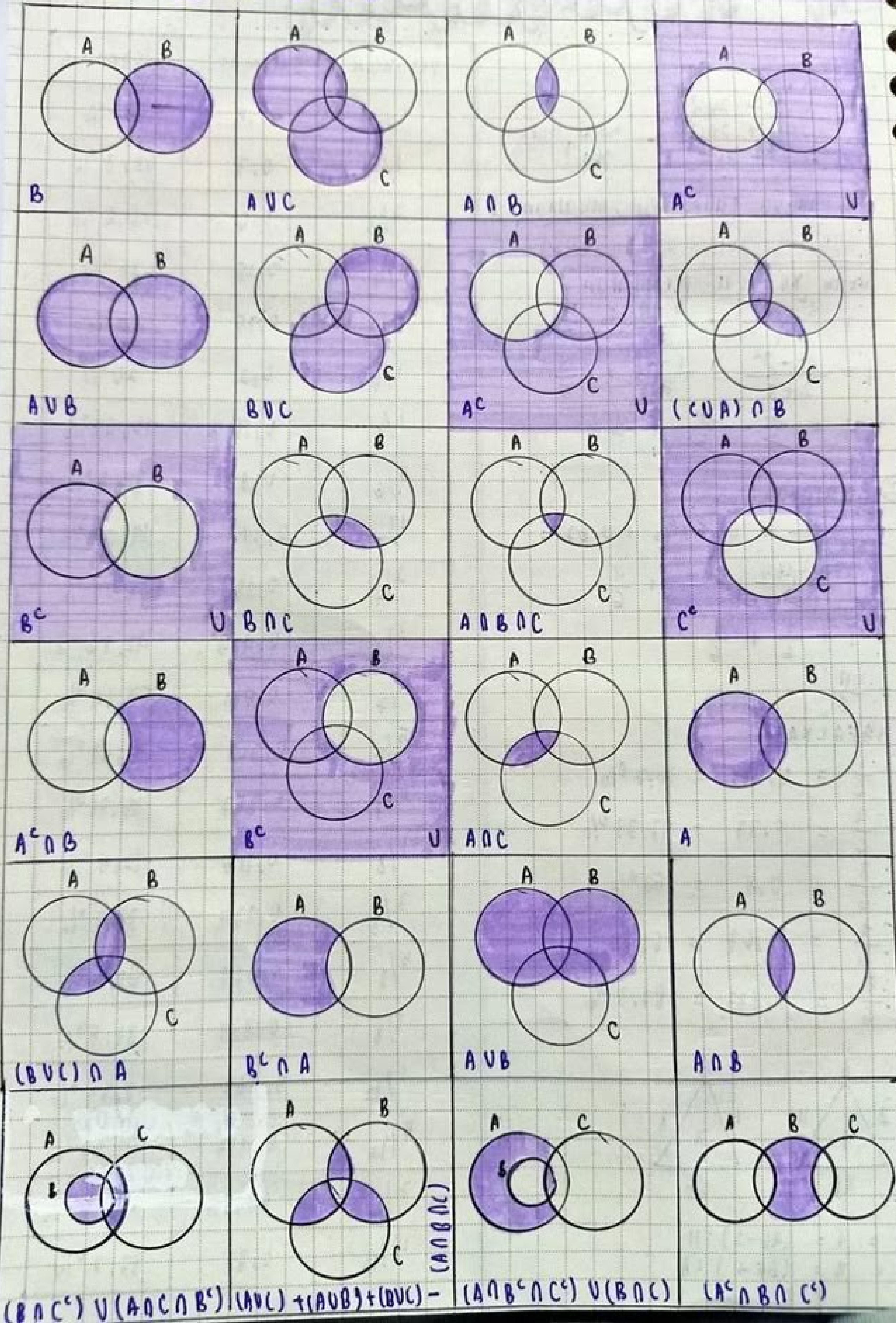
himpunan


A B
B
A B C
$A \cup C$
A B C
$A \cap B$
A B
A^c U
A B
$A \cup B$
A B C
$B \cup C$
A B C
A^c U
A B C
$(C \cup A) \cap B$
A B
B^c U
A B C
$B \cap C$
A B C
$A \cap B \cap C$
A B C
C^c U
A B
$A^c \cap B$
A B C
B^c U
A B C
$A \cap C$
A B
A
A B C
$(B \cup C) \cap A$
A B
$B^c \cap A$
A B C
$A \cup B$
A B
$A \cap B$
A B C
$(B \cap C^c) \cup (A \cap C \cap B^c)$
A B C
$(A \cup C) + (A \cup B) + (B \cup C) - (A \cap B \cap C)$
A B C
$(A \cap B^c \cap C^c) \cup (B \cap C)$
A B C
$(A^c \cap B \cap C^c)$

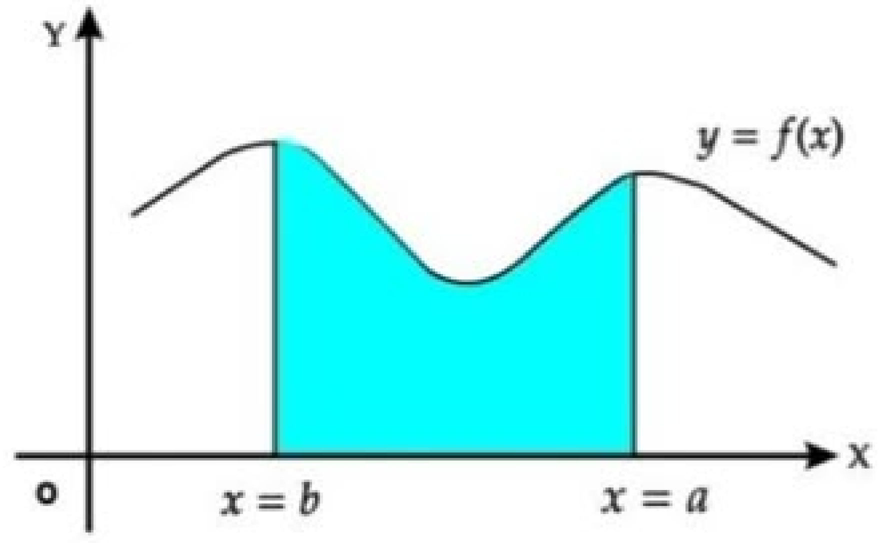
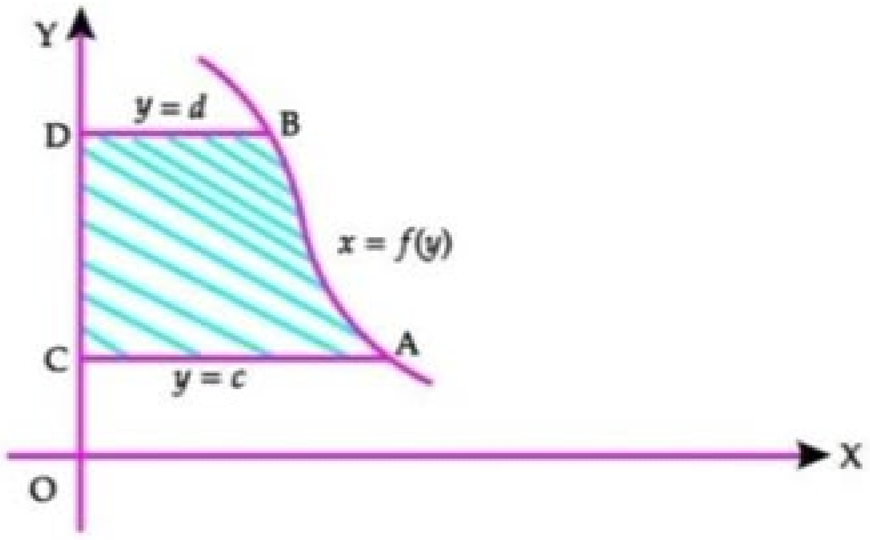
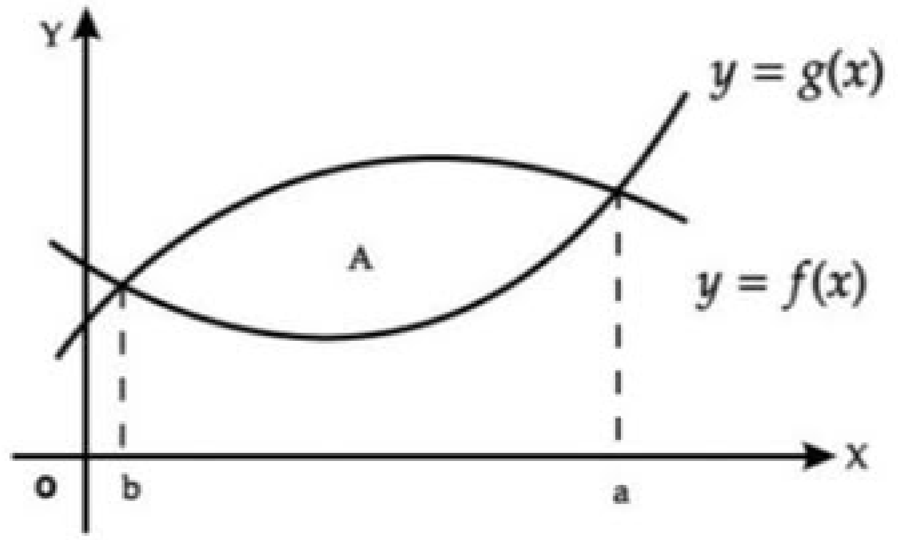
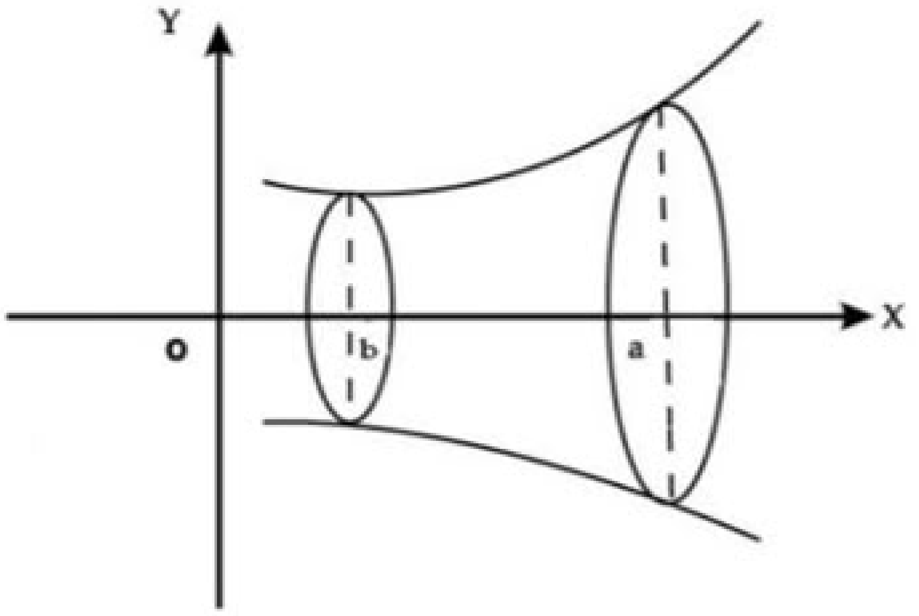
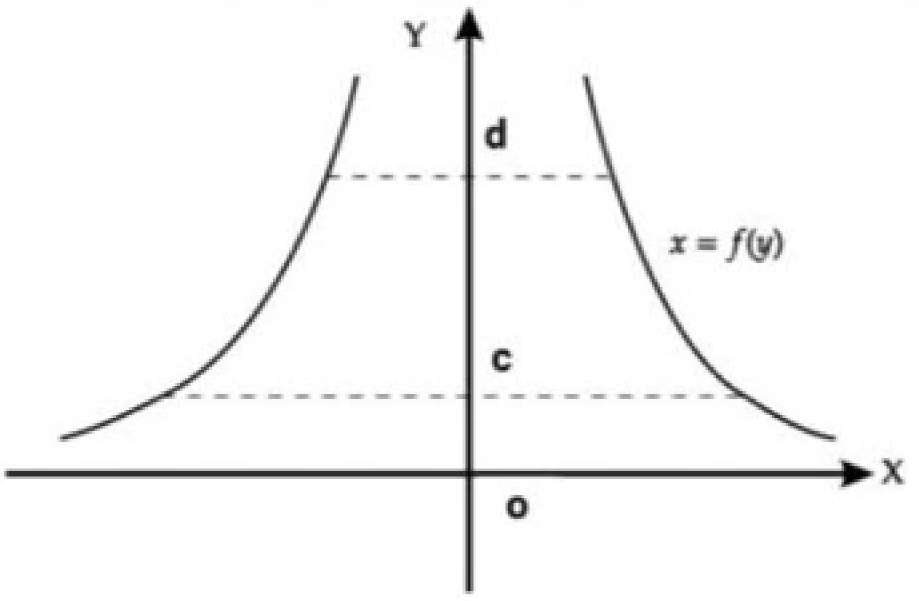
TYPE OF ROTATION	Matrix to be multiplied
Rotation of 90° (clock wise)	$\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$
Rotation of 90° (counter clock wise)	$\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$
Rotation of 180° (clock wise & counter clock wise)	$\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$
Rotation of 270° (clock wise)	$\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$
Rotation of 270° (counter clock wise)	$\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$

Calculus Symbols

$\lim_{x \to 0} f(x)$ limit	ε epsilon	y' derivative	y'' second derivative
$y^{(n)}$ nth derivative	$\frac{dy}{dx}$ derivative	$\frac{d^2y}{dx^2}$ second derivative	$\frac{d^ny}{dx^n}$ nth derivative
$\dot{y}$ time derivative	$\ddot{y}$ time second derivative	$D_x y$ derivative	$D_x^2 y$ second derivative
$\frac{\partial f(x,y)}{\partial x}$ partial derivative	$\int$ integral	$\iint$ double integral	$\iiint$ triple integral
$\oint$ closed line integral	$\oiint$ closed surface integral	$\oiiint$ closed volume integral	i imaginary unit
z^* complex conjugate	$\bar{z}$ complex conjugate	$\vec{x}$ vector	$\hat{x}$ unit vector
$x * y$ convolution	$\mathcal{L}$ laplace transform	$\mathcal{F}$ fourier transform	δ delta function

LAWS OF EXPONENTS

Law	Example
$a^0 = 1$	$2^0 = 1$
$a^1 = a$	$17^1 = 17$
$\sqrt{a} = a^{\frac{1}{2}}$	$\sqrt{4} = 4^{\frac{1}{2}}$
$\sqrt[n]{a} = a^{\frac{1}{n}}$	$\sqrt[3]{27} = 27^{\frac{1}{3}}$
$a^{-m} = \frac{1}{a^m}$	$9^{-2} = \frac{1}{9^2}$
$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$	$\left(\frac{5}{6}\right)^2 = \frac{5^2}{6^2}$
$a^m \times a^n = a^{m+n}$	$5^2 \times 5^4 = 5^{2+4}$
$\frac{a^m}{a^n} = a^{m-n}$	$\frac{4^5}{4^3} = 4^{5-3}$
$(a^m)^n = a^{m \times n}$	$(2^5)^3 = 2^{5\times3}$
$a^n \times b^n = (a \times b)^n$	$2^5 \times 3^5 = (2 \times 3)^5$
$a^{\frac{m}{n}} = \sqrt[n]{a^m}$	$81^{\frac{3}{2}} = \sqrt[2]{81^3}$
$\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$	$\left(\frac{3}{4}\right)^{-2} = \left(\frac{4}{3}\right)^2$
$\frac{a^{-n}}{b^{-m}} = \frac{b^m}{a^n}$	$\frac{3^{-2}}{4^{-5}} = \frac{4^5}{3^2}$

Graph	Area
	Area of the curve bounded by x – axis $Area = \int_b^a f(x)dx$
	Area of the curve bounded by y – axis $Area = \int_c^d f(y)dy$
	Area between two curves $Area = \int_b^a (f(x) - g(x))dx$
	Volume of Revolution Rotation about x – axis : $Area : \pi \int_b^a y^2 dx$
	Volume of Revolution Rotation about y – axis : $Area : \pi \int_c^d x^2 dx$

$$\log_{\color{red}\blacksquare}{\color{blue}\blacksquare} = {\color{yellow}\blacksquare} \quad\longleftrightarrow\quad {\color{red}\blacksquare}^{\color{yellow}\blacksquare} = {\color{blue}\blacksquare}$$

$${\color{red}\blacksquare}^{(\log_{\color{red}\blacksquare}{\color{blue}\blacksquare})} = {\color{blue}\blacksquare}$$

$$\log_{\color{red}\blacksquare}({\color{red}\blacksquare}^{\color{blue}\blacksquare}) = {\color{blue}\blacksquare}$$

$$\log_{\color{red}\blacksquare}({\color{blue}\blacksquare} \text{ X } {\color{yellow}\blacksquare}) = \log_{\color{red}\blacksquare}{\color{blue}\blacksquare} + \log_{\color{red}\blacksquare}{\color{yellow}\blacksquare}$$

$$\log_{\color{red}\blacksquare}\left(\frac{\color{blue}\blacksquare}{\color{yellow}\blacksquare}\right) = \log_{\color{red}\blacksquare}{\color{blue}\blacksquare} - \log_{\color{red}\blacksquare}{\color{yellow}\blacksquare}$$

$$\log_{\color{red}\blacksquare}({\color{blue}\blacksquare}^{\color{yellow}\blacksquare}) = {\color{yellow}\blacksquare}\log_{\color{red}\blacksquare}{\color{blue}\blacksquare}$$

$$\log_{\color{red}\blacksquare}{\color{blue}\blacksquare} = \frac{\log_{\color{yellow}\blacksquare}{\color{blue}\blacksquare}}{\log_{\color{yellow}\blacksquare}{\color{red}\blacksquare}}$$

$$\log_{\color{red}\blacksquare}\left(\sqrt[\color{yellow}\blacksquare]{\color{blue}\blacksquare}\right) = \frac{\log_{\color{red}\blacksquare}{\color{blue}\blacksquare}}{\color{yellow}\blacksquare}$$

$${\color{yellow}\blacksquare}^{(\log_{\color{red}\blacksquare}{\color{blue}\blacksquare})} = {\color{blue}\blacksquare}^{(\log_{\color{red}\blacksquare}{\color{yellow}\blacksquare})}$$

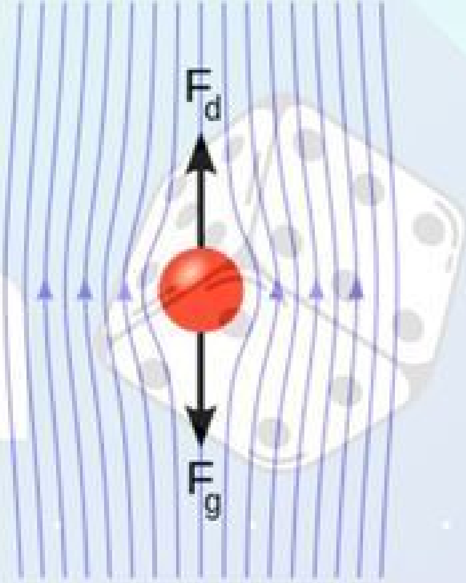
PHYSICS

STOKE'S LAW

$$V = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g R^2$$

mathsolverr

- g is the gravitational field strength (m/s^2)
- R is the radius of the spherical particle (m)
- ρ_p is the mass density of the particle (kg/m^3)
- ρ_f is the mass density of the fluid (kg/m^3)
- μ is the dynamic viscosity (kg/(m*s)).



$$F = 6\pi\eta r v$$

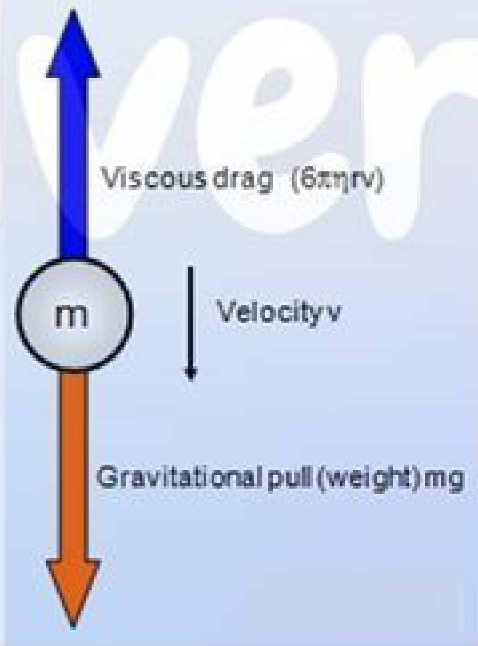
F = drag force

π = pi

r = sphere radius

η = fluid viscosity

v = velocity of the sphere



MATH

Euler's Formula

$$I = \int \frac{dx}{1+x^2} = \tan^{-1}(x) \qquad 1$$

$$I = \frac{1}{i}\int \frac{idx}{1-(ix)^2} = \frac{1}{2i}\ln\left(\frac{1+ix}{1-ix}\right) \qquad 2$$

from 1 and 2

$$\therefore \tan^{-1}(x) = \frac{1}{2i}\ln\left(\frac{1+ix}{1-ix}\right)$$

$$\therefore 2i\tan^{-1}(x) = \ln\left(\frac{1+ix}{1-ix}\right)$$

Put $x = \tan(\theta)$

$$\therefore 2i\tan^{-1}(\tan(\theta)) = \ln\left(\frac{1+i\tan(\theta)}{1-i\tan(\theta)} \times \frac{\cos\theta}{\cos\theta}\right)$$

$$\therefore 2i\theta = \ln\left(\frac{\cos\theta + i\sin\theta}{\cos\theta - i\sin\theta}\right)$$

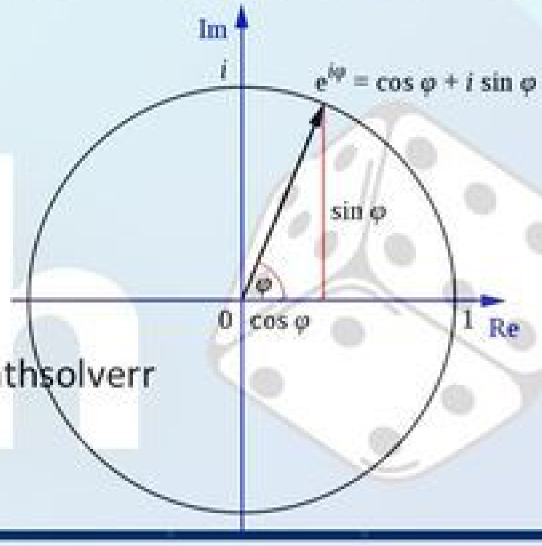
$$\therefore 2i\theta = \ln\left(\frac{\cos\theta + i\sin\theta}{\cos\theta - i\sin\theta} \times \frac{\cos\theta + i\sin\theta}{\cos\theta + i\sin\theta}\right)$$

$$2i\theta = \ln\left(\frac{(\cos\theta + i\sin\theta)^2}{\cos^2\theta + \sin^2\theta}\right) = \ln[(\cos\theta + i\sin\theta)^2]$$

$$\therefore 2i\theta = 2\ln(\cos\theta + i\sin\theta)$$

$$\therefore i\theta = \ln(\cos\theta + i\sin\theta)$$

$$\boxed{\therefore e^{i\theta} = \cos\theta + i\sin\theta}$$



$$\boxed{e^{ix} = \cos x + i\sin x}$$

e

2.71828183

SAVE IT FOR LATER

Coulomb's Law & Newton's Law

Coulomb's Law

The Force between two point charges is directly proportional to the product of the CHARGES and inversely proportional to the square of their distance apart.

$$F \propto Q_1 Q_2 \qquad F \propto \frac{1}{r^2}$$

$$\boxed{F = k\frac{Q_1 Q_2}{r^2}}$$

$k = 9 \times 10^9\ Nm^2C^{-2}$

Newton's Law

The Force between two point masses is directly proportional to the product of the MASSES and inversely proportional to the square of their distance apart.

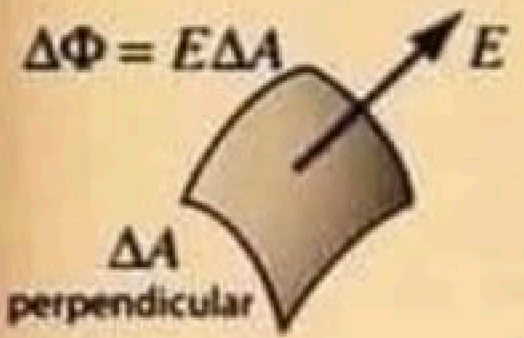
$$F \propto m_1 m_2 \qquad F \propto \frac{1}{r^2}$$

$$\boxed{F = G\frac{m_1 m_2}{r^2}}$$

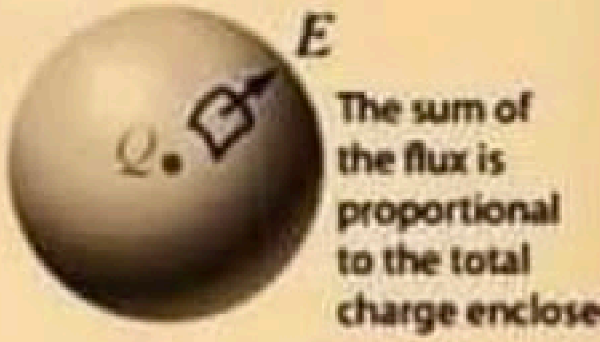
$G = 6.6742 \times 10^{-11}\ m^3kg^{-1}s^{-2}$

Gauss's Law

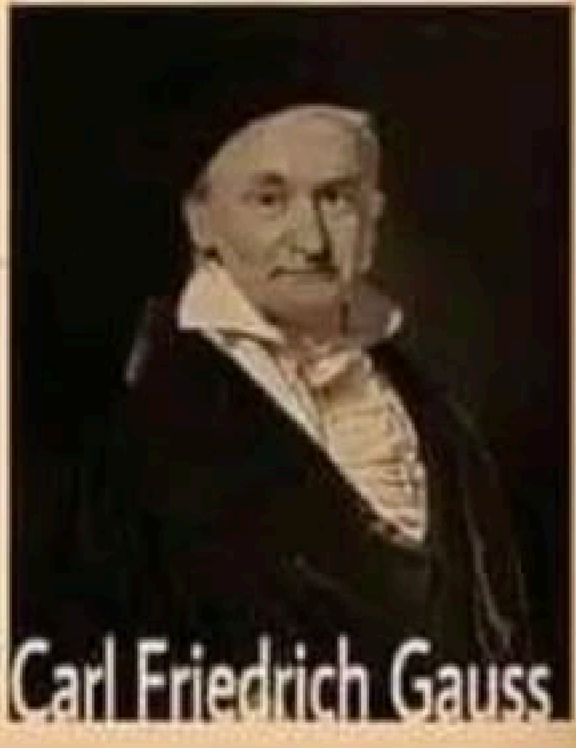
The total of the electric flux out of a closed surface is equal to the charge enclosed divided by the permittivity.



$$\Phi_{electric} = \frac{Q}{\varepsilon_0}$$



$$\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\varepsilon_0}$$



The area integral of the electric field over any closed surface is equal to the net charge enclosed in the surface divided by the permittivity of space.

Ampere-Maxwell equation

@joshi_physics_classes

Differential Form

Reminder that the magnetic field is a vector

Reminder that the current density is a vector

The electric permittivity of free space

The rate of change of the electric field with time

Reminder that the dell operator is a vector

The differential operator called "del" or "nabla"

$$\vec{\nabla} \times \vec{H} = \left(\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$

The magnetic field in A/m

The electric current density in amperes per square meter

Integral Form

Dot product tells you to find the part of $\vec{H}$ parallel to $d\vec{l}$ (along path C)

An incremental segment of path C

The electric current in amperes

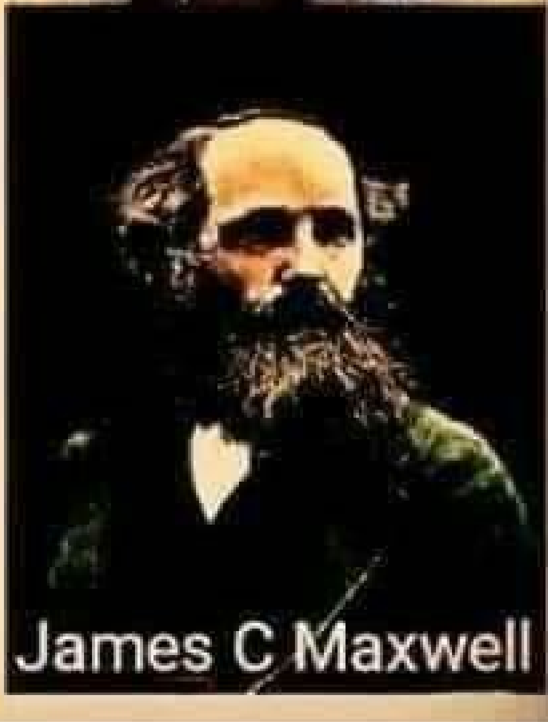
The rate of change with time

$$\oint_C \vec{H} \circ d\vec{l} = \left(I_{enc} + \varepsilon_0 \frac{d}{dt} \underbrace{\int_S \vec{E} \circ \hat{n}\, da}_{} \right)$$

Tells you to sum up the contributions from each portion of the closed path C in direction given by ruth-hand rule

Reminder that only the enclosed current contributes

The electric flux through a surface bounded by C



Ohm's Law

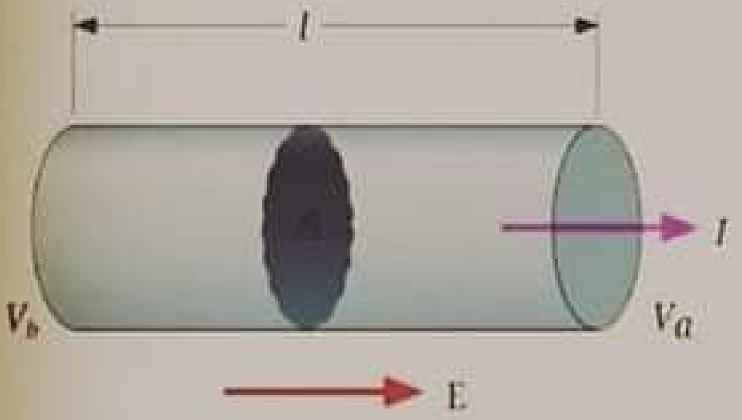
Georg Ohm

$$V_{ab} = -\int_b^a \vec{E} \cdot d\vec{l} = \int_a^b \vec{E} \cdot d\vec{l}$$

$\vec{E}$ is constant and parallel to $d\vec{l}$ along l

$$V_{ab} = El_{ab} \rightarrow \boldsymbol{V = El}$$

$$I = \iint_S \vec{J} \cdot d\vec{S}$$



$\vec{J}$ is constant and parallel to $d\vec{S}$ on S

$$\boldsymbol{I = JS}$$

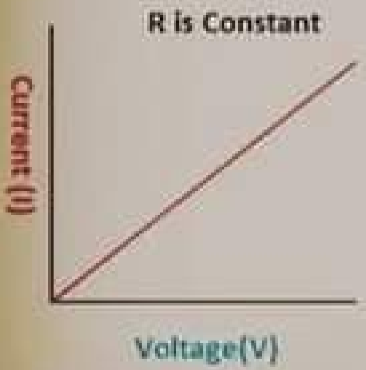
$$R = \frac{l}{\sigma S} \rightarrow \boldsymbol{R = \frac{V}{I}\frac{J}{\sigma E}}$$

$$\vec{J} = \sigma\vec{E} \rightarrow \boldsymbol{J = \sigma E}$$

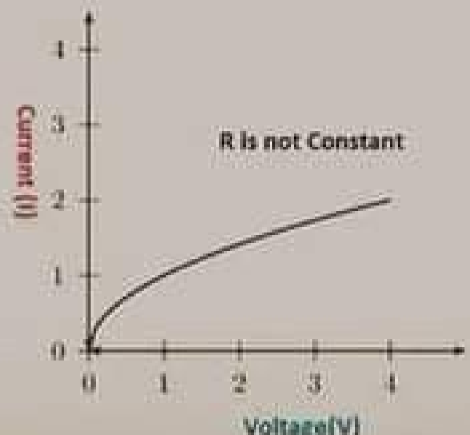
$$R = \frac{V}{I}\frac{J}{J} \rightarrow R = \frac{V}{I}$$

$$\boxed{\boldsymbol{V = RI}}$$

V: voltage
R: resistance
E: electric field
l: conductor's length
I: current
J: current density
S: conductor's cross section
σ: conductivity



Ohmic Devices Graph

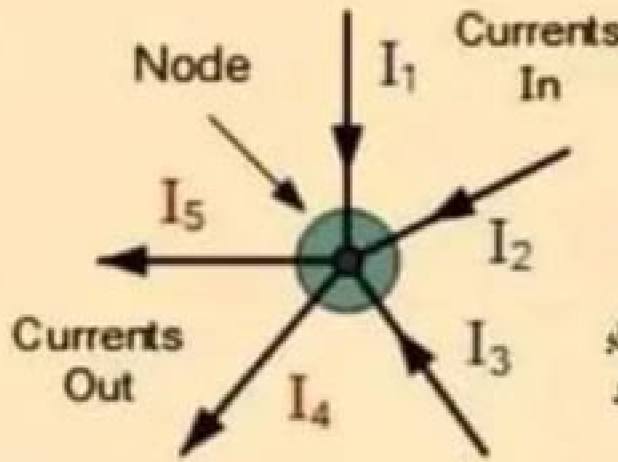


Non-Ohmic Devices Graph

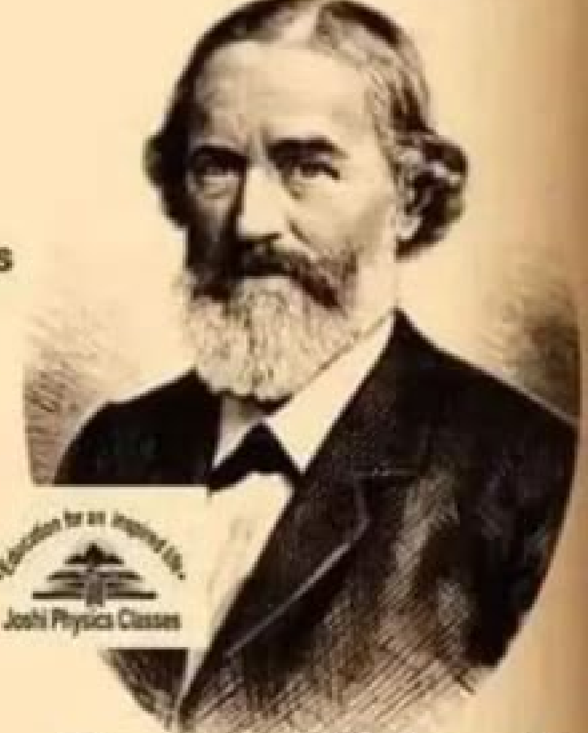
Kirchhoff's Circuit Law

Kirchhoff's Current Law

Currents Entering the Node
Equals
Currents Leaving the Node



$$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$$

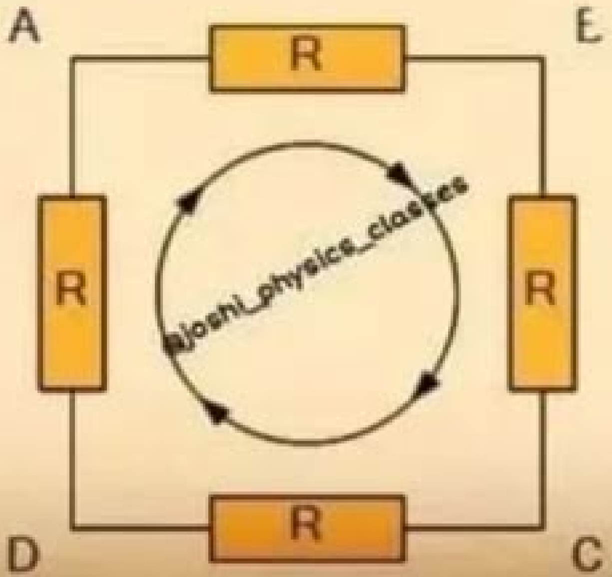


Gustav Kirchhoff

Kirchhoff's Voltage Law

The sum of all the Voltage
Drops around the loop
is equal to Zero

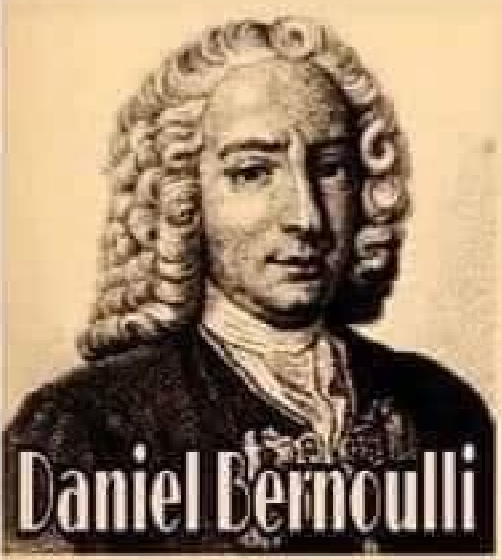
$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$



Also Known for:

- Kirchhoff's law of thermal radiation
- Kirchhoff's laws of spectroscopy
- Kirchhoff's law of thermochemistry

Bernoulli's principle

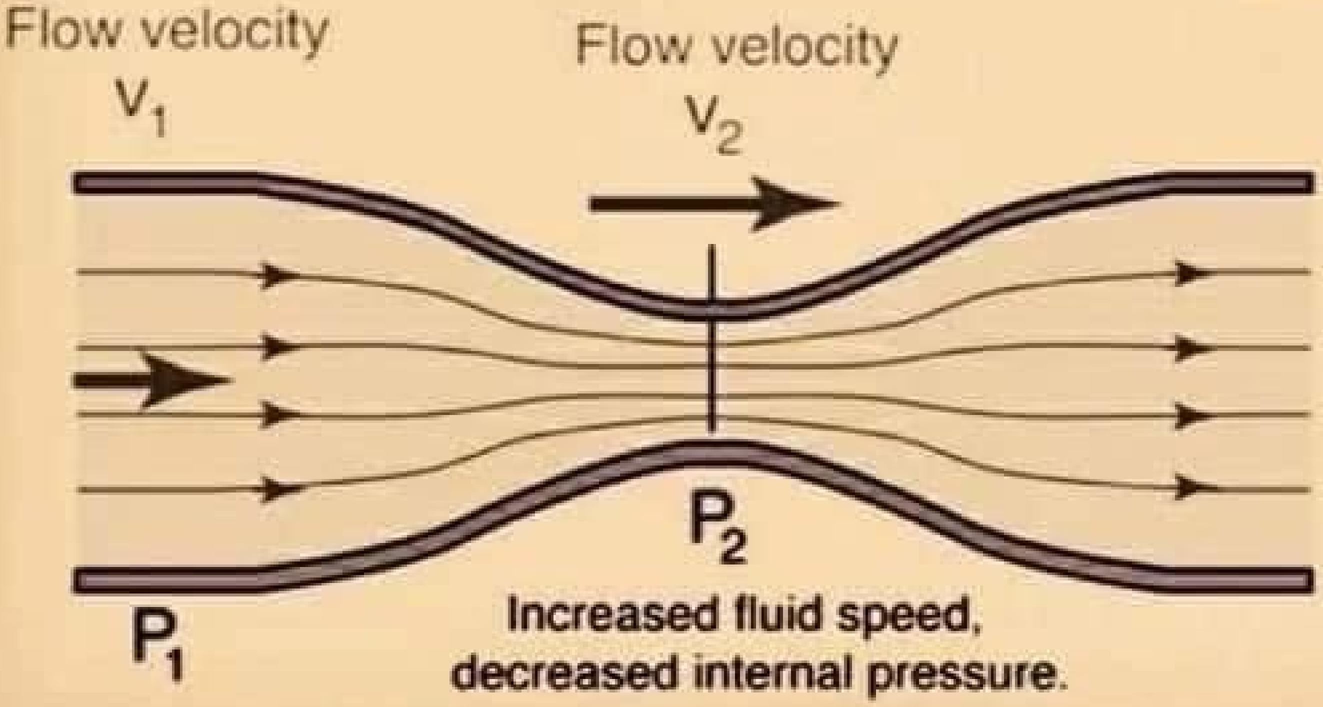


Energy per unit volume before = Energy per unit volume after

$$\underbrace{P_1}_{\text{Pressure Energy}} + \underbrace{\tfrac{1}{2}\rho v_1^2}_{\text{Kinetic Energy per unit volume}} + \underbrace{\rho g h_1}_{\text{Potential Energy per unit volume}} = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2$$

•Education for an inspired life•

Joshi Physics Classes



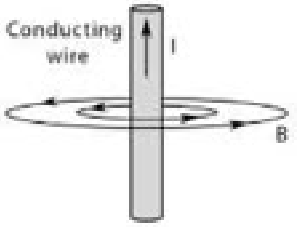
Increased fluid speed, decreased internal pressure.

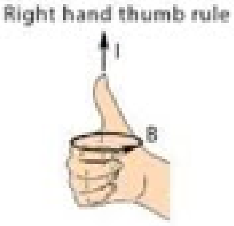
$A_2 < A_1$

$v_2 > v_1$

$\boxed{P_2 < P_1\,!}$

AMPERE'S CIRCUITAL LAW

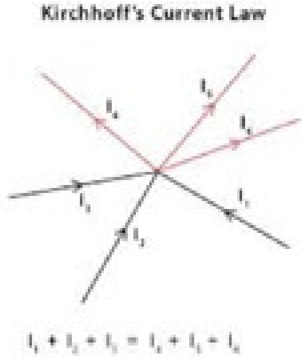


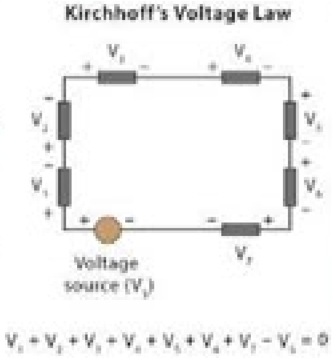


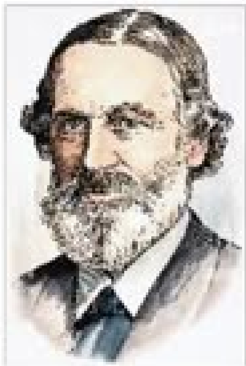
$$\oint_C \vec{B}.\vec{dl} = \mu_o I$$

The magnetic field created by an electric current is proportional to the size of that electric current with a constant of proportionality equal to the permeability of free space.

KIRCHOFF'S LAW



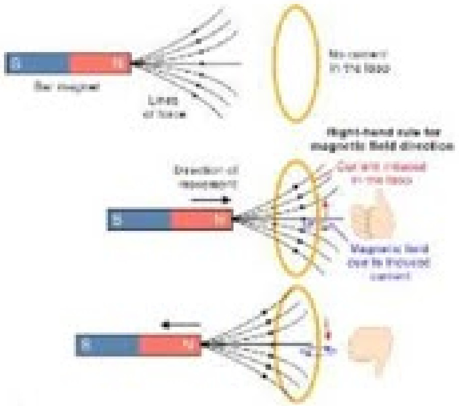




The total current entering a junction or a node is equal to the charge leaving the node as no charge is lost.

The voltage around a loop equals the sum of every voltage drop in the same loop for any closed network and equals zero.

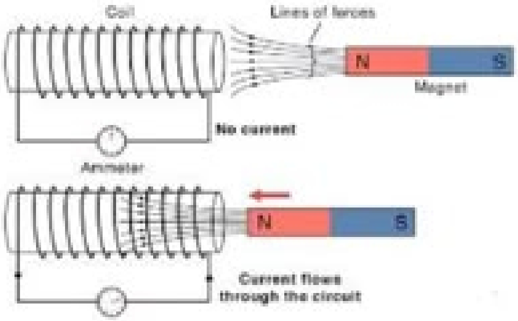
LENZ'S LAW

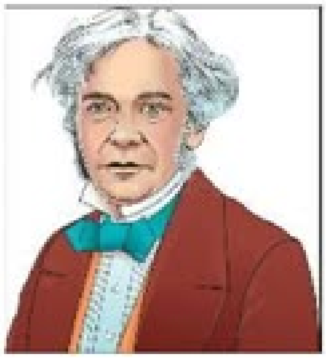


$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

The direction of an electric current induced in a conductor by a changing magnetic field is such that the magnetic field created by the induced current opposes changes in the initial magnetic field.

FARADAY'S LAW OF EMI





1st LAW

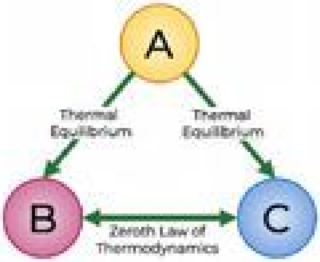
Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced. If the conductor circuit is closed, a current is induced, which is called induced current.

2nd LAW

The induced emf in a coil is equal to the rate of change of flux linkage.

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

ZEROTH LAW OF THERMODYNAMICS



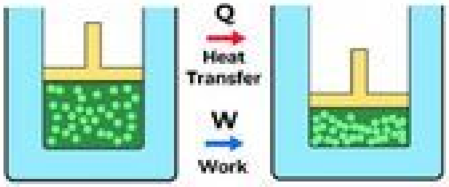
ROLPH H FOWLER

If two thermodynamic systems are both in thermal equilibrium with a third system, then the two systems are in thermal equilibrium with each other.

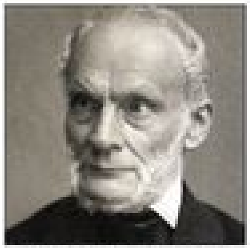
Two systems are said to be in thermal equilibrium if they are linked by a wall permeable only to heat, and they do not change over time.

Pinterest: @Shadabalfaaz98

FIRST LAW OF THERMODYNAMICS



State 1 State 2



RUDOLPH CLAUSIUS

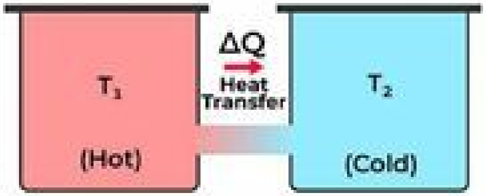
$$\Delta U = Q - W$$

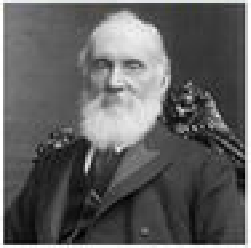
ΔU = change in internal energy
Q = heat added
W = work done by the system

The change in internal energy of a system equals the net heat transfer into the system minus the net work done by the system. It is based on Conservation of Energy.

Pinterest: @Shadabalfaaz98

SECOND LAW OF THERMODYNAMICS





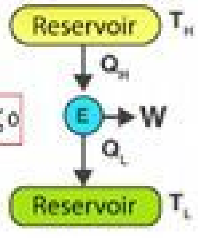
WILLIAM THOMSON

Entropy of an isolated system will never decrease over time.

ΔS = Entropy = $\frac{\Delta Q}{T}$

1. Kelvin-Planck Statement- It is impossible for a heat engine to produce a net amount of work in a complete cycle if it exchanges heat only with bodies at a single fixed temperature.
2. The Clausius statement: It is impossible to construct a device that operates on a cycle and produces no other effect than the transfer of heat from a cooler body to a hotter body.

$$\oint \frac{dQ}{T} \le 0$$



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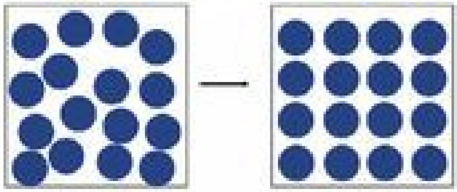
THIRD LAW OF THERMODYNAMICS



$T > 0K$ $T = 0K$
$S > 0$ $S = 0$
Entropy becomes zero at 0K

WALTHER NERST

$$\Delta S = \int_{T_1}^{T_2} \frac{C(T)\, dT}{T}$$

The entropy of a closed system at thermodynamic equilibrium approaches a constant value when its temperature approaches absolute zero.

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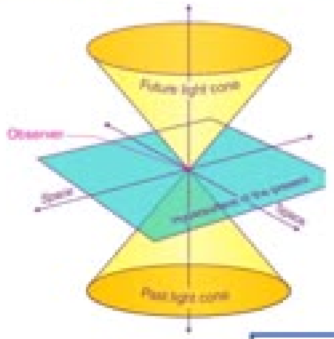
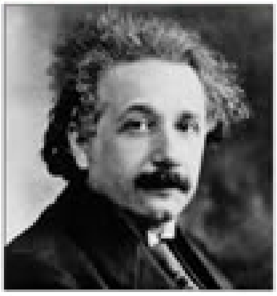
EINSTEIN THEORY OF RELATIVITY



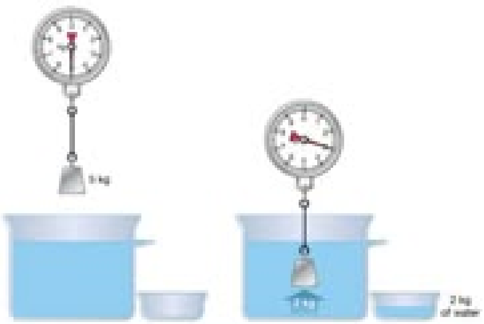


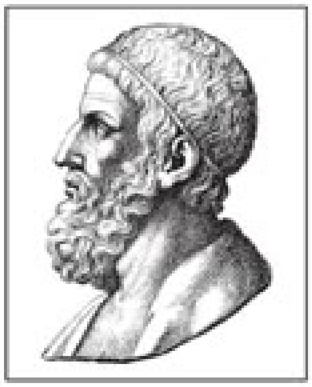
$$E = mc^2$$

E = Energy in Joule
m = Mass of an object in Kg
c = Speed of light = 3,00,00,000 m/sec

1. The laws of physics are the same for all observers in any inertial frame of reference relative to one another (principle of relativity).
2. The speed of light in a vacuum is the same for all observers, regardless of their relative motion or of the motion of the light source.

ARCHIMEDES PRINCIPLE





$$F_b = -\rho g V$$

Archimedes' principle states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially, is equal to the weight of the fluid that the body displaces.

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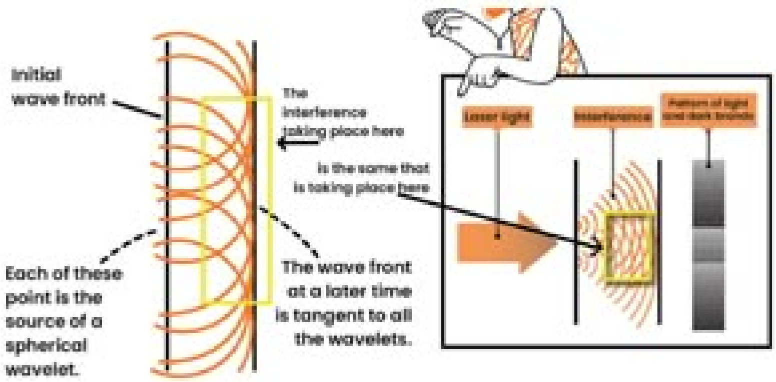
HUYGEN'S PRINCIPLE

Every point on a wavefront is in itself the source of spherical wavelets which spread out in the forward direction at the speed of light. The sum of these spherical wavelets forms the wavefront.



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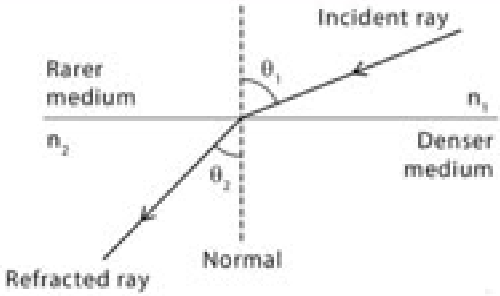
SNELL'S LAW



$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Snell's Law gives a relationship between the angles of incidence ($Ø_1$) and refraction ($Ø_2$) when a ray of light travels from a rarer medium of refractive index (n_1) to a denser medium of refractive index (n_2).

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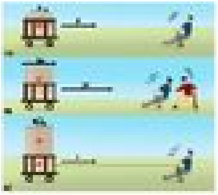
NEWTON'S LAWS OF MOTION

1st Law

A body remains in the state of rest or uniform motion in a straight line unless and until an external force acts on it.

2nd Law

The net force on a body is equal to the body's acceleration multiplied by its mass or, equivalently, the rate at which the body's momentum changes with time.



3rd Law

For every action, there is an equal and opposite reaction.

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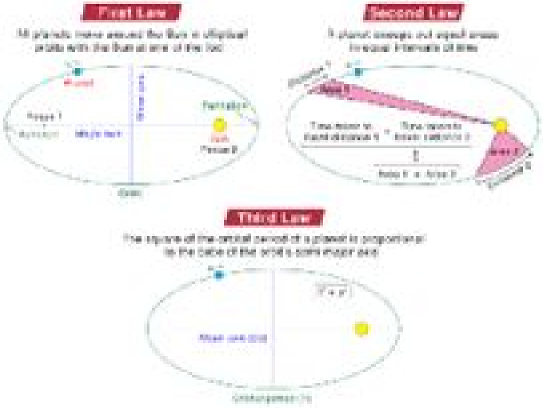
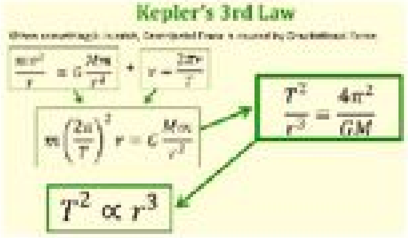
KEPLER'S LAW OF PLANETARY MOTION



1st Law -> The orbit of a planet is an ellipse with the Sun at one of the two foci.
2nd Law -> A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.
3rd Law -> The square of a planet's orbital period is proportional to the cube of the length of the semi-major axis of its orbit.



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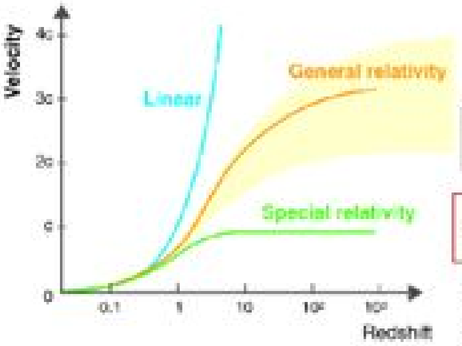
HUBBLE'S LAW



Redshift Formula

$$z = \frac{\lambda_{obs} - \lambda_{rest}}{\lambda_{rest}}$$

z = redshift
λ_{obs} = observed wavelength
λ_{rest} = rest wavelength

The greater the distance of a galaxy, the faster it recedes. Hubble established the cosmological velocity-distance law:

$$v = H_0 D$$

v = recessional velocity
H_0 = Hubble's constant $= 71\frac{km/s}{mpc} = 2.3x10^{-18}s^{-1}$
D = proper distance

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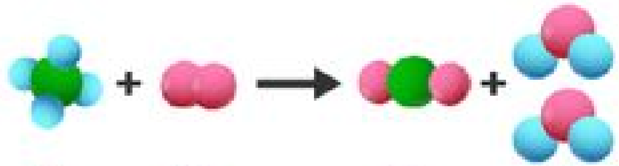
LAW OF CONSERVATION OF MASS



CH_4	$2O_2$	CO_2	$2H_2O$
Methane	Oxygen	Carbon Dioxide	Water
16 g	2 x 32 g	44 g	2 x 18 g
80 g		80 g	

ANTOINE LAVOISIER

Matter can neither be created nor be destroyed in a chemical reaction. In other words, the mass of products in chemical reactions equals the mass of reactants.

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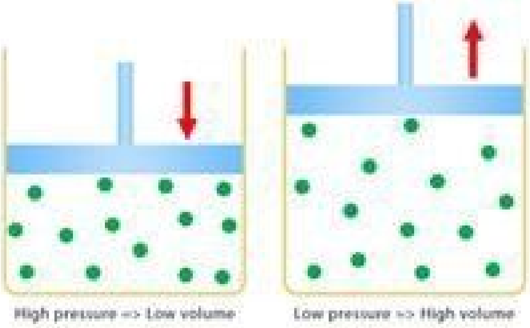
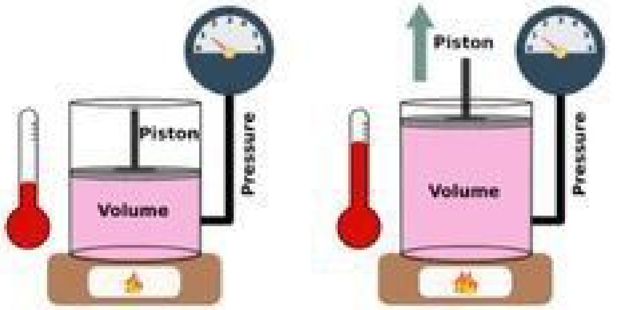
BOYLE'S LAW



$$P_1V_1 = P_2V_2$$

The absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remain unchanged within a closed system.

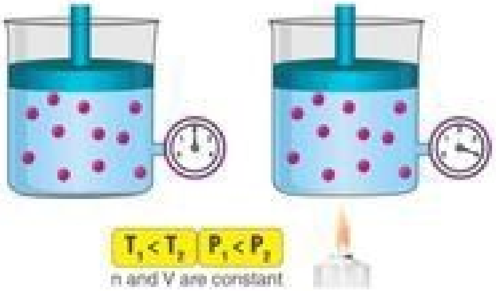
CHARLES' LAW



$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

The volume occupied by a fixed amount of gas is directly proportional to its absolute temperature, if the pressure remains constant.

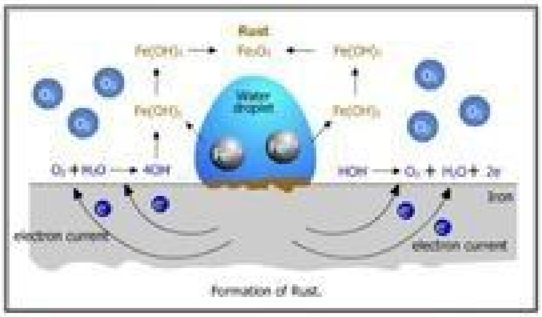
GAY LUSAAC'S LAW



$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

The pressure exerted by a gas (of a given mass and kept at a constant volume) varies directly with the absolute temperature of the gas.

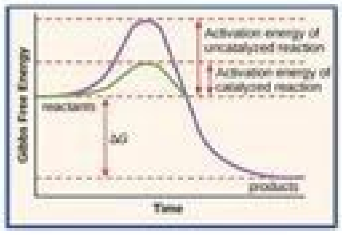
GIBBS FREE ENERGY



Formation of Rust.

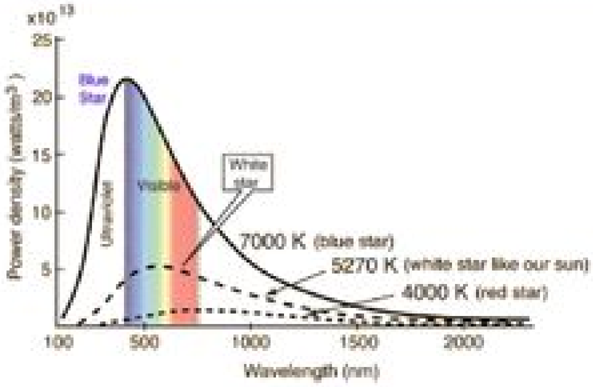
$$\Delta G = \Delta H - T\Delta S$$

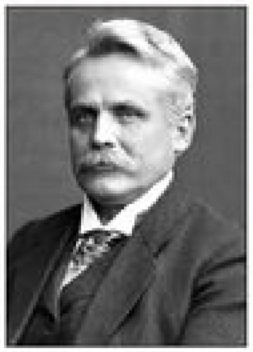
ΔG = change in Gibbs Free Energy
ΔH = change in enthalpy
T = temperature in Kelvin
ΔS = change in entropy



Gibbs free energy is a thermodynamic potential that can be used to calculate the maximum amount of work, other than pressure-volume work, that may be performed by a thermodynamically closed system at constant temperature and pressure.

WIEN DISPLACEMENT LAW



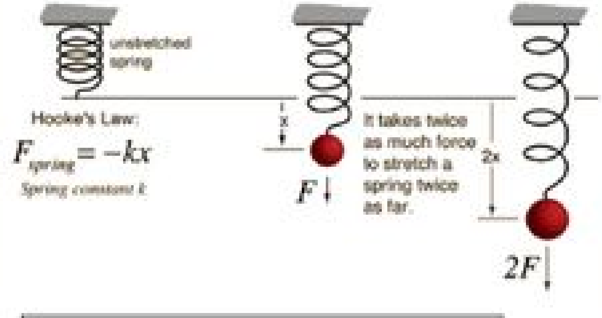


$$\lambda_{max} = \frac{b}{T}$$

b = Wein's Displacement Constant = 0.002898 m
T = absolute Temperature in Kelvin

Wien's displacement law states that the black-body radiation curve for different temperatures will peak at different wavelengths that are inversely proportional to the temperature.

HOOKE'S LAW

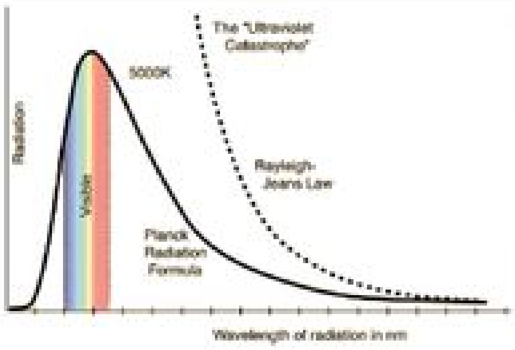


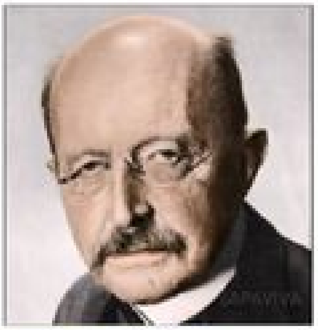
F_s = spring force
k = spring constant
x = spring stretch or compression

$$F_s = -kx$$

Hooke's law states that the force required to extend or compress a spring by some distance is directly proportional to that distance.

PLANCK'S LAW



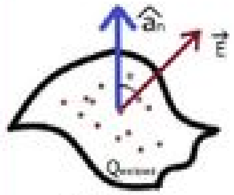


$$B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}.$$

B = spectral radiance of a body
ν = frequency
T = absolute temperature
k_B = Boltzmann constant
h = Planck constant
c = speed of light in the medium

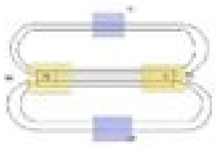
Electromagnetic radiation from heated bodies is not emitted as a continuous flow but is made up of discrete units or quanta of energy, the size of which involves a fundamental physical constant (Planck's constant).

MAXWELL'S LAW



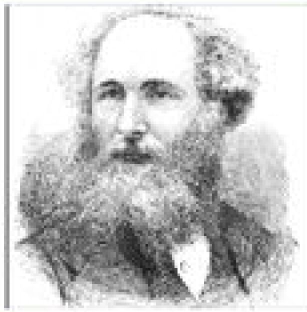
$\nabla \cdot E = \rho / \varepsilon_0$

Gauss Law of Electricity



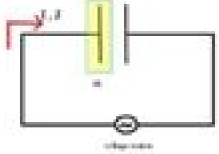
$\nabla \cdot B = 0$

Gauss Law of Magnetism



$\nabla \times E = - dB / dt$

Faraday's Law of Induction

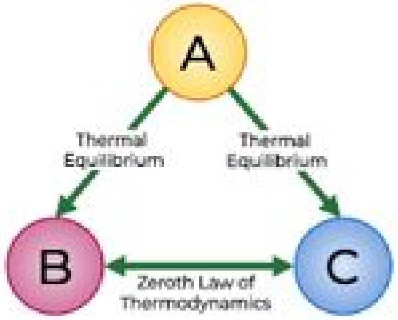


$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \partial E / \partial t$

Ampere's Law

Differential equations	Meaning
$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$	The electric field leaving a volume is proportional to the charge inside.
$\nabla \cdot \mathbf{B} = 0$	There are no magnetic monopoles; the total magnetic flux piercing a closed surface is zero.
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	The voltage accumulated around a closed circuit is proportional to the time rate of change of the magnetic flux it encloses.
$\nabla \times \mathbf{B} = \mu_0\left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}\right)$	Electric currents and changes in electric fields are proportional to the magnetic field circulating about the area they pierce.

ZEROTH LAW OF THERMODYNAMICS

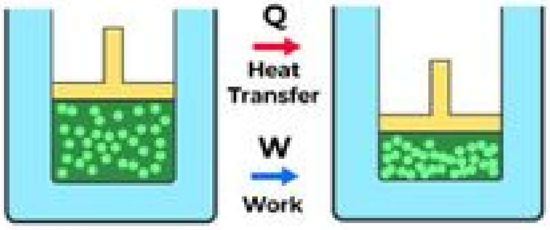


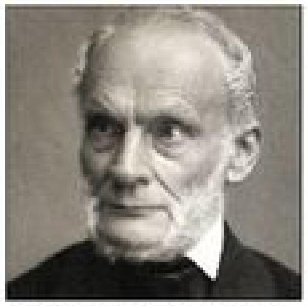
ROLPH H FOWLER

If two thermodynamic systems are both in thermal equilibrium with a third system, then the two systems are in thermal equilibrium with each other.

Two systems are said to be in thermal equilibrium if they are linked by a wall permeable only to heat, and they do not change over time.

FIRST LAW OF THERMODYNAMICS





RUDOLPH CLAUSIUS

$$\Delta U = Q - W$$

ΔU = change in internal energy
Q = heat added
W = work done by the system

The change in internal energy of a system equals the net heat transfer into the system minus the net work done by the system. It is based on Conservation of Energy.

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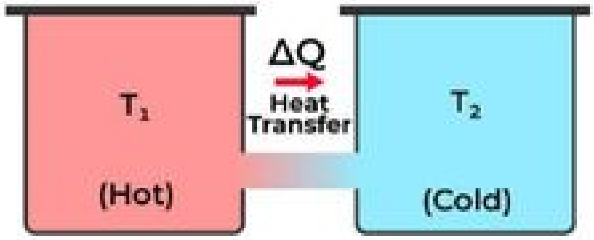
SECOND LAW OF THERMODYNAMICS



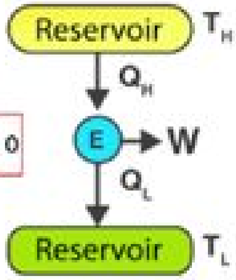
WILLIAM THOMSON

Entropy of an isolated system will never decrease over time.

ΔS = Entropy = $\frac{\Delta Q}{T}$

1. Kelvin-Planck Statement- It is impossible for a heat engine to produce a net amount of work in a complete cycle if it exchanges heat only with bodies at a single fixed temperature.
2. The Clausius statement: It is impossible to construct a device that operates on a cycle and produces no other effect than the transfer of heat from a cooler body to a hotter body.

$$\oint \frac{dQ}{T} \leq 0$$



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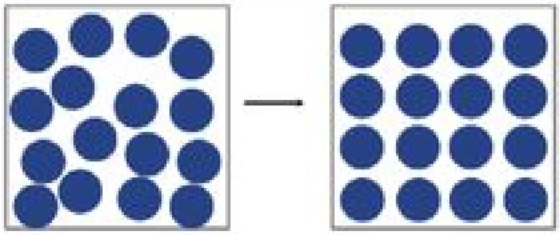
THIRD LAW OF THERMODYNAMICS



T > 0K
S > 0

T = 0K
S = 0

Entropy becomes zero at 0K

WALTHER NERST

$$\Delta S = \int_{T_1}^{T_2} \frac{C(T)\, dT}{T}$$

The entropy of a closed system at thermodynamic equilibrium approaches a constant value when its temperature approaches absolute zero.

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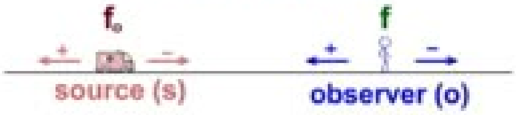
DOPPLER EFFECT

+ observer toward source
- observer away from source

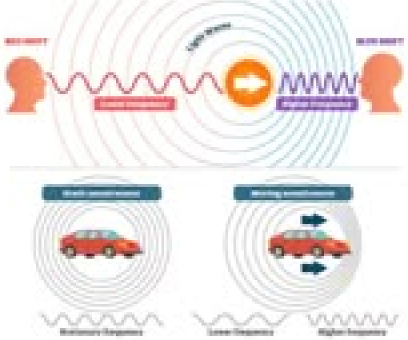
$$f = f_o\left(\frac{V \pm V_o}{V \mp V_s}\right)$$

- source toward observer
+ source away from observer

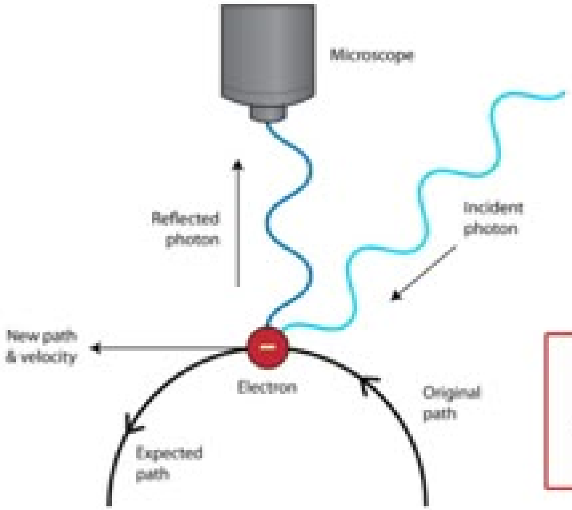


v : velocity of sound

The Doppler effect or the Doppler shift describes the changes in the frequency of any sound or light wave produced by a moving source with respect to an observer.



HEISENBERG UNCERTAINTY PRINCIPLE



$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

There is a limit to the precision with which certain pairs of physical properties, such as position and momentum, can be simultaneously known. It is impossible to accurately measure the energy of a system in some finite amount of time.

SCHRODINGER EQUATION

$$i\hbar \frac{1}{\xi(t)} \frac{\delta \xi(t)}{\delta t} = -\frac{1}{\phi(x)} \frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} \phi(x) + \hat{V}$$

$$\xi(t) = e^{-(iEt/\hbar)}$$

$$-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} \psi(x) + \hat{V}\psi(x) = E\psi(x)$$

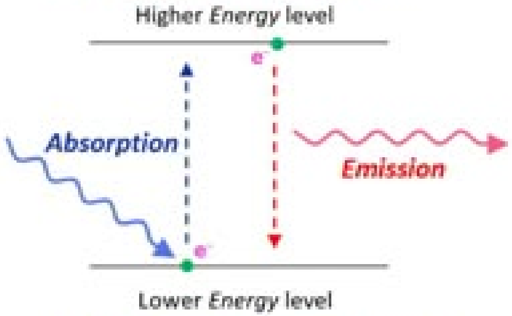
$$\psi(x, t) = \phi(x)\, e^{-(iEt/\hbar)}$$

solving the time-independent Schrödinger equation is enough to know about the time-evolution of a particle

The Schrodinger wave equation is a mathematical expression describing the energy and position of the electron in space and time, taking into account the matter wave nature of the electron inside an atom.

RYDBERG EQUATION

Emission occurs when the **electron** falls from an *excited* (**high energy**) to the ground, or in general, a **lower energy level.**



Absorbing light with sufficient energy **moves the electron in a higher energy level.**

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

R_H = Rydberg constant = $\frac{me^4}{8\varepsilon_0^2 h^3 c}$ = $1.0973 \times 10^7\ m^{-1}$

The Rydberg formula is the mathematical formula to determine the wavelength of light emitted by an electron moving between the energy levels of an atom.