General Physics

(Unit 1)



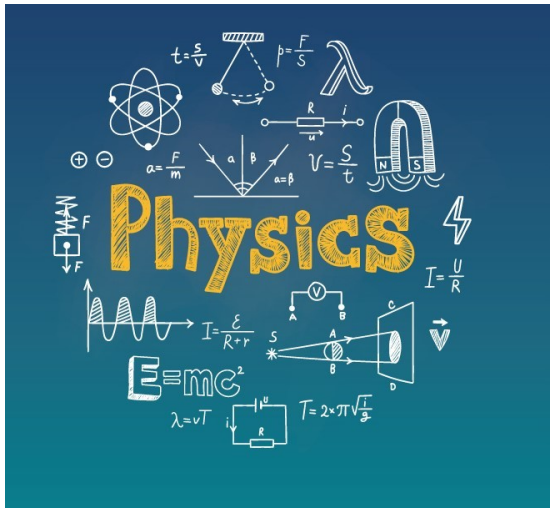
Department of Physics

Addis Ababa Science and Technology University

fppt.com

CHAPTER ONE
PRELIMINARIES

The word physics comes from the Greek word meaning “nature”. Today physics is treated as the base for science and have various applications for the ease of life. Physics deals with matter in relation to energy and the accurate measurement of natural phenomenon. Thus physics is inherently a science of measurement.



fppt.com

Learning Objectives: At the end of this chapter, you will be able to:

- Explain physics.
- Describe how SI base units are defined.
- Describe how derived units are created from base units.
- Express quantities given in SI units using metric prefixes.
- Describe the relationships among models, theories, and laws.
- Know the units used to describe various physical quantities.
- Become familiar with the prefixes used for larger and smaller quantities.
- Master the use of unit conversion (dimensional analysis) in solving problems.
- Understand the relationship between uncertainty and the number of significant figures in a number.

fppt.com

physical quantity



Length of a car is 4.5 m

physical quantity — magnitude

Physical quantity is a quantifiable or assignable property ascribed to a particular phenomenon or body, for instance the length of a rod or the mass of a body.

Measurement is the act of comparing a physical quantity with a certain standard.

fppt.com

A. Basic Physical Quantities:

Basic quantities are the quantities which cannot be expressed in terms of any other physical quantity. Example: length, mass and time.

B. Derived Physical Quantities:

Derived quantities are quantities that can be expressed in terms of fundamental quantities. Examples: area, volume, density.

1.1.2. SI Units: Basic and Derived Units

SI unit is the abbreviation for **International System of Units** and is the modern form of metric systemfinallyagreeduponattheeleventhInternationalconferenceofweightsandmeasures,1960. This

fppt.com

Table 1.1: Basic quantities and their SI units

Property	Symbol	Unit	Dimension
Length	L	meter (m)	L
Mass	m	kilogram (kg)	M
Time	t	second (s)	T
Temperature	T	kelvin (K)	θ
Electric Current	I	ampere (A)	I
Amount of Substance	N	mole (N)	1
Luminous Intensity	F	candela (cd)	J

Table 1.2: Derived quantities, their SI units and dimensions

Property	Symbol	Unit	Dimension
Force	F	newton (N)	$\mathrm{kg{\cdot}m{\cdot}s^{-2}} = \mathrm{kg{\cdot}m{\cdot}/s^2}$
Speed	v	meter per second (m/s)	$\mathrm{m{\cdot}s^{-1}} = \mathrm{m/s}$
Pressure	P	pascal (Pa)	(force per unit area) $\mathrm{kg{\cdot}m^{-1}{\cdot}s^{-2}}$
Energy	E	joule (J)	$\mathrm{kg{\cdot}m^2{\cdot}s^{-2}}$
Power	W	watt (W)	(energy per unit time) $\mathrm{kg{\cdot}m^2{\cdot}s^{-3}}$

fppt.com

1.1.3. Conversion of Units

Quantity	From	To	Operation
Length	inch (in)	m	$(\text{inch}) \times 0.0254$
	foot (ft)	m	$(\text{foot}) \times 0.3048$
	mile (mi)	m	$(\text{mile}) \times 1609.34$
Mass	pound (lb)	kg	$(\text{pound}) \times 0.4536$
	metric ton (t)	kg	$(\text{ton}) \times 1000$
	ounce	kg	$(\text{ounce}) \times 0.02835$
Volume	liter (l)	m^3	$(liter) \times 0.001$
	gallon (ga)	m^3	$(\text{gallon}) \times 0.00379$
Temperature	fahrenheit (F)	K	$\{(\text{fahrenheit}) - 32\} \times \frac{5}{9} + 273.15$
	celcius (C)	K	$(\text{celcius}) + 273.15$

fppt.com

Activities:

1. A common Ethiopian cities speed limit is 30km/hr. What is this speed in miles per hours?
2. How many cubic meters are in 250,000 cubic centimeters?
3. The average body temperature of a house cat is 101.5oF. What is this temperature in Celsius?

1.2. Uncertainty in Measurement and Significant Digits

1. **Systematic Error** - errors resulting from measuring devices being out of calibration. Such measurements will be consistently too small or too large. These errors can be eliminated by pre-calibrating against a known, trusted standard.
2. **Random Errors** - errors resulting in the fluctuation of measurements of the same quantity about the average. The measurements are equally probable of being too large or too small. These errors generally result from the fineness of scale division of a measuring device.

fppt.com

1. Uncertainty in a scale measuring device is equal to the smallest increment divided by 2.

$$\sigma_x = \frac{Smallest\ increament}{2}$$

Example: Meter Stick (scale device)

$$\sigma_x = \frac{1mm}{2} = 0.5mm = 0.05cm$$

2. Uncertainty in a digital measuring device is equal to the smallest increment.

$$\sigma_x = smallest\ increament$$

Example: A reading from digital Balance (digital device) is 5.7513 kg, therefore

$$\sigma_x = 0.0001$$

$Measurement = x_{best} \pm \sigma_x$

Where, x_{best}= best estimate of measurement, σ_x= uncertainty (error) in measurement.

fppt.com

1.2.1. Significant digits

In general to determine significant digits in a given number

1. All non-zero numbers are significant.
2. Zeros within a number are always significant.
3. Zeros that do nothing but set the decimal point are not significant. Both 0.000098 and 0.98 contain two significant figures.
4. Zeros that aren't needed to hold the decimal point are significant. For example, 4.00 has three significant figures.
5. Zeros that follow a number *may* be significant.

fppt.com

Rules for significant digits:

Rule 1: When approximate numbers are multiplied or divided, the number of significant digits in the final answer is the same as the number of significant digits in the least accurate of the factors.

Example: $X = \frac{45}{(3.22m)x(2.005m)} = 6.97015\ \frac{N}{m^2}$.

Least significant factor (45) has only two (2) digits so only two are justified in the answer. The appropriate way to write the answer is P = 7.0 N/m^2.

Rule 2: When approximate numbers are added or subtracted, the number of significant digits should equal the smallest number of decimal places of any term in the sum or difference.

Example: 9.65 cm + 8.**4** cm - 2.89 cm = 15.**1**6 cm

fppt.com

1.3. Vectors: composition and resolution

Scalar quantities are measured with numbers and units.



length
(e.g. 16 cm)



temperature
(e.g. 102 °C)



time
(e.g. 7 s)

fppt.com

Vector quantities are measured with numbers and units, but also have a specific **direction**.



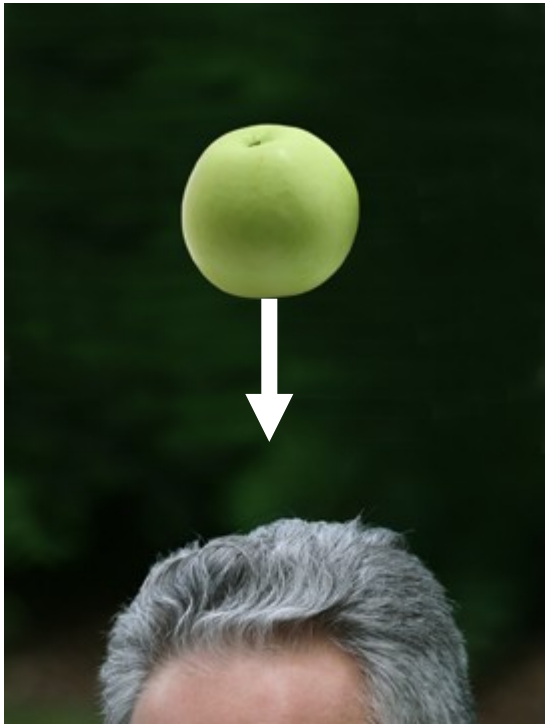
acceleration

(e.g. 30 m/s^2 upwards)



displacement

(e.g. 200 miles northwest)



force

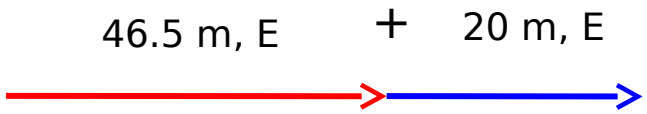
(e.g. 2 N downwards)

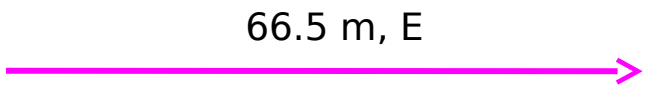
fppt.com

VECTOR APPLICATION

ADDITION: When two (2) vectors point in the **SAME** direction, simply add them together.

EXAMPLE: A man walks 46.5 m east, then another 20 m east. Calculate his displacement relative to where he started.





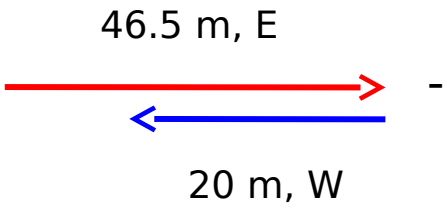
fppt.com

VECTOR APPLICATION

SUBTRACTION: When two (2) vectors point in the **OPPOSITE** direction, simply subtract them.

EXAMPLE: A man walks 46.5 m east, then another 20 m west.

Calculate his displacement relative to where he started.

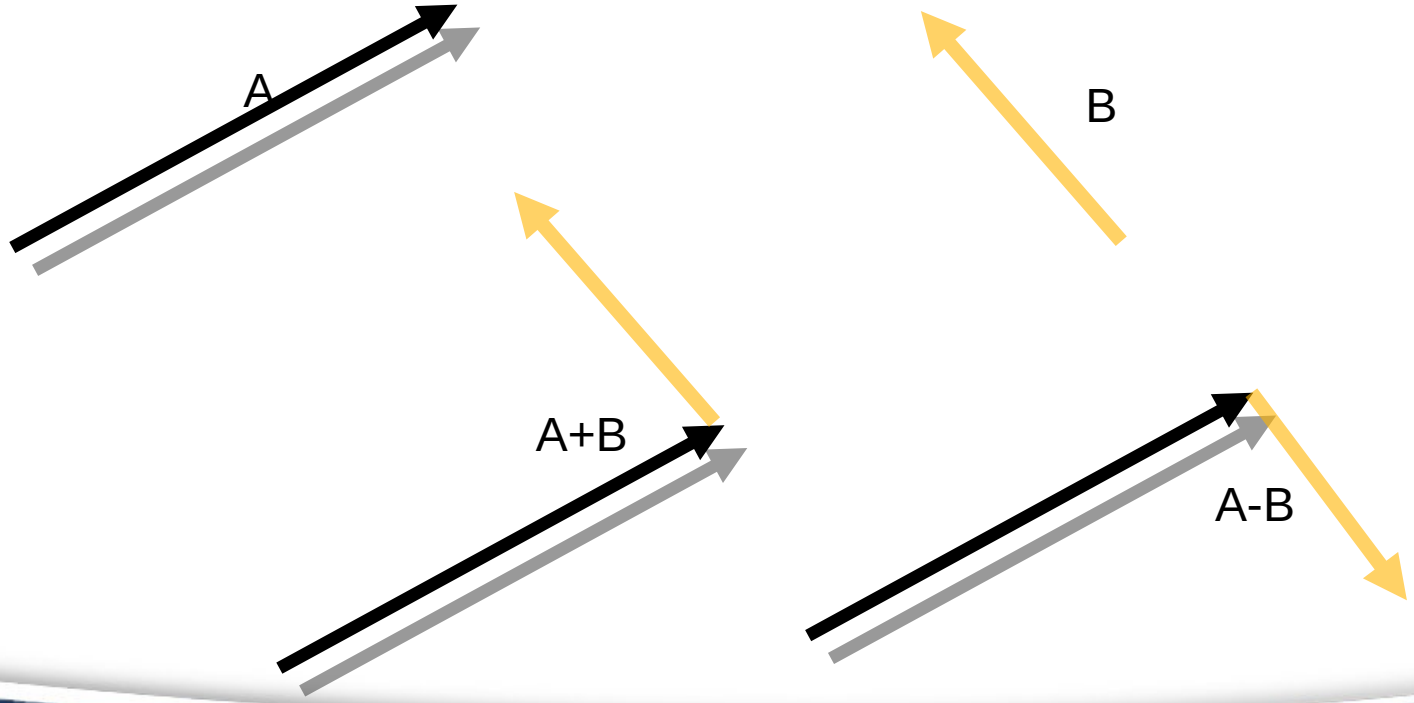



26.5 m, E

fppt.com

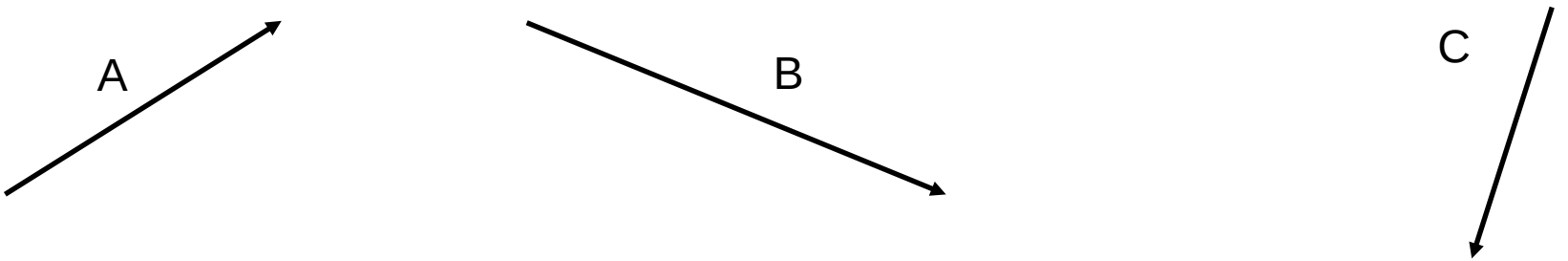
Vectors are always added head to tail

For example draw what you think it would look like if I added these two vectors together: A+B. Then draw what you think A-B would look like.



fppt.com

You try on the whiteboard



a. A+C
b. B+C
c. A-B
d. C-B
e. A+B

fppt.com

NON-COLLINEAR VECTORS

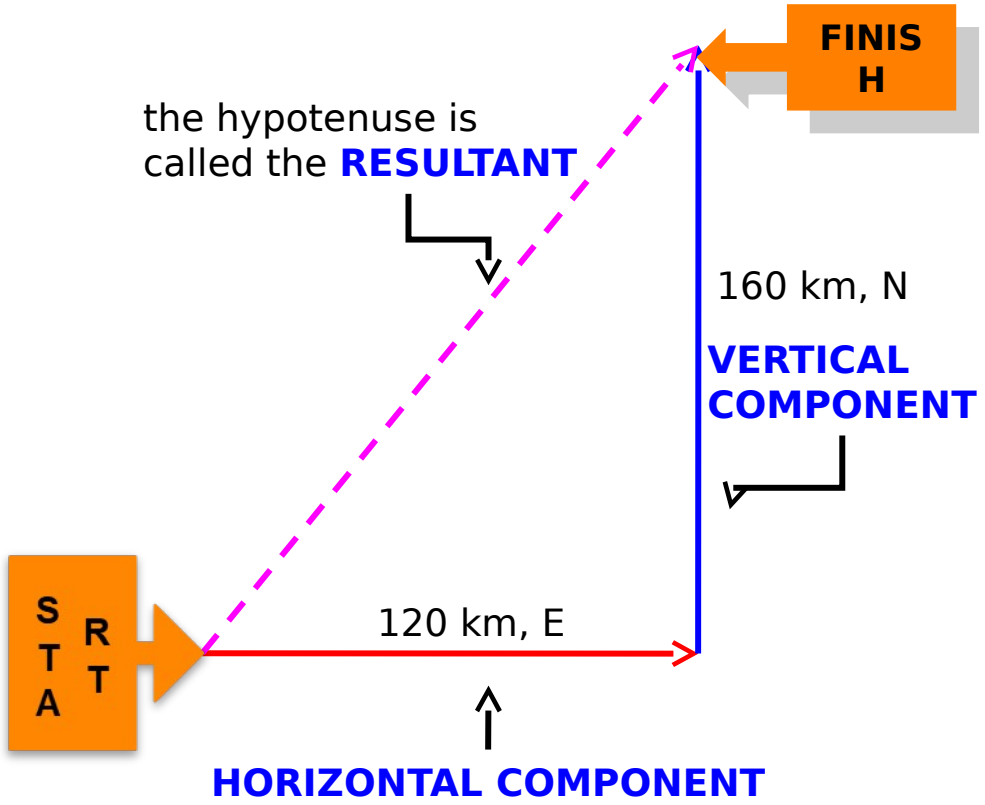
When two (2) vectors are **PERPENDICULAR** to each other, you must use the **PYTHAGOREAN THEOREM**

Example: A man travels 120 km east then 160 km north. Calculate his resultant displacement.

$$c^2 = a^2 + b^2 \quad \rightarrow \quad c = \sqrt{a^2 + b^2}$$

$$c = resultant = \sqrt{\left[(120)^2 + (160)^2\right]}$$

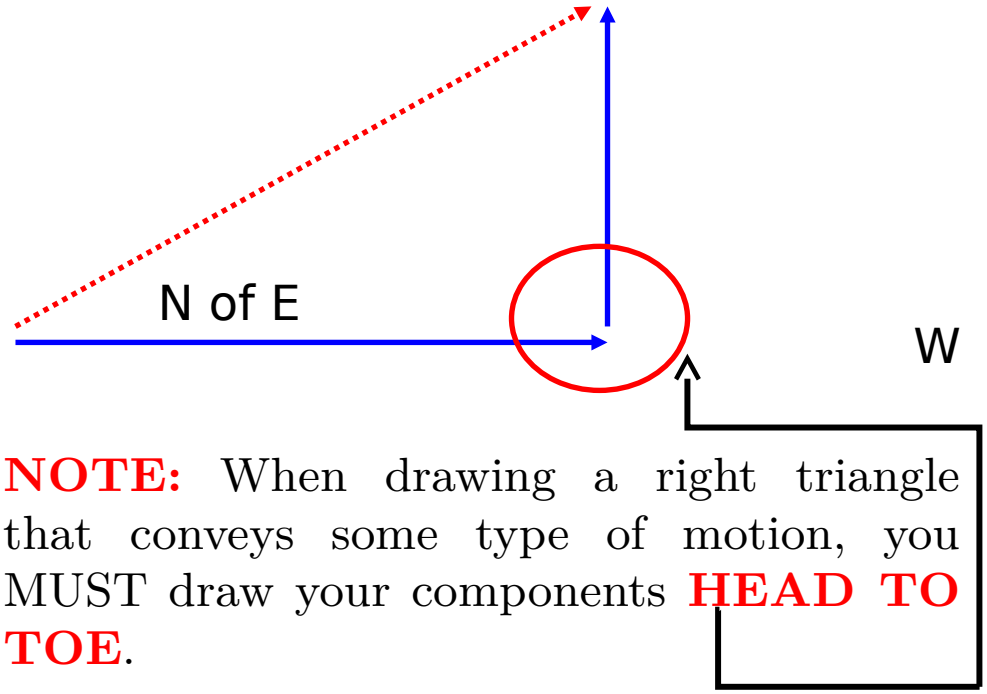
$$c = 200\,km$$



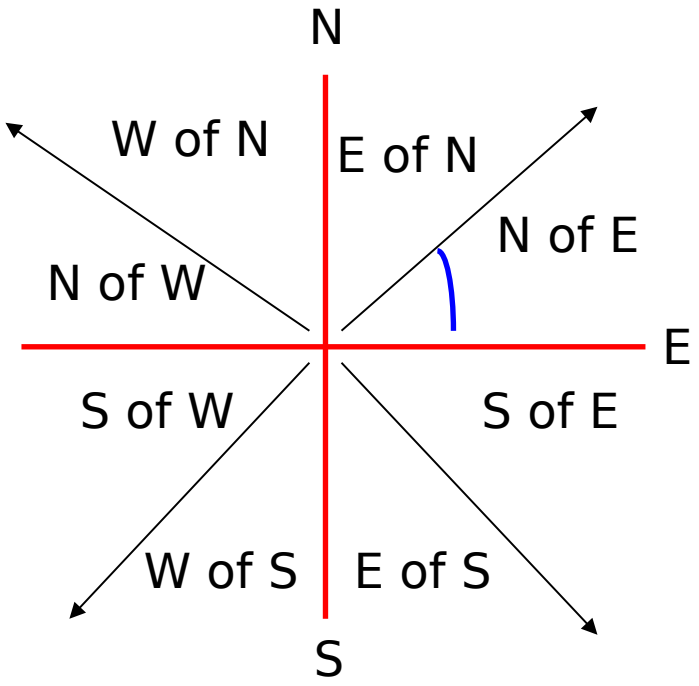
fppt.com

WHAT ABOUT DIRECTION?

In the example, **DISPLACEMENT** asked for and since it is a **VECTOR** quantity, we need to report its direction.

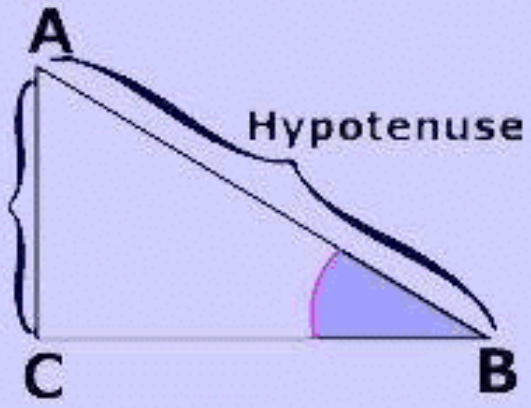


NOTE: When drawing a right triangle that conveys some type of motion, you MUST draw your components **HEAD TO TOE**.



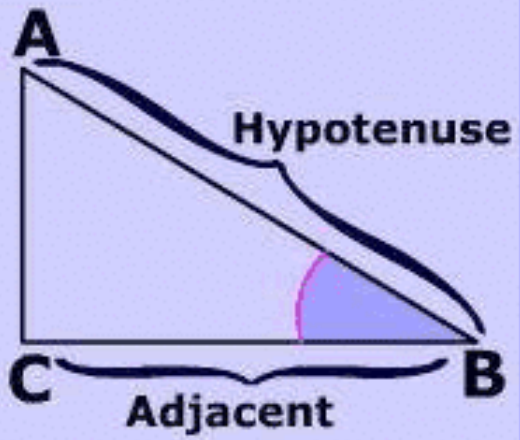
fppt.com

Sine



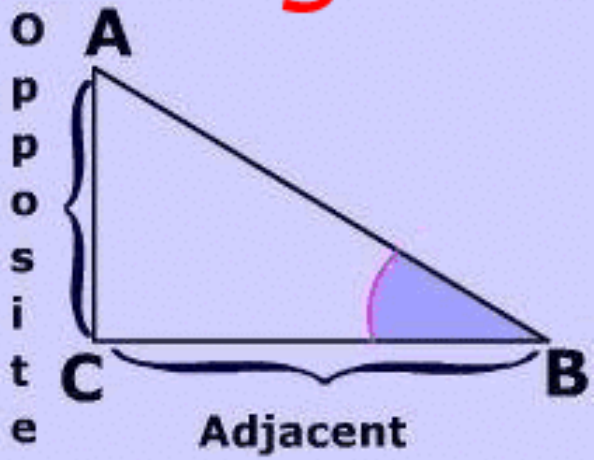
$$\frac{\text{opposite}}{\text{hypotenuse}}$$

Cosine



$$\frac{\text{adjacent}}{\text{hypotenuse}}$$

Tangent

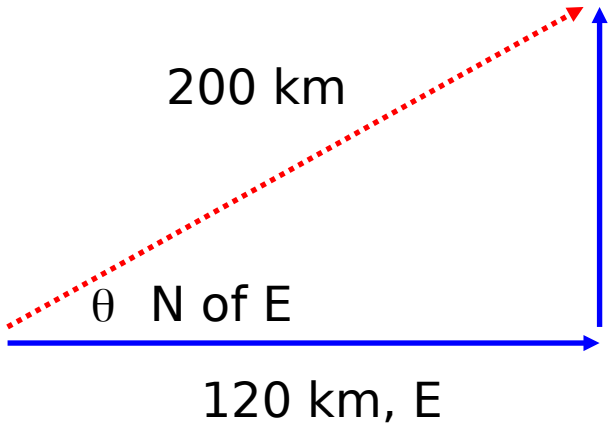


$$\frac{\text{opposite}}{\text{adjacent}}$$

fppt.com

NEED A VALUE – ANGLE !

Just putting N of E is not good enough (how far north of east ?).
We need to find a numeric value for the direction.



To find the value of the angle we use a Trig function called TANGENT.

$$Tan\,\theta = \frac{opposite\ side}{adjacent\ side} = \frac{160}{120} = 1.333$$

$$\theta = Tan^{-1}(1.333) = 53.1^{\circ}$$

So the COMPLETE final answer is : **200 km, 53.1 degrees North of East**

fppt.com

Example

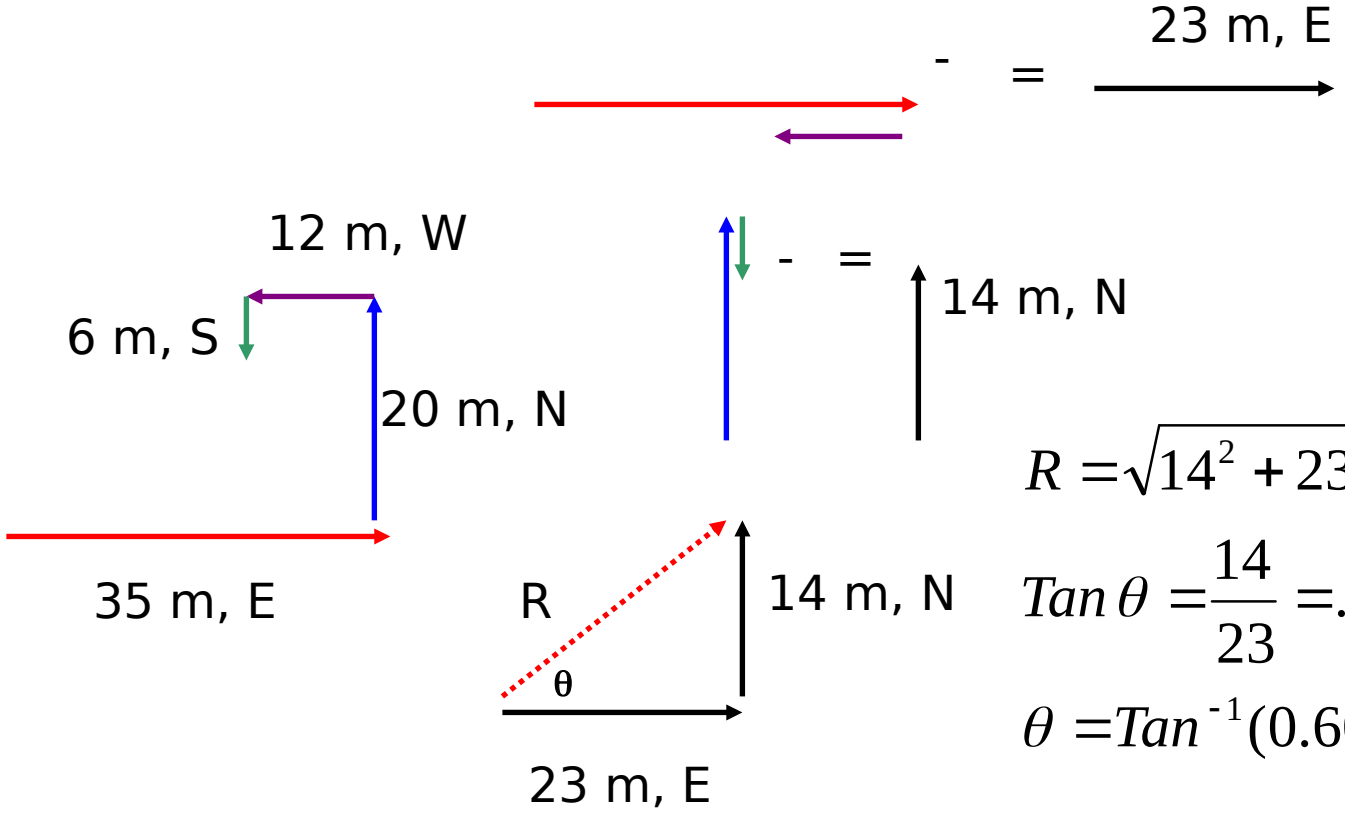
A bear, searching for food wanders 35 meters east then 20 meters north. Frustrated, he wanders another 12 meters west then 6 meters south. Calculate the bear's displacement.

- Draw the vector diagram
- Combine ‘like’ vectors
- Determine the resultant AND the angle of direction

fppt.com

Example

A bear, searching for food wanders 35 meters east then 20 meters north. Frustrated, he wanders another 12 meters west then 6 meters south. Calculate the bear's displacement.



$$R = \sqrt{14^2 + 23^2} = 26.93m$$

$$Tan\,\theta = \frac{14}{23} = .6087$$

$$\theta = Tan^{-1}(0.6087) = 31.3^{\circ}$$

The Final Answer: **26.93 m, 31.3 degrees NORTH or EAST**

fppt.com

Example

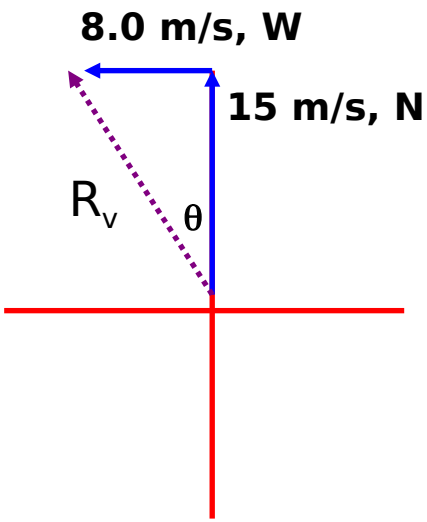
A boat moves with a velocity of 15 m/s, N in a river which flows with a velocity of 8.0 m/s, west. Calculate the boat's resultant velocity with respect to due north.

- Draw the vector diagram
- Combine ‘like’ vectors (if necessary)
- Determine the resultant AND the angle of direction

fppt.com

Example

A boat moves with a velocity of 15 m/s, N in a river which flows with a velocity of 8.0 m/s, west. Calculate the boat's resultant velocity with respect to due north.



$$R_v = \sqrt{8^2 + 15^2} = 17\, m/s$$

$$Tan\,\theta = \frac{8}{15} = 0.5333$$

$$\theta = Tan^{-1}(0.5333) = 28.1^\circ$$

fppt.com

Example

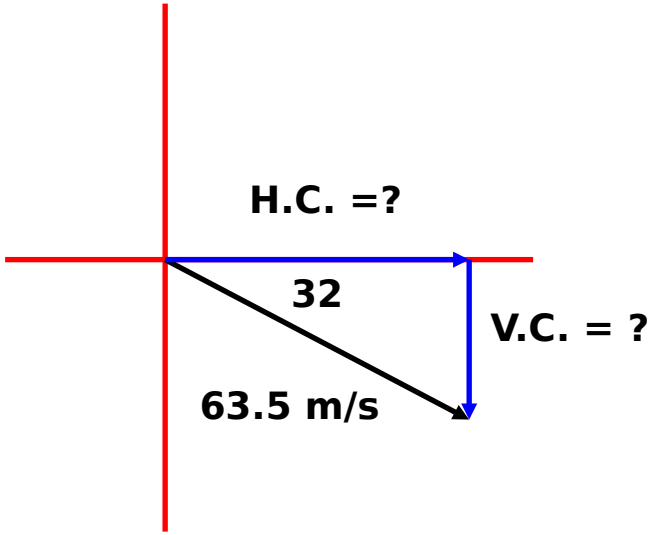
A plane moves with a velocity of 63.5 m/s at 32 degrees South of East. Calculate the plane's horizontal and vertical velocity components.

- Draw the vector diagram
- Combine ‘like’ vectors (if necessary)
- Determine the resultant AND the angle of direction

fppt.com

Example

A plane moves with a velocity of 63.5 m/s at 32 degrees South of East. Calculate the plane's horizontal and vertical velocity components.



$$\text{cosine}\,\theta = \frac{adjacent\ side}{hypotenuse} \qquad \text{sine}\,\theta = \frac{opposite\ side}{hypotenuse}$$

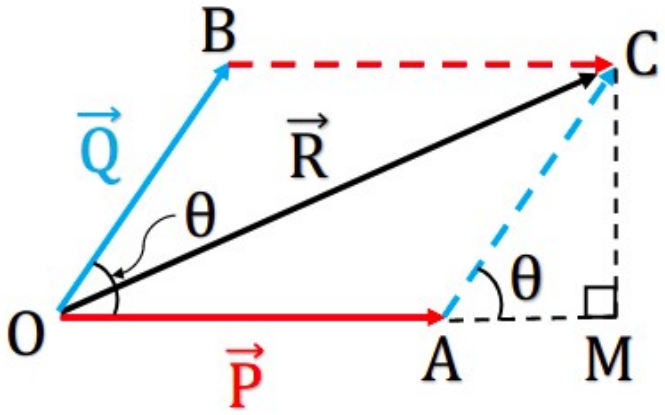
$$adj = hyp\cos\theta \qquad opp = hyp\sin\theta$$

$$adj = H.C. = 63.5\cos 32 = 53.85\,m/s, E$$

$$opp = V.C. = 63.5\sin 32 = 33.64\,m/s, S$$

fppt.com

Magnitude of Resultant



In ΔOCM,

$$OC^2 = OM^2 + CM^2$$

$$OC^2 = (OA + AM)^2 + CM^2$$

$$OC^2 = OA^2 + 2OA \times AM + AM^2 + CM^2$$

$$OC^2 = OA^2 + 2OA \times AM + AC^2$$

In ΔCAM,

$$\cos\theta = \frac{AM}{AC} \quad \Rightarrow \quad AM = AC\cos\theta$$

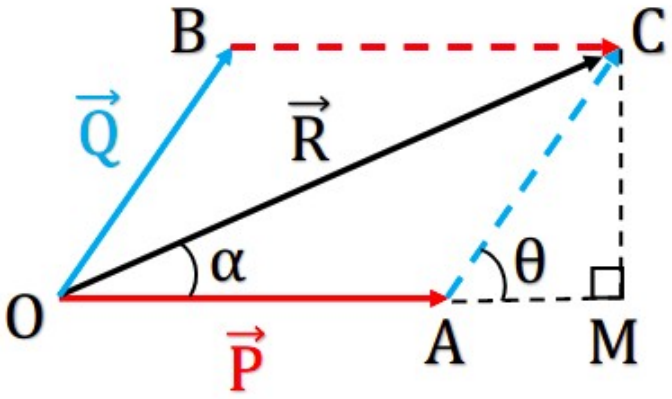
$$OC^2 = OA^2 + 2OA \times AC\cos\theta + AC^2$$

$$R^2 = P^2 + 2P \times Q\cos\theta + Q^2$$

$$R = \sqrt{P^2 + 2PQ\cos\theta + Q^2}$$

fppt.com

Direction of Resultant



In ΔCAM,

$$\sin\theta = \frac{CM}{AC} \quad \Rightarrow \quad CM = AC\sin\theta$$

$$\cos\theta = \frac{AM}{AC} \quad \Rightarrow \quad AM = AC\cos\theta$$

In ΔOCM,

$$\tan\alpha = \frac{CM}{OM}$$

$$\tan\alpha = \frac{CM}{OA+AM}$$

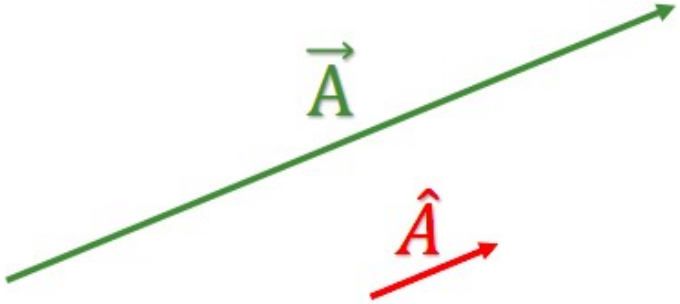
$$\tan\alpha = \frac{AC\sin\theta}{OA+AC\cos\theta}$$

$$\tan\alpha = \frac{Q\sin\theta}{P+Q\cos\theta}$$

fppt.com

Unit vectors

A unit vector is a vector that has a magnitude of exactly 1 and drawn in the direction of given vector.



- It lacks both dimension and unit.
- Its only purpose is to specify a direction in space.

fppt.com

Unit vectors

- A given vector can be expressed as a product of its magnitude and a unit vector.
- For example $\vec{A}$ may be represented as,

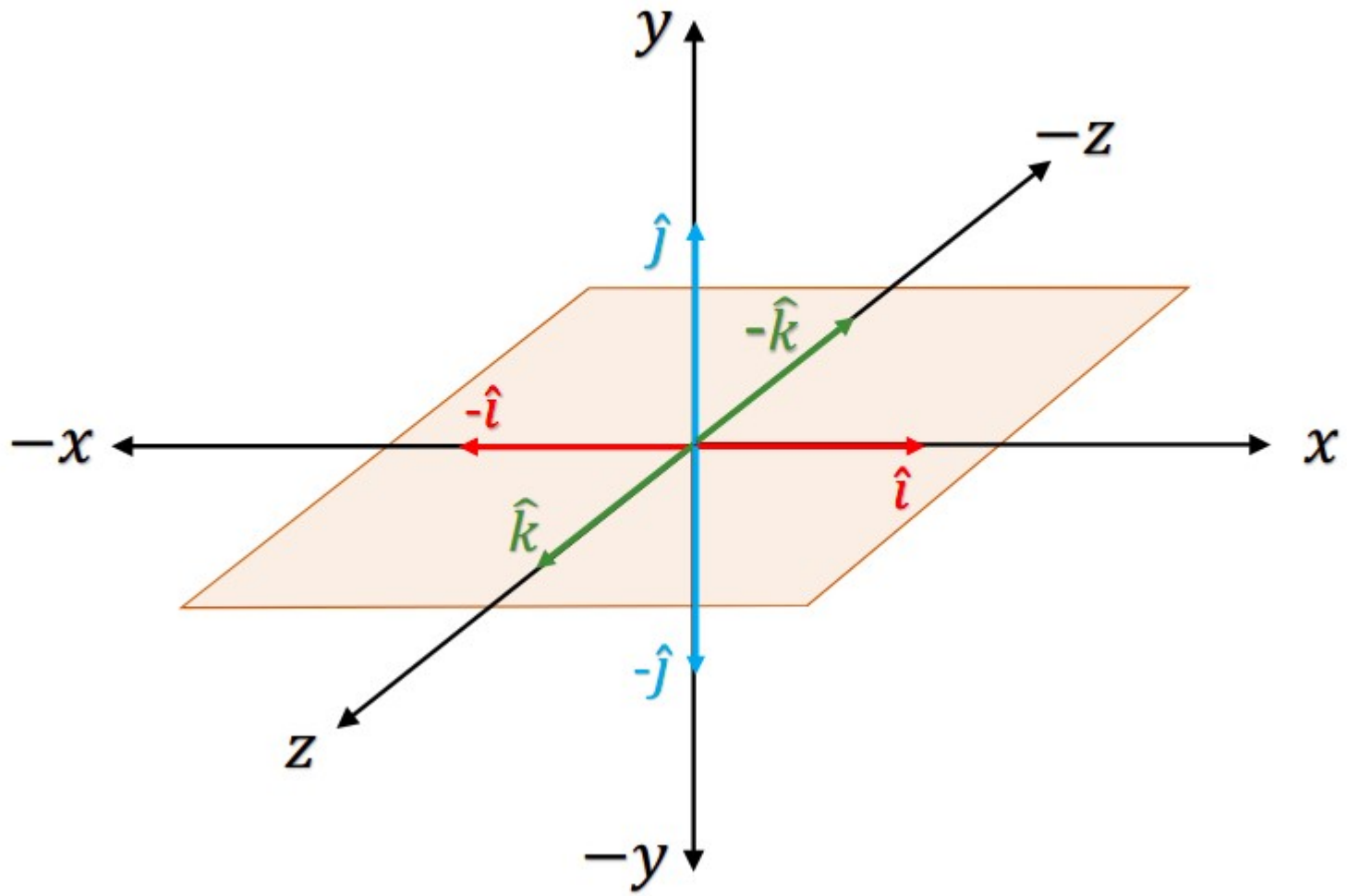
$$\vec{A} = A\,\hat{A}$$

A = magnitude of $\vec{A}$

$\hat{A}$ = unit vector along $\vec{A}$

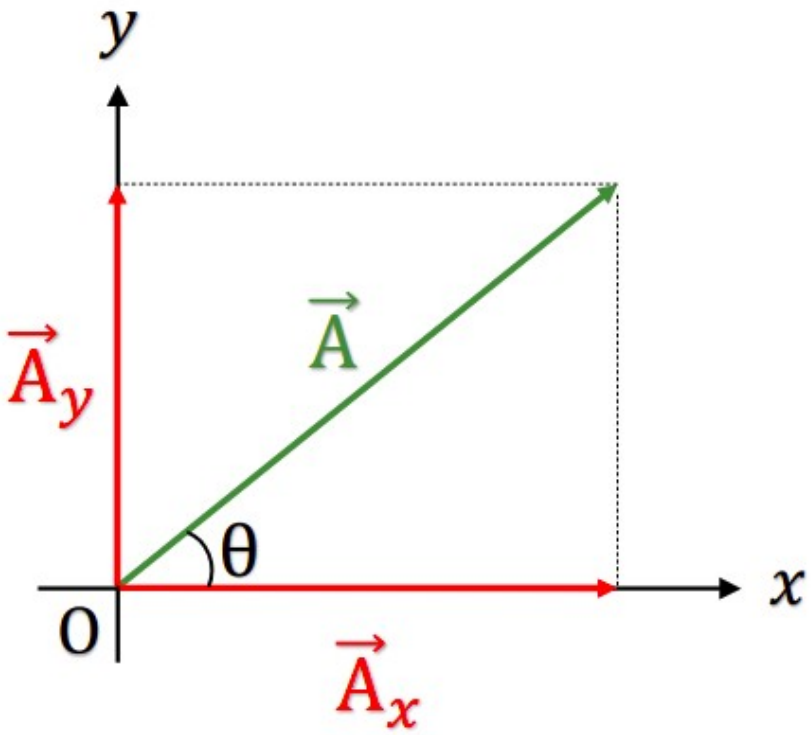
fppt.com

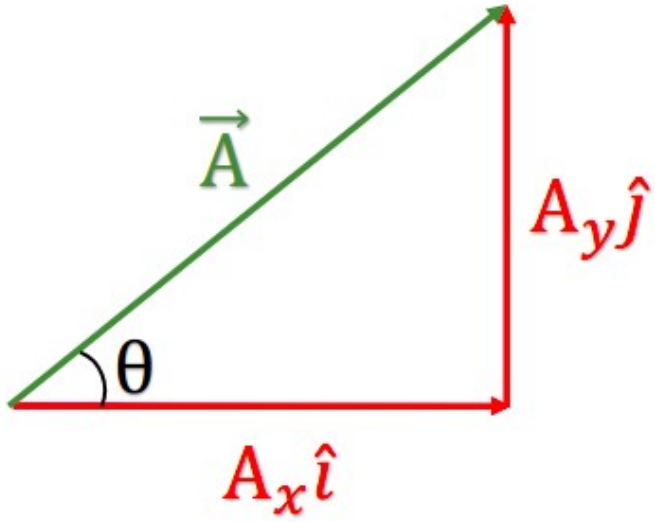
Cartesian unit vectors



fppt.com

Rectangular Components of 2D Vectors



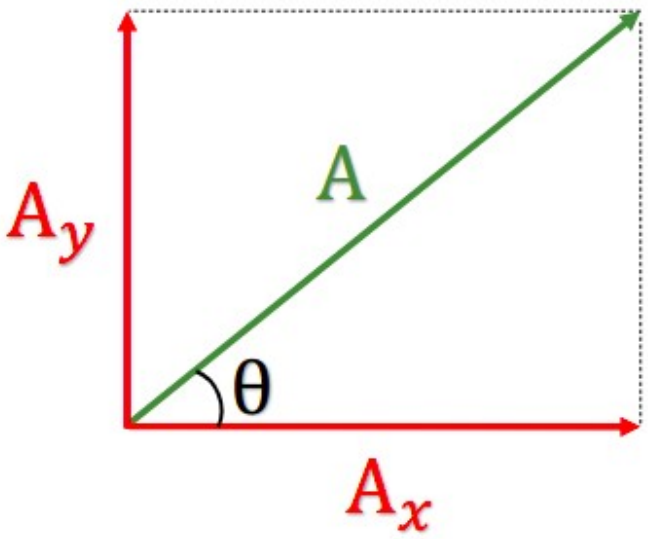


$$\vec{A} = A_x\hat{i} + A_y\hat{j}$$

fppt.com

Magnitude & direction from components

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath}$$



Magnitude:

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

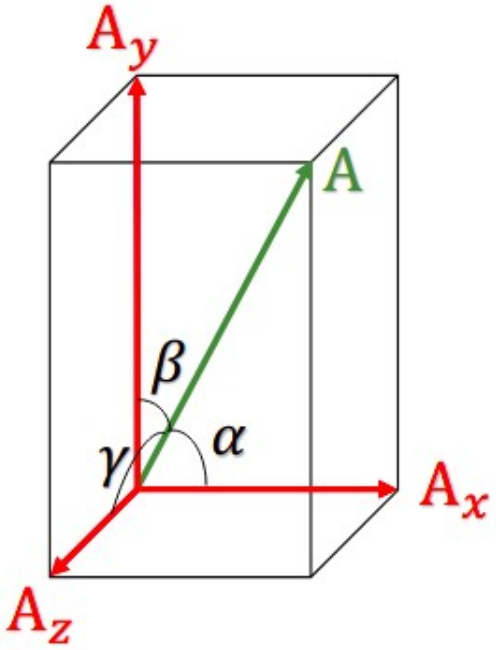
Direction:

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

fppt.com

Magnitude & direction from components

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$$



Magnitude:

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

Direction:

$$\alpha = \cos^{-1}\left(\frac{A_x}{A}\right) \qquad \beta = \cos^{-1}\left(\frac{A_y}{A}\right)$$

$$\gamma = \cos^{-1}\left(\frac{A_z}{A}\right)$$

fppt.com

Adding vectors by components

Let us have

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}$$

then

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

$$\vec{R} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k} + B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}$$

$$\vec{R} = (A_x + B_x)\hat{\imath} + (A_y + B_y)\hat{\jmath} + (A_z + B_z)\hat{k}$$

$$R_x\hat{\imath} + R_y\hat{\jmath} + R_z\hat{k} = (A_x+B_x)\hat{\imath} + (A_y+B_y)\hat{\jmath} + (A_z+B_z)\hat{k}$$

$$R_x = (A_x + B_x)$$

$$R_y = (A_y + B_y)$$

$$R_z = (A_z + B_z)$$

fppt.com

Multiplying a vector by a scalar

- If we multiply a vector $\vec{A}$ by a scalar s, we get a new vector.
- Its magnitude is the product of the magnitude of $\vec{A}$ and the absolute value of s.
- Its direction is the direction of $\vec{A}$ if s is positive but the opposite direction if s is negative.

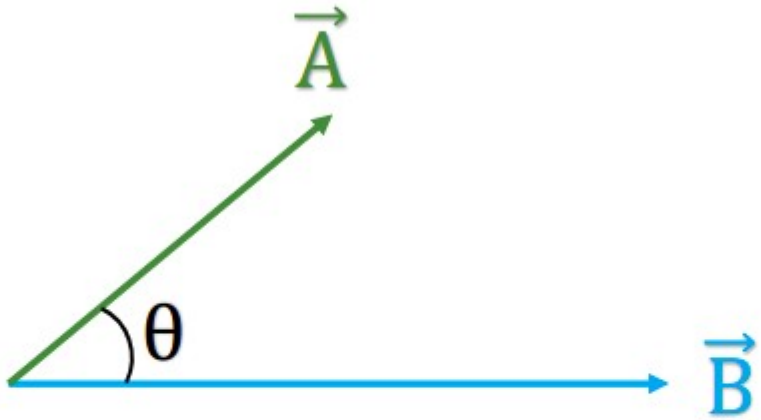
fppt.com

Multiplying a vector by a vector

- There are two ways to multiply a vector by a vector:
- The first way produces a scalar quantity and called as scalar product (dot product).
- The second way produces a vector quantity and called as vector product (cross product).

fppt.com

Scalar product



$$\vec{A} \cdot \vec{B} = AB\cos\theta$$

fppt.com

Examples of scalar product

$$W = \vec{F} \cdot \vec{s}$$

$$W = Fs\cos\theta$$

W = work done

F = force

s = displacement

$$P = \vec{F} \cdot \vec{v}$$

$$P = Fv\cos\theta$$

P = power

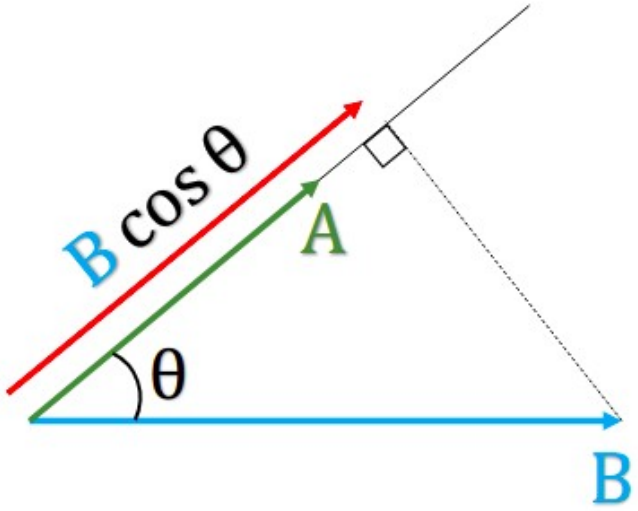
F = force

v = velocity

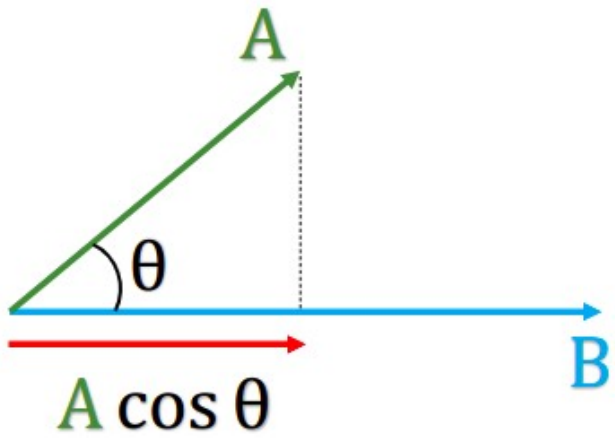
fppt.com

Geometrical meaning of Scalar product

$$\vec{A} \cdot \vec{B} = A(B\cos\theta)$$



$$\vec{A} \cdot \vec{B} = (A\cos\theta)B$$



fppt.com

Calculating scalar product using components

Let us have

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}$$

then

$$\vec{A}\cdot\vec{B} = \left(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}\right) \cdot \left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right)$$

$$\vec{A}\cdot\vec{B} = A_x\hat{\imath}\cdot\left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right) + A_y\hat{\jmath}\cdot\left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right) + A_z\hat{k}\cdot\left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right)$$

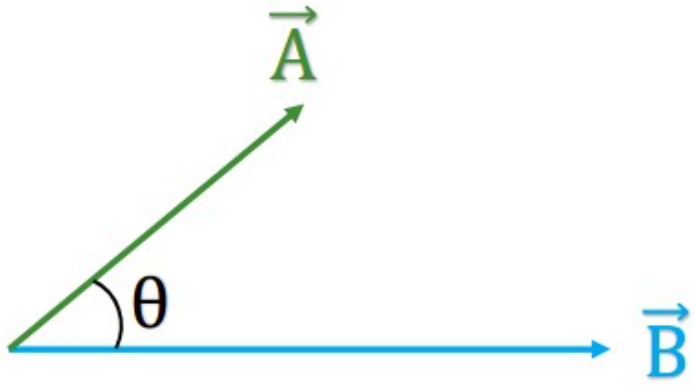
$$= A_xB_x\hat{\imath}\cdot\hat{\imath} + A_xB_y\hat{\imath}\cdot\hat{\jmath} + A_xB_z\hat{\imath}\cdot\hat{k} + A_yB_x\hat{\jmath}\cdot\hat{\imath} + A_yB_y\hat{\jmath}\cdot\hat{\jmath} + A_yB_z\hat{\jmath}\cdot\hat{k} + A_zB_x\hat{k}\cdot\hat{\imath} + A_zB_y\hat{k}\cdot\hat{\jmath} + A_zB_z\hat{k}\cdot\hat{k}$$

$$= A_xB_x(1) + A_xB_y(0) + A_xB_z(0) + A_yB_x(0) + A_yB_y(1) + A_yB_z(0) + A_zB_x(0) + A_zB_y(0) + A_zB_z(1)$$

$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$

fppt.com

Vector product



$$\vec{A} \times \vec{B} = AB \sin\theta \, \hat{n} = \vec{C}$$

fppt.com

Examples of vector product

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{\tau} = rF \sin\theta \, \hat{n}$$

τ = torque

r = position

F = force

$$\vec{L} = \vec{r} \times \vec{p}$$

$$\vec{L} = rp \sin\theta \, \hat{n}$$

L = angular momentum

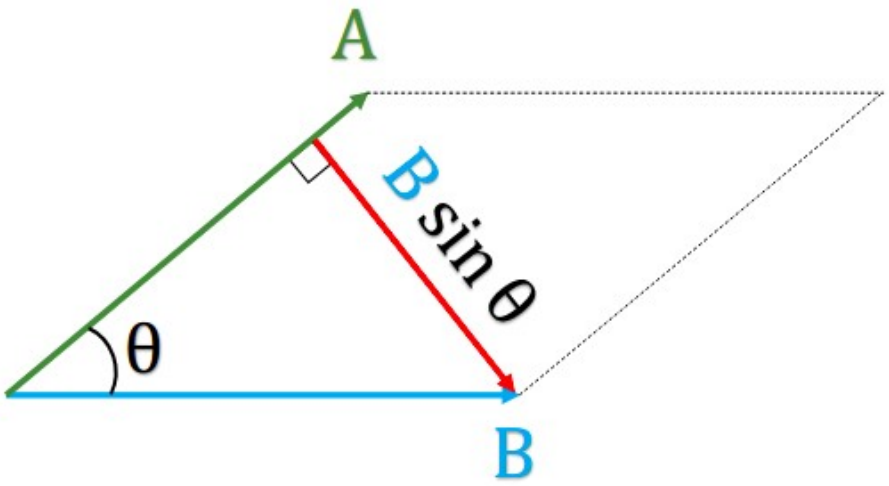
r = position

p = linear momentum

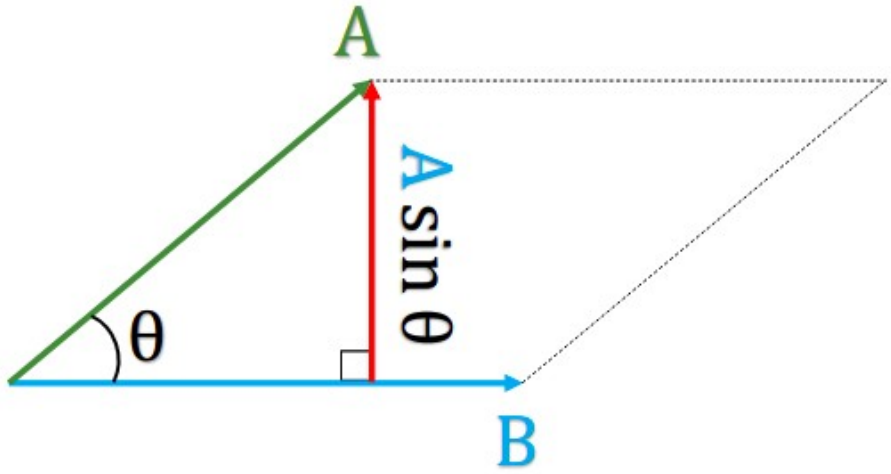
fppt.com

Geometrical meaning of Vector product

$$|\vec{A} \times \vec{B}| = A(B \sin\theta)$$



$$|\vec{A} \times \vec{B}| = (A \sin\theta)B$$



$|\vec{A} \times \vec{B}|$ = Area of parallelogram made by two vectors

fppt.com

Examples of vector product

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{\tau} = rF \sin\theta \, \hat{n}$$

τ = torque

r = position

F = force

$$\vec{L} = \vec{r} \times \vec{p}$$

$$\vec{L} = rp \sin\theta \, \hat{n}$$

L = angular momentum

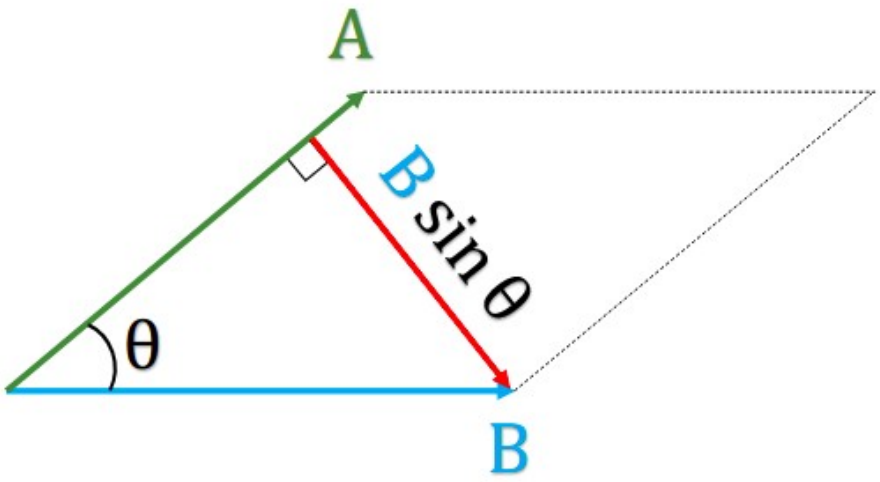
r = position

p = linear momentum

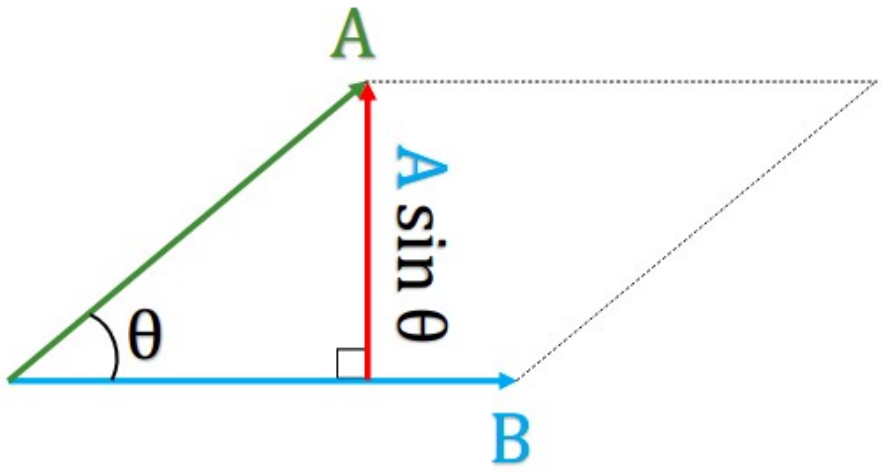
fppt.com

Geometrical meaning of Vector product

$$|\vec{A} \times \vec{B}| = A(B \sin\theta)$$

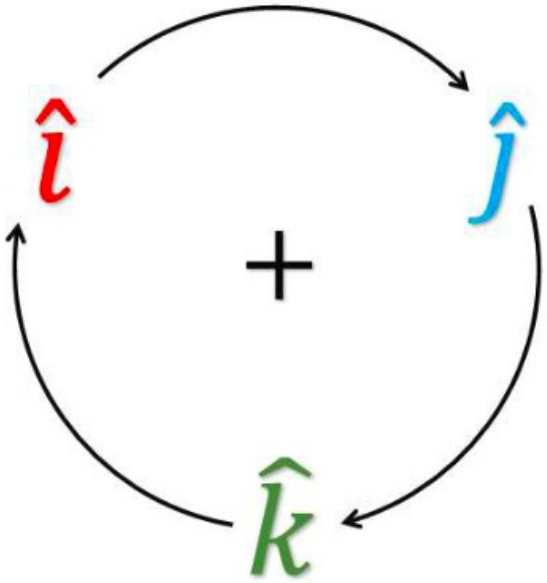


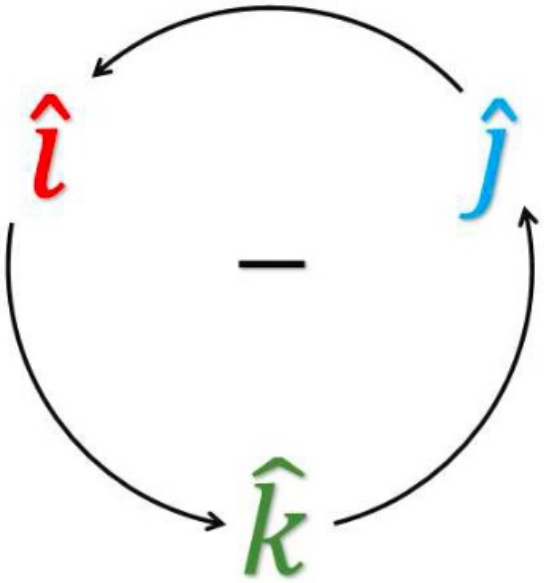
$$|\vec{A} \times \vec{B}| = (A \sin\theta)B$$



$|\vec{A} \times \vec{B}|$ = Area of parallelogram made by two vectors

fppt.com





fppt.com

Calculating vector product using components

Let us have

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}$$

then

$$\vec{A} \times \vec{B} = \left(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}\right) \times \left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right)$$

$$\vec{A} \times \vec{B} = A_x\hat{\imath} \times \left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right) + A_y\hat{\jmath} \times \left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right) + A_z\hat{k} \times \left(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}\right)$$

$$= A_xB_x\hat{\imath} \times \hat{\imath} + A_xB_y\hat{\imath} \times \hat{\jmath} + A_xB_z\hat{\imath} \times \hat{k} + A_yB_x\hat{\jmath} \times \hat{\imath} + A_yB_y\hat{\jmath} \times \hat{\jmath} + A_yB_z\hat{\jmath} \times \hat{k} + A_zB_x\hat{k} \times \hat{\imath} + A_zB_y\hat{k} \times \hat{\jmath} + A_zB_z\hat{k} \times \hat{k}$$

$$= A_xB_x(\vec{0}) + A_xB_y(\hat{k}) + A_xB_z(-\hat{\jmath}) + A_yB_x(-\hat{k}) + A_yB_y(\vec{0}) + A_yB_z(\hat{\imath}) + A_zB_x(\hat{\jmath}) + A_zB_y(-\hat{\imath}) + A_zB_z(\vec{0})$$

$$= A_yB_z(\hat{\imath}) - A_zB_y(\hat{\imath}) + A_zB_x(\hat{\jmath}) - A_xB_z(\hat{\jmath}) + A_xB_y(\hat{k}) - A_yB_x(\hat{k})$$

fppt.com

Calculating vector product using components

$$\vec{A} \times \vec{B} = \hat{\imath}\,(A_y B_z - A_z B_y) - \hat{\jmath}\,(A_x B_z - A_z B_x) + \hat{k}\,(A_x B_y - A_y B_x)$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

fppt.com

Chapter Review Questions and Problems

1. Vector $\vec{A}$ has magnitude of 8units and makes an angle of 45^0 with the positive x-axis. Vector $\vec{B}$ also has the same magnitude of 8units and directed along the negative x-axis. Find
   a. The magnitude and direction of $\vec{A} + \vec{B}$
   b. The magnitude and direction of $\vec{A} - \vec{B}$
2. Given the displacement vectors $\vec{A} = 3\hat{\imath} - 4\hat{\jmath} + 4\hat{k}$, $\vec{B} = 2\hat{\imath} + 3\hat{\jmath} - 7\hat{k}$. Find the magnitudes of the vectors a) $\vec{A}+\vec{B}$ b) $2\vec{A}-\vec{B}$
3. If $\vec{A} = 6\hat{\imath} - 8\hat{\jmath}$, $\vec{B} = -8\hat{\imath} + 3\hat{\jmath}$ and $\vec{C} = 26\hat{\imath} + 19\hat{\jmath}$. Find a and b Such that $a\vec{A} + b\vec{B} + \vec{C} = 0$
4. Find a unit vector in the direction of the resultant of vectors $\vec{A} = 2\hat{\imath} - 3\hat{\jmath} + \hat{k}$, $\vec{B} = \hat{\imath} + \hat{\jmath} + 2\hat{k}$ and $\vec{C} = 3\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$

fppt.com

Thank you

fppt.com

General Physics

(Unit 2)



AASTU

Department of Physics

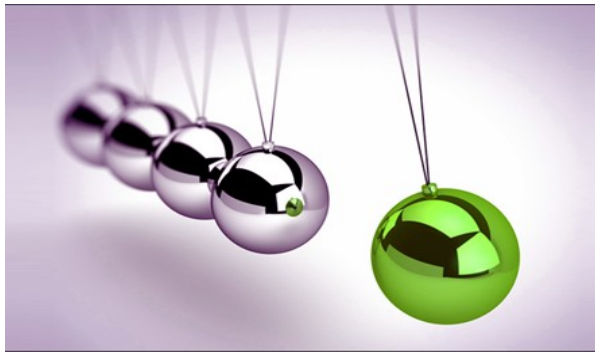
Addis Ababa Science and Technology University

fppt.com

CHAPTER TWO

KINEMATICS AND DYNAMICS OF PARTICLES

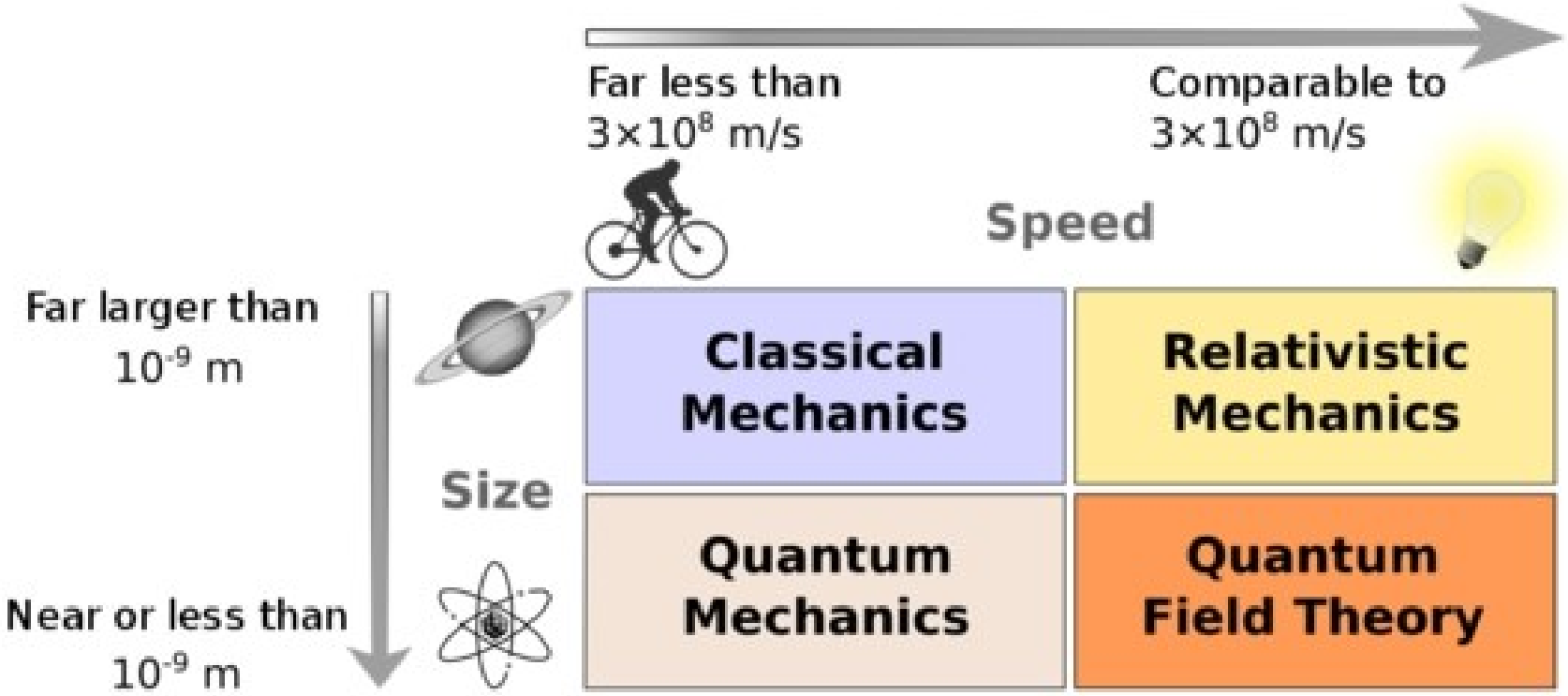
MECHANICS – The branch of Physics that deals with the motion of objects and the forces that change this motion.



Kinematics – The motion part of Mechanics.

Dynamics – The force part of Mechanics.

fppt.com


Far less than
3×10^8 m/s
Comparable to
3×10^8 m/s
Speed
Far larger than
10^-9 m
Size
Near or less than
10^-9 m
Classical Mechanics
Relativistic Mechanics
Quantum Mechanics
Quantum Field Theory

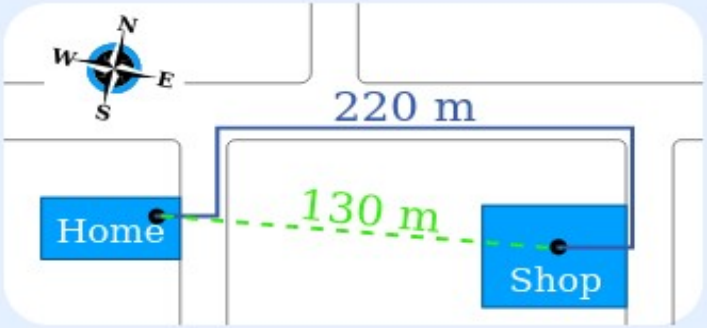
fppt.com

2.1. Kinematics in One and Two Dimensions



fppt.com

Example: You walk from home to the shop in 100 seconds, what is your speed and what is your velocity?



$$\text{Speed} = \frac{220\text{ m}}{100\text{ s}} = 2.2\text{ m/s}$$

$$\text{Velocity} = \frac{130\text{ m}}{100\text{ s}}\text{ East} = 1.3\text{ m/s East}$$

You forgot your money so you turn around and go back home in 120 more seconds: what is your round-trip speed and velocity?

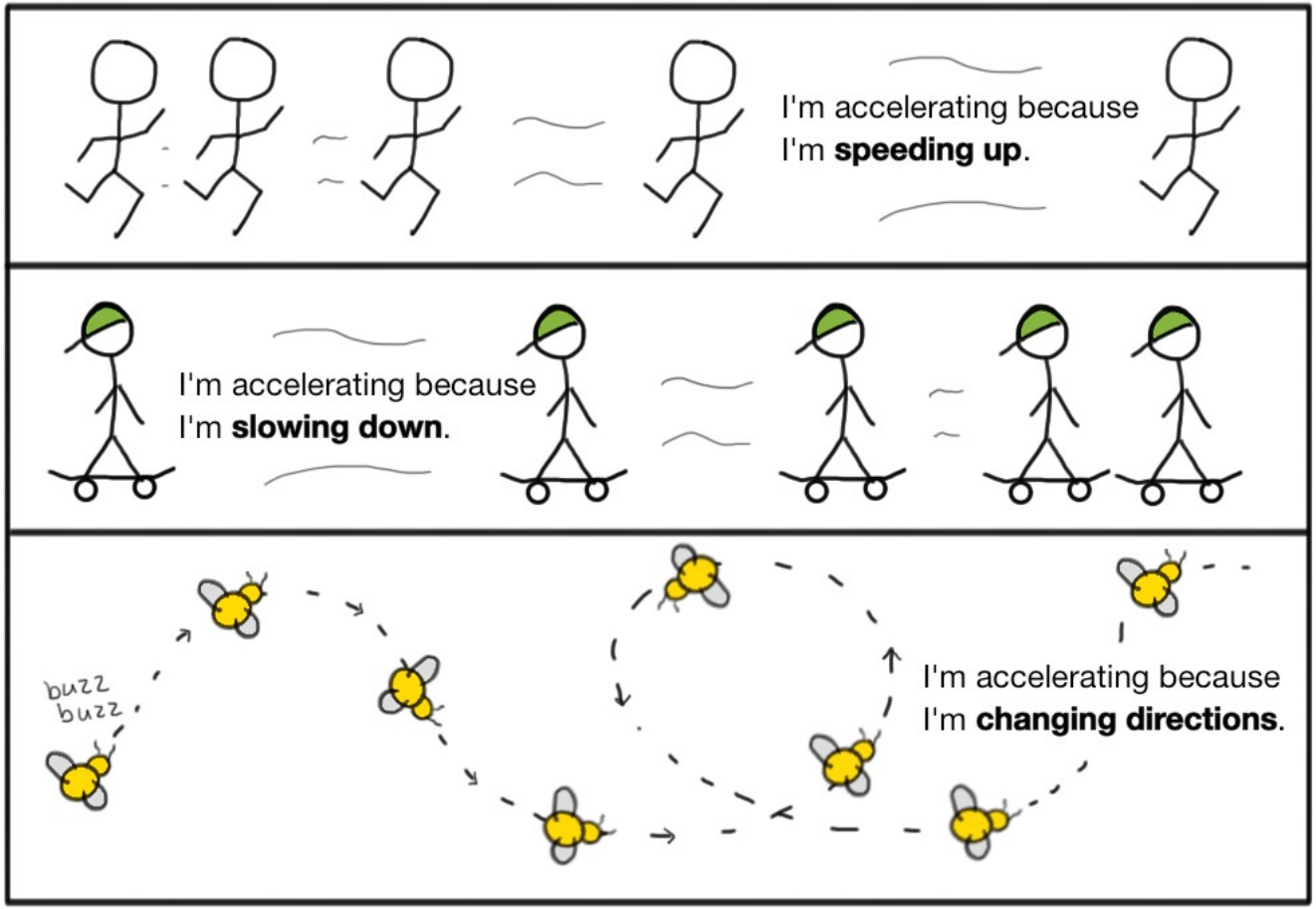
The total time is 100 s + 120 s = 220 s:

$$\text{Speed} = \frac{440\text{ m}}{220\text{ s}} = 2.0\text{ m/s}$$

$$\text{Velocity} = \frac{0\text{ m}}{220\text{ s}} = 0\text{ m/s}$$

Yes, the velocity is zero as you ended up where you started.

fppt.com



$$a = \frac{v - u}{t}$$

fppt.com

Linear Motion - 1D

Constant Speed

$$v = s/t$$

Changing Speed

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

$$s = \frac{1}{2}(u + v)t$$

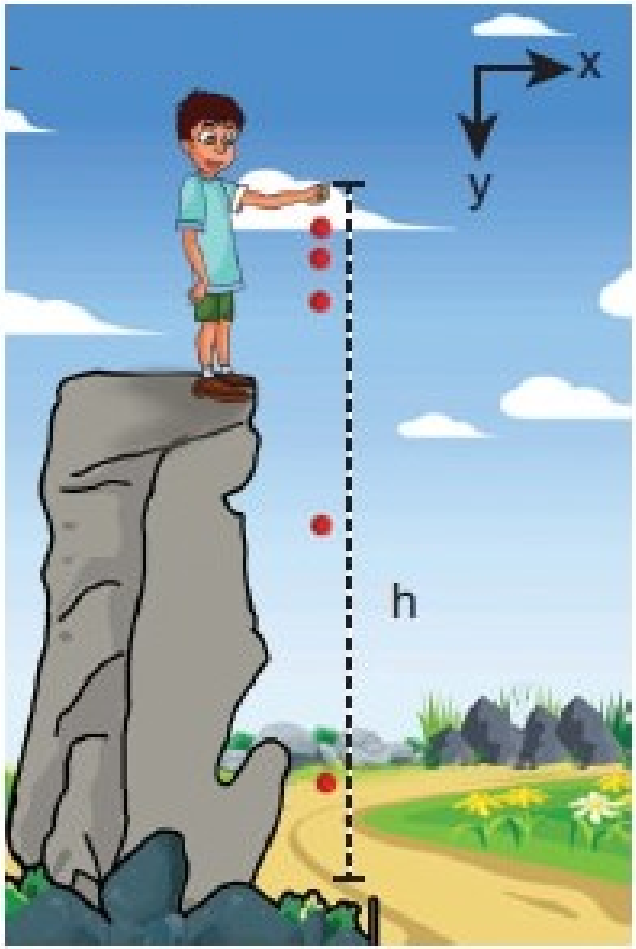
fppt.com

Activity:

1. At t=0s, a particle moving in the x-y plane with constant acceleration has a velocity of $\vec{v}_i = (3\hat{\imath}\text{-}2\hat{\jmath})$ m/s, and is at the origin. At t=3s, the particle's velocity is $\vec{v}_f = (9\hat{\imath}+7\hat{\jmath})$ m/s. Find (a)the acceleration of the particle (b) Its coordinates at t=3s

fppt.com

Vertical projectile motion



$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

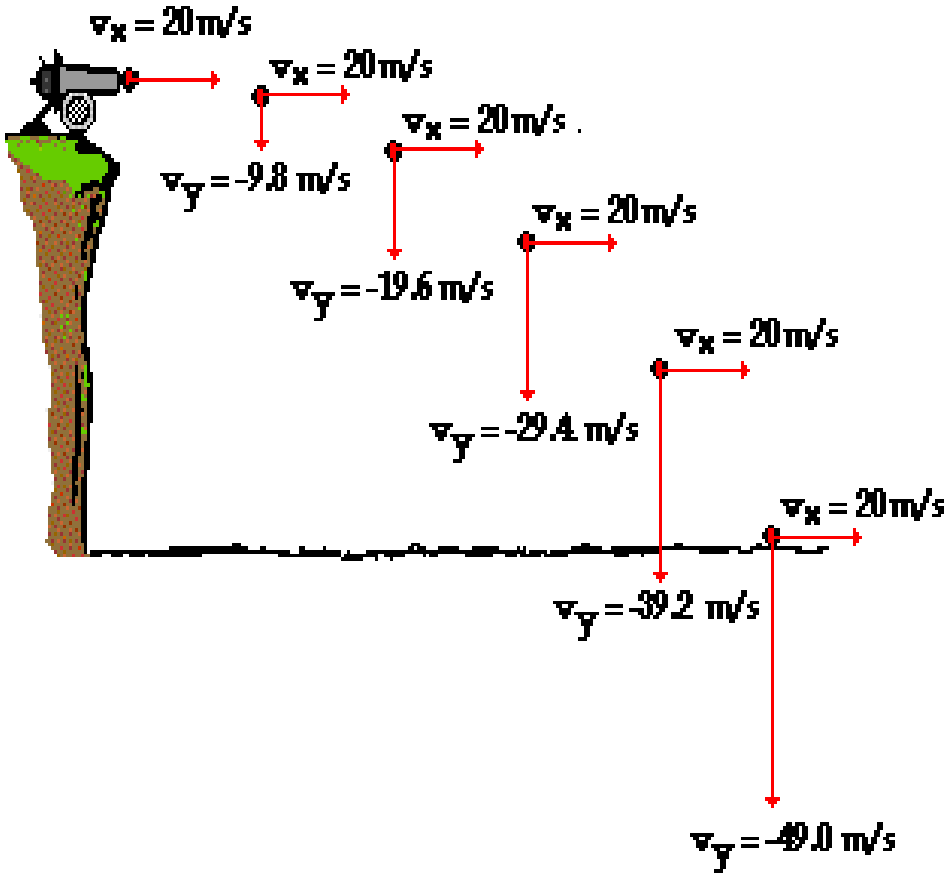
$$s = vt - \frac{1}{2}at^2$$

$$s = \frac{1}{2}(u + v)t$$



fppt.com

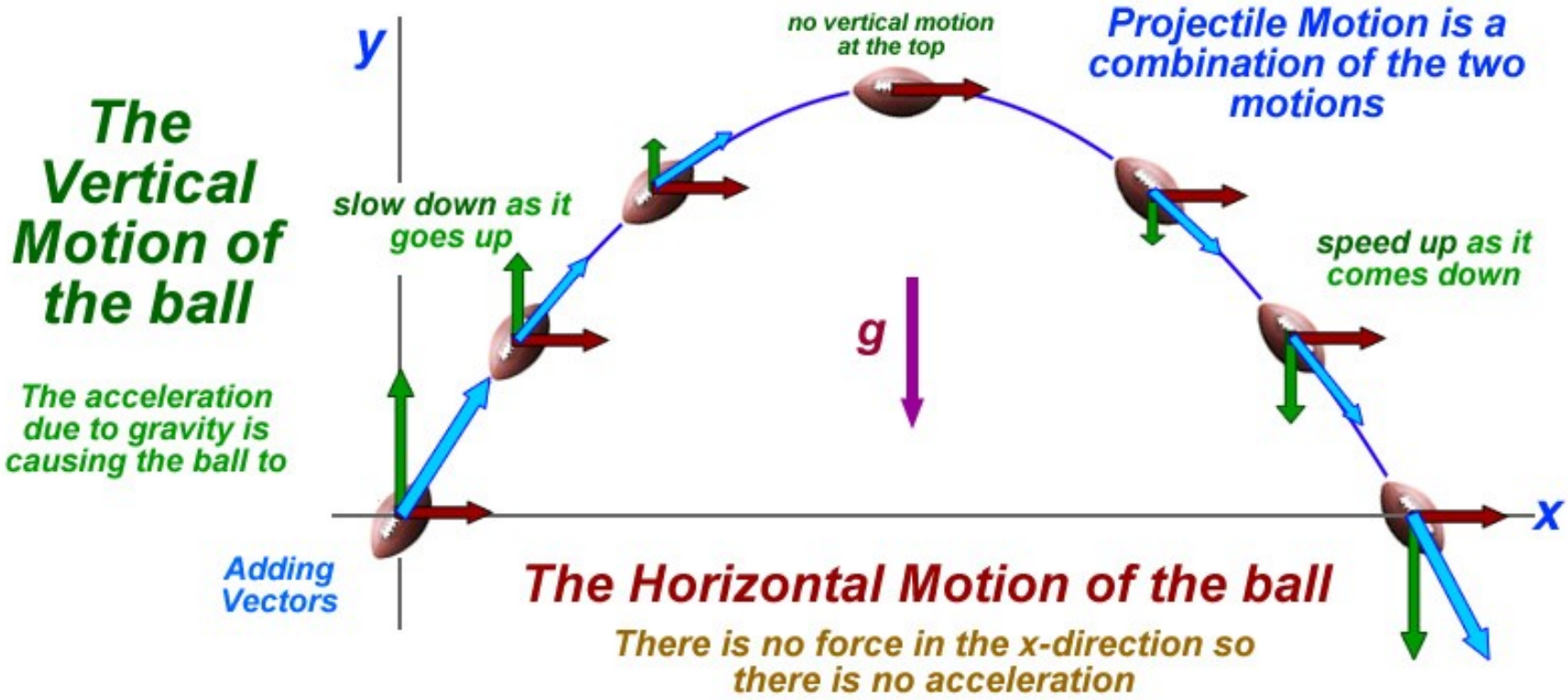
Horizontal projectile motion - 2D



Horizontal	Vertical
$a_x = 0$	$a_y = -g$
v_x = constant	

fppt.com

Inclined projectile motion - 2D



fppt.com

Inclined projectile motion - 2D

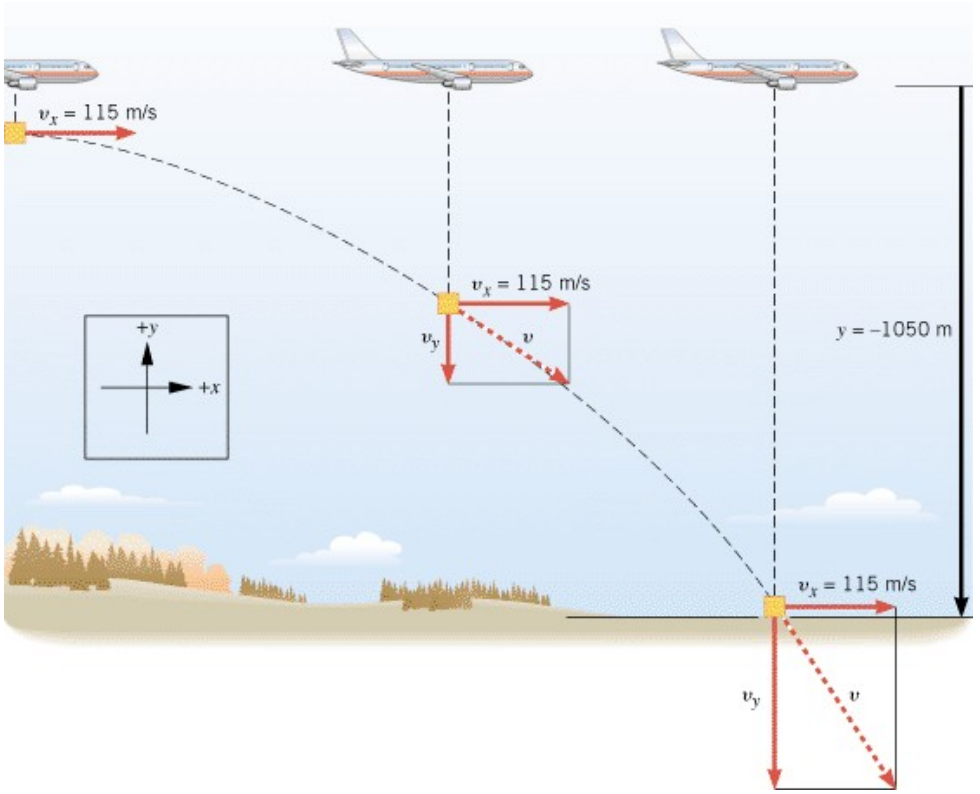
Horizontal ***Vertical***



fppt.com

Example

A plane drops a package to a party of explorer. If the plane is travelling horizontally at 115 m/s and is 1050m above the ground, where does the package strike the ground relative to the point at which it is released?



fppt.com

Activities

1. A ball is thrown with an initial velocity of $\vec{u} = (10\hat{\imath}+15\hat{\jmath})$ m/s. When it reaches the top of its trajectory, neglecting air resistance, what is its a) velocity? b) Acceleration?
2. An astronaut on a strange planet can jump a maximum horizontal distance of 15m if his initial speed is 3m/s. What is the free fall acceleration on the planet?

fppt.com

Thank you

fppt.com

General Physics

(Unit 3)



AASTU

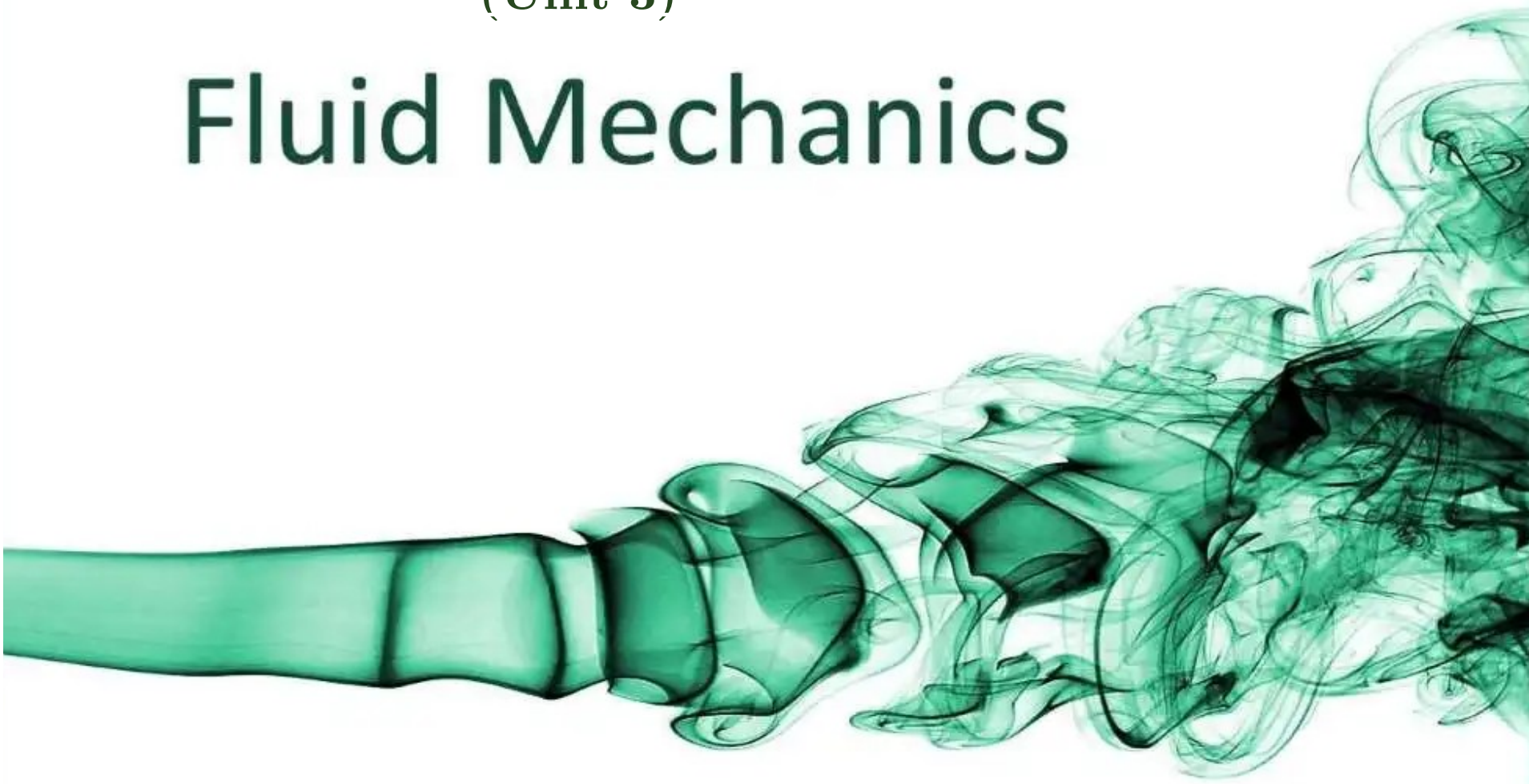
Department of Physics

Addis Ababa Science and Technology University

fppt.com

(Unit 3)

Fluid Mechanics



fppt.com

Fluid mechanics

- Is a broad study of fluid behaviour (liquids, gases, blood, and plasma) at rest and in motion.

- is the branch of physics concerned with the mechanics of fluids in motion (fluid dynamics) or at rest (fluid statics) and the forces on them.

- has enormous applications: breathing, blood flow, swimming, pumps, fans, turbines, air planes, ships, rivers, windmills, pipes, missiles, icebergs, engines, filters, jets, and sprinklers, to name a few.

fppt.com

Fluid Definition and Examples

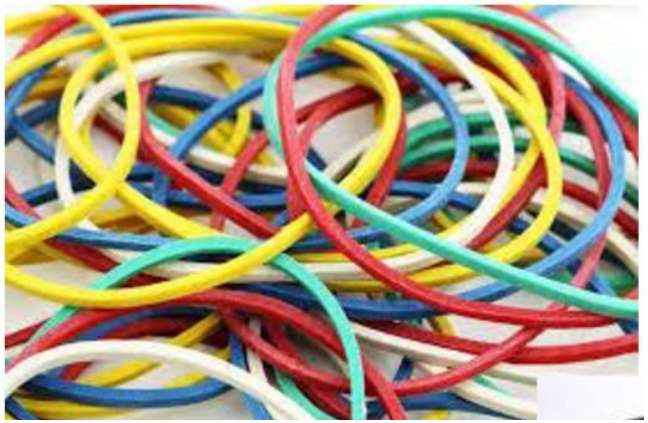
A fluid is a liquid, gas, or other material that flows or continuously deforms under a shear (tangential) force.



fppt.com

3.1. Properties of Bulk Matter

Elastic materials : materials that regain their original shape and size when the deforming force is removed.



Elastic deformation : a reversible deformation by a force applied within the elastic limit.

Beyond elastic limit, a force applied on an object causes permanent and irreversible deformation called **plastic deformation**.

Plastics materials : do not regain their original shape and size when the deforming force is removed.

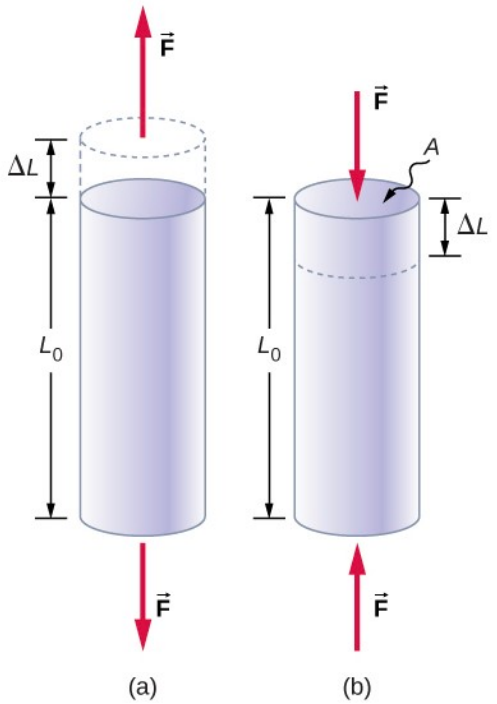


fppt.com

The elastic properties of solid materials are described in terms of **stress and strain.**

Stress is the force per unit area that is causing some deformation on an object.

Strain : measures the amount of deformation by the applied stress and defined as the change in configuration of a body divided by its initial configuration. Strain is unit less quantity.



Stress

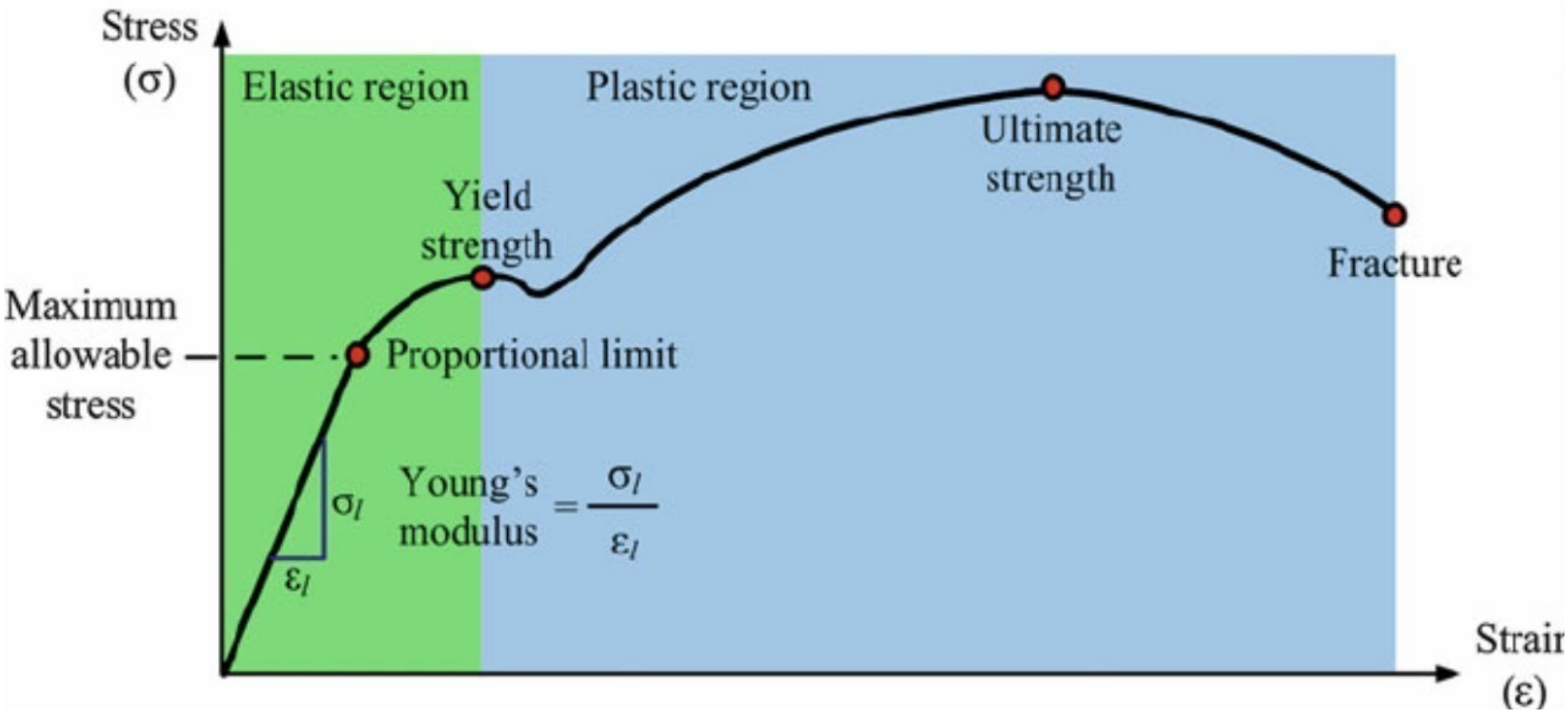
$$Stress = \frac{Force\ (or\ load)}{Area} \qquad \sigma = \frac{F}{A}$$

Strain

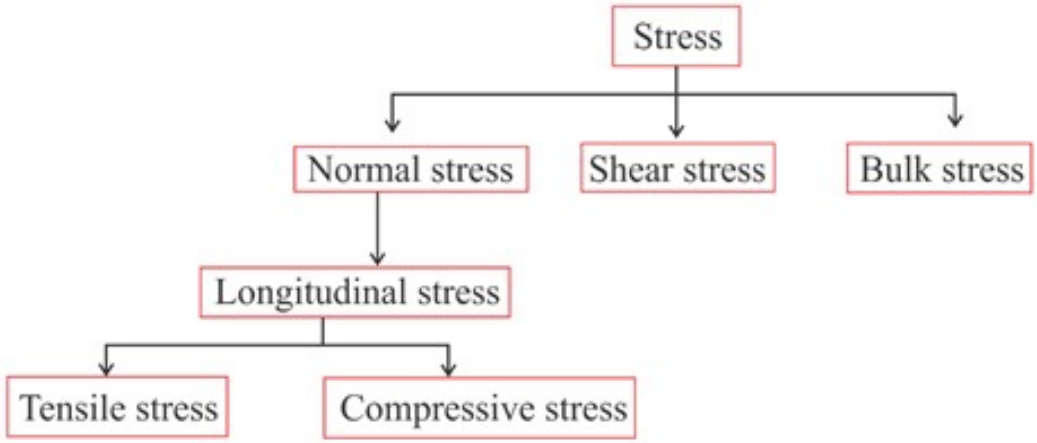
$$Strain = \frac{Length\ of\ Stretch}{Original\ Length} \qquad \varepsilon = \frac{\delta}{L}$$

fppt.com

STRESS STRAIN CURVE

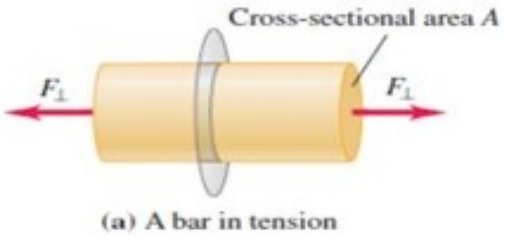


fppt.com

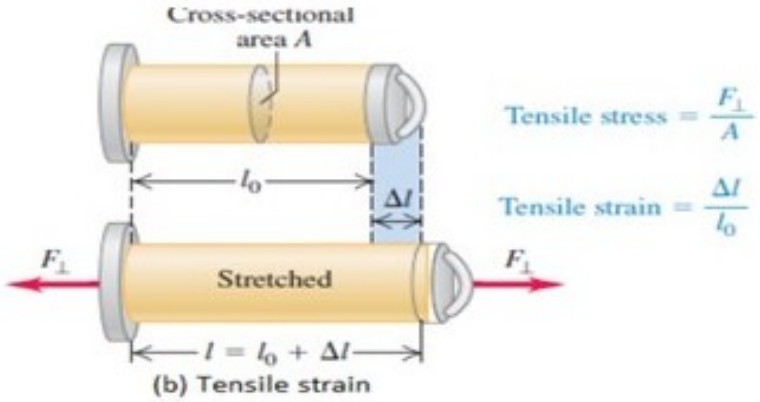


1. Tensile Stress / Tensile Strain

- - the fractional change in length of an object by a given tensile stress.
  - is a strain due to tensile stress



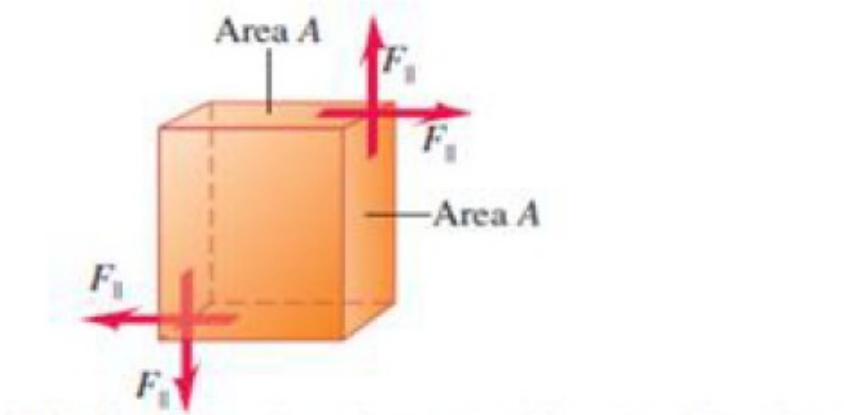
(a) A bar in tension



(b) Tensile strain

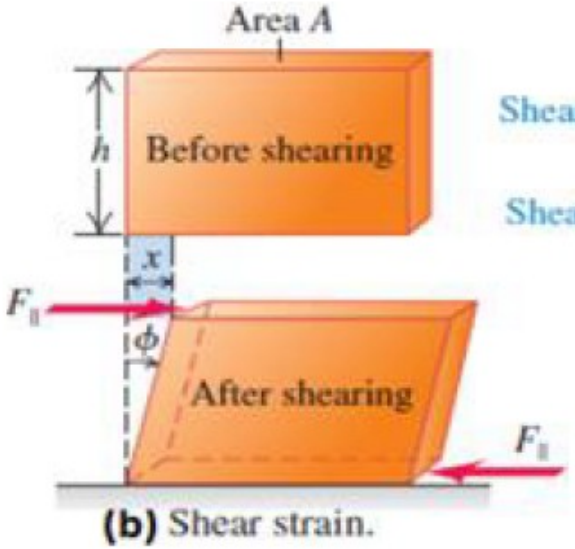
fppt.com

2. Shear Stress / Shear Strain



A block subjected to shear stress from two directions

(a) Shear stress.

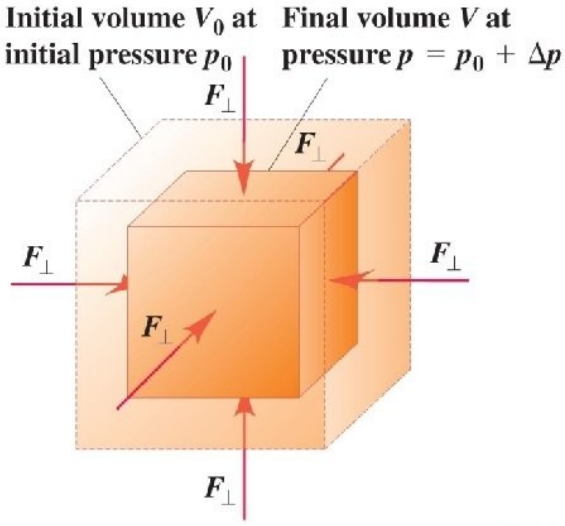


$$\text{Shear stress} = \frac{F_\parallel}{A}$$

$$\text{Shear strain} = \frac{x}{h}$$

(b) Shear strain.

3. Volume Stress / Volume Strain



$$\text{Volume stress} = \Delta p \quad \text{Volume strain} = \frac{\Delta V}{V_0}$$

fppt.com

Elastic modulus

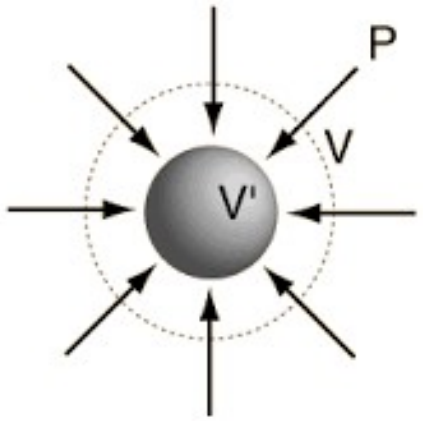
Formula

$$E = \frac{\sigma}{\varepsilon} = \frac{\text{stress}}{\text{strain}}$$

E ⟶ Young's Modulus (Elasicity)

σ ⟶ stress

ε ⟶ strain



Bulk modulus:

$$B = \frac{\Delta P}{\Delta V/V}$$

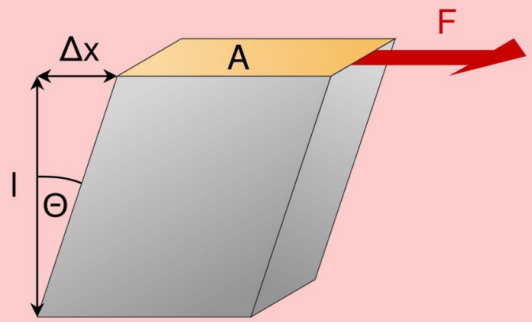
P = pressure
V = volume

Shear Modulus

Modulus of Rigidity

The shear modulus is the shear stiffness of a material.

$$G = \frac{\tau_{xy}}{\gamma_{xy}} = \frac{F/A}{\Delta x/l} = \frac{Fl}{A\Delta x}$$



It is the ratio of shear stress to shear strain.

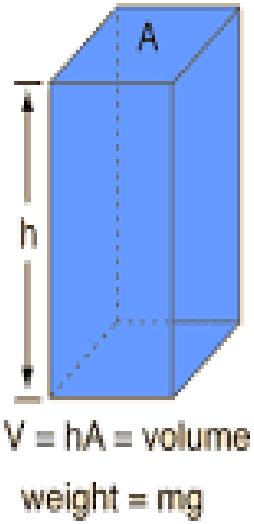


STRAIN ENERGY

Strain energy is a sort of potential energy that is stored in an object due to elastic deformation.

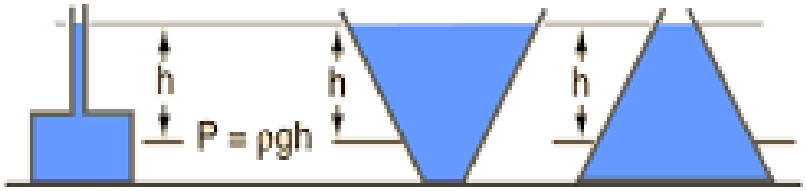
fppt.com

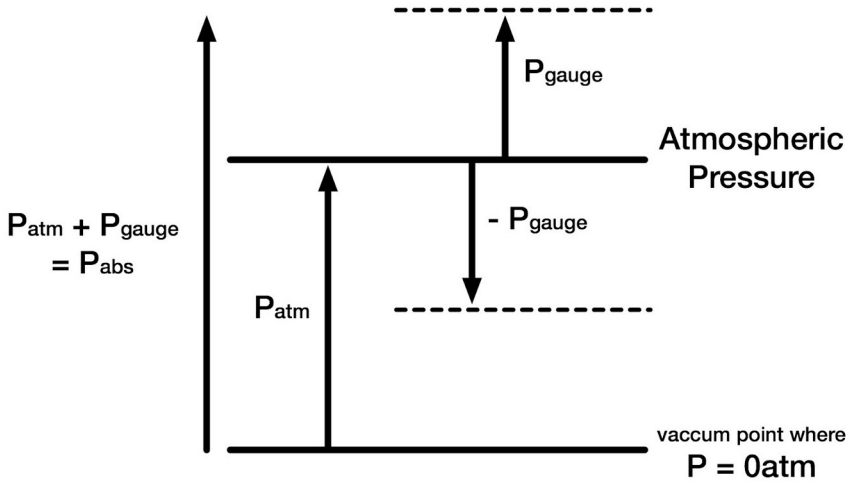
Fluid Pressure



Static fluid pressure does not depend on the shape, total mass, or surface area of the liquid.

$$\text{Pressure} = \frac{\text{weight}}{\text{area}} = \frac{mg}{A} = \frac{\rho V g}{A} = \rho g h$$

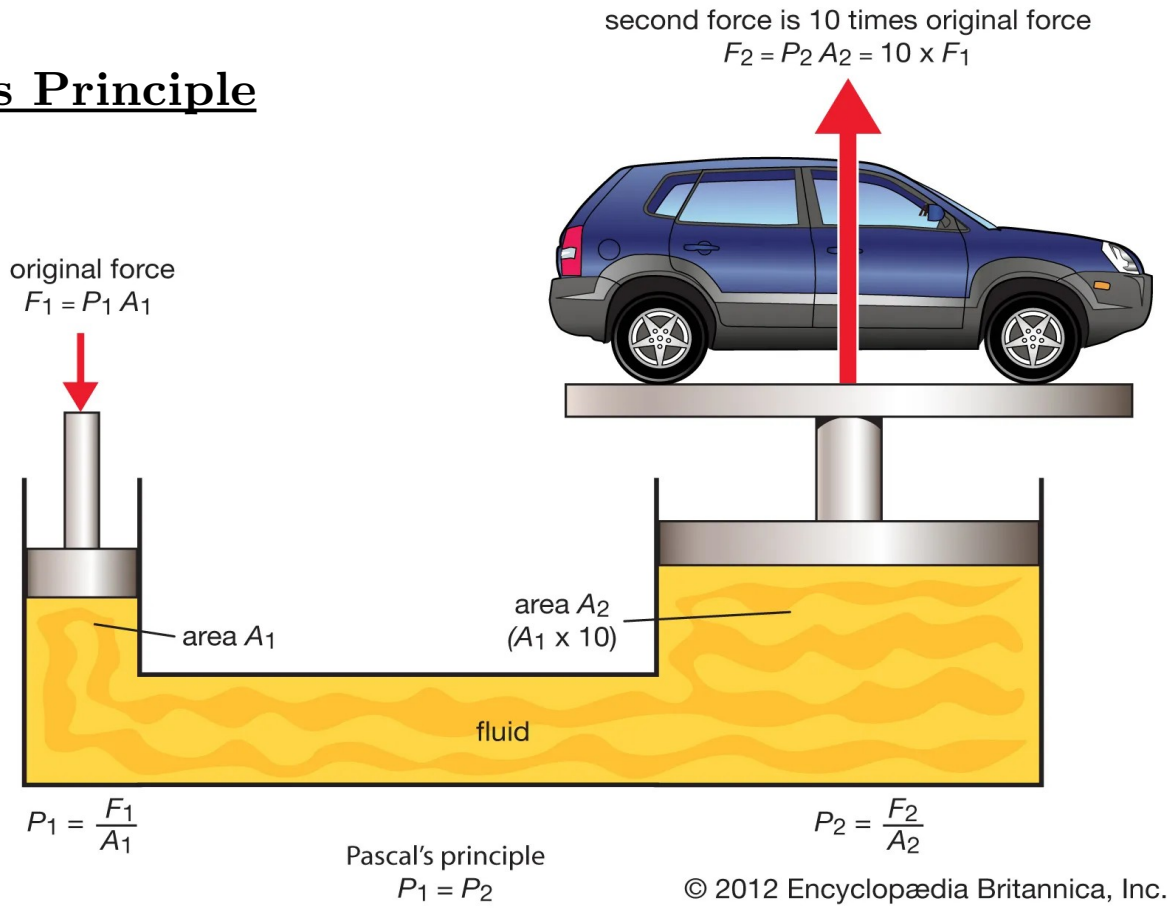




$$P_{abs} = P_{guage} + P_{atm}$$

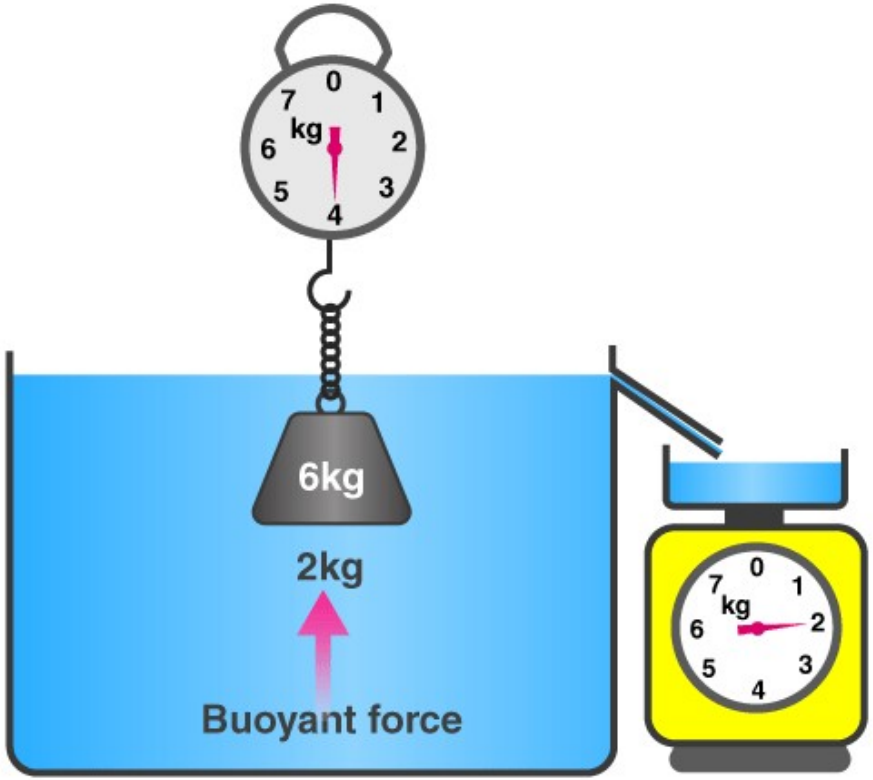
fppt.com

Pascal's Principle



A hydraulic press has one piston of diameter 2cm & the other piston of diameter 8cm. What force must be applied to the smaller piston to obtain a force of 1600 N at the larger piston? _____ N

fppt.com



Archimedes' Principle

the buoyant force is equal to
the weight of the displaced water

$$F_b = -\rho g V$$

F_b = buoyant force
ρ = fluid density
g = acceleration due to gravity
V = fluid volume

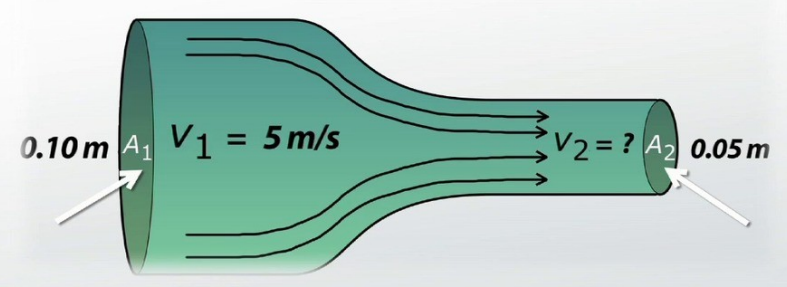
A rock, which weighs 1400 N in air, has an apparent weight of 900 N when submerged in fresh water (998 kg/m3). The volume of the rock is:

A. $0.14\ m^3$ B. $0.60\ m^3$ C. $0.90\ m^3$ D. $5.1 \times 10^{-2}\ m^3$

fppt.com

3.4. Moving Fluids and Bernoulli Equations (Fluid Dynamics)

Continuity equation



$$A_1 v_1 = A_2 v_2$$

A_1 = cross-sectional area of region 1

v_1 = flow velocity in region 1

A_2 = cross-sectional area of region 2

v_2 = flow velocity in region 2

Bernoulli's Principle

Theory - Equation

$$P_1 + \frac{1}{2}\rho V_1^{\,2} + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^{\,2} + \rho g h_2$$

Where (in SI units)

P= static pressure of fluid at the cross section

ρ= density of the flowing fluid

g= acceleration due to gravity;

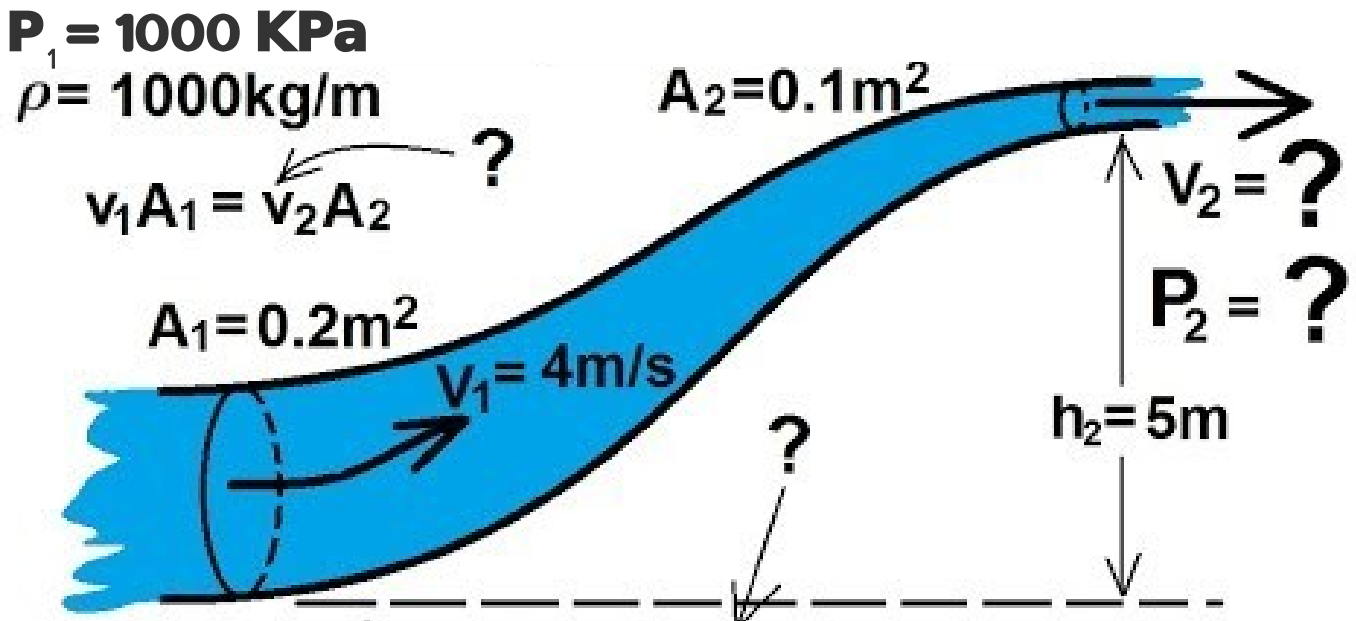
v= mean velocity of fluid flow at the cross section

h= elevation head of the center of the cross section with respect to a datum.

fppt.com

Example 1

Bernoulli's Eqn: Unknown Velocity



$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

fppt.com

Example 2

A cylindrical water tower of diameter 3 m supplies water to a house. The level of water in the water tower is 35 m above the point where the water enters the house through a pipe that has an inside diameter 5cm. The intake pipe delivers water at a maximum rate of 2×10^{-3} $m^3.s^{-1}$. The pipe is connected to a narrower pipe leading to the second floor that has an inside diameter 2.5 cm.

- Calculate the pressure of the water in the narrow pipe at 5 m height.
- Find the speed of the water in the narrow pipe.

(Use: Patm = 1atm = 101.3 KPa, $\rho = 1000$ Kg/m^3 , $g = 10$ m/s^2

fppt.com

Thank you

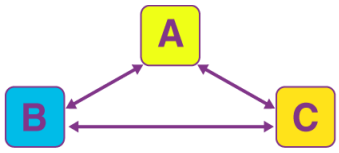
fppt.com

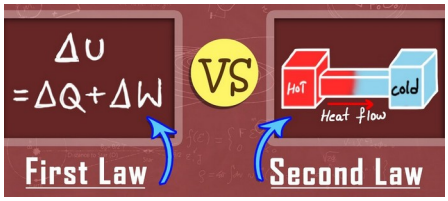
CHAPTER FOUR – HEAT AND THERMODYNAMICS

Thermodynamics is a science of the relationship between heat, work, temperature, and energy. In broad terms, thermodynamics deals with the transfer of energy from one system to another and from one form to another.

Heat is the total kinetic energy and potential energy obtained by molecules in an object. Temperature is the average K.E of molecules in a substance. Heat flows from hot body to cold body. It rises when heated and falls down when an object is cooled down. Heat and work are two possible ways of transferring energy from one system to another.

Laws of thermodynamics





The *Third Law* of Thermodynamics

"It is impossible to reach a temperature of absolute zero."

Isolated system : $\Delta U = 0$, U = Constant

Isochoric process : volume constant, $W = 0$, $\Delta U = Q$

Cyclic Process : $\Delta U = 0$, $Q = W$

Adiabatic Process : $Q = 0$, $\Delta U = W$

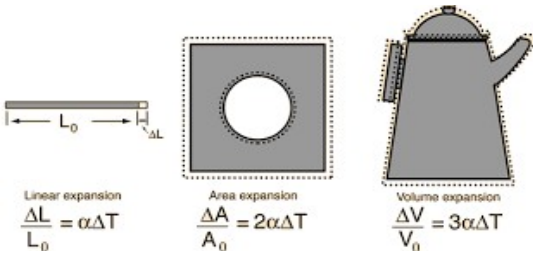
Isothermal Process : $\Delta U = 0$, $Q = -W = -Pdv = nRT \ln(Vf/Vi)$

Isobaric process : constant pressure $\Delta U = Q - P\Delta V$

Temperature Scales : On the Celsius scale, the freezing point of water is 0 ^{0}C and the boiling point is 100 ^{0}C.

4.2. Thermal Expansion





4.4. Specific Heats : The amount of heat required to raise the temperature of a unit mass of any substance through a unit degree.

Latent Heats (Hidden heat) : Latent Heat the heat required per unit mass of a substance to produce a phase change at constant temperature.

Specific Heat

$$Q = mc\Delta T$$

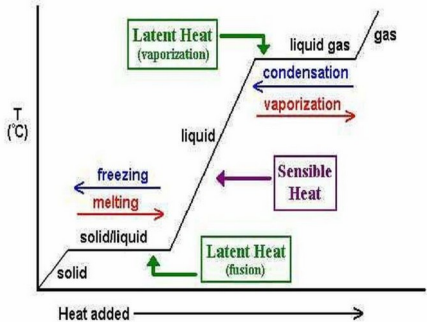
$$Q = mL$$

Q = Heat Change (J or Nm)
m = mass (kg)
L = specific latent heat (J kg^{-1})

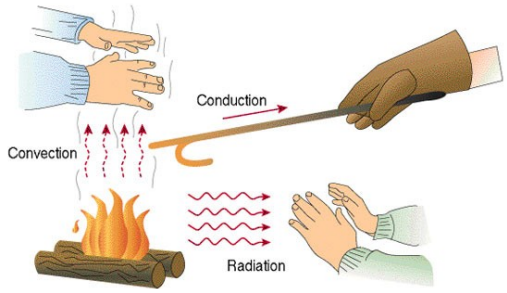
Water:
Specific Heat Capacities
and Latent Heats

Energy Values for Water in Joule

To warm ice (specific heat of ice)	2.06 J/gC°
To melt ice (the heat of fusion)	334 J/g
To warm water (specific heat of water)	4.18 J/gC°
To evaporate water (heat of vaporization)	2290 J/g
To warm water vapor (specific heat of steam)	20.2 J/gC°



4.5. Heat Transfer Mechanisms



Exercise

1 - A system absorbs 35J of heat and in the process it does 11J of work. (a) If the initial internal energy is 205J what is the final internal energy? (b) The system follows a different thermodynamic path to the same final state and does 15J of work, what is the heat transferred?

2 - 2000 J of heat leaves the system and 2500 J of work is done on the system. What is the change in internal energy of the system?

3 - A system undergoes an adiabatic process in which its internal energy increases by 20 J. Which of the following statements is true?

A. *20 J of work was done on the system*
B. *20 J of work was done by the system*
C. *the system received 20 J of energy as heat*
D. *the system lost 20 J of energy as heat*

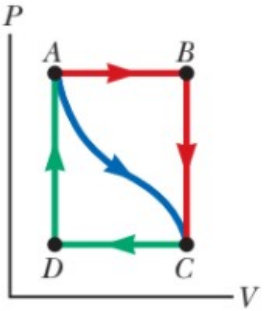
4 - If the temperature of a cube made of copper with initial volume 3m^3, changes from 10 ^{0}C to 15 ^{0}C, its change in volume is _____ m^3 (use: = 17 x 10^{-6} K^{-1})

5 - In the Fig below ,the change in internal energy of a gas that is taken from A to C is = +800J. The work done on the gas along path ABC is = - 500 J. (6 pts)

(a) How much energy must be added to the system by heat as it goes from A through B to C ?

(b) If the pressure at point A is five times that of point C, what is the work done on the system in going from C to D?

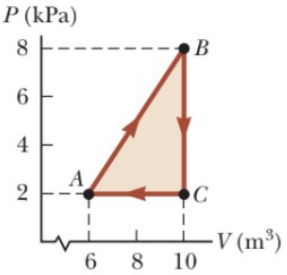
(c) What is the energy exchanged with the surroundings by heat as the cycle goes from C through D to A.



6 - If 90 g of molten lead at 327.3 0C is poured into a 300 g casting form made of iron and initially at 20.00C, what is the final temperature of the system? Assume no energy is lost to the environment.

7 - How much heat energy is required to change a 40 g ice cube from a solid at -10 °C to steam at 110 °C?

8 - A gas is taken through the cyclic process described in Figure 1. (a) Find the net energy transferred to the system by heat during one complete cycle. (b) If the cycle is reversed-that is, the process follows the path ACBA - what is the net energy input per cycle by heat?



General Physics

(Unit 6)



AASTU

Department of Physics

Addis Ababa Science and Technology University

fppt.com

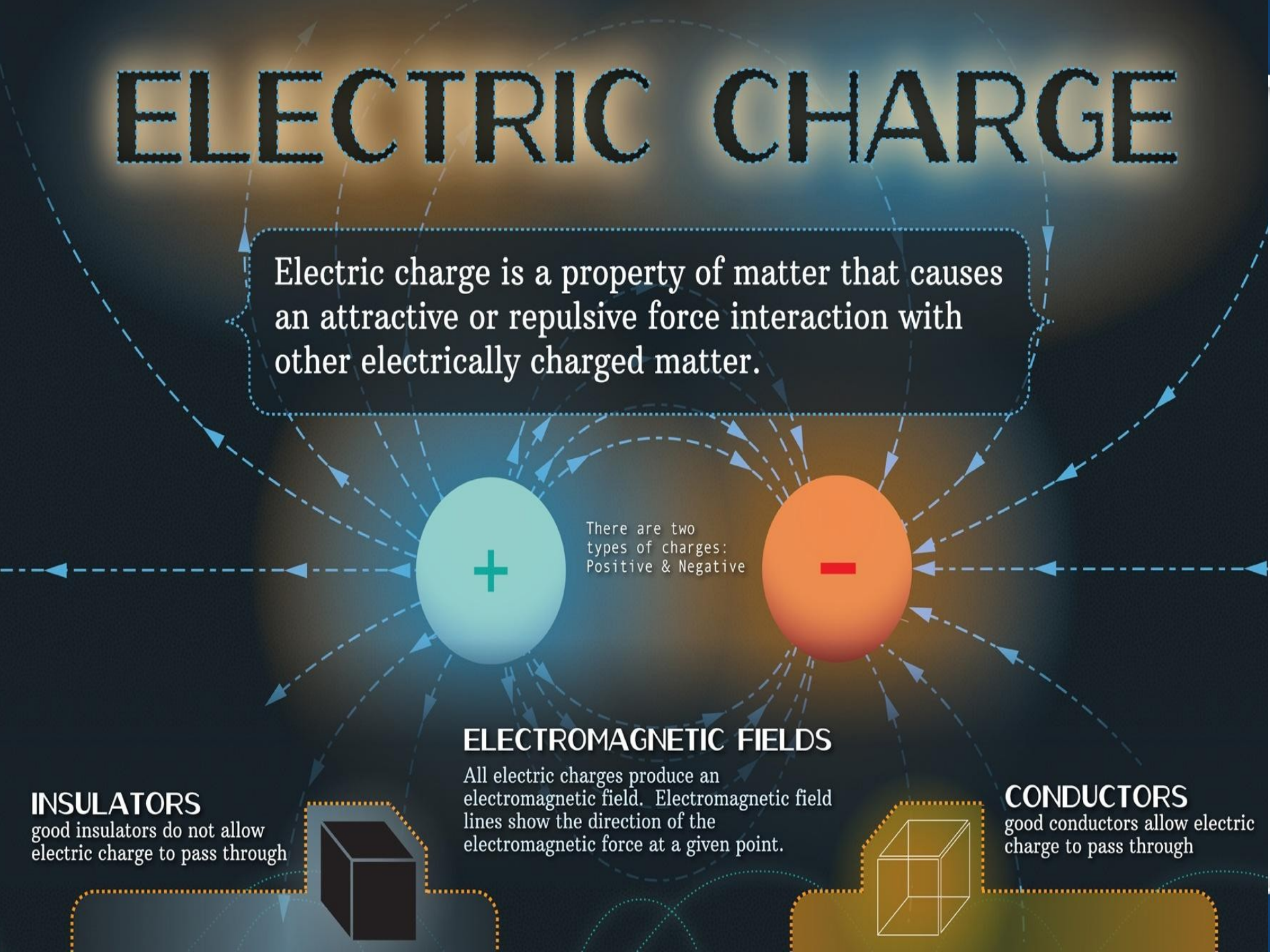


(Unit 6)

fppt.com

ELECTRIC CHARGE

Electric charge is a property of matter that causes an attractive or repulsive force interaction with other electrically charged matter.



ELECTROMAGNETIC FIELDS

All electric charges produce an electromagnetic field. Electromagnetic field lines show the direction of the electromagnetic force at a given point.

INSULATORS

good insulators do not allow electric charge to pass through

CONDUCTORS

good conductors allow electric charge to pass through

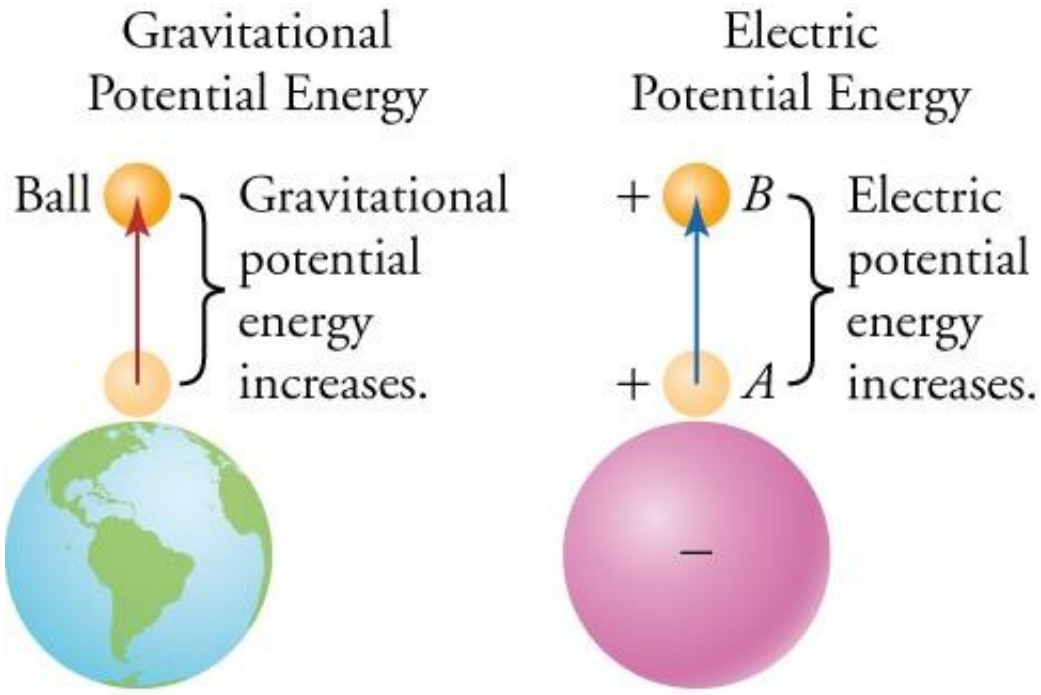
Gravity vs. Electromagnetic Force

Gravity Force

- Attracts
- inverse square law
- surround objects
- cannot be shielded
- incredibly weaker

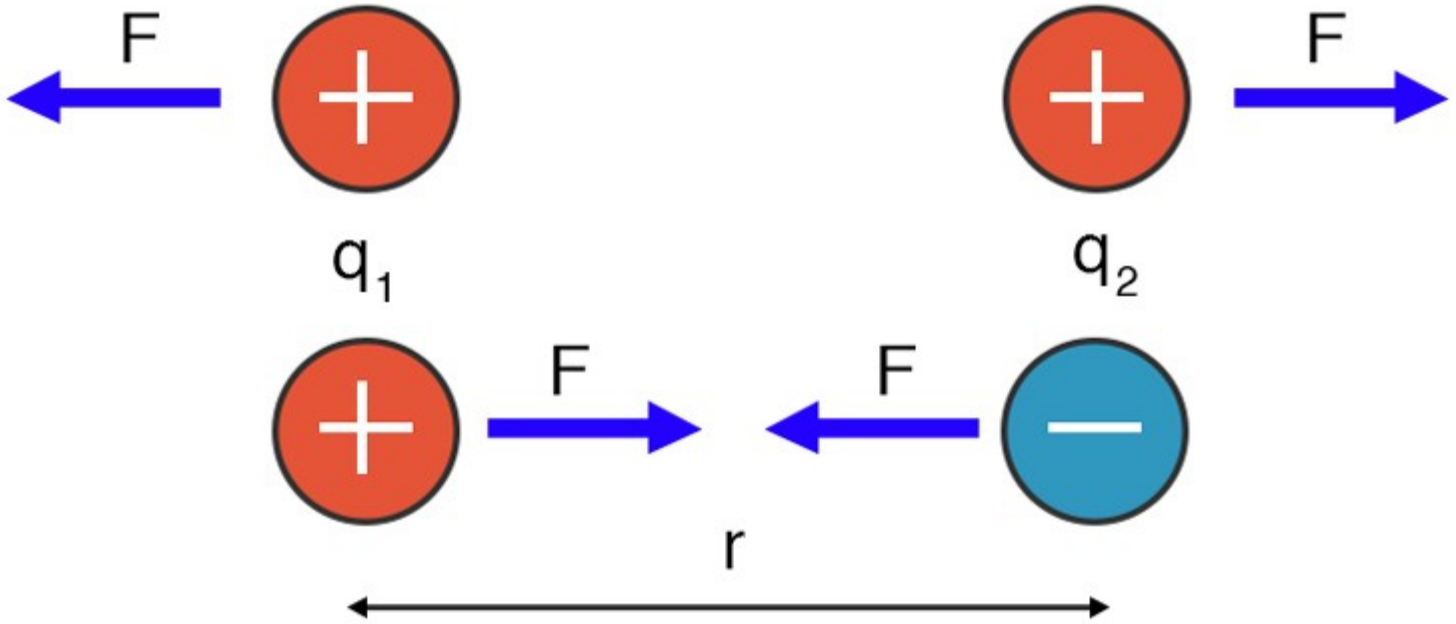
Electromagnetic

- attracts and repels
- inverse square law
- surround objects
- can be shielded
- enormously stronger



fppt.com

Coulomb's Law



$$F = k \frac{q_1 \cdot q_2}{r^2}$$

fppt.com

Review on Coulomb's Law and the electric field definition



- Coulomb's Law: the force between two point charges $\vec{\mathbf{F}}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}_{12}$

$k_e = 8.987\,6 \times 10^9\ \mathrm{N \cdot m^2 / C^2} \quad \varepsilon_0 = 8.854\,2 \times 10^{-12}\ \mathrm{C^2 / N \cdot m^2}$

- The electric field is defined as $\vec{\mathbf{E}} \equiv \frac{\vec{\mathbf{F}}}{q_{test}}$

- The force a charge experiences in an electric filed $\vec{\mathbf{F}} = q\vec{\mathbf{E}}$

fppt.com

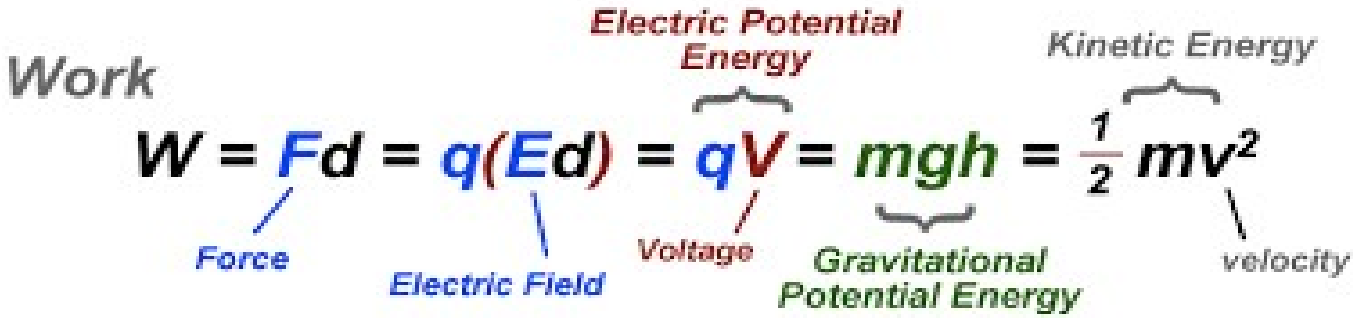
A particle with charge 2-μC is placed at the origin, an identical particle, with the same charge, is placed 2 m from the origin on the x axis, and a third identical particle, with the same charge, is placed 2 m from the origin on the y axis. The magnitude of the force on the particle at the origin is:

A. 9.0×10^{-3} N

B. 6.4×10^{-3} N

C. 1.3×10^{-2} N

D. 1.8×10^{-2} N

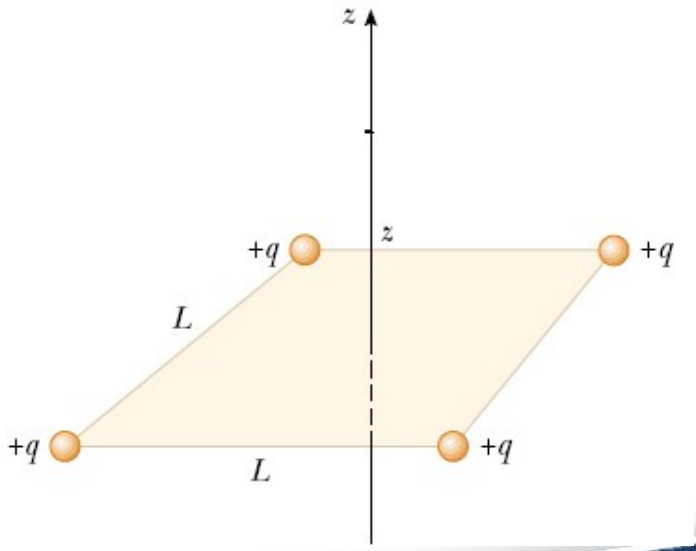


fppt.com

Four identical charges ……

Four identical charges, each having a charge of +, are fixed at the corners of a square of side L= m.

- Find the electric field at a point P that lies at a distance Z = 2m along the line perpendicular to the plane of the square and passing through the center of the square .(Fig. below) (3pts.)
- Find the net electric force on a fifth point charge +, at a point P that lies at Z= 2m above the center of the square due to the other four charges. (2pts.)
- Calculate the potential energy due to the four charge's distribution located on the square (2pt) (use: K = 9 x10^9 Nm2/ C2)



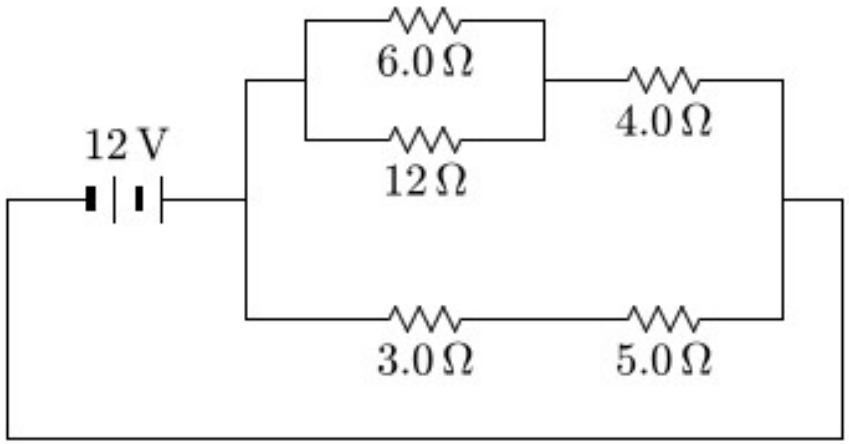
fppt.com

Ohm's Law

If identical resistors of 8 are connected in parallel combination, their equivalent resistance is 2 . The number of resistors in the circuit are _____

The current in the 5.0-Ω resistor in the circuit shown is:

A. 0.42 A
B. 0.67 A
C. 1.5 A
D. 2.4 A

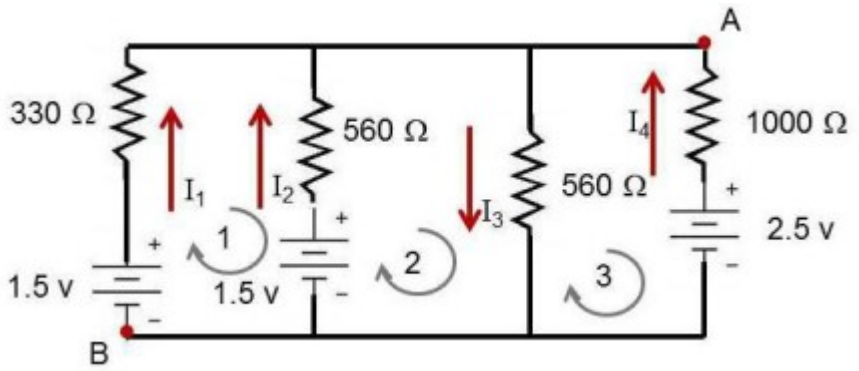


fppt.com

Kirchhoff's Law

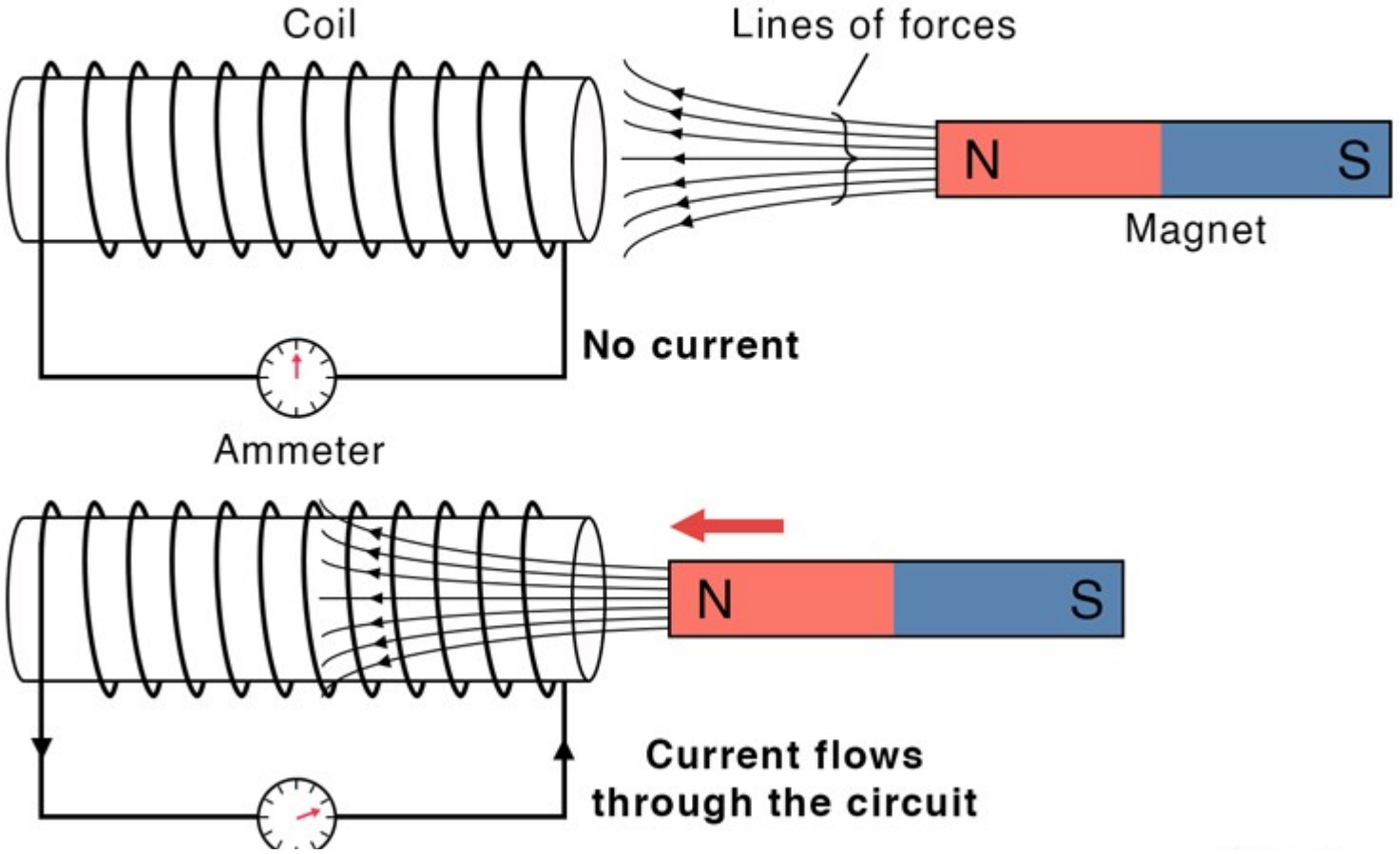
In the circuit shown below, use Kirchhoff's Law and find: (6 pts)

- The currents in each resistors.
- The voltage drops across the resistors
- The potential difference between points A and B



fppt.com

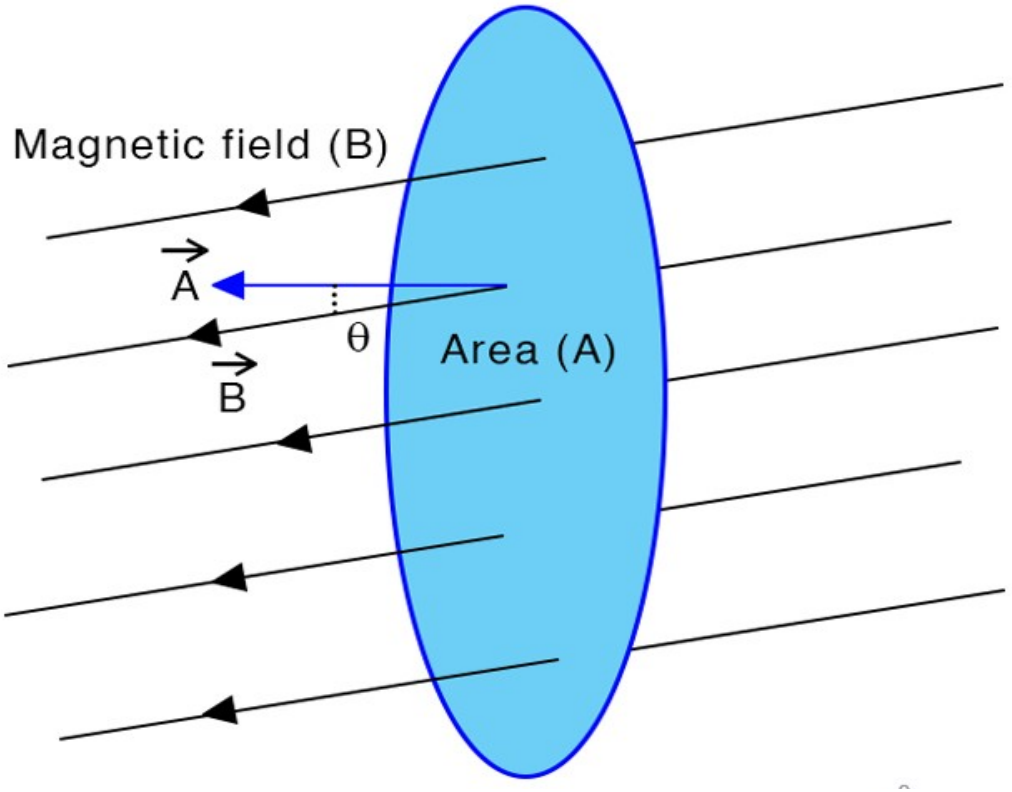
Electromagnetic Induction



fppt.com

Magnetic Flux Equation

Flux = ϕ = BA cos θ



fppt.com

Maxwell's Equations

Differential form

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$$

Maxwell's Equations

Integral form

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\varepsilon_0}$$

$$\oint \vec{E} \cdot d\vec{l} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{a}$$

$$\oint \vec{B} \cdot d\vec{a} = 0$$

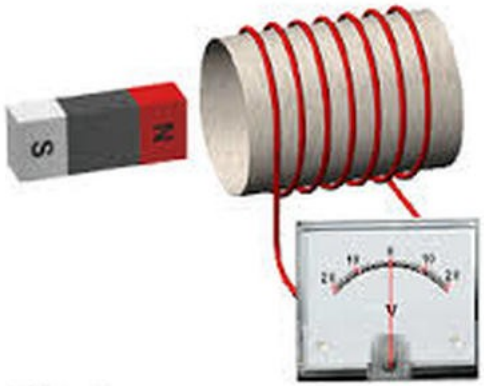
$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \int \frac{\partial \vec{E}}{\partial t}$$

fppt.com

Faraday's Law:

When the external magnetic flux Φ_B through a closed conducting loop with one turn *changes*, the emf induced in the closed loop is:

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$



(for a loop with N turns: $\mathcal{E} = -N\frac{d\Phi_B}{dt}$)

Note that Φ_B changes if:

$$\mathcal{E} = -\frac{d}{dt}(BA\cos\theta)$$

1) ***B*** changes
2) the <u>area</u> of the circuit changes (***dA***)
3) the <u>orientation</u> of the circuit changes (***B*·*dA***)

fppt.com

LENZ'S LAW

An induced Current always flows in a direction such that it opposes the change which produced it.

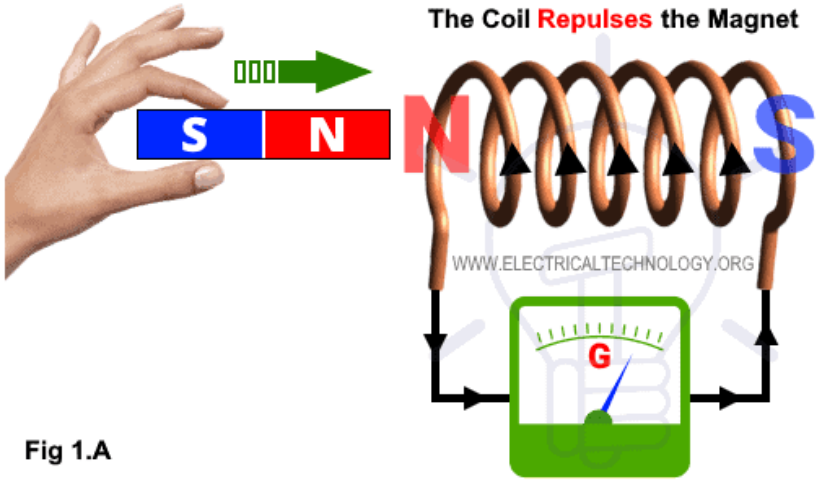


Fig 1.A

When the "N" Pole of the magnet is moved towards the coil, end of the coil becomes "N" Pole.

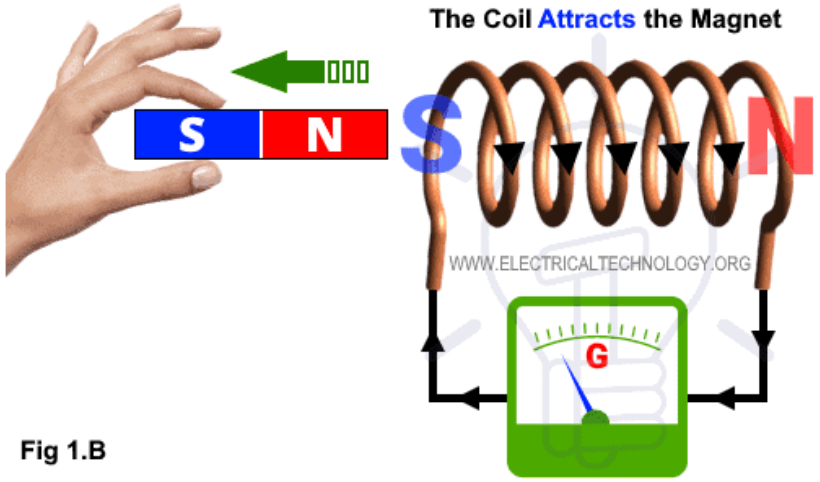


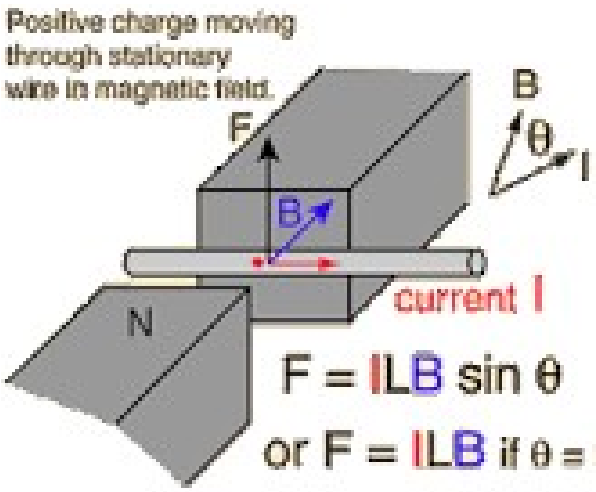
Fig 1.B

When the "N" Poles of the magnet is moved away from the coil, end of the coil becomes "S" Pole.

$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

fppt.com

How much force does a wire feel?



This relationship arises from the basic magnetic force:

$$F = qvB \sin\theta$$

which for a charge q traveling length L in a wire can be written

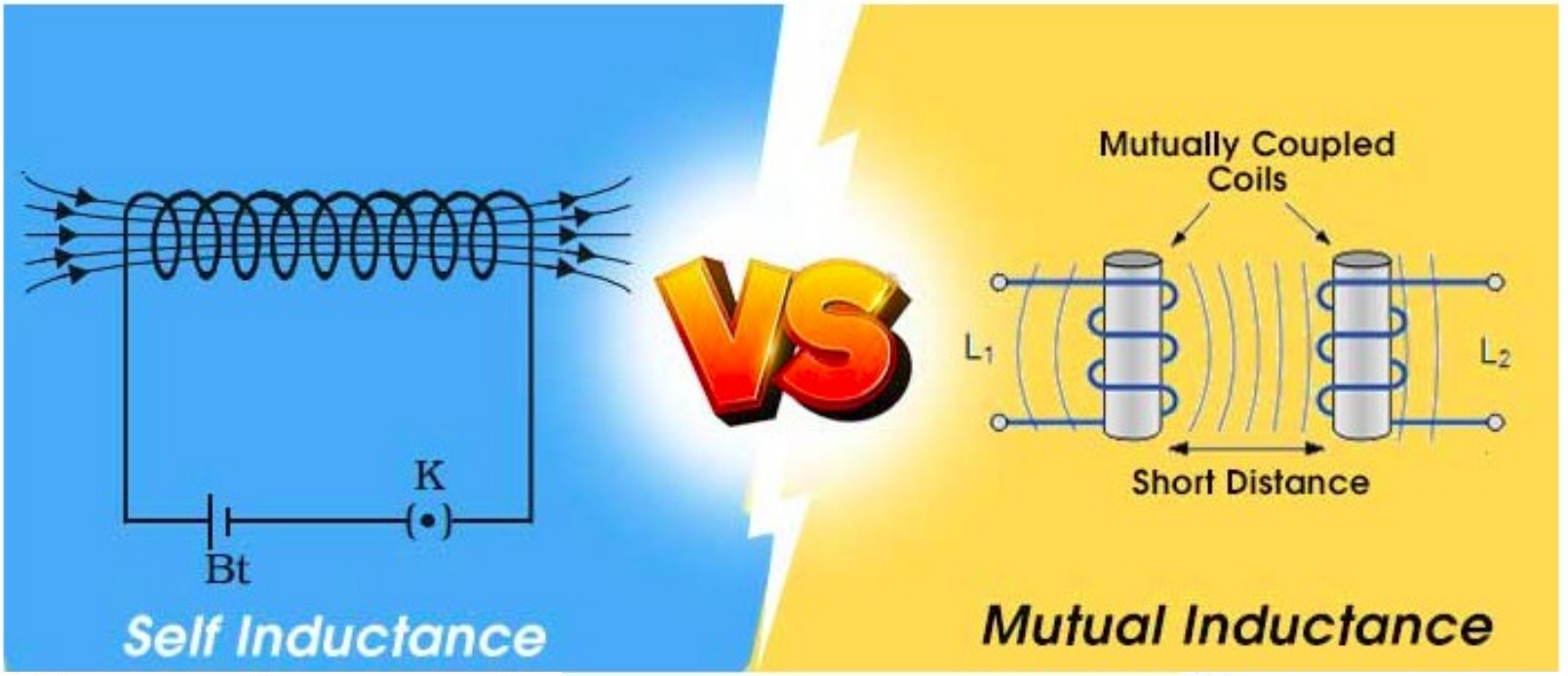
$$F = q\frac{L}{t} B \sin\theta$$

$$F = \frac{q}{t} LB \sin\theta$$

$$F = ILB \sin\theta$$

At one instant an electron ($q = 1.6 \times 10^{-19}$) is moving in the XY-plane and the components of its velocity is $v_x = 5 \times 10^5$ m/s & $v_y = 3 \times 10^5$ m/s. If magnetic field of 0.8 T is in +X-direction, then the magnitude of magnetic force is _____ N.

fppt.com



$$\mathscr{E} = -N\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}.$$

$$L = \frac{N\Phi_B}{I}.$$

$$\mathscr{E}_2 = -M\frac{dI_1}{dt}.$$

$$M_{21} = \frac{N_2\Phi_{21}}{I_1}.$$

- **Energy density stored in magnetic field:**

$$u = \text{energy density} = \frac{1}{2}\frac{B^2}{\mu_0}.$$

fppt.com

Thank you

fppt.com