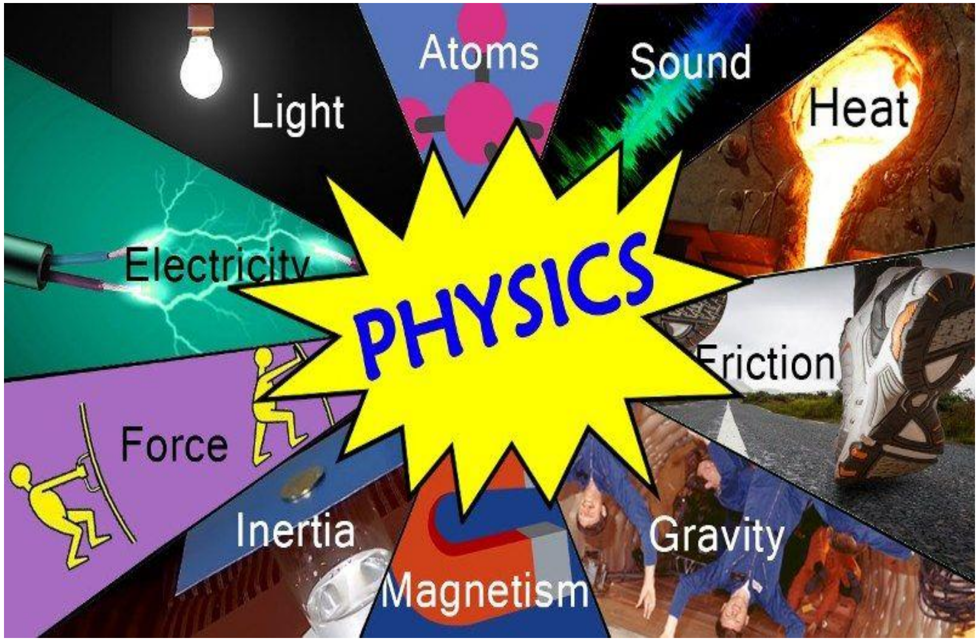
GENERAL PHYSICS I



FOR EDUCATION

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OUTLINES

Chapter 1

- **Introduction**
- **International System of units (SI)**
- **Units Conversion**
- **Scalar quantities and vector quantities**
- **Operations on vectors**

Chapter 2

- **Motion**
- **Types of motion**
- **Laws o f motion**

Chapter 3

- **Forces**
- **Newton’s laws**
- **Applications on newton’s laws**

Chapter 4

- **Work and Energy**
- **Laws and theories on work and energy**

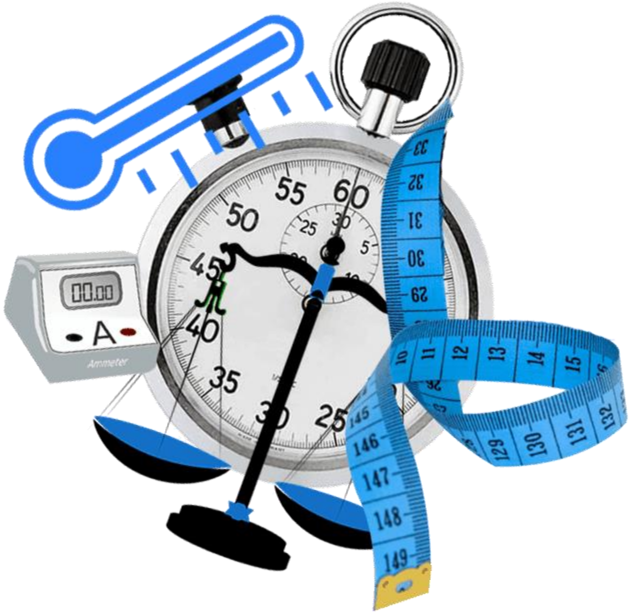
CHAPTER 1

OUTLINES

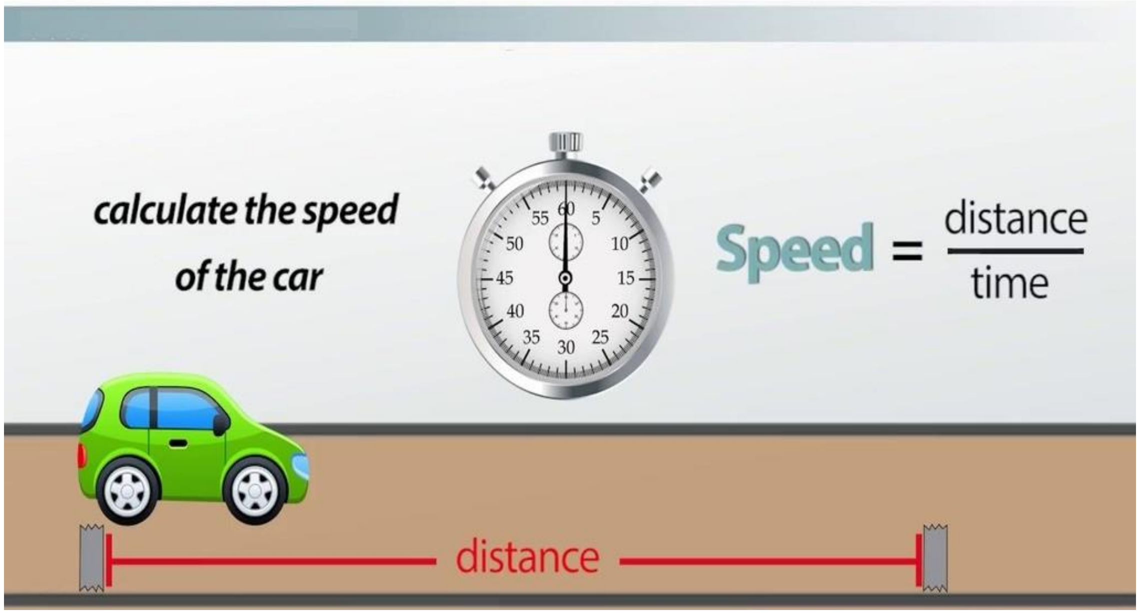
- ☐ **Introduction**
- ☐ **International System of units (SI)**
- ☐ **Units Conversion**
- ☐ **Scalar quantities and vector quantities**
- ☐ **Operations on vectors**

What is Physics?

- Physics is a natural science based on experiments, measurements and mathematical analysis.
- Allows us to understand natural phenomena and relate them to our daily activities.
- Physics precisely define fundamental measurable quantities in the universe (e.g., speed, electric field, energy) and find the relationships between those measured.
- However, all other natural sciences stem (branch) from physics.



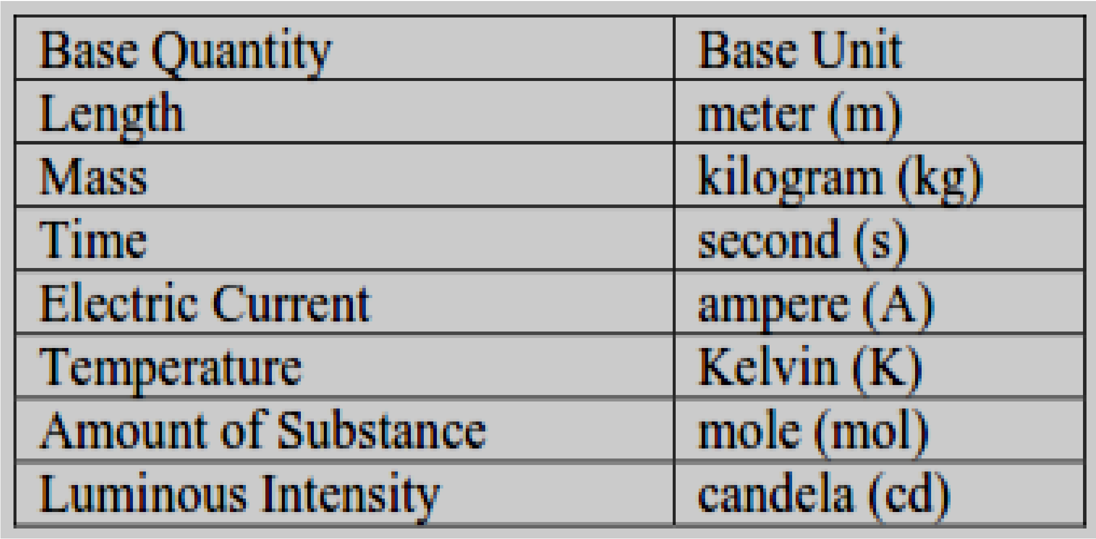
- Example, we can define distance and time by describing the method in which we can measure both of them, and thus we can define the **speed** of a moving object by calculating the **distance** divided by **time**. In this case, both the **distance** and **time** are essential quantity while the **speed** is called a ***Derived Physical Quantity***.



International System of units (SI):

Two systems of units are widely used in the world, the **Metric** or **British** and the **imperial** or **US** system. The metric system measures the length in meters whereas, the **imperial** system makes use of the foot, inch. However, the metric system is the most widely used. Therefore, **metric system will be considered in this course.**

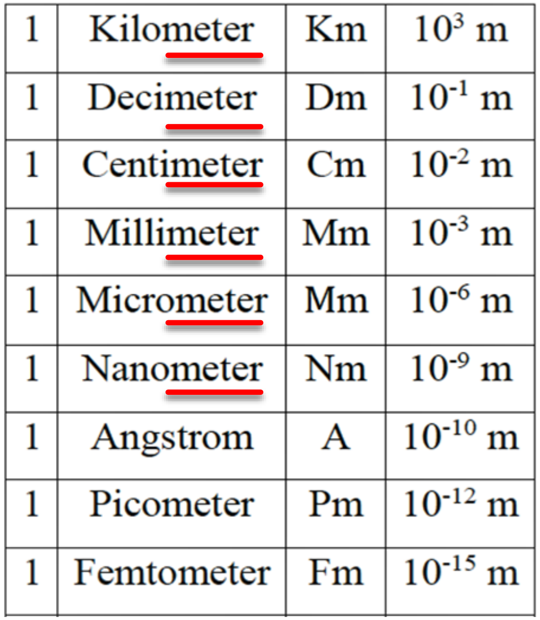
According to the international agreement, the metric system was formalized in 1971 into the *International System of Units* **(SI)**: It consists of **seven base quantities** and their corresponding **base units**



Base Quantity	Base Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Electric Current	ampere (A)
Temperature	Kelvin (K)
Amount of Substance	mole (mol)
Luminous Intensity	candela (cd)

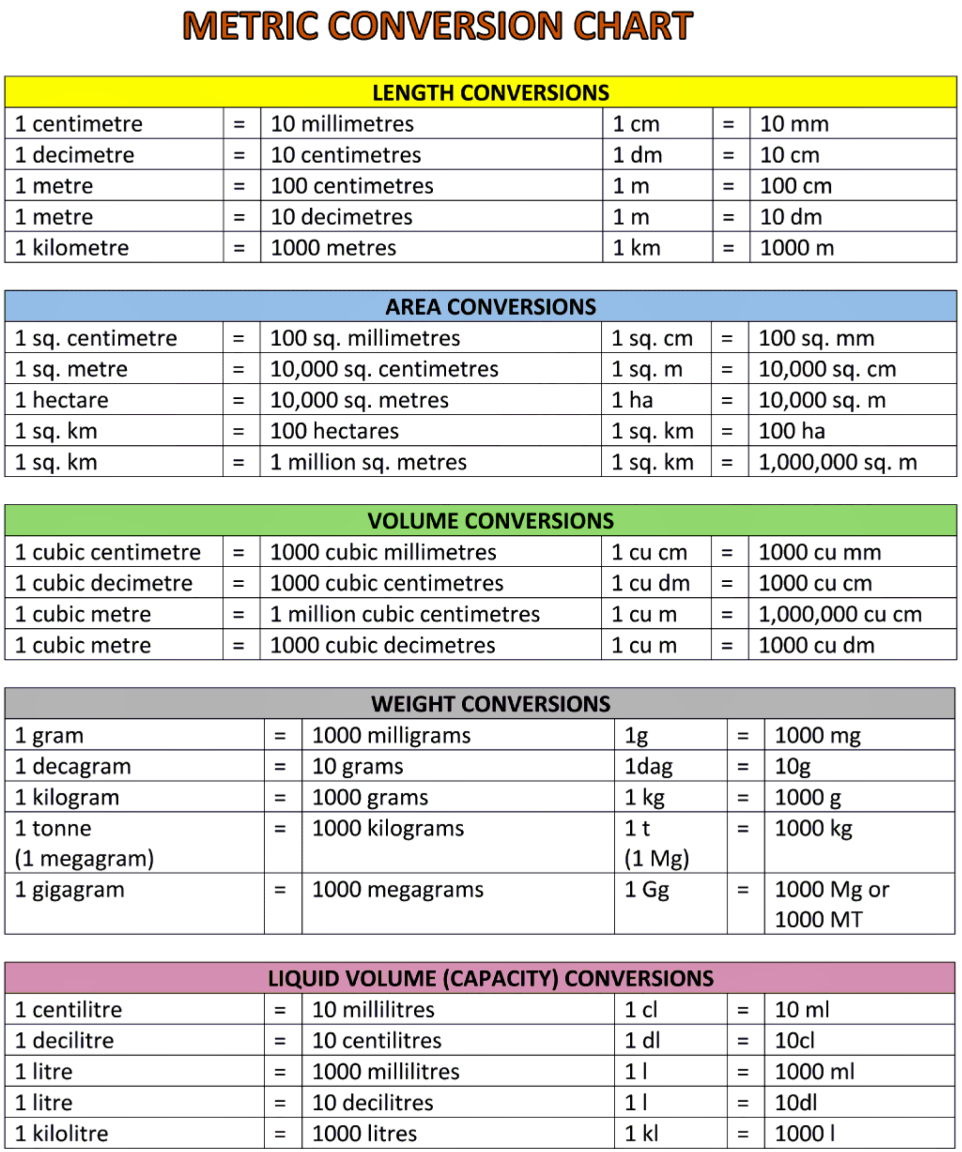
UNIT CONVERSION

- Measurements of physical quantities are expressed in terms of *units*, which are standardized values.
- The four fundamental units are abbreviated as follows: meter, m; kilogram, kg; second, s; and ampere, A.



1	Kilometer	Km	10^3 m
1	Decimeter	Dm	10^{-1} m
1	Centimeter	Cm	10^{-2} m
1	Millimeter	Mm	10^{-3} m
1	Micrometer	Mm	10^{-6} m
1	Nanometer	Nm	10^{-9} m
1	Angstrom	A	10^{-10} m
1	Picometer	Pm	10^{-12} m
1	Femtometer	Fm	10^{-15} m

The metric system also uses a standard set of prefixes to denote each order of magnitude greater than or lesser than the fundamental unit itself (see the table)



METRIC CONVERSION CHART

LENGTH CONVERSIONS					
1 centimetre	=	10 millimetres	1 cm	=	10 mm
1 decimetre	=	10 centimetres	1 dm	=	10 cm
1 metre	=	100 centimetres	1 m	=	100 cm
1 metre	=	10 decimetres	1 m	=	10 dm
1 kilometre	=	1000 metres	1 km	=	1000 m

AREA CONVERSIONS					
1 sq. centimetre	=	100 sq. millimetres	1 sq. cm	=	100 sq. mm
1 sq. metre	=	10,000 sq. centimetres	1 sq. m	=	10,000 sq. cm
1 hectare	=	10,000 sq. metres	1 ha	=	10,000 sq. m
1 sq. km	=	100 hectares	1 sq. km	=	100 ha
1 sq. km	=	1 million sq. metres	1 sq. km	=	1,000,000 sq. m

VOLUME CONVERSIONS					
1 cubic centimetre	=	1000 cubic millimetres	1 cu cm	=	1000 cu mm
1 cubic decimetre	=	1000 cubic centimetres	1 cu dm	=	1000 cu cm
1 cubic metre	=	1 million cubic centimetres	1 cu m	=	1,000,000 cu cm
1 cubic metre	=	1000 cubic decimetres	1 cu m	=	1000 cu dm

WEIGHT CONVERSIONS					
1 gram	=	1000 milligrams	1g	=	1000 mg
1 decagram	=	10 grams	1dag	=	10g
1 kilogram	=	1000 grams	1 kg	=	1000 g
1 tonne (1 megagram)	=	1000 kilograms	1 t (1 Mg)	=	1000 kg
1 gigagram	=	1000 megagrams	1 Gg	=	1000 Mg or 1000 MT

LIQUID VOLUME (CAPACITY) CONVERSIONS					
1 centilitre	=	10 millilitres	1 cl	=	10 ml
1 decilitre	=	10 centilitres	1 dl	=	10cl
1 litre	=	1000 millilitres	1 l	=	1000 ml
1 litre	=	10 decilitres	1 l	=	10dl
1 kilolitre	=	1000 litres	1 kl	=	1000 l

Example: Find the height of a person of 5.3 feet in meters.

1 meter = 3.281 feet

The man height = 1.615 meters

Besides, **astronomical** distances are sometimes described in terms of **light-years** (ly).

A light-year is the distance that light will travel in one year (yr). How far in meters does light travel in one year?

Solution:

Distance = (speed) • (time) ------- (1)

(**One light year corresponds to the distance**).

Since the speed of light in meters per second, we need to know how many seconds are in a year.

We can accomplish this by converting units.

We know that:

1 year = 365.25 days, 1 day = 24 hours, 1 hour = 60 minutes, 1 minute= 60 seconds.

Therefore, number of seconds in a year is: 365.25 x 24 x 60 x 60 = 31,557,600 s.

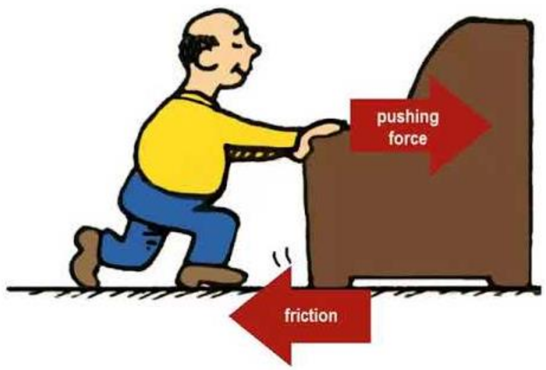
Recall Eq. 1:

Distance = (speed of light) • (time) = $3\text{x}10^8$ **m**/s x 31,557,600 s

= $9.461 \text{ x } 10^{15}$ m.

Scalar and vector quantities

Scalar and vector quantities are differentiated depending on their definition. A scalar quantity is defined as the physical quantity that has only magnitude, for example, mass. On the other hand, a vector quantity is defined as the physical quantity that has both magnitude as well as direction like force.




Mass


Time


Temperature

How to represent (draw) a vector

Vector quantities have magnitude and direction therefore, **arrows** are usually used to represent vectors. The standard coordinate system is used to represent vectors. Points can be represented in the coordinate by (*x*,*y*) therefore, X and Y axes are used to determine the value and direction of vectors.

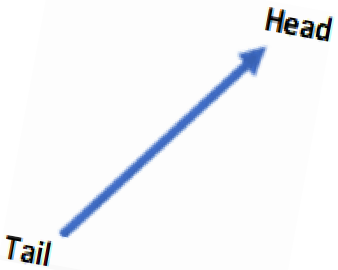
A coordinate system consists of four basic elements:

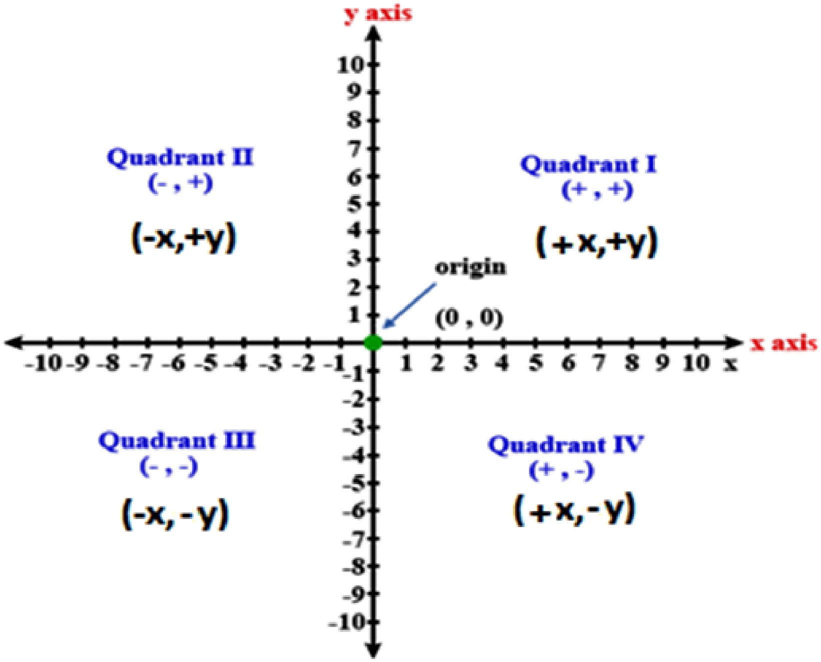
(1) Choice of origin

(2) Choice of axes

(3) Choice of positive direction for each axis

(4) Choice of **unit** vectors for each axis

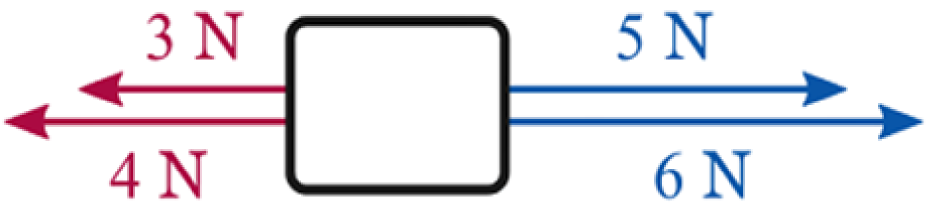


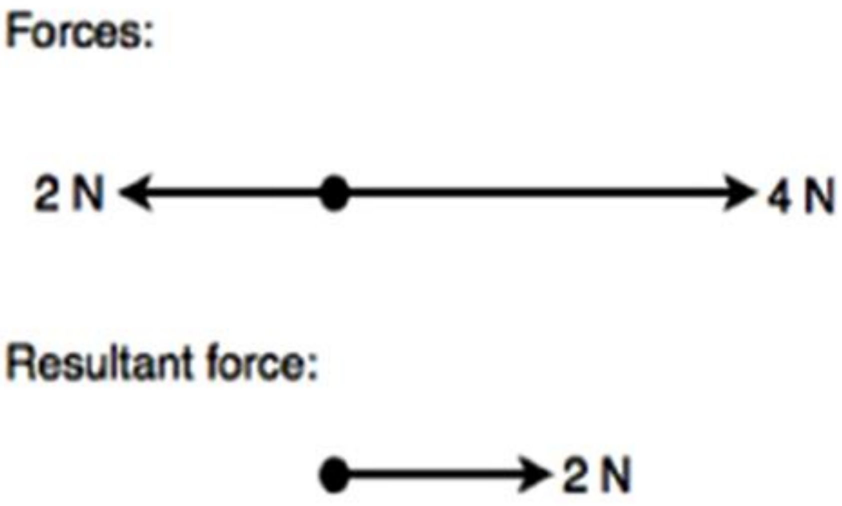


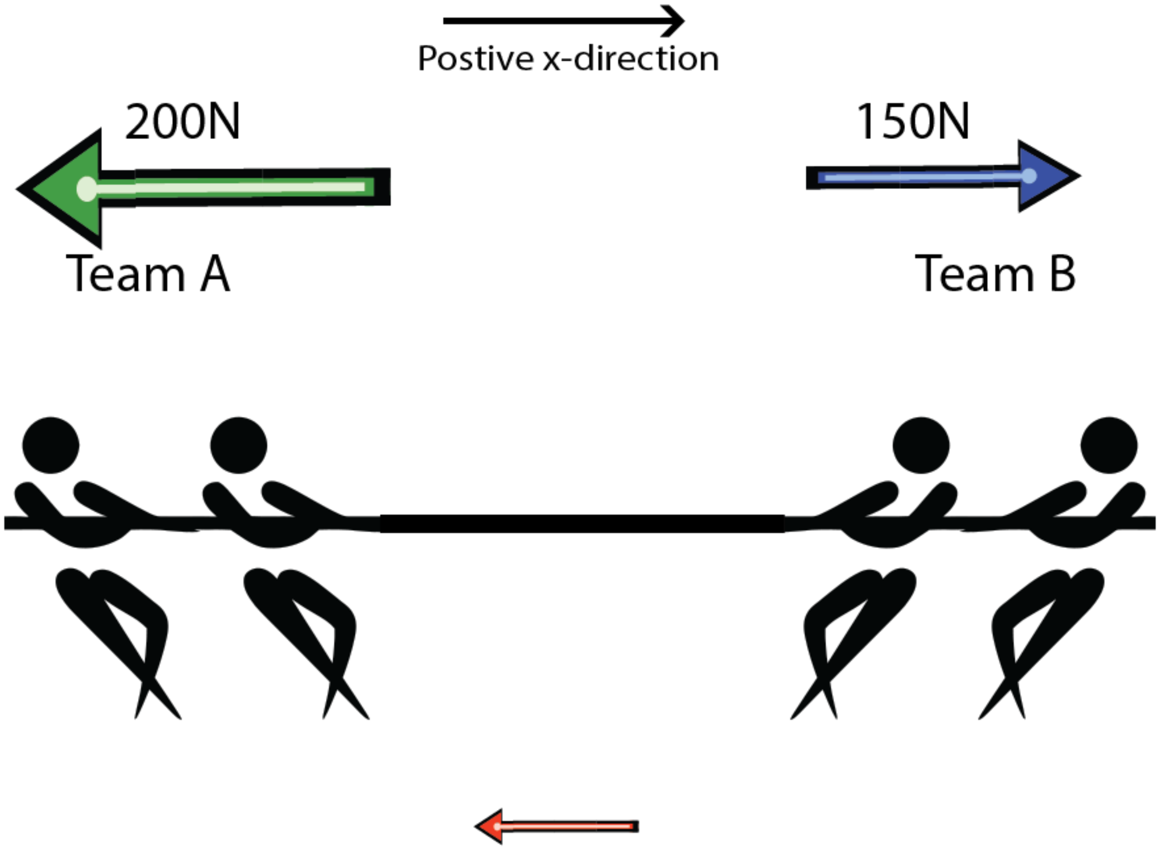
Operations on vectors

1. Addition of vectors

a. Parallel vectors (zero angle)







Postive x-direction

200N

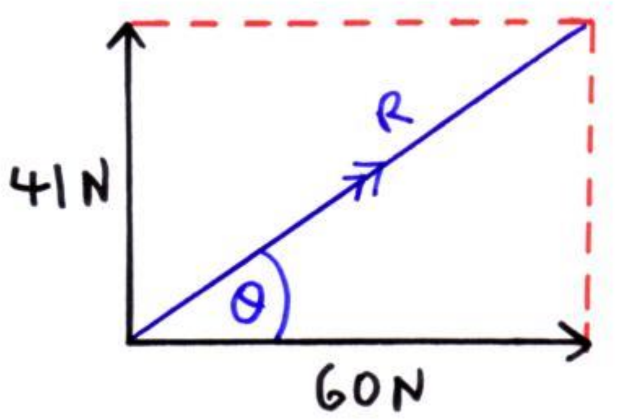
Team A

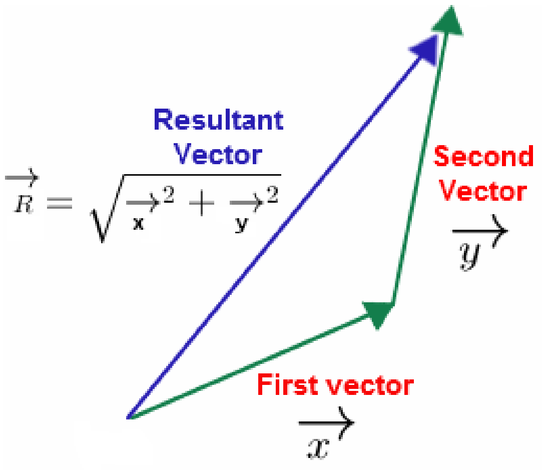
150N

Team B

Resultant force: 50N

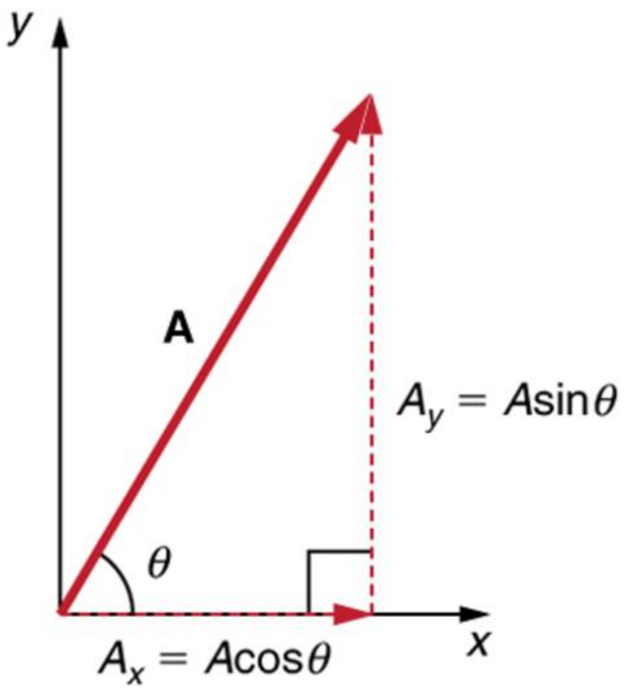
b. Vectors with angle



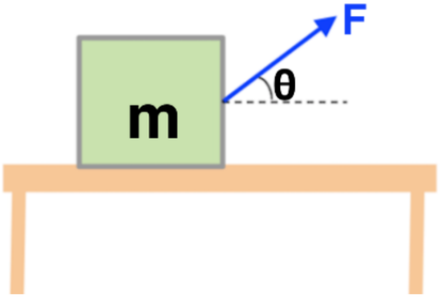


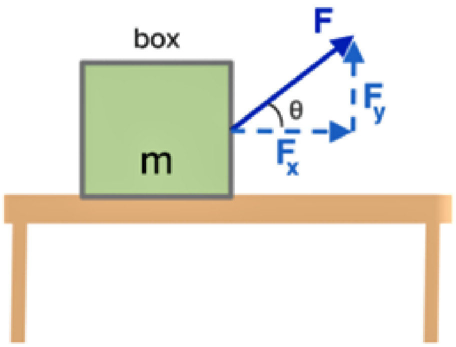
b. Vectors with angle

When the vector makes an angle (θ) with the horizontal, the vector will have two components, one components along x-axis and the other vector along y-axis. The resultant can be found by using Pythagorean theory.



[cosine component always align with the x-axis and sine component with the y-axis]





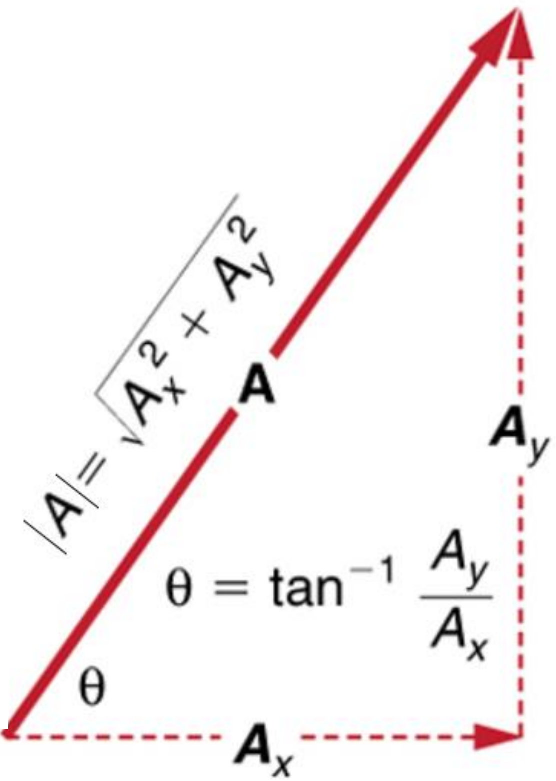
Finding vector direction

To find the angle θ of the vector from the horizontal axis, we can use the horizontal component A_x and vertical component A_y in the trigonometric identity:

$$\tan\theta = \left|\frac{A_y}{A_x}\right|$$

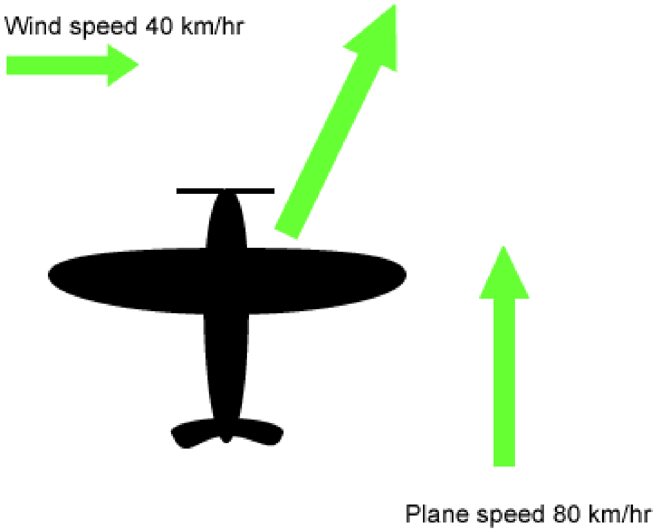
We take the inverse of the $\tan$ function to find the angle θ:

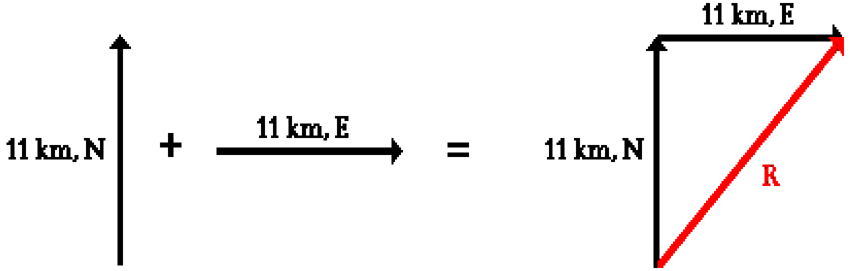
$$\theta = \tan^{-1}\left|\frac{A_y}{A_x}\right|$$



2. Vertical vectors

As it can be seen in the figure, two vectors with magnitude and direction of 11 km, North and 11 km, East can be added together to produce a resultant vector that is directed both north and east. When the two vectors are added head-to-tail as shown below, the resultant is the hypotenuse of a right triangle. The sides of the right triangle have lengths of 11 km and 11 km. The resultant can be determined using the Pythagorean theorem; it has a magnitude of 15.6 km.



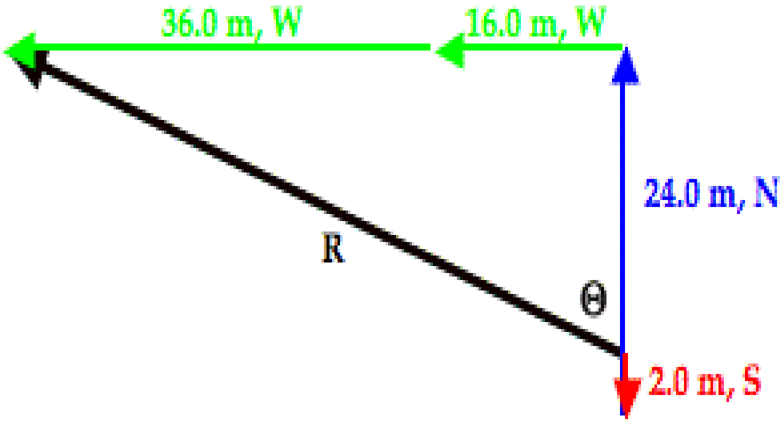


$$11^2 + 11^2 = R^2$$

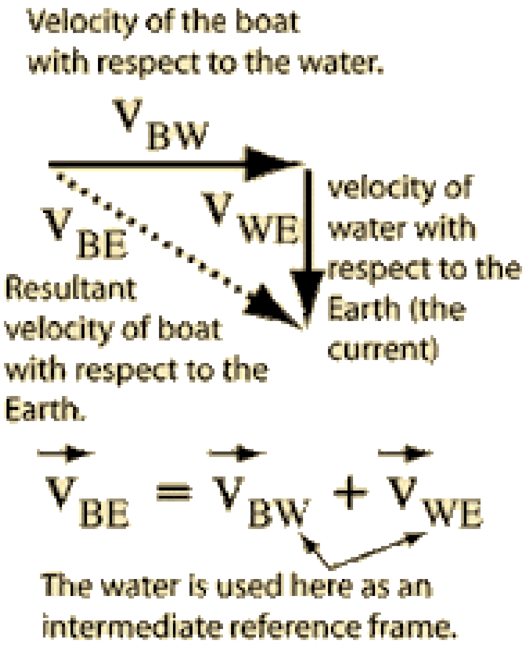
$$242 = R^2$$

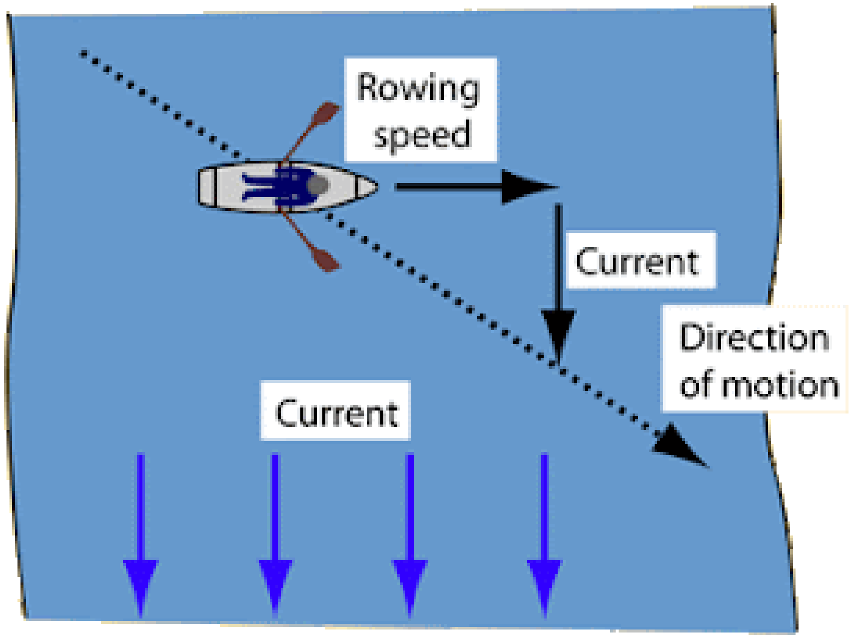
$$15.6 = R$$

With the vectors rearranged, the resultant is the hypotenuse of a right triangle that has two perpendicular sides with lengths of 22.0 m, North and 52.0 m, West. The 22.0 m, North side is the result of 2.0 m, South and 24.0 m, North added together. The 52.0 m, West side is the result of 16.0 m, West and 36.0 m, West added together. The magnitude of the resultant vector (R) can be determined using the Pythagorean Theorem. The direction of the resultant Theta (Θ) can be calculated using the tangent function.

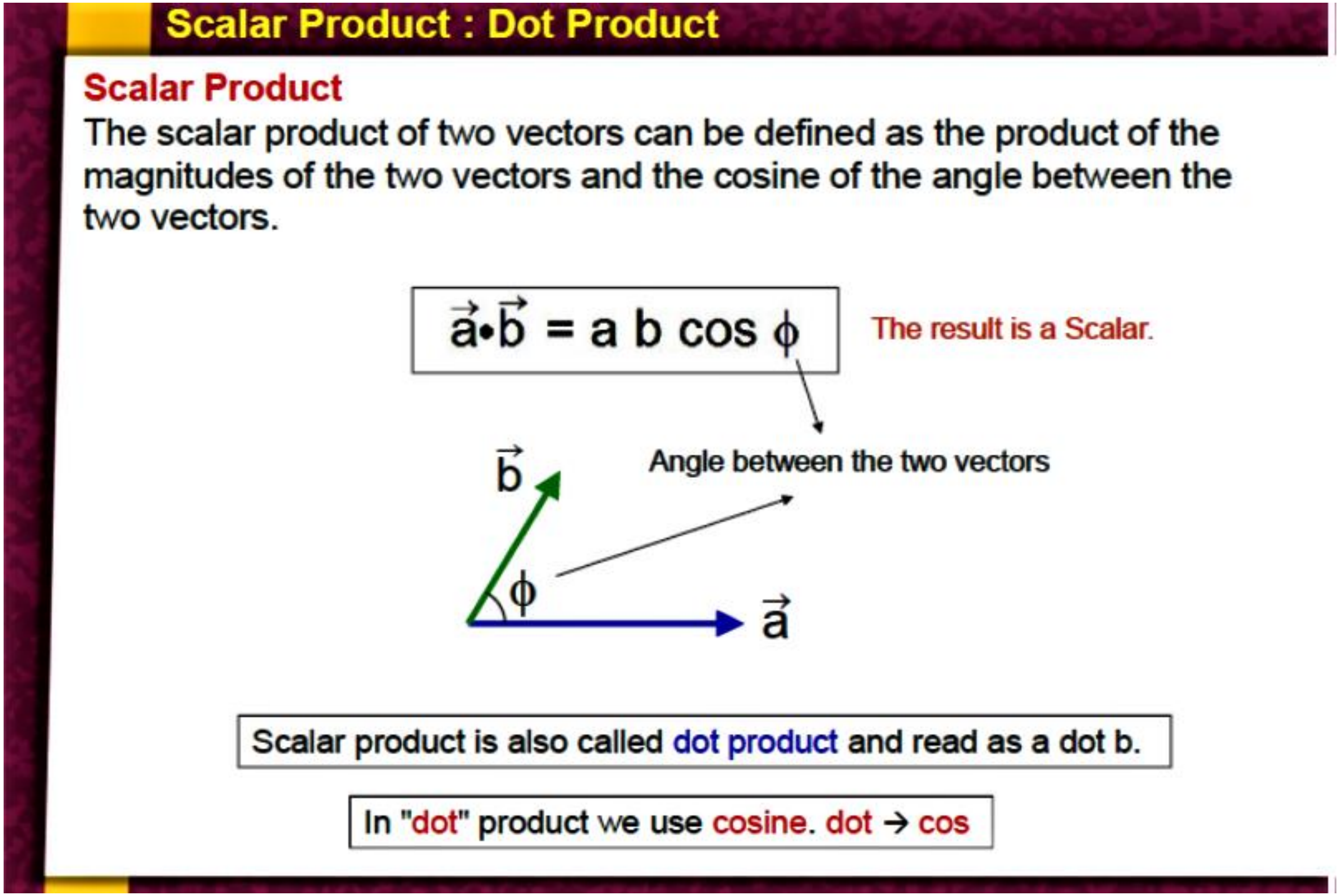


Tangent (Θ) = Opposite/Adjacent
Tangent (Θ) = 52.0/22.0
Tangent (Θ) = 2.3636
$\Theta = \tan^{-1}(2.3636)$
Θ = 67.067°
Θ =67.1°


Velocity of the boat with respect to the water.
V_{BW}
V_{WE}
velocity of water with respect to the Earth (the current)
V_{BE}
Resultant velocity of boat with respect to the Earth.
$\vec{V}_{BE} = \vec{V}_{BW} + \vec{V}_{WE}$
The water is used here as an intermediate reference frame.


Rowing speed
Current
Direction of motion
Current

2. Multiplication of vectors



Scalar Product : Dot Product

Scalar Product

The scalar product of two vectors can be defined as the product of the magnitudes of the two vectors and the cosine of the angle between the two vectors.

$$\vec{a}\bullet\vec{b} = a\ b\cos\phi$$

The result is a Scalar.

Angle between the two vectors

Scalar product is also called dot product and read as a dot b.

In "dot" product we use cosine. dot → cos

Example 1

Consider the two vectors $\vec{a}$ of magnitude 15 and $\vec{b}$ of magnitude 25.
The angle between the vectors is 50^{o}.
Calculate the scalar product of $\vec{a}$ and $\vec{b}$?

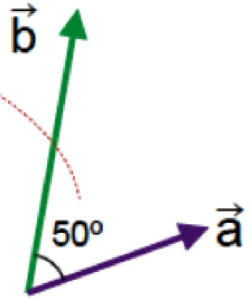
Solution

$$\vec{a} \cdot \vec{b} = |\vec{a}|\ |\vec{b}| \cos \boxed{50}$$

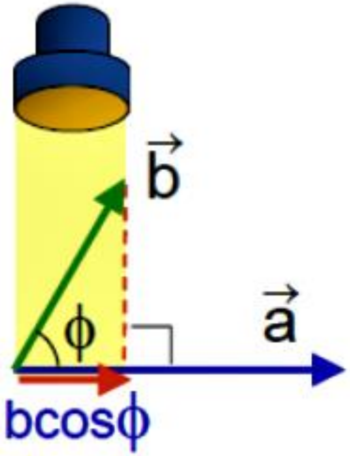
$$= (15)\ (25) \cos 50$$

$$= 375 \text{ x } (0.96)$$

$$= 360$$

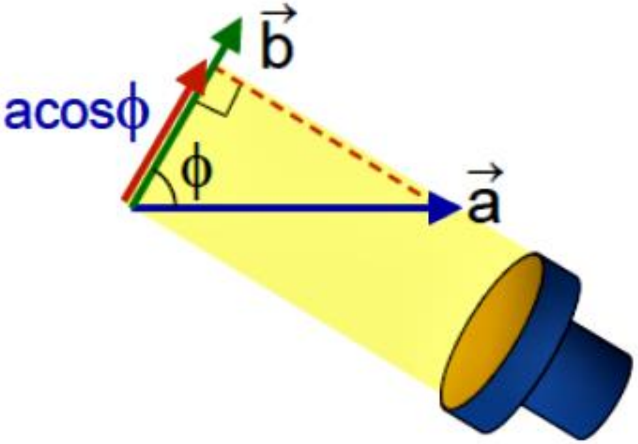


The scalar product is also defined as "the product of the projection of the first vector onto the second vector" and "the magnitude of the second vector".



$$\vec{a}\bullet\vec{b} = a\ b\cos\phi$$

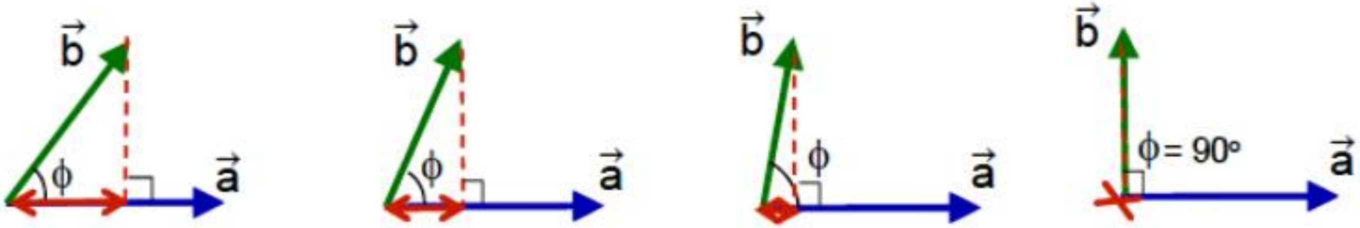
The component of vector b along the direction of vector a is b cos ϕ



$$\vec{a}\bullet\vec{b} = b\ a\cos\phi$$

The component of vector a along the direction of vector b is a cos ϕ

❖ Projection with angle



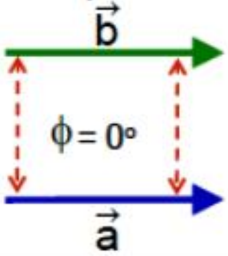
As the lines become perpendicular, the projection gets shorter and becomes zero when the angle is 90º.

The result of dot product of two vectors is zero if the two vectors are perpendicular.

cos(90º) = 0 $\quad \vec{a}\cdot\vec{b} = ab\,\overset{0}{\cancel{\cos}}90 = 0$

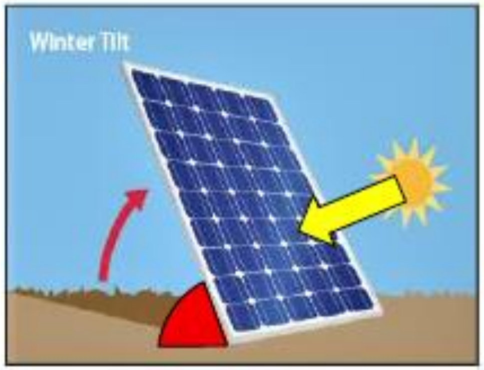
The result of dot product of two vectors is largest if the two vectors are parallel.

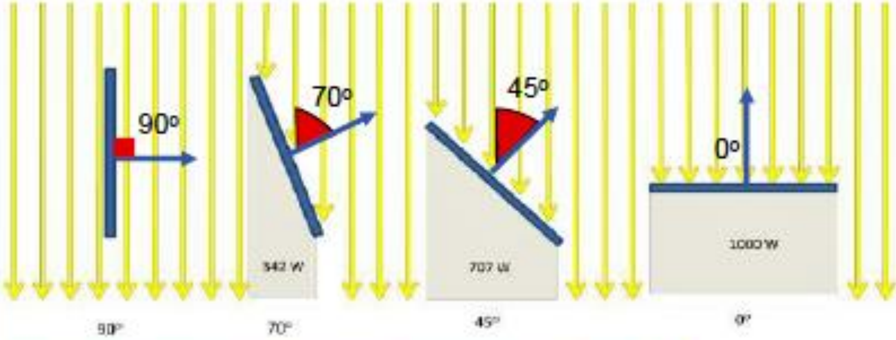
cos(0º) = 1 $\quad \vec{a}\cdot\vec{b} = ab\,\overset{1}{\cancel{\cos}}0 = ab$

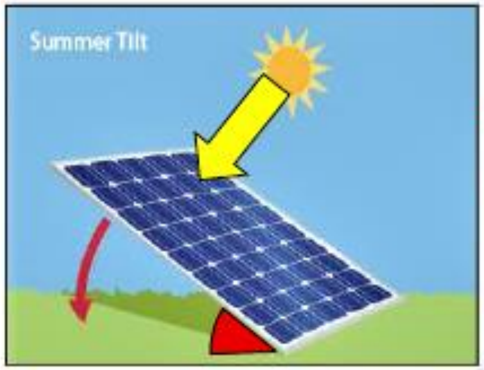


Why are solar panels usually mounted on an angle?

To get the optimum benefit from sunlight, the maximum amount of sunlight should hit the solar panel surface. Alignment of the solar panel effects the amount of Sun light it receives and the electricity it produces. Depending on the position of the Sun, tilt angle of the panel should be changed to increase the efficiency.







Example 3

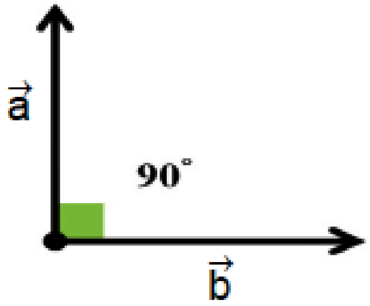
Vector a has magnitude 4, vector b has magnitude 6 and Calculate $\vec{a}\bullet\vec{b}$:

a) If the angle between the vectors a and b is 90°.

b) If the vectors a and b are parallel.

Solution

a) If the angle is 90º than cos(90º) = 0



$$\vec{a}\bullet\vec{b} = a\ b \cos \phi$$

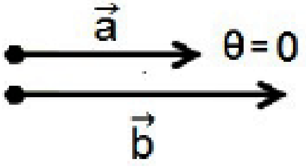
$|\vec{a}| = 4$

$|\vec{b}| = 6$

$$\vec{a}\bullet\vec{b} = a.b \cancelto{0}{\cos 90}$$

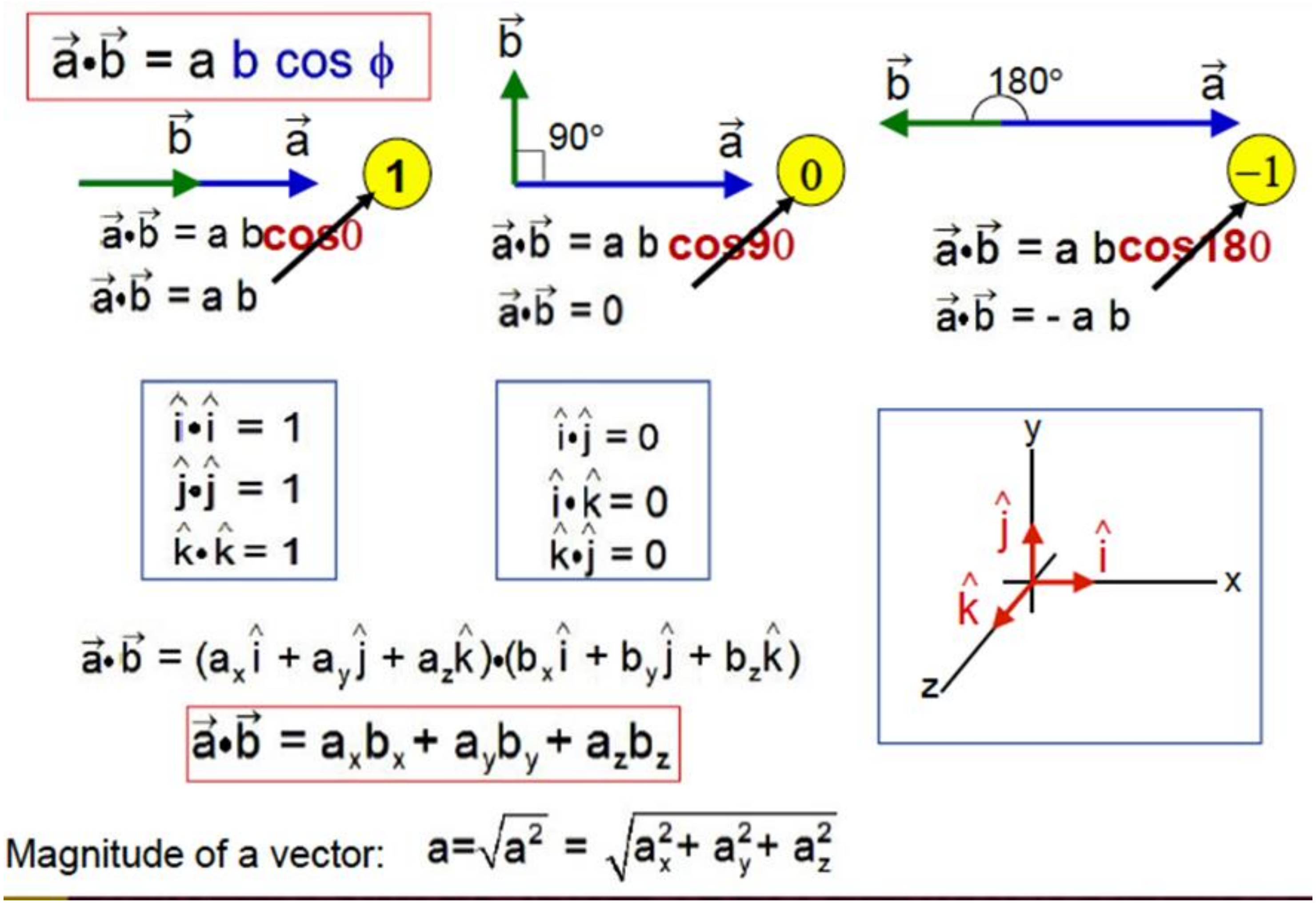
$$\vec{a}\bullet\vec{b} = 4.6.0 = 0$$

b) If the angle is 0º than cos(0º) = 1



$$\vec{a}\bullet\vec{b} = a.b \cancelto{1}{\cos 0}$$

$$\vec{a}\bullet\vec{b} = 4.6.1 = 24$$



$$\boxed{\vec{a}\cdot\vec{b} = a\,b\cos\phi}$$

$$\vec{a}\cdot\vec{b} = a\,b\cos 0$$

$$\vec{a}\cdot\vec{b} = a\,b$$

$$\vec{a}\cdot\vec{b} = a\,b\cos 90$$

$$\vec{a}\cdot\vec{b} = 0$$

$$\vec{a}\cdot\vec{b} = a\,b\cos 180$$

$$\vec{a}\cdot\vec{b} = -\,a\,b$$

$$\hat{i}\cdot\hat{i} = 1$$
$$\hat{j}\cdot\hat{j} = 1$$
$$\hat{k}\cdot\hat{k} = 1$$

$$\hat{i}\cdot\hat{j} = 0$$
$$\hat{i}\cdot\hat{k} = 0$$
$$\hat{k}\cdot\hat{j} = 0$$

$$\vec{a}\cdot\vec{b} = (a_x\hat{i} + a_y\hat{j} + a_z\hat{k})\cdot(b_x\hat{i} + b_y\hat{j} + b_z\hat{k})$$

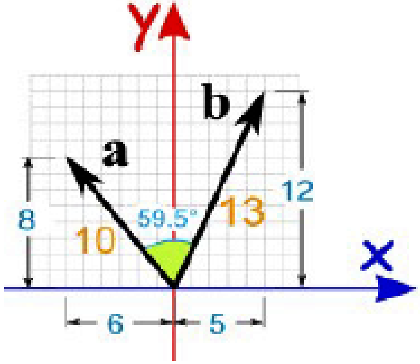
$$\boxed{\vec{a}\cdot\vec{b} = a_x b_x + a_y b_y + a_z b_z}$$

Magnitude of a vector: $a=\sqrt{a^2} = \sqrt{a_x^2 + a_y^2 + a_z^2}$

Example 5

According to the graph and calculate the value of $\vec{a} \bullet \vec{b}$.

The values of a = 10, and b = 13.



Solution I: $\vec{a} \bullet \vec{b} = a\ b \cos \phi$

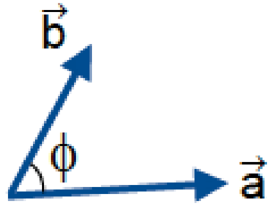
$\vec{a} \bullet \vec{b} = 10 \times 13 \times \cos (59.5) = 130 \times (0.505)$
$\vec{a} \bullet \vec{b} = 66$

Solution II: $a_x = -6 \quad b_x = 5 \quad a_y = 8 \quad b_y = 12$

$\vec{a} \bullet \vec{b} = a_x . b_x + a_y . b_y = -6.5 + 8.12$
$\vec{a} \bullet \vec{b} = 66$

One of the common applications of the **scalar(dot) product** is to find the angle between two vectors.

$$\vec{a} \cdot \vec{b} = a\ b \cos\phi \;\Rightarrow\; \cos\phi = \frac{\vec{a} \cdot \vec{b}}{a\ b}$$



Example 6

What is the angle between $\vec{a} = 3.0\hat{i} - 4.0\hat{j}$ and $\vec{b} = -2.0\hat{i} + 3.0\hat{k}$?

Solution

$$\vec{a} \cdot \vec{b} = a\ b \cos\phi$$

$$\cos\phi = \frac{\boxed{\vec{a} \cdot \vec{b}}}{\boxed{a\ b}}$$

$$\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z$$

$$\vec{a} \cdot \vec{b} = (3.0)(-2.0) + (-4.0)(0) + (0)(3.0) = -6.0$$

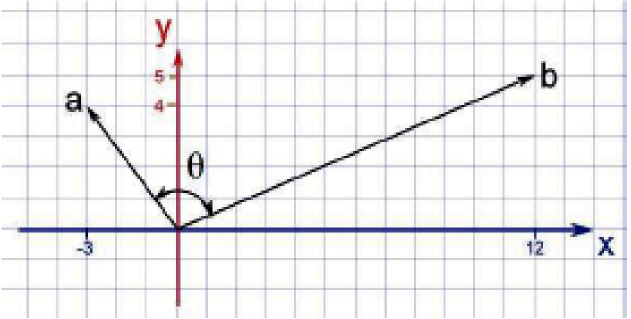
$$a = \sqrt{3.0^2 + (-4.0)^2} = 5.0$$

$$b = \sqrt{(-2.0)^2 + (3.0)^2} = 3.6$$

$$\phi = \cos^{-1} \frac{-6.0}{(5.0)(3.6)} = 110°$$

Example 7

Use the dot product and calculate the angle θ.



Solution

$\vec{a} = -3\,\hat{i} + 4\,\hat{j}$

$\vec{b} = 12\,\hat{i} + 5\,\hat{j}$

$IaI = \sqrt{(3)^2 + (4)^2} = 5$

$IbI = \sqrt{(12)^2 + (5)^2} = 13$

$\boxed{IaI.IbI = 5.13 = 65}$

$\vec{a}\bullet\vec{b} = a_x . b_x + a_y . b_y$ $a_x = -3$; $b_x = 12$; $a_y = 4$; $b_y = 5$

$\vec{a}\bullet\vec{b} = a_x . b_x + a_y . b_y = -3.12 + 4.5 = -16$

$$\cos\theta = \frac{\vec{a}\bullet\vec{b}}{a\ b} = \frac{-16}{65} = -0.18$$

$$\boxed{\theta = 104.3^o}$$

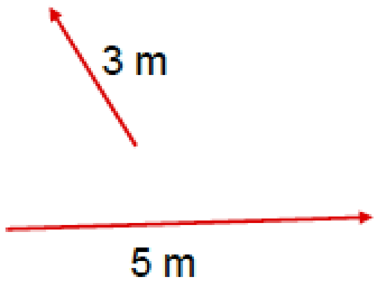
Example 8

Two vectors have magnitudes of 5 m and 3 m respectively. What is the angle between them if their dot product is:

a) zero

b) 15 m^2

c) -15 m^2



Solution

$\phi = 90°$

$\phi = 0°$

$\phi = 180°$

Vector Product

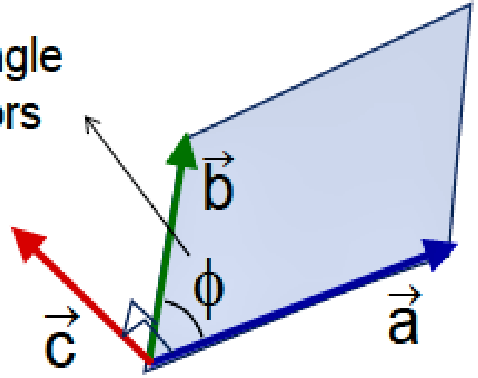
The vector product or cross product of two vectors is defined as “the vector perpendicular to the plane” determined by” the two vectors whose magnitude is the product of the magnitudes of the two vectors and the sine of the angle between the two vectors”.

$$\vec{a} \times \vec{b} = \vec{c}$$

$$c = a\, b \sin\phi$$

The result is a Vector.

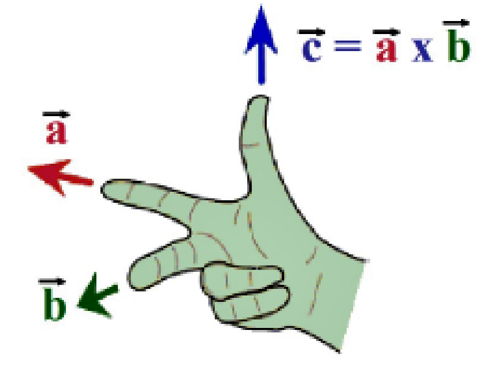
ϕ is the smaller angle between the vectors a and b.



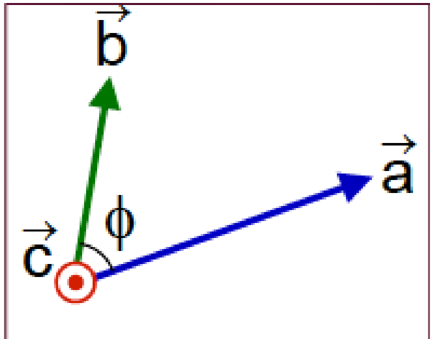
Two vectors a and b, a × b (read "a cross b"), is a vector that is perpendicular to both a and b.

For cross product we use sine. cross →sine

Right-hand rule



$$\vec{a} \times \vec{b} = -\vec{b} \times \vec{a}$$



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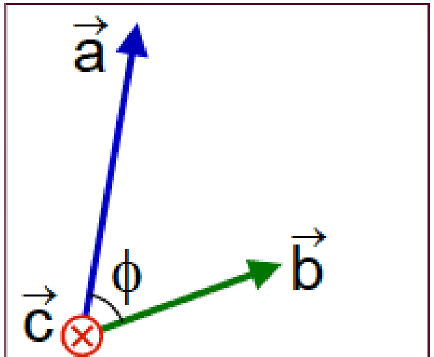

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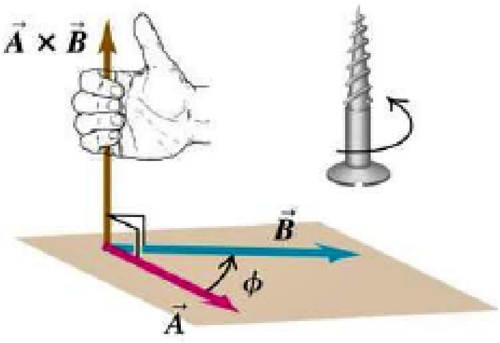
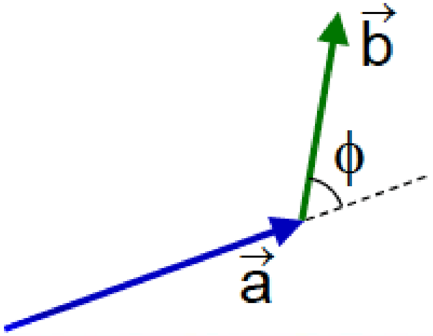
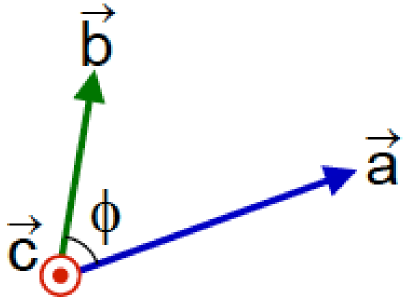
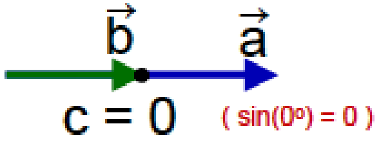




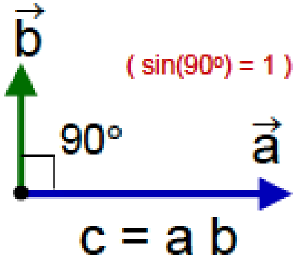


$\vec{c} = \vec{a} \times \vec{b}$

$c = a\,b \sin \phi$

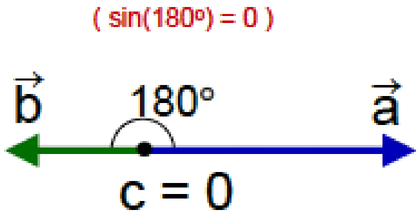


$c = 0$ (sin(0º) = 0)



(sin(90º) = 1)

$c = a\,b$



(sin(180º) = 0)

$c = 0$

$\hat{i} \times \hat{i} = 0$

$\hat{j} \times \hat{j} = 0$

$\hat{k} \times \hat{k} = 0$

$\hat{i} \times \hat{j} = \hat{k}$

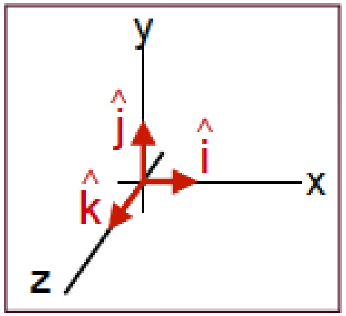
$\hat{j} \times \hat{k} = \hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$

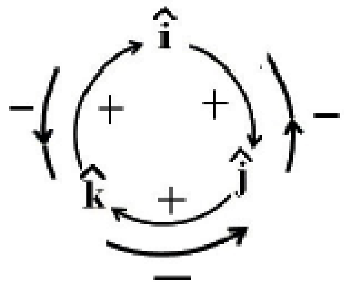
$\hat{j} \times \hat{i} = -\hat{k}$

$\hat{k} \times \hat{j} = -\hat{i}$

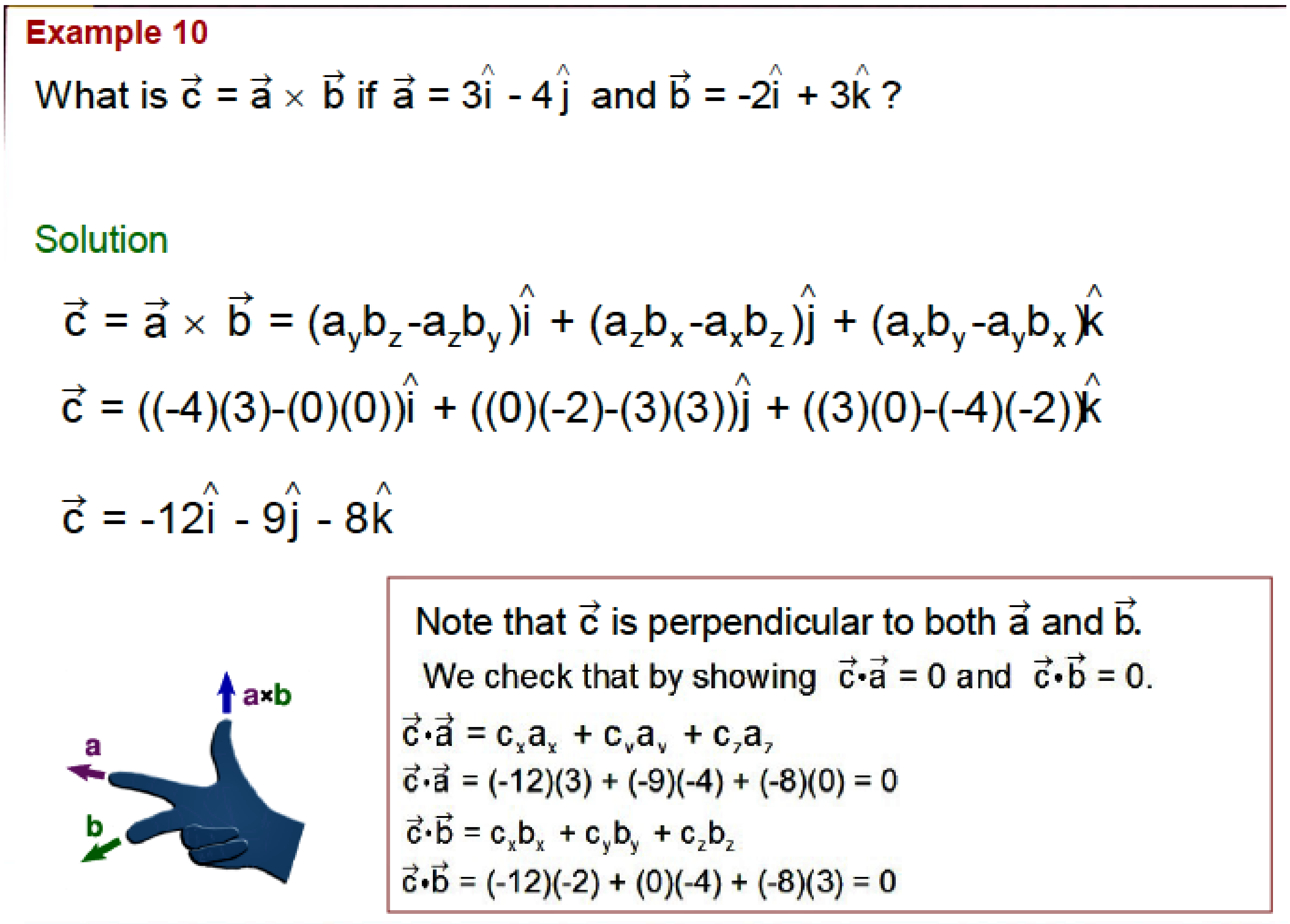
$\hat{i} \times \hat{k} = -\hat{j}$



The order of unit vectors is important.
i always comes before j.
j always comes before k.
k always comes before i.
If they are not in this order,
then the answer is negative.



In the clockwise direction the signal is positive, in the counterclockwise direction the signal is negative.



Example 10

What is $\vec{c} = \vec{a} \times \vec{b}$ if $\vec{a} = 3\hat{i} - 4\hat{j}$ and $\vec{b} = -2\hat{i} + 3\hat{k}$?

Solution

$$\vec{c} = \vec{a} \times \vec{b} = (a_y b_z - a_z b_y)\hat{i} + (a_z b_x - a_x b_z)\hat{j} + (a_x b_y - a_y b_x)\hat{k}$$

$$\vec{c} = ((-4)(3)-(0)(0))\hat{i} + ((0)(-2)-(3)(3))\hat{j} + ((3)(0)-(-4)(-2))\hat{k}$$

$$\vec{c} = -12\hat{i} - 9\hat{j} - 8\hat{k}$$

Note that $\vec{c}$ is perpendicular to both $\vec{a}$ and $\vec{b}$.

We check that by showing $\vec{c} \cdot \vec{a} = 0$ and $\vec{c} \cdot \vec{b} = 0$.

$$\vec{c} \cdot \vec{a} = c_x a_x + c_y a_y + c_z a_z$$

$$\vec{c} \cdot \vec{a} = (-12)(3) + (-9)(-4) + (-8)(0) = 0$$

$$\vec{c} \cdot \vec{b} = c_x b_x + c_y b_y + c_z b_z$$

$$\vec{c} \cdot \vec{b} = (-12)(-2) + (0)(-4) + (-8)(3) = 0$$

Example 11

Vector **a** lies on x axis and vector **b** lies on y axis. Let the magnitude of vector **a** is 2 and **b** is 5, and the angle between them is 30º. Find **a** x **b.**

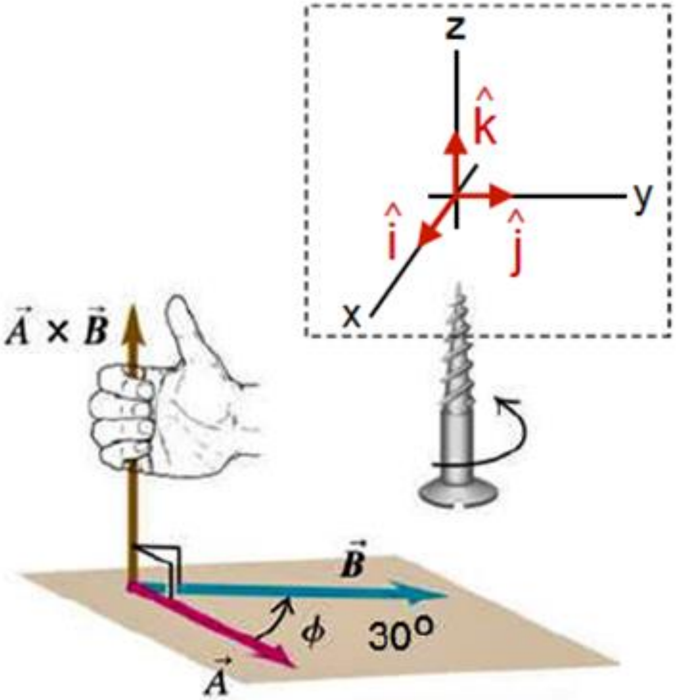
Solution

a = 2 and b = 5.

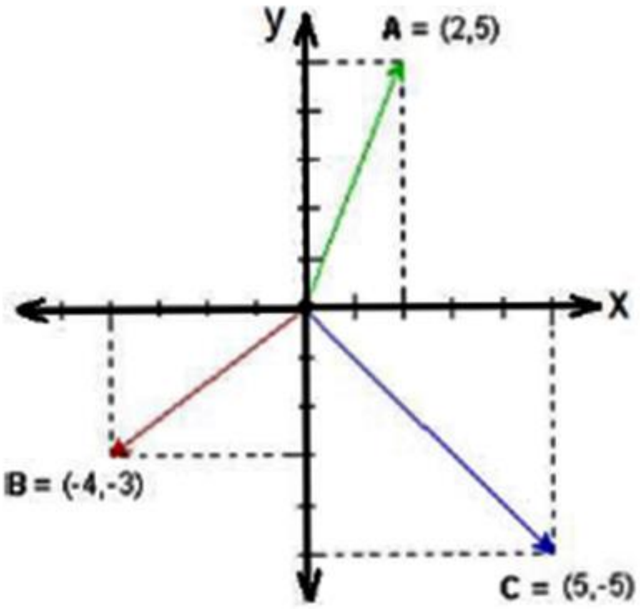
$$\vec{a}\times\vec{b}=a\ b\ \sin\phi$$

$$\vec{a}\times\vec{b}=2\cdot 5\ \sin 30^{o}$$

$$\vec{a}\times\vec{b}=10\ .\ (0.5)=5\,\hat{k}$$



Example 12



Consider the vectors **A, B** and **C** in the graph.

a) Write down the vectors in unit vector notation.

b) Find **K = A + B**

c) Calculate the vector product: **K** x **C.**

Solution

CHAPTER 2

OUTLINES

☐ **Motion**

☐ **Types of motion**

☐ **Projectiles**

☐ **Definitions and concepts on motion**

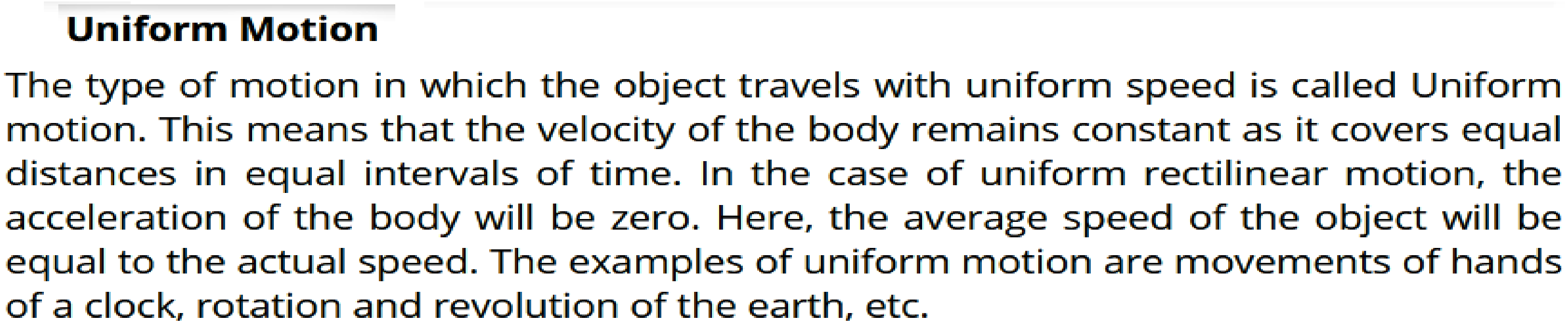
☐ **Laws of motion**

Linear Motion (1D Motion): Uniform motion and non-uniform motion

Motion in one dimension is the motion where the object moves in a straight line. So, it is also sometimes called Motion in a straight line. One-dimensional motion can be described using some terminologies such as:

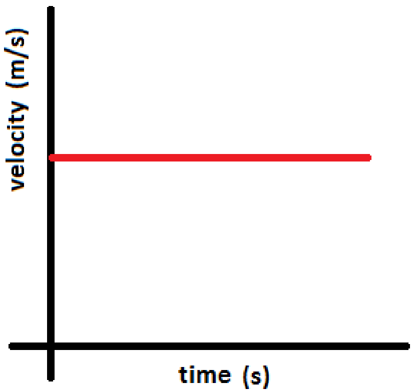
1. **Distance (m)**
2. **Displacement (m)**
3. **Time (s)**
4. **Speed (m/s)**
5. **Velocity (m/s)**
6. **Acceleration (m/s^2)**

Uniform motion and non-uniform motion

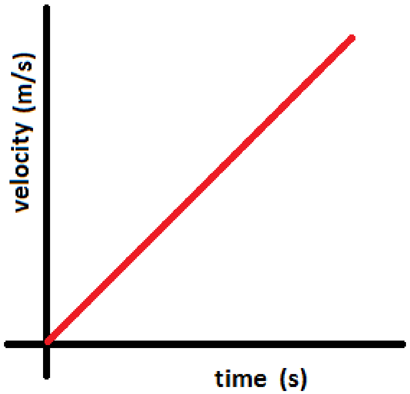


Uniform Motion

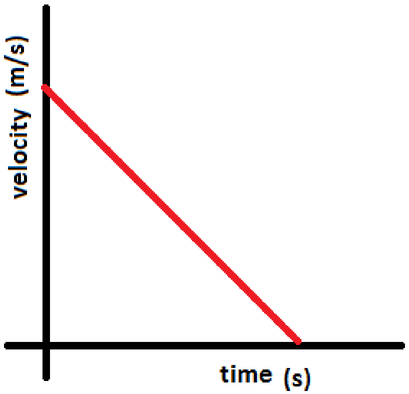
The type of motion in which the object travels with uniform speed is called Uniform motion. This means that the velocity of the body remains constant as it covers equal distances in equal intervals of time. In the case of uniform rectilinear motion, the acceleration of the body will be zero. Here, the average speed of the object will be equal to the actual speed. The examples of uniform motion are movements of hands of a clock, rotation and revolution of the earth, etc.



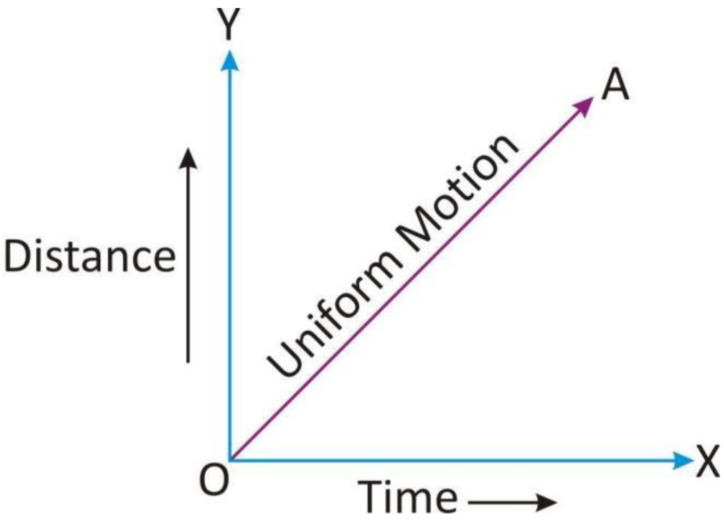
a) Velocity time graph for Uniform Motion.



b) Velocity time graph for uniformly accelerated motion

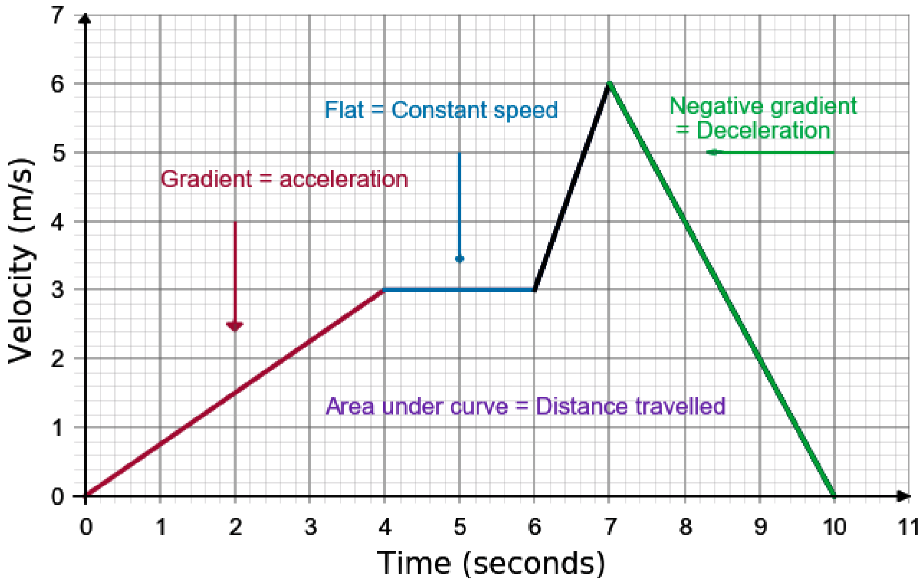


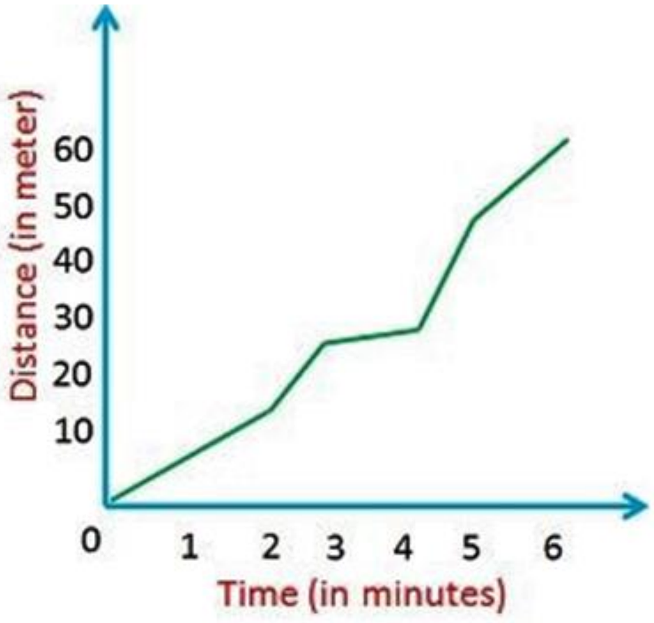
c) Velocity time graph for uniformly retarded motion



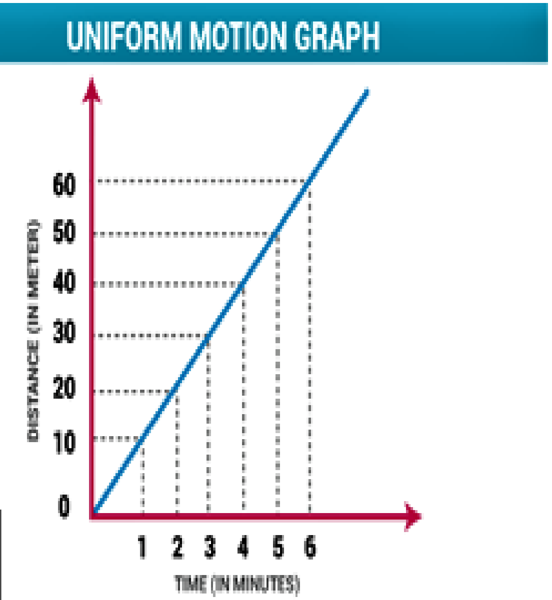
Uniform motion and non-uniform motion

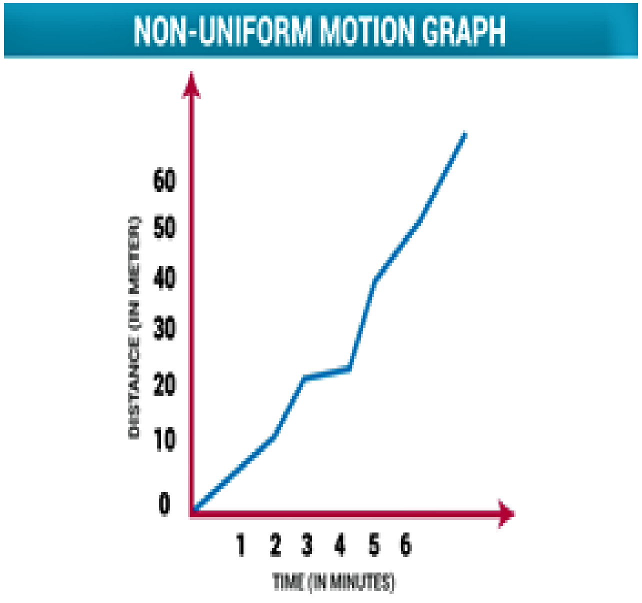
Non-uniform motion occurs when an object travels different distances in equal time intervals. This happens when the object is speeding up or slowing down, so its velocity is changing (the object has acceleration).

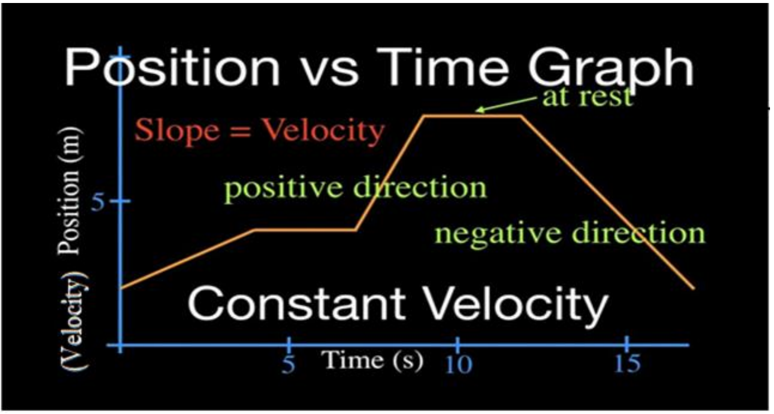




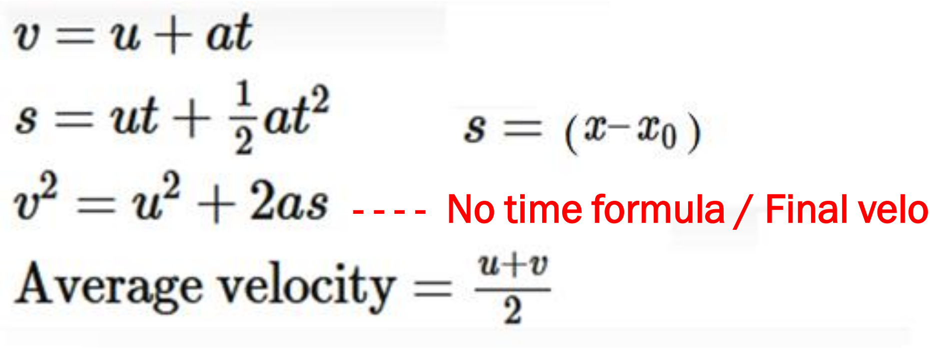
Uniform motion and non-uniform motion







Motion Equations (Laws of motion)

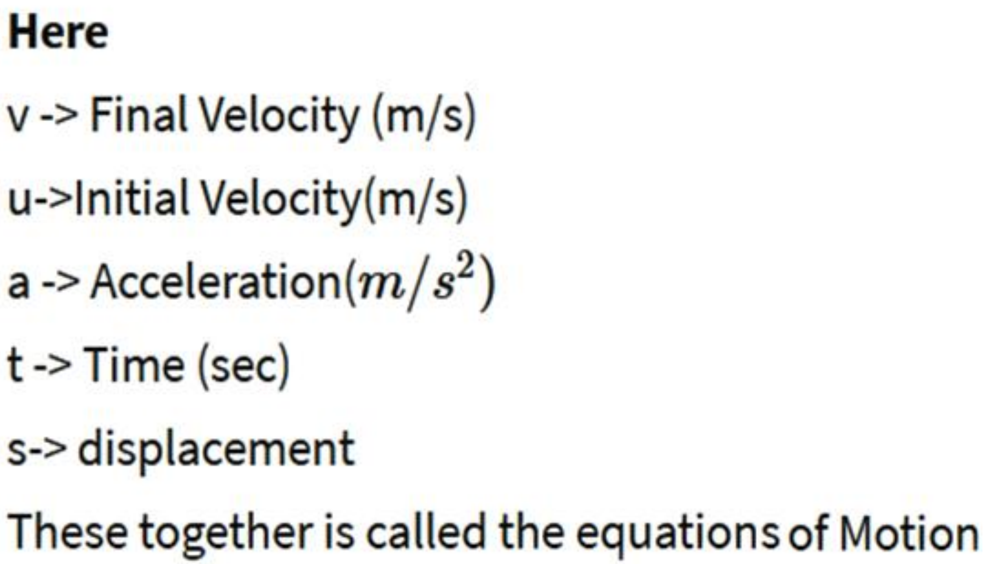


$$v = u + at$$

$$s = ut + \frac{1}{2}at^2 \qquad s = (x - x_0)$$

$$v^2 = u^2 + 2as$$ ---- No time formula / Final velocity

$$\text{Average velocity} = \frac{u+v}{2}$$



Here

v -> Final Velocity (m/s)

u->Initial Velocity(m/s)

a -> Acceleration(m/s^2)

t -> Time (sec)

s-> displacement

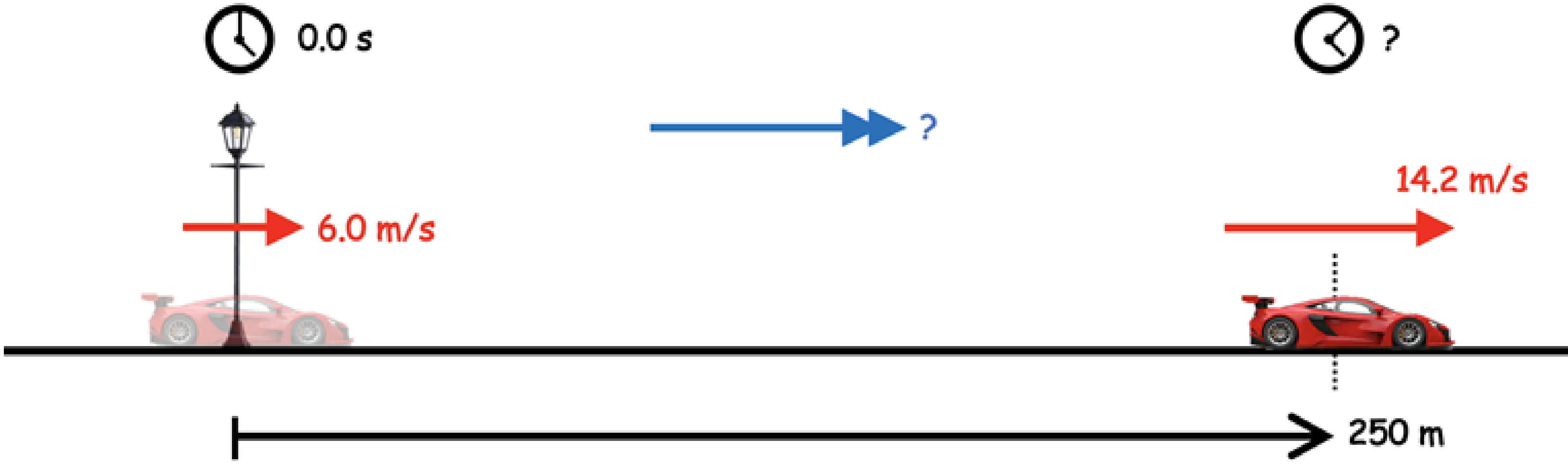
These together is called the equations of Motion

Q1/ A car starts motion with a velocity of 6 m/s. The car was accelerated to pass 250 m with a velocity of 14.2m/s. Find the time spent.

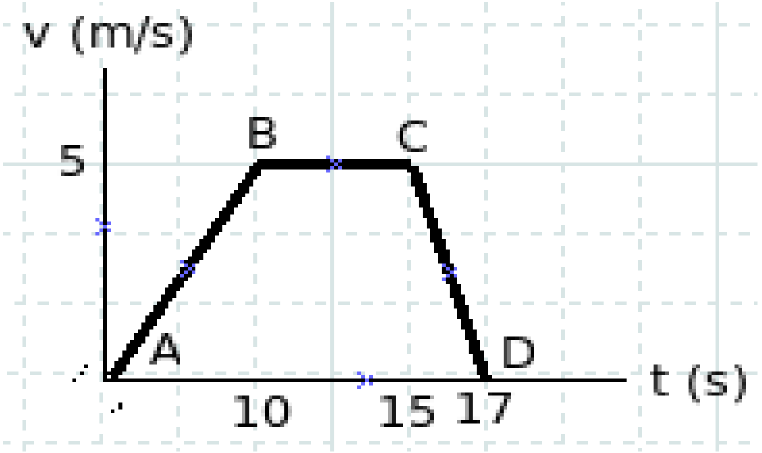
$V_2 = V_1 + at$

We need to find (a)

$V^2{}_2 = v_1{}^2 + 2\ as$

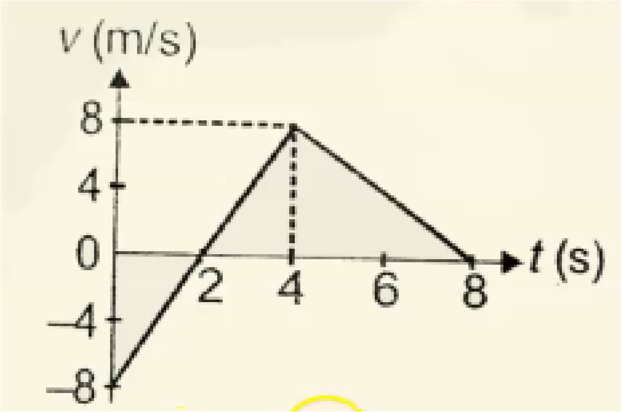


Q3/Graph of velocity (**v**) vs. time (***t***) shown in the figure below. What is the acceleration at regions AB, BC and CD according to the graph.

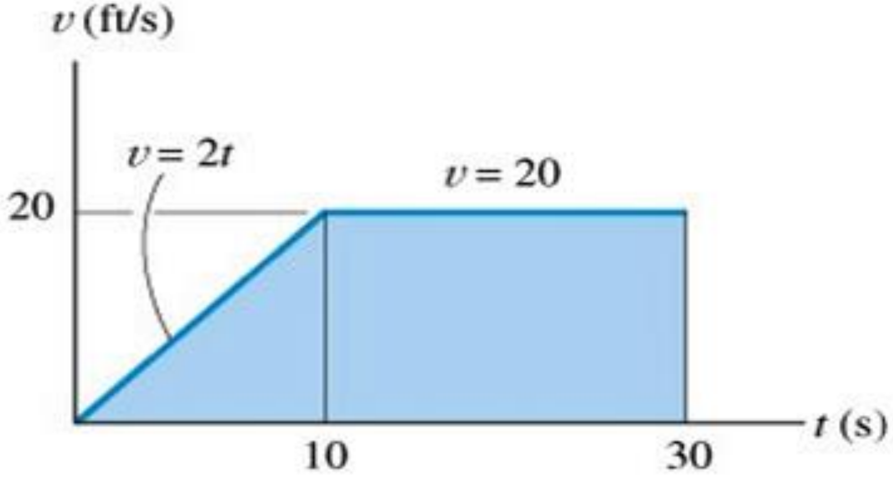


<u>**Hint**</u>: The slope gives acceleration value

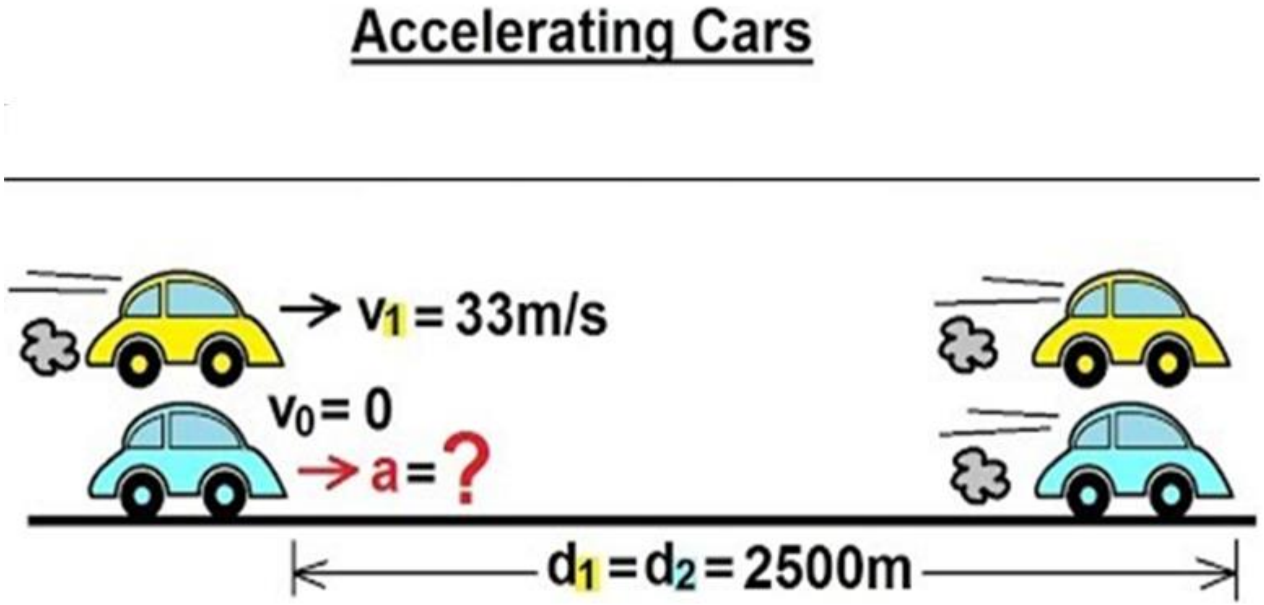
Q4/ Find the acceleration and the deceleration.



Q5/ Find the acceleration and total distance traveled by the car.

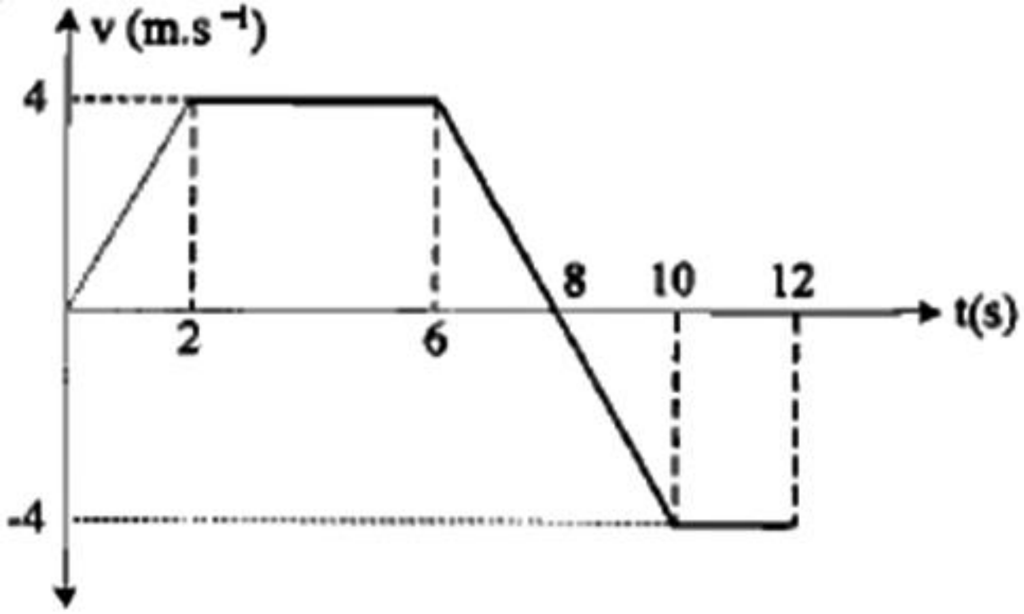


Q6/ Car 1 moves at 33 m/s and passed a distance of 2500m. At what acceleration car 2 needs to be accelerated to catch car 1?



Q6/ Graph of velocity (v) vs. time (*t*) for linear motion shown in figure below. What is the distance traveled for 12 seconds.

Answer: 36 m



Q7/ An 800-kg car travels along a straight line with the initial velocity of 36 km/hour. After travels 150 meters, car’s velocity = 72 km/hour. Determine the time interval.

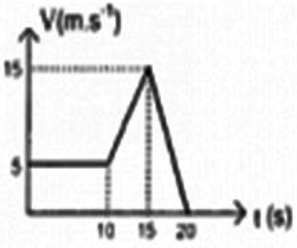
Hints:

1. Check the units!
2. Use no time Eq.
3. Use velocity Eq.

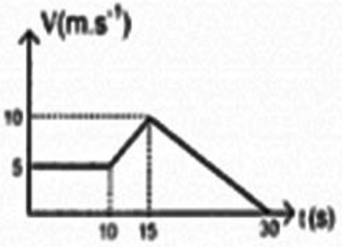
Q8/ A car travels at a constant 5 m/s in 10 seconds, then accelerated 1 m/s^2 in 5 seconds. Then decelerated until rest after car travels 137.5 meters.

1. Draw graph (*v*-*t*) shows the object’s travels.
2. Which figure represents the car motion?

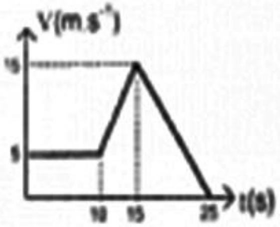
A.



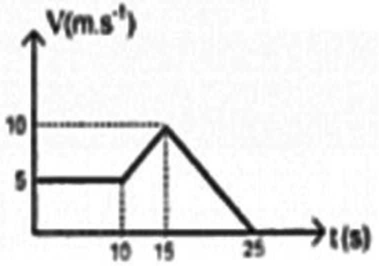
B.



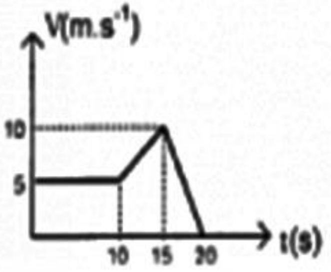
C.



D.

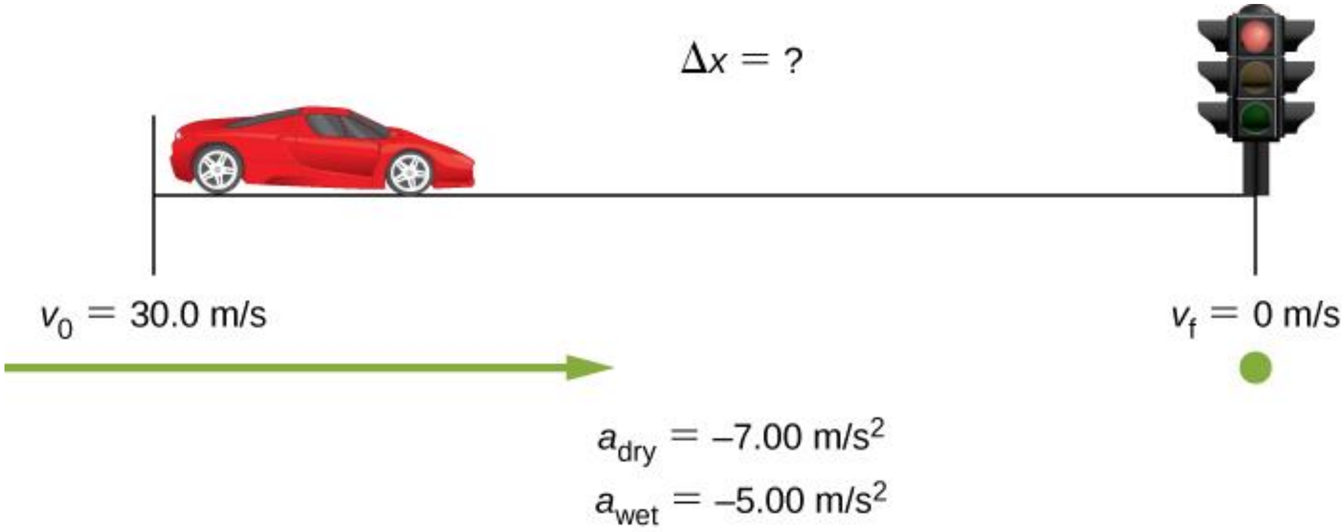


E.



Q9/ On dry concrete, a car can decelerate at a rate of 7.00 m/s^2, whereas on wet concrete it can decelerate at only 5.00 m/s^2. Find the distances necessary to stop a car moving at 30.0 m/s on (a) dry concrete and (b) wet concrete. (c) Repeat both calculations and find the displacement from the point where the driver sees a traffic light turn red, considering his reaction time of 0.500 s to get his foot on the brake.

Hints:
For **a** and **b**; Use no time Eq.
For **c** use displacement Eq.

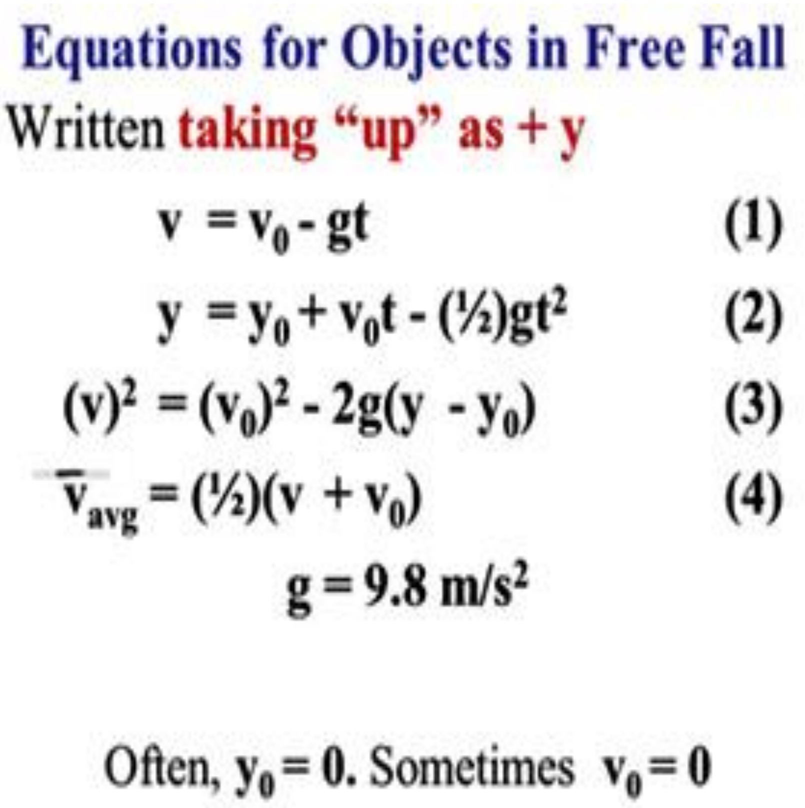


Free fall motion:

Free fall means that an object is falling freely with no forces acting upon it except gravity, a defined constant, g = **- 9.8** m/s^2. The distance the object falls, or height, h, is 1/2 gravity × the square of the time falling. Velocity is defined as gravity × time.

$h = 1/2\ gt^2$ (m)

$V = gt$ (m/s)



Equations for Objects in Free Fall

Written **taking "up" as + y**

$$v = v_0 - gt \qquad (1)$$

$$y = y_0 + v_0 t - (½)gt^2 \qquad (2)$$

$$(v)^2 = (v_0)^2 - 2g(y - y_0) \qquad (3)$$

$$\bar{v}_{avg} = (½)(v + v_0) \qquad (4)$$

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

Often, $y_0 = 0$. Sometimes $v_0 = 0$

Q1/ A ball is thrown down vertically with an initial speed of 20 m/s from a height of 60 m. Find **(a)** its speed just before it strikes the ground and **(b)** how long it takes for the ball to reach the ground.

Take g = 10 m/s^2.

a. We do not know the time, but taking y_o = 60 m and y = 0, we can use

$$\mathbf{v^2 = v_o^2 + 2\,g\,y}$$

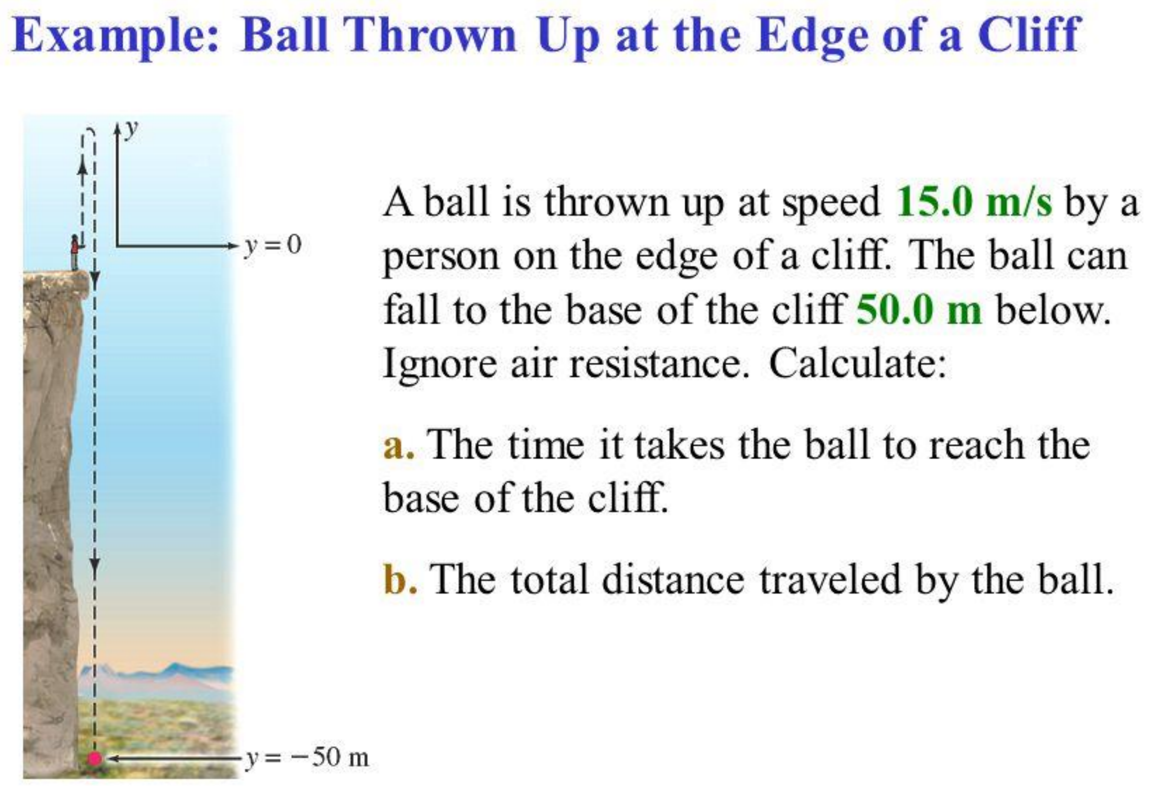
$$v^2 = (-20\ \text{m/s})^2 + 2(-10)\ \text{m/s}^2 \times 60\ \text{m} = (400 + 1200)\ \text{m}^2/\text{s}^2,$$

v = - 40 m/s (the negative sign indicates direction).

b. $v = v_o + at$, - 40 m/s = -20 m/s - 10 m/s^2 t, **t** = 2 s

<u>Hints</u>:

1. Find t
2. Find maximum height and add it to the rest distance to reach ground.

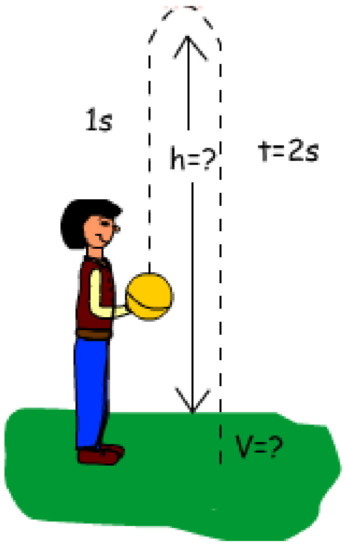


Example: Ball Thrown Up at the Edge of a Cliff

A ball is thrown up at speed **15.0 m/s** by a person on the edge of a cliff. The ball can fall to the base of the cliff **50.0 m** below. Ignore air resistance. Calculate:

a. The time it takes the ball to reach the base of the cliff.

b. The total distance traveled by the ball.



$V= g.t$

$V= g.t=10m/s^2.1s=10m/s$

ball is thrown with 10 m/s velocity

at the top our velocity is zero,
ball does free fall

$V=-g.t$

$V=-g.t=-10m/s^2.2s= \underline{-20m/s}$

we put "-" sign in front of the g because
we take upward direction "+"

$$\text{Distance}=\frac{1}{2}\ g.t^2$$

$$h_{max}= \frac{1}{2}\ 10m/s^2.(2s)^2$$

$$h_{max}= 20m$$

A stone is thrown upwards from the edge of a cliff 18m high. It just misses the cliff on the way down and hits the ground below with a speed of 18.8m/s.

(a) With what velocity was the stone released?

(b) What is its maximum height from the ground during its flight?

Let *yo* = 0 at the top of the cliff.

(a)

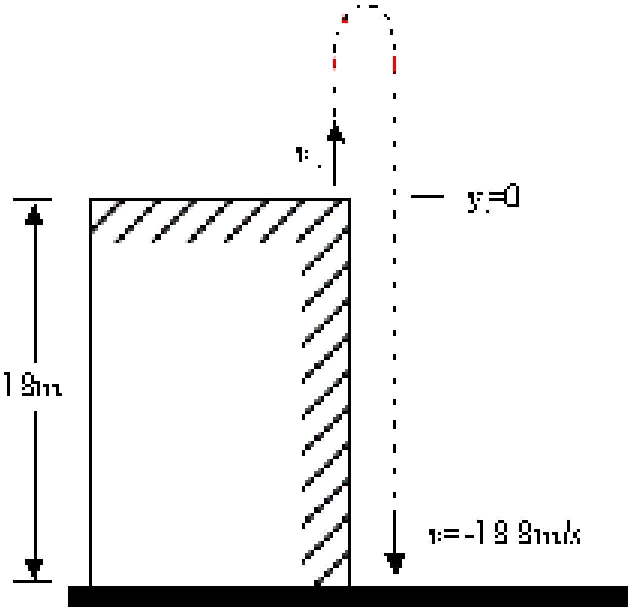
$v^2 = vo^2 - 2g\ (y\text{-}yo)$

$(18.8)^2 = vo^2 - 2 \times 9.8 \times 18$

$vo^2 = 0.8\ m/s$

(b) The maximum height reached by the stone is *h*

$$h = \frac{v^2}{2g} = \frac{18}{2 \times 9.8} = 18\ \text{m}$$



The End

CHAPTER 3

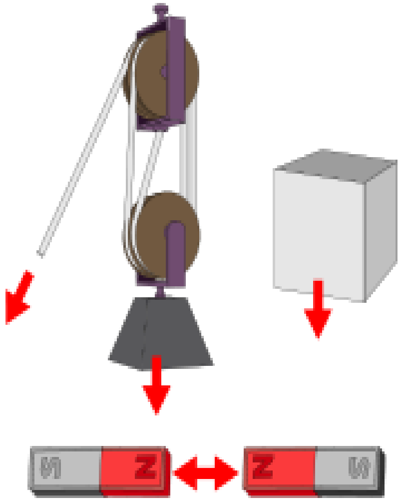
OUTLINES

- ☐ **Forces**
- ☐ **Newton's laws**
- ☐ **Applications on newton's laws**

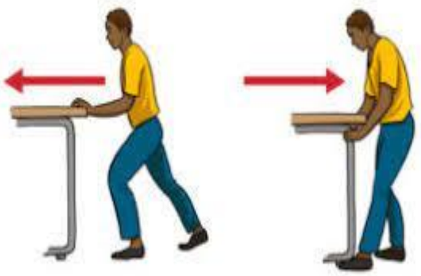
Dynamics and Kinematics

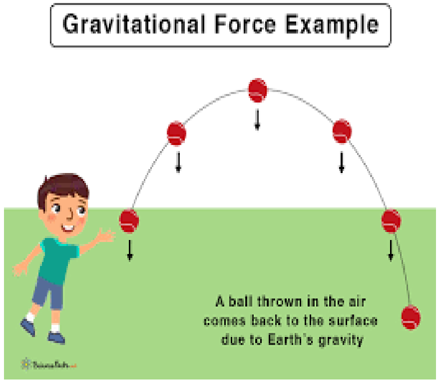
Kinematics is the study of motion of a system of bodies without directly considering the forces or potential fields affecting the motion. **Dynamics** on the other hand is the study of the causes of motion. The forementioned types are belong to **Mechanics.**

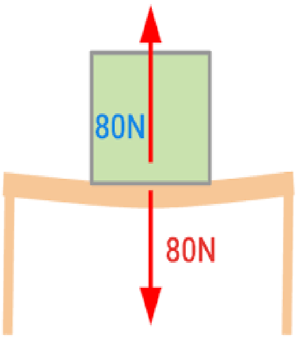
Force is an influence that can change the motion of an object. A force can cause an object with mass to change its velocity (e.g., moving from a state of rest), i.e., to accelerate. Force can also be described actions such as a push or a pull. A force has both magnitude and direction, making it a vector quantity. It is measured in the SI unit of newton (N).



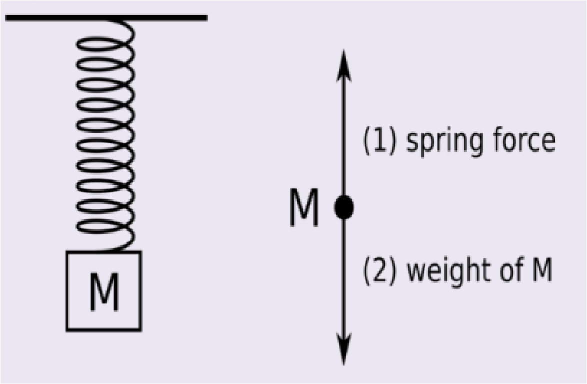
Type of Force (and Symbol)	**Description of Force**
Applied Force F_{app}	An applied force is a force that is applied to an object by a person or another object. If a person is pushing a desk across the room, then there is an applied force acting upon the object. The applied force is the force exerted on the desk by the person.
Gravity Force **(also known as Weight)** F_{grav}	The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object. All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: **Fgrav = m * g** where g = 9.8 N/kg (on Earth) and m = mass (in kg)
Normal Force F_{norm}	The normal force is the support force exerted upon an object that is in contact with another stable object. For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book. On occasions, a normal force is exerted horizontally between two objects that are in contact with each other. For instance, if a person leans against a wall, the wall pushes horizontally on the person.

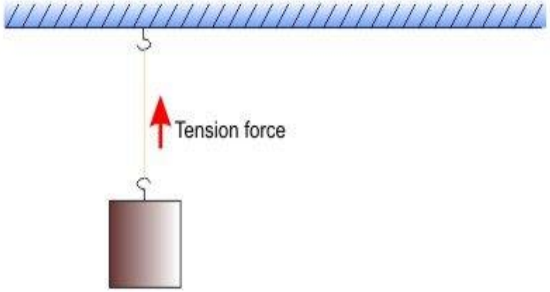
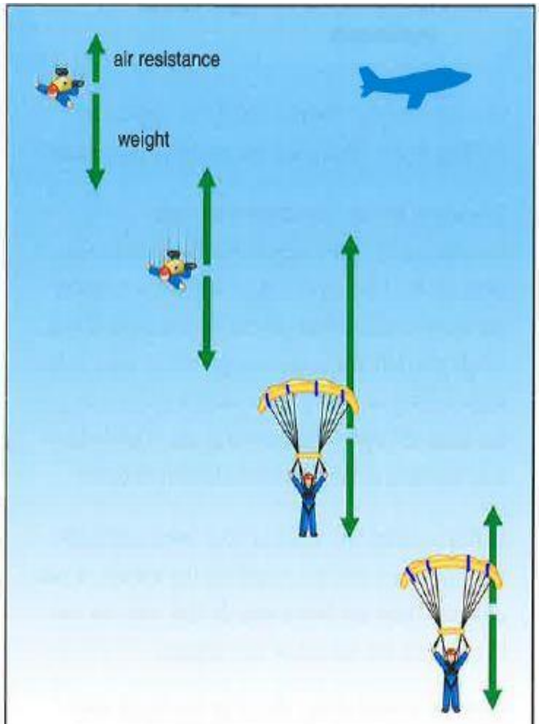






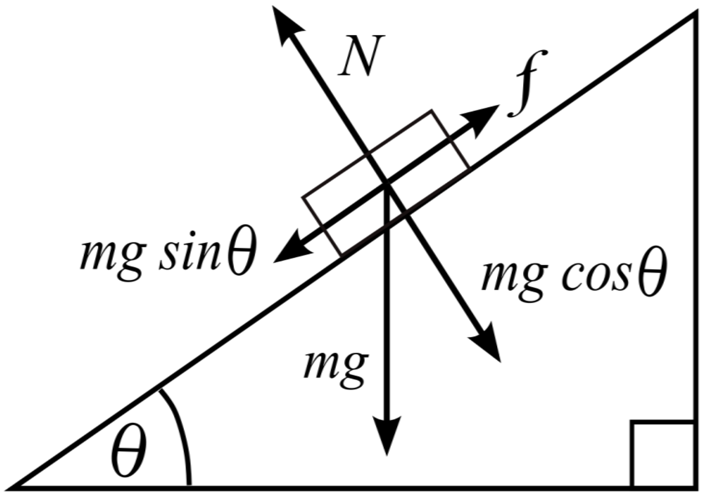
Type of Force (and Symbol)	Description of Force
Friction Force F_{frict}	The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - sliding and static friction. Though it is not always the case, the friction force often opposes the motion of an object. For example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula below: $F_{frict} = \mu \bullet F_{norm}$
Spring Force F_{spring}	The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it. An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position. For most springs (specifically, for those that are said to obey "Hooke's Law"), the magnitude of the force is directly proportional to the amount of stretch or compression of the spring.

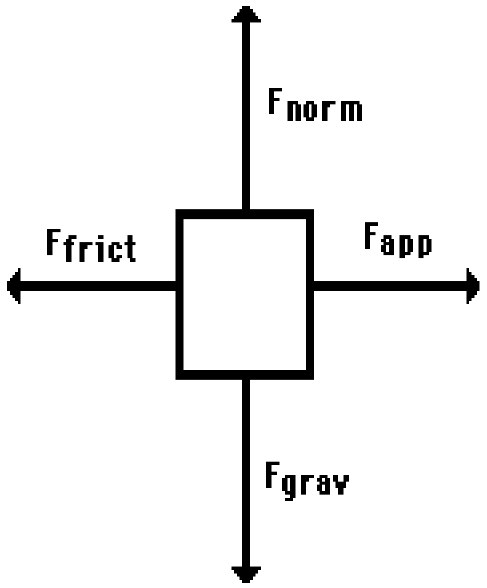


Type of Force (and Symbol)	Description of Force	
Tension Force F_{tens}	The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.	
Air Resistance Force F_{air}	The air resistance is a special type of frictional force that acts upon objects as they travel through the air. The force of air resistance is often observed to oppose the motion of an object. This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value). It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas. Air resistance .	

Free-Body Diagrams

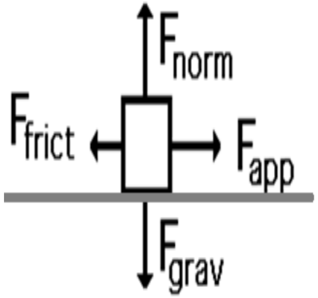
A free body diagram consists of a diagrammatic representation of a single body, or a subsystem of bodies isolated from its surroundings showing all the forces acting on it. free body diagram is used to visualize forces and moments applied to a body and to calculate reactions in mechanics problems.



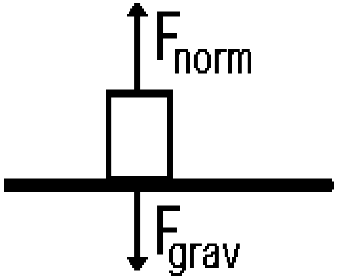


Q1/ A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Draw the forces acting on the book.

Ans:



Q2/ A book is at rest on a tabletop. A free-body diagram for this situation looks like:



Newton's laws

Newton's laws are three laws that describe the relationship between the motion of an object and the forces acting on it.

Newton’s First Law (The Law of Inertia): An object at rest remains at rest, and an object in motion remains in motion at constant speed unless acted on by an unbalanced force.

$$F_{net} = 0$$

Newton’s Second Law (Force Law): The acceleration of an object depends on the mass of the object and the amount of force applied.

$$F_{(N)} = m_{(Kg)} * a_{(m/S^2)}$$

Newton’s Third Law (Action & Reaction): When one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

$$F_A = - F_B$$

Newton's laws

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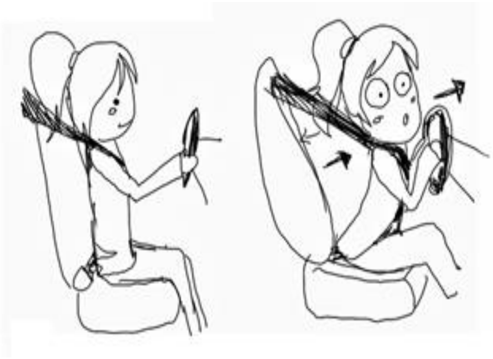
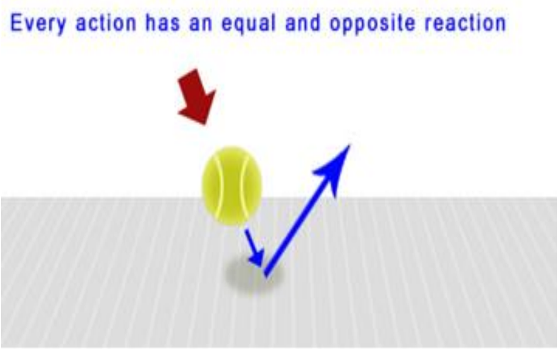
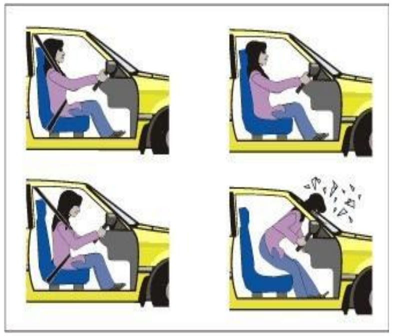




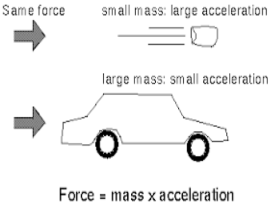
Applications on newton’s laws

Newton's laws of motion can be applied in numerous situations to solve problems of motion. The normal force on an object is not always equal in magnitude to the weight of the object. If an object is accelerating, the normal force will be less than or greater than the weight of the object.

1. A driver of automobile brakes abruptly and, by inertia, passengers shoots forward.

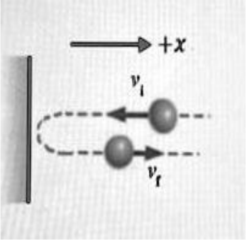


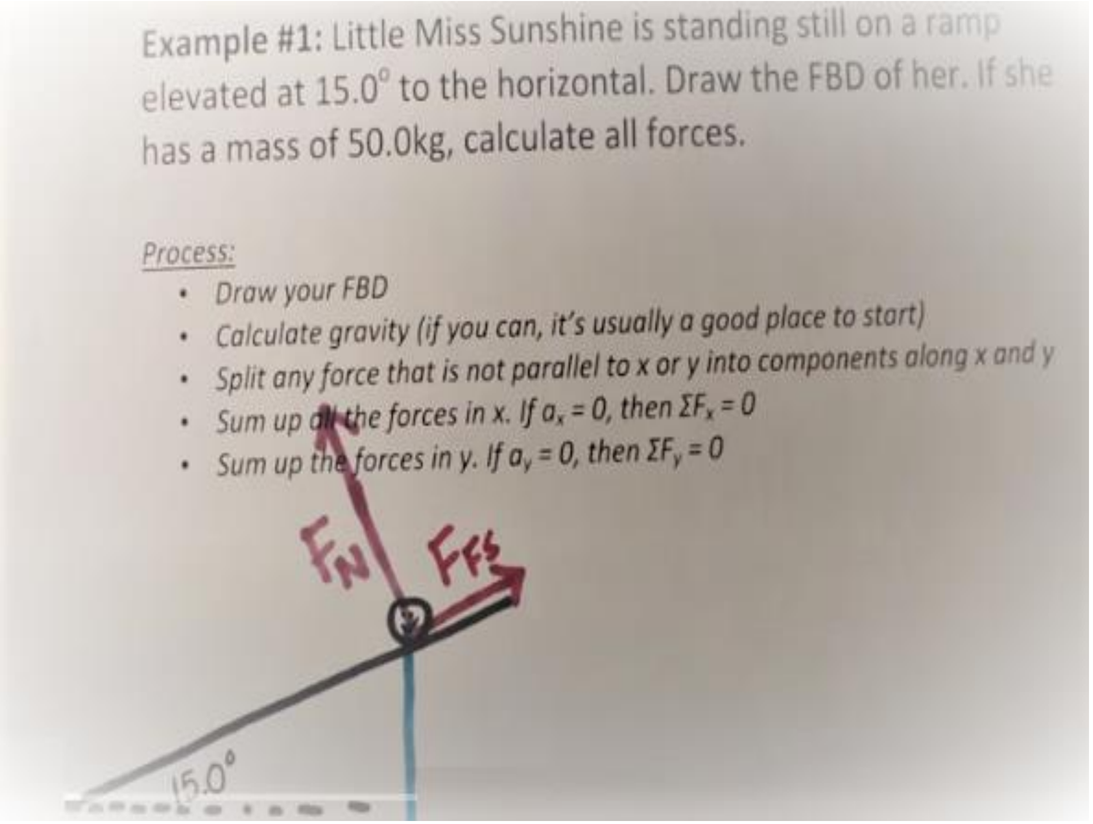
A book lying on the table remains at rest a force acts on it.



2. Accelerating an object by applying external force

3. The bouncing of a tennis ball from

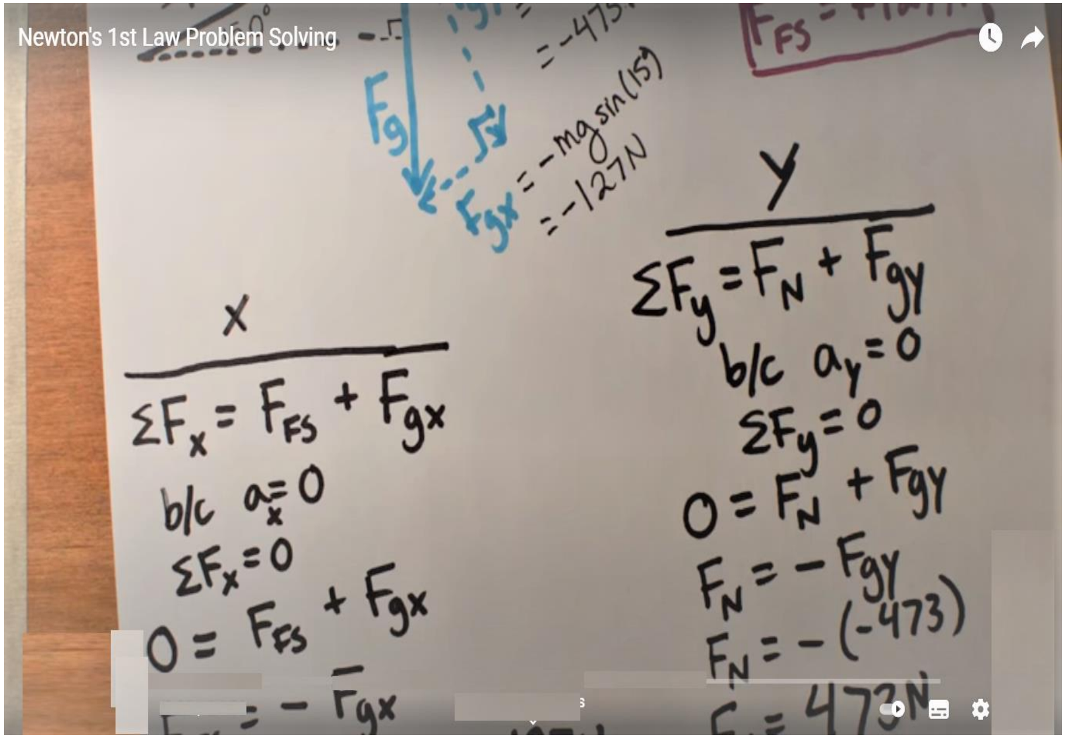




Example #1: Little Miss Sunshine is standing still on a ramp elevated at 15.0° to the horizontal. Draw the FBD of her. If she has a mass of 50.0kg, calculate all forces.

Process:

- *Draw your FBD*
- *Calculate gravity (if you can, it's usually a good place to start)*
- *Split any force that is not parallel to x or y into components along x and y*
- *Sum up all the forces in x. If $a_x = 0$, then $\Sigma F_x = 0$*
- *Sum up the forces in y. If $a_y = 0$, then $\Sigma F_y = 0$*



x

$\Sigma F_x = F_{FS} + F_{gx}$

b/c $a_x = 0$

$\Sigma F_x = 0$

$0 = F_{FS} + F_{gx}$

$= -F_{gx}$

y

$\Sigma F_y = F_N + F_{gy}$

b/c $a_y = 0$

$\Sigma F_y = 0$

$0 = F_N + F_{gy}$

$F_N = -F_{gy}$

$F_N = -(-473)$

$F_N = 473N$