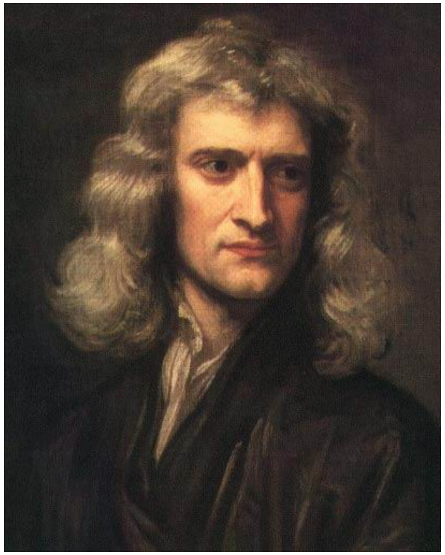
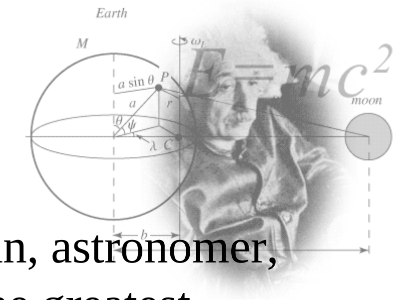
# PHYSICISTS TIME-LINE

| Classical Period 500 BC | Middle Ages 400 AD | Renaissance Ages 1300 | Classical Physics 1700 -1900 EM | Thermo- |
|---|---|---|---|---|
| Aristotle (c. 300 BC) | Al-Fazari (735-806) | Copernicus (1473-1543) | Franklin (1706 – 1790) | Carnot (1796-1832) |
| Ptolomy (c. 200 AD) | Al-khwarizmi (850-926) | Kepler (1571-1630) | Coulomb (1736 – 1806) | Kelvin (1824 – 907) |
| | Ibn Sina, (965-1039) | Galileo (1564-1642) | Faraday (1791 – 1867) | Boltzmann (1844 -1906) |
| | Ibn Al-Haitham (980-1037) | Newton (1642-1727) | Maxwell (1831 – 1879) | |

Modern Physics 1900 - PRESENT





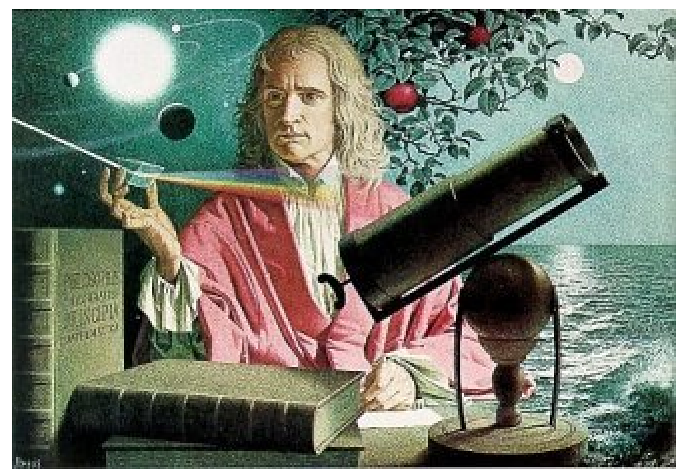

# Isaac Newton (1643 –1727)

Newton was an English physicist, mathematician, astronomer, and natural philosopher, regarded by many as the greatest person in the history of science.

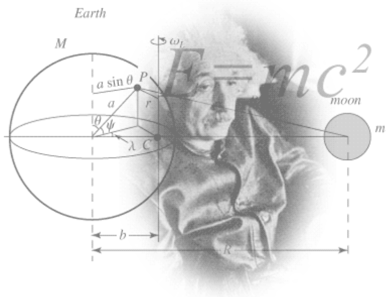
He was born at Woolsthrope in the county of Lincolnshire east of England. In **1661,** he admitted to Trinity Collage in Cambridge.

In his book ***Principia*** , published in **1687**, he described *the universal gravitation* and *the three laws of motion*, which put down the foundation for classical mechanics.

By demonstrating consistency between Kepler's laws of planetary motion and the motion of objects on Earth, *he was the first to unify the heavean and the earth by showing that both systems are governed by the same set of natural laws*.



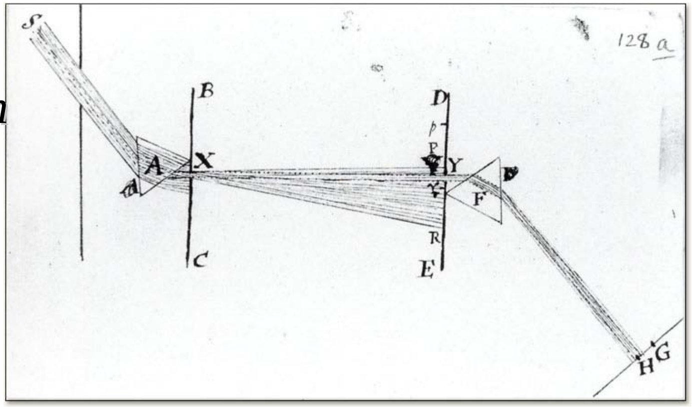
## CONTRIBUTIONS :




### 1- Optics:

- In 1660s, people thought that color was a mixture of light and darkness, and that prisms *colored* light.

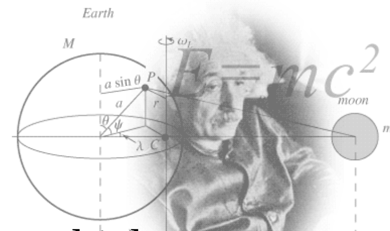
- From **1670** to **1672**, Newton investigated the *refraction of light*, demonstrating that a ***prism*** could decompose white light into a spectrum of colors, and that a lens and a second prism could recompose the multicolored spectrum into white light.




- From this work he concluded that any *refracting telescope* would suffer from the dispersion of light into colours, so he invented a ***reflecting telescope*** (today known as a Newtonian telescope) to bypass that problem.

- Newton argued that light is composed of particles, extremely fine ***corpuscles***. But he had to associate them with waves to explain the diffraction of light. Later physicists instead favoured a purely wavelike explanation of light. Today's quantum mechanics restores the idea of "wave-particle duality".

# 2- Mechanics



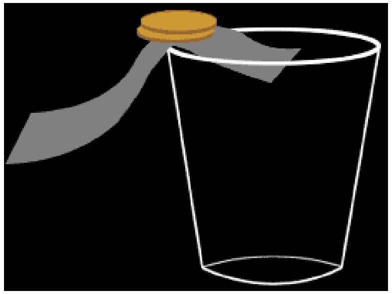

## ❑ NEWTON'S LAWS OF MOTION:

- In 1687, Isaac Newton laid down ***three fundamental laws of motion***, which are:

**1st .** ***Every body continues in its state of rest, or of uniform motion in a straight line, unless it is forced to change that state by forces impressed upon it.***

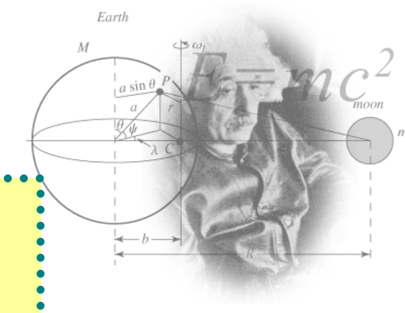
- Newton's First law describes the ***inertia*** in more general form.

**WHAT IS INERTIA?** *It the property of matter to resist changes in motion.*



**This means that:** in the absence of applied forces, matter simply persists in its current velocity state-forever

- On the surface of the Earth the ***inertia*** is often masked by the effects of ***friction*** which brings moving objects to rest relatively quickly.
- Non-accelerated reference frames (e.g. those considered at 'rest' or moving with constant velocity in a straight line) are called ***inertial reference frames***
- If we can neglect the effect of the earth’s rotations, a frame of reference fixed in *the earth is an inertial reference frame*




# 2nd .

***The change of motion is proportional to the net force impressed and is made in the direction of that force.***

- In the SI system, Newton's 2nd law can be expressed in the familiar form :

$$\vec{F} = \frac{d\vec{p}}{dt} = \frac{d}{dt}\left(m\vec{v}\right) = m\vec{a}$$

- **Mass** is a quantitative measure of how hard it is to accelerate the object. I.e. *it measures the **inertia*** . That is why it is known as the ***Inertial Mass***.

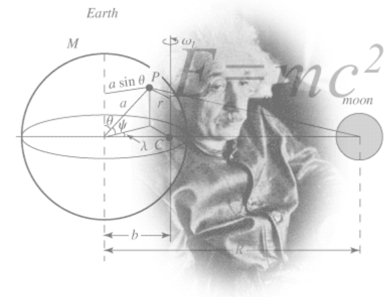
- **Force** is required to accelerate an object. I.e. *to change the **magnitude** or **direction** of its velocity*

**Forces are Unbalanced** $F_{net} \neq 0$

**There is an acceleration** $a = F_{net} / m$

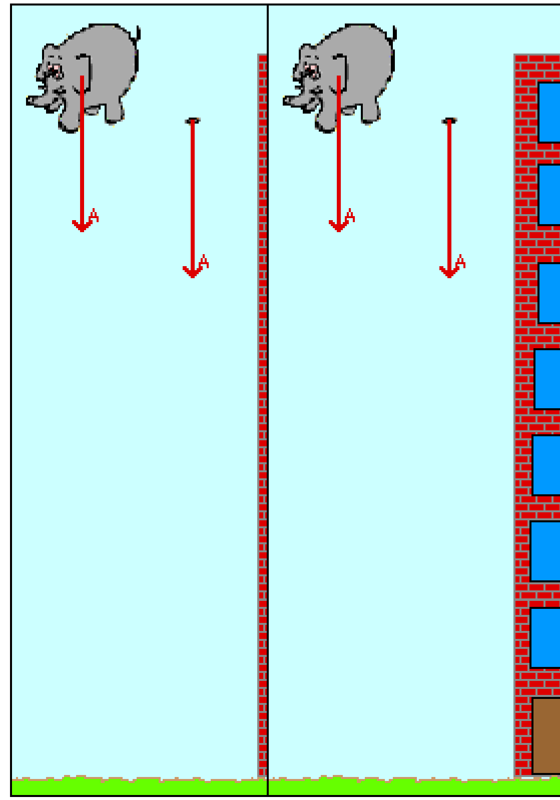
**The acceleration depends directly upon the "net force"**

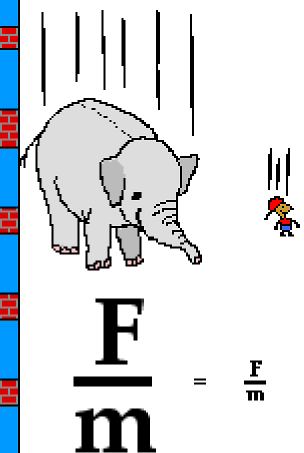
**The acceleration depends inversely upon the object's mass.**




## Free Fall Motion:

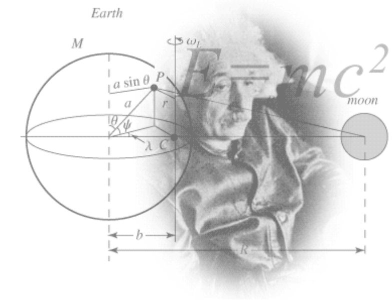
*all objects free fall at the same rate regardless of their mass*






## Falling with Air Resistance

*Heavier objects free fall faster*

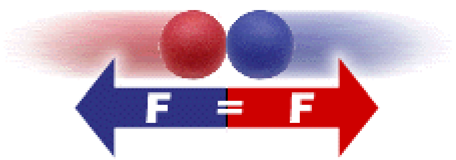



# 3rd .

***To every action there is always an equal and opposite reaction.***

Or; ***two interacting bodies exert equal and opposite forces upon one another***.

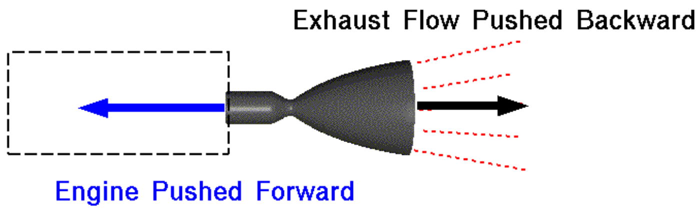
$$F_1 = -F_2$$




Which is equivalent to:

$$\frac{d}{dt}(P_1 + P_2) = 0 \quad \Rightarrow \quad P_1 + P_2 = cons.$$

**Rocket Engine Thrust**

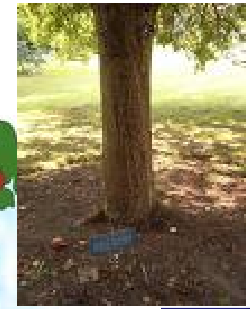


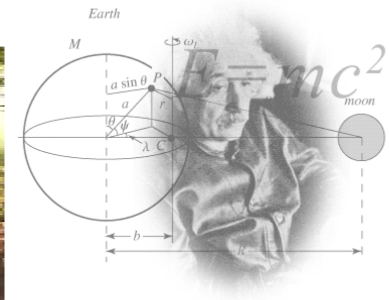

*For every action, there is an equal and opposite re-action.*

In other words, Newton's 3rd law implies that:

***the total momentum of two mutually interacting bodies is a constant.***

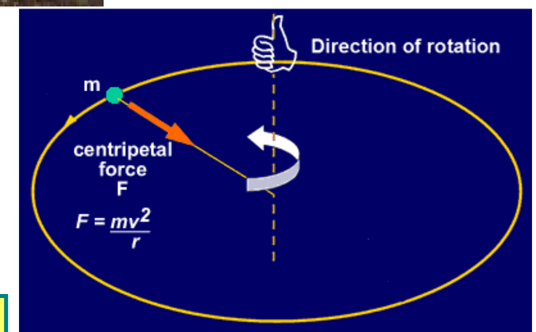
## ❒ NEWTON'S LAW OF GRAVITATION:






❍ During his study of the motions of the planets and of the moon, Newton discovered the fundamental charter of the gravitational attraction between any two bodies.

### ❍ Circular Motion




Builds upon the idea that **any curved motion** is due to some **FORCE** that provides the ***Centripetal acceleration*** , and for **the** *Uniform Circular Motion* this acceleration is**:** $a = v^2 / R$

Then, ***the Centripetal Force*** must be given by something like; $F = m\, v^2 / R$

Where the Force is toward the center, perpendicular to direction of motion.

***Kepler's Third Law*** Provides a key;

$$T^2 = k\, R^3$$

- But, period = $T = 2\pi\, R / v$ ⇨ $4\pi^2\, R^2 / v^2 = k\, R^3$
- **Therefore,** $v^2 = 4\pi^2 / k\, R$
- **Substituting this form for $v^2$ into Newton's 2nd Law gives:**

$$F = \frac{4\pi^2}{k}\frac{m}{R^2} \qquad (1)$$

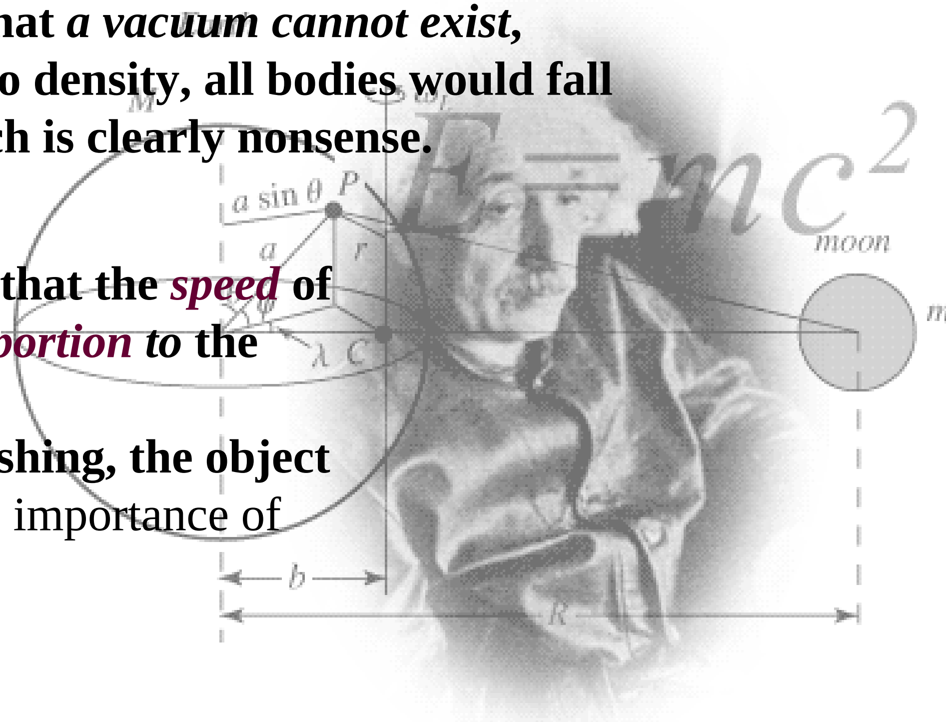
**Aristotle made two quantitative statements about how things fall (*natural motion*):**

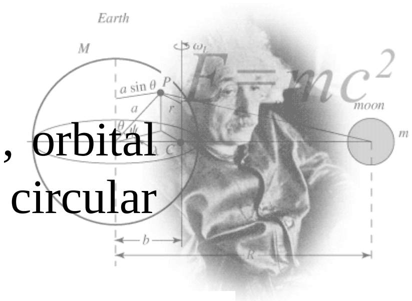
**1- Heavier things fall faster, the speed being proportional to the weight.**

**2- The speed of fall of a given object depends *inversely* on the density of the medium it is falling through.**

**He didn't check out these rules in any serious way. From the second assertion above, he concluded that *a vacuum cannot exist*, because if it did, since it has zero density, all bodies would fall through it at infinite speed which is clearly nonsense.**

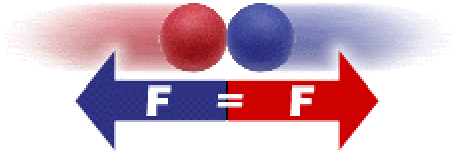
**For *violent motion*, Aristotle stated that the *speed* of the moving object was *in direct proportion to* the applied *force*.**
**This means first that if you stop pushing, the object stops moving (** He did not realize the importance of friction in these situations ).






This is the **force** that the Sun must exert on a planet of mass *m* , orbital radius R, in order that the planet obeys Kepler's Laws in the circular motion.

Consider Newton's 3rd Law, there must be an equal force also exert on the Sun by the planet, but in the opposite direction.




Therefore, Kepler's constant *k* is not really a universal constant!
It must depend on the mass of the Sun *M* !!

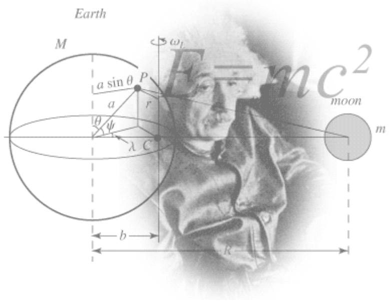
The only form of the law that is symmetric in the two masses is:

$$F = GM\frac{m}{R^2} \qquad \textbf{(2)}$$

Where *M* and *m* are the mass of the sun and mass of the planet, *R* is the distance between them and *G* is a universal constant. The numerical value of *G* (in SI units ) is

***G* = 6.67×10-11 *N.m2/kg2***

from (1) &(2) one can find that Kepler's constant k is equal to;

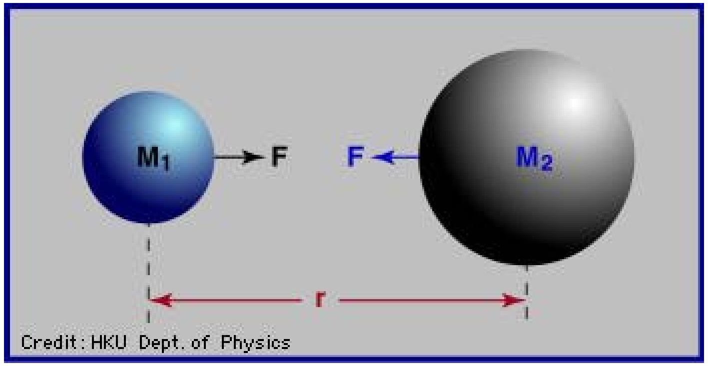


$$k = \frac{4\pi^2}{GM}$$

- Newton, then, generated this result for all bodies in his famous **law of gravitation** which may be stated as follows:

***Every particle of matter in the universe attracts every other particle with force (Fg) that is directly proportional to the product of the masses (m1, m2) of the particles and inversely proportional to the square of the distance between them (r).***

$$F_g = \frac{Gm_1m_2}{r^2}$$




- This law tells us that if **the distance *r* is doubled**, the **force decreases by a factor of four**, and so on.

- Even when the masses of the particles are different, the two interaction forces have equal magnitude.

# PHYSICISTS TIME-LINE

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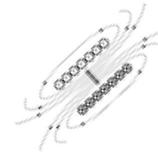
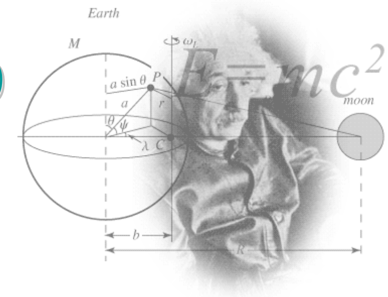
# 4- PHYSICISTS BETWEEN 1700-1900

## FIRST: ELECTROMAGNETISM






### William Gilbert
### (1544 –1603)

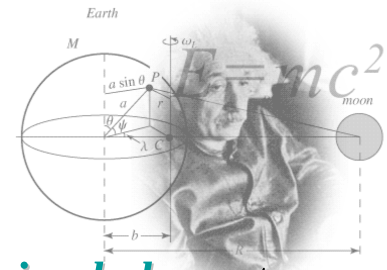
The British scientist William Gilbert proposed, in his *De Magnete* (1600), that electricity and magnetism, while both capable of causing attraction and repulsion of objects, were different effects.

Mariners had noticed that lightning strikes had the ability to disturb a compass needle, but the link between lightning and electricity was not confirmed until Benjamin Franklin's proposed experiments in 1752

### Benjamin Franklin
### (1706 –1790)

Franklin was regarded as the First Great American Scientist. He performed extensive research on the relationship between lightning and static electricity. This relationship was proved by his famous kite-flying experiment, in which he extracted electrical sparks from a cloud.

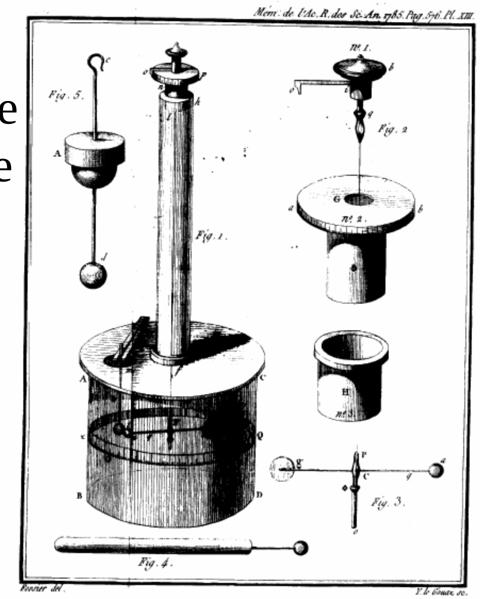
Franklin's electrical experiments led him to invent the ***lightning rod*****.** He was the first to label electric charges as positive and negative and the first to discover the principle of conservation of charge.




# Charles de Coulomb
## (1736 –1806)

Coulomb was a French physicist who used a ***torsion balance*** to establish the electric charge.

In his famous inverse-square law, ***Coulomb's law,*** he indicated the magnitude and direction of ***electrostatic force*** that one small, stationary, electrically charged object exerts on another.

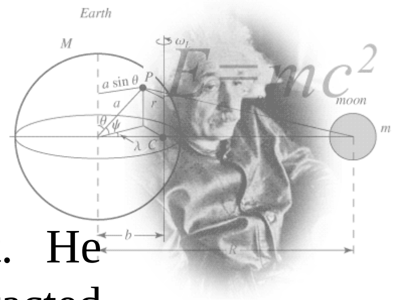



- ***Coulomb's law*** may be stated as follows:

> ***The magnitude of the electrostatic force between two point charges is directly proportional to the magnitudes of each charge and inversely proportional to the square of the distance between the charges***

- Coulomb explained the laws of attraction and repulsion between electric charges and magnetic poles, although he did not find any relationship between the two phenomena. He thought that the attraction and repulsion were due to different kinds of fluids.
- The unit of the electric charge (*Coulomb*) is named after him.

## Luigi Galvani (1737–1798)



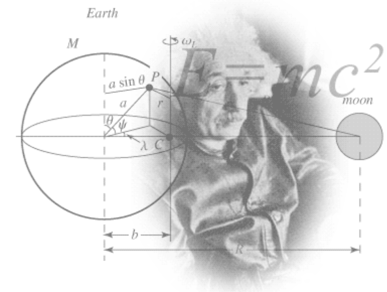

He was an Italian physician and physicist. He discovered that the muscles of dead frogs contracted when struck by a spark. He discovered that muscle and nerve cells produce electricity.

Galvani did not recognize electricity as separable from biology. He believed that the animal electricity came from the muscle.

## Alessandro Volta (1745-1827)

Volta was an Italian physicist associated to Galvani. In opposition to Galvani, Volta reasoned that the animal electricity was a physical phenomenon.

- In 1800, he developed the so-called ***voltaic pile***, the first kind of *the electric battery*, which produced a steady electric current.
- Volta had determined that the most effective pair of dissimilar metals to produce electricity was **zinc** and **silver**.
- In 1881 an important electrical unit, the ***volt***, was named in his honor.




## Romagnosi & Ørsted
## (1761 –1835) & (1777 –1851)

One of the first to discover and publish a link between man-made electric current and magnetism was ***Romagnosi***, an Italian physicist, who in **1802** noticed that connecting a wire across a Voltaic pile (battery) deflected a nearby compass needle.

However, the effect did not become widely known until **1820**, when ***Ørsted***, a Danish physicist, performed a similar experiment.

## André-Marie Ampère
## (1775–1836)

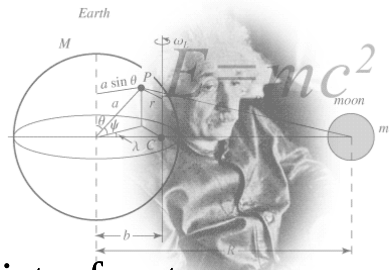
***Ampère*** was a French physicist who is generally credited as one of the main discoverers of ***electromagnetism***.

He was influenced by Ørsted work, so he produced, only a week later, a ***theory of electromagnetism*** that set the subject on a mathematical foundation.

Ampère's law relates the magnetic field ***H*** to its source, the current density ***J*** as;

$$\nabla \times \vec{H} = \vec{J}$$

The SI unit of electric current, the ***ampere***, is named after him.




## Carl Friedrich Gauss
## (1777 –1855)

Gauss was a German mathematician and scientist of extreme genius who contributed significantly to many fields.

His foamous Law, ***Gauss's law*** , gives the relation between the ***electric flux*** flowing out of a **closed surface** and, respectively, the ***electric charge*** or mass enclosed in the surface.
In differential form, the equation becomes:

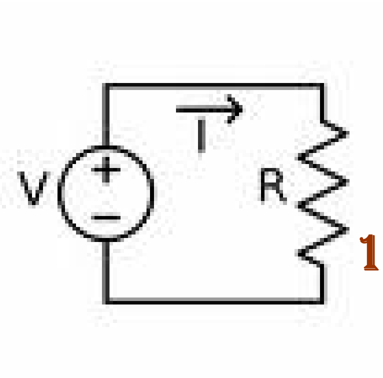
$$\nabla . \varepsilon \vec{E} = \rho_{free}$$

where $\varepsilon$ is the *electric permittivity* and $\rho_{\mathbf{free}}$ is the *free* electric *charge density*.

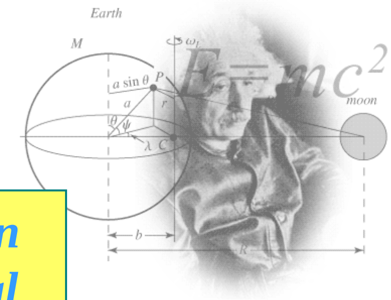
## George Simon Ohm
## (1789 - 1854)

Ohm was a German physicist started his research with the recently invented electrochemical cell, invented by Volta.

Using equipments of his own creation, Ohm determined the relationship between ***applied voltage*** and ***current*** passing through simple electrical circuits containing wires of different sizes.




Ohm found out that:




**1-** ***the current passing through a conductor between two points is directly proportional to the potential difference across the two points, and inversely proportional to the resistance between them.***

**2-** ***the current that flows through a wire is proportional to its cross sectional area and inversely proportional to its length.***

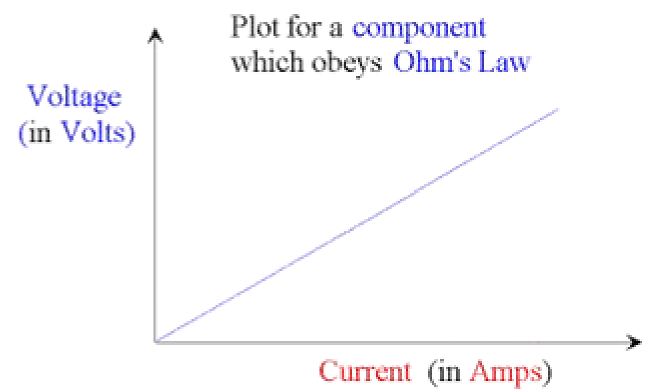
The common form of **OHM'S LAW** is:

$$V = R.I$$

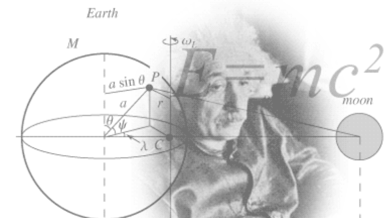
Physicists often use the continuum form of Ohm's Law:

$$E = \rho.J$$

where ***J*** is the current density (current per unit area), $\rho$ is the resistivity and ***E*** is the electric field.

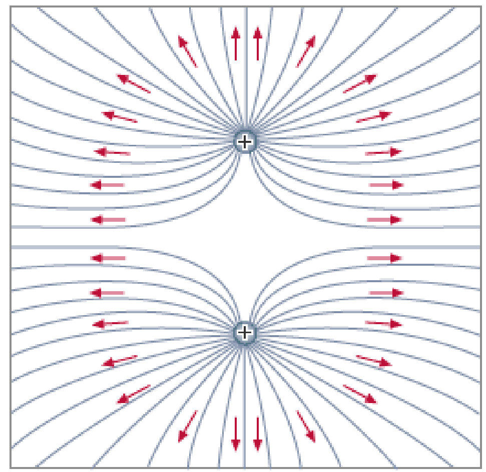


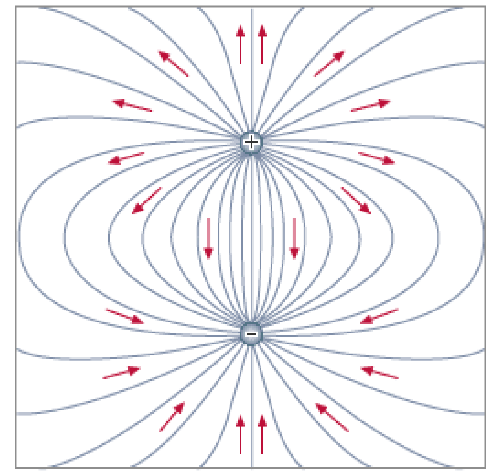
# Michael Faraday
(1791–1867)




Faraday was an English chemist and physicist who contributed significantly to the fields of electromagnetism.

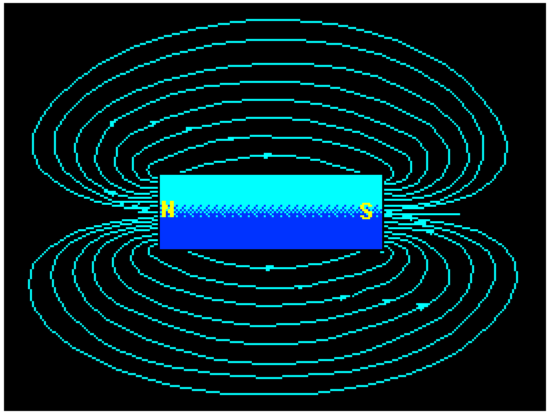
The SI unit of capacitance, the ***farad***, is named after him.





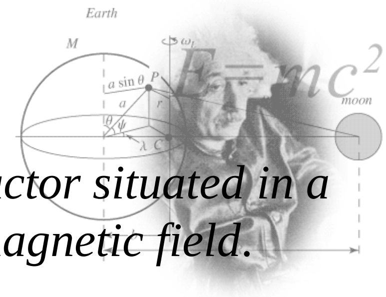
## CONTRIBUTIONS:

### 1- The Concept of Field:




The idea of an 'action-at-a-distance' was held until ***Faraday*** introduced the concept of "***Field*** " or ***Lines of Force***. He studied the magnetic field around a conductor carrying a DC electric current, and according to his model: charge A creates a field in the space, and charge B - placed at some point in space- undergoes a force from the field at that point

## 2- The electromagnetic induction

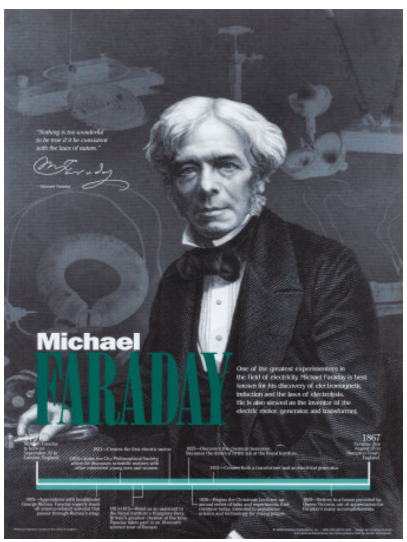



***Electromagnetic induction*** is the *production of voltage across a conductor situated in a changing magnetic field or a conductor moving through a stationary magnetic field*.

Faraday found that the ***electromotive force*** (**emf**) produced around a closed path is proportional to the rate of change of the ***magnetic flux*** through any surface bounded by that path. I.e;

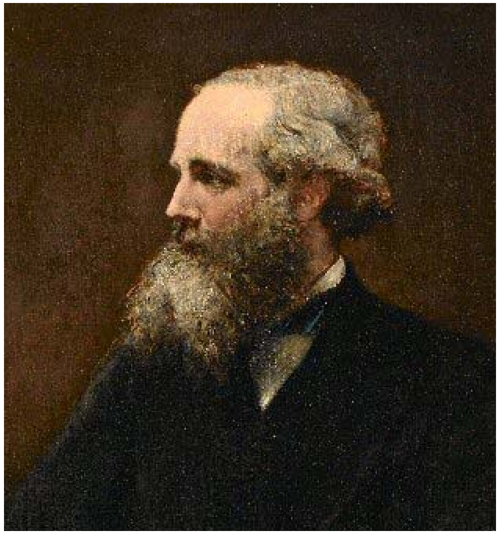
$$emf = -\frac{dB}{dt}$$

where; (*emf*) is the electromotive force in volts and ***B*** is the magnetic flux in webers.



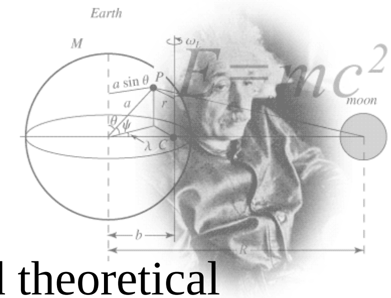

Electromagnetic induction underlies the operation of generators, induction motors, transformers, and most other electrical machines

Faraday established that magnetism could affect rays of light and that there was an underlying relationship between the two phenomena



# James Clerk Maxwell

## (1831 –1879)




Maxwell was a Scottish mathematician and theoretical physicist.

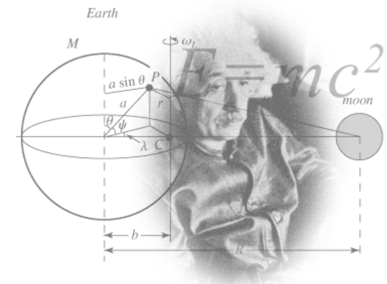
His most significant achievement was formulating a set of equations — called ***Maxwell's equations*** — that for the first time expressed the basic laws of **electricity** and **magnetism** in a unified fashion.

He also developed the ***Maxwell distribution***, a statistical means to describe aspects of the kinetic theory of gases.
He is also known for creating the first true color photograph in 1861

## CONTRIBUTIONS:

## 1- Maxwell's equations:

For the field theory to be really useful it must account for all the known experimental laws of electromagnetism. In **1861** Maxwell succeeded in generating ***a set of four equations*** which *describe the behavior of fields in all circumstances*.




These equations express:

**(i)** how electric charges produce electric fields (***Gauss's law***),

**(ii)** the experimental absence of *magnetic monopoles*.

**(iii)** how changing magnetic fields produce electric fields (***Faraday's law***), and

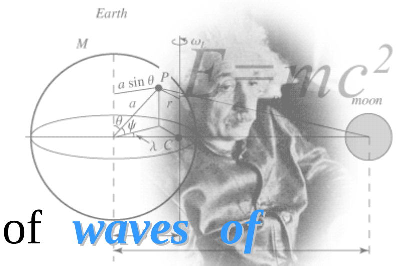
**(iv)** how electric currents and changing electric fields produce magnetic fields (***Ampère's Law***).

$k = \frac{1}{4\pi\varepsilon_0} =$ Coulomb's constant $\qquad c^2 = \frac{1}{\mu_0\varepsilon_0}$

| Name | Differential form | Integral form |
|---|---|---|
| **Gauss's law** | $\nabla \cdot E = \frac{\rho}{\varepsilon_0} = 4\pi k\rho$ | $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$ |
| **Gauss' law for magnetism** | $\nabla \cdot B = 0$ | $\oint \vec{B} \cdot d\vec{A} = 0$ |
| **Faraday's law of induction:** | $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ | $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$ |
| **Ampère's Law (with Maxwell's extension)** | $\nabla \times B = \frac{4\pi k}{c^2} J + \frac{1}{c^2}\frac{\partial E}{\partial t}$ | $\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2}\frac{\partial}{\partial t}\int \vec{E} \cdot d\vec{A}$ |

## 2- Nature of light:

- Maxwell showed that the equations predict the existence of ***waves of oscillating electric and magnetic fields that travel through empty space at a speed*** that could be predicted to be ($c = 1/(\varepsilon_0\mu_0)^{1/2}$). Using the data available at the time, Maxwell obtained a velocity of **310,740,000 m/s**.

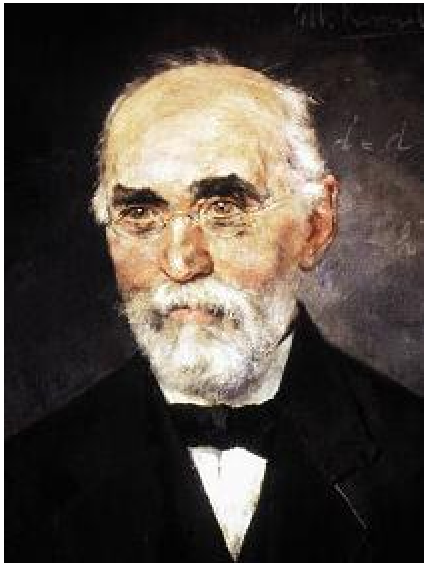


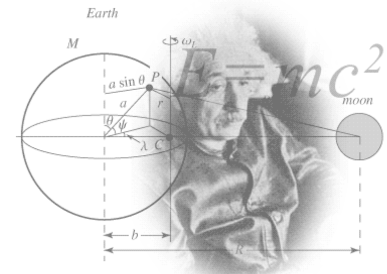

- Maxwell found that the speed of propagation of an electromagnetic field is approximately that of the ***speed of light*** obtained by astronomical measurements. In **1864** he proposed that *the phenomenon of light is therefore an electromagnetic phenomenon .*

- Because charges can oscillate with any frequency, Maxwell concluded that visible light forms only a small part of the entire spectrum of possible electromagnetic radiation.

- **Maxwell quantitative connection between light and electromagnetism is considered one of the great achievements of 19th century physics**

- At that time, Maxwell believed that the propagation of light required a medium for the waves, the ***luminiferous aether*** .






## Hendrik Lorentz
**(1853 - 1928)**

He was a Dutch physicist who shared the 1902 Nobel Prize in Physics with **Pieter Zeeman** for the discovery and explanation of the ***Zeeman effect***.

He is also well-known for his transformations, the ***Lorentz transformations***, which formed the mathematical frame of the theory of *Special relativity*.

## LORENTZ FORCE:

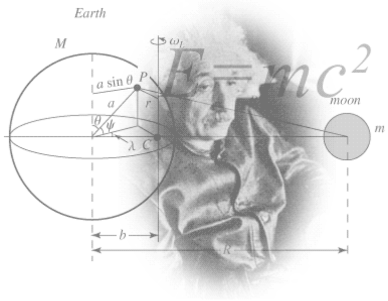
- Whilst the Maxwell equations describe the fields themselves we also need to describe the **forces exerted by these continuous fields** on the discrete charges.

- In **1895** Lorentz provided an equation of motion for charged particles in the electromagnetic field. The Lorentz equation shows that; the force produced by an ***electric field*** is **parallel** to the field and independent of the velocity of the charge;

$$F_E = qE$$

- Whereas ***the magnetic force*** can only defined by a moving charge and is always **perpendicular** to the velocity and field;

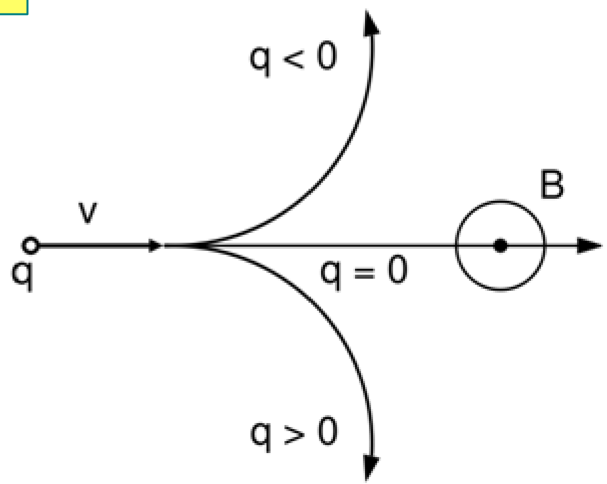
$$F_B = q\, v \times B$$




Combining these two forces gives the ***Lorentz force equation*** (or law) is:

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

Thus a positively charged particle will be accelerated in the ***same*** linear orientation as the **E** field, but will curve **perpendicularly** to the **B** field according to the ***right-hand rule***

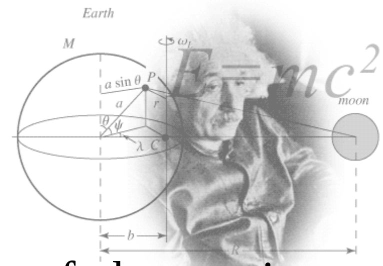



❍ Combining Lorentz's equation with Maxwell's equations gives ***a complete theory of electromagnetism*** within which we can predict future configurations of fields and charges if we know their present pattern.

# PHYSICISTS TIME-LINE

| Classical Period 500 BC | Middle Ages 400 AD | Renaissance Ages 1300 | Classical Physics 1700 -1900 EM | Thermo- | Modern Physics 1900 - PRESENT |
|---|---|---|---|---|---|
| Aristotle (c. 300 BC) | Al-Fazari (735-806) | Copernicus (1473-1543) | Franklin (1706 – 1790) | Carnot (1796-1832) | |
| Ptolomy (c. 200 AD) | Al-khwarizmi (850-926) | Kepler (1571-1630) | Coulomb (1736 – 1806) | Kelvin (1824 – 907) | |
| | Ibn Sina, (965-1039) | Galileo (1564-1642) | Faraday (1791 – 1867) | Boltzmann (1844 -1906) | |
| | Ibn Al-Haitham (980-1037) | Newton (1642-1727) | Maxwell (1831 – 1879) | | |

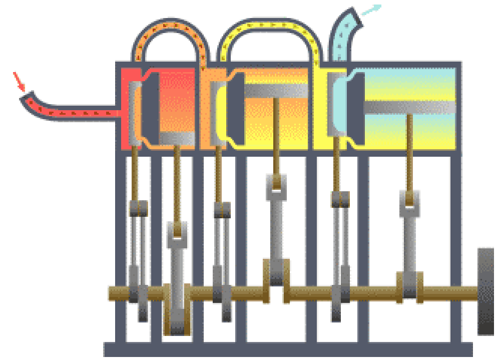
# 4- PHYSICISTS BETWEEN 1700-1900




## SECOND: THERMODYNAMICS

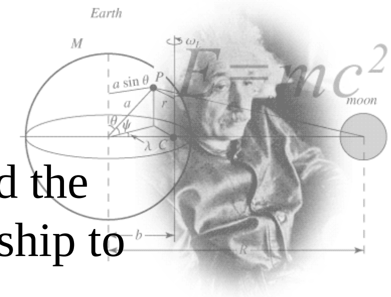
**Thermodynamics** is a branch of physics that studies the effects of changes in ***temperature, pressure***, and ***volume*** on physical systems by analyzing the collective ***motion*** of their particles using the statistics. In essence *thermodynamics studies the movement of energy and how energy instills movement*.

Historically, thermodynamics developed out of need to increase the *efficiency of early steam engines*.

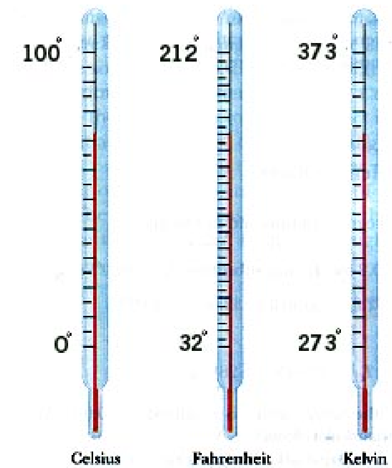


- In **1824** **Sadi Carnot** , the "*father of thermodynamics*", wrote his famous paper: ***Reflections on the Motive Power of Fire***. This paper was the starting point for thermodynamics as a modern science. Carnot defined "***motive power***" to be the expression of the useful effect (***the efficiency***) that a motor is capable to produce.

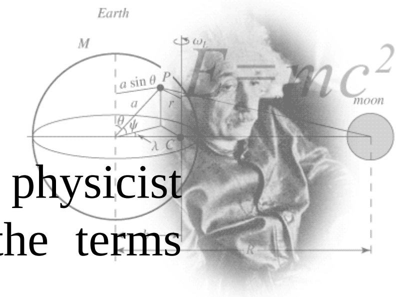
- Carnot introduced us to the first definition of "***work***": *weight lifted through a height*. The relation *of this useful effect* to "work" is at the core of all modern day thermodynamics.




- The English physics **James Joule**, studied the nature of ***heat***. In **1847** he discovered its relationship to ***mechanical work***.
- This led to the theory of ***conservation of energy***, which led to the development of the ***first law of thermodynamics***.
- The SI unit of work, the **joule**, is named after him.




- The name "**thermodynamics**," however, did not arrive until some twenty-five years later when, in **1849**, the British mathematician and physicist **William Thomson** (**Lord Kelvin**) create the term ***thermodynamics*** in a paper on the efficiency of steam engines.
- William Thomson, or **1st Baron Kelvin**, was an outstanding leade in the physical sciences of the 19th century. He is widely known for developing the *Kelvin scale of absolute temperature* measurement.
- The title **Baron Kelvin** **(Lord Kelvin)** was given in honour of his achievements, and named after the River ***Kelvin***, which flowed past his university in Glasgow, Scotland.




❑ In **1850**, the well-known mathematical physicist **Rudolf Clausius** originated and defined the terms ***enthalpy*** and ***entropy*** *as;*

> **ENTHALPY** (*H*): ***the total heat of the system*,**
> **ENTROPY** (*S*): ***the heat lost or turned into waste.***

He stated the ***second law of thermodynamics***.

❑ In **1875**, the Austrian physicist **Ludwig Boltzmann** formulated a precise connection between the ***entropy S*** and molecular motion:

$$S = k \log W$$

Where ***W*** is the number of possible states such motion could occupy, and ***k*** is the Boltzmann's constant.