow

(Knight Text Book Chapter 2) ③

Free fall : The motion of an object moving under the influence of gravity only, and no other forces is called free fall

Any two objects in free fall, regardless of their mass, have the same acceleration $\vec{a}_{freefall} = 9.8\ m/sec^2$ vertically down

Magnitude of $\vec{a}_{freefall}$ is known as the free fall acceleration

$g = 9.8\ m/s^2$ → this is always +ve

Never use -ve value of g.

$a_y = -g = a_{freefall}$ ay is negative not g.

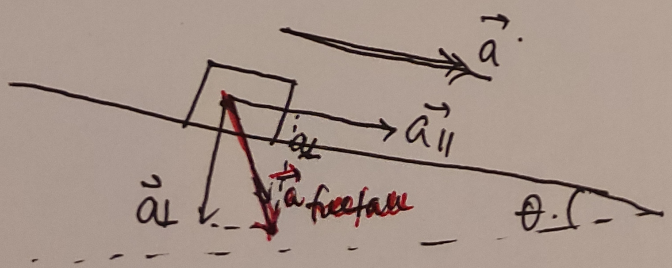
Equations to describe motion with constant acceleration

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2} a t^2$ x_0 is position at $t=0$

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

Motion on an inclined plane



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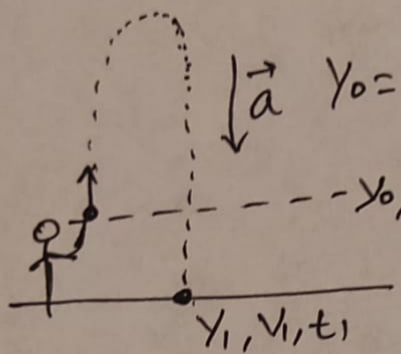
Problem 2.19 in Knight text Book

A student standing on the ground throws a ball straight up, the ball leaves the student's hand with 15 m/s speed when the hand is 2.0 m above the ground. How long is the ball in the air before it hits the ground? (The student moves her hand out of the way.)



$a_y = -9.8\ m/sec^2$

$v_0 = 15\ m/sec$ $\quad t_0 = 0$

$t_1 = ?$

$$y_1 = y_0 + v_0 \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Rightarrow -2 = 0 + 15 \cdot t + \frac{1}{2}(-9.8)t^2$$

$$\Rightarrow t = \underline{3.2}\ sec$$