Physics Equation List :Form 4
Introduction to Physics

Relative Deviation

$$\text{Relative Deviation} = \frac{\text{Mean Deviation}}{\text{Mean Value}} \times 100\%$$

Prefixes

Prefixes	Value	Standard form	Symbol
Tera	1 000 000 000 000	10^{12}	T
Giga	1 000 000 000	10^{9}	G
Mega	1 000 000	10^{6}	M
Kilo	1 000	10^{3}	k
deci	0.1	10^{-1}	d
centi	0.01	10^{-2}	c
milli	0.001	10^{-3}	m
micro	0.000 001	10^{-6}	μ
nano	0.000 000 001	10^{-9}	n
pico	0.000 000 000 001	10^{-12}	p

Units for Area and Volume

1 m $= 10^2$ cm (100 cm)

1 m^2 $= 10^4$ cm^2 (10,000 cm^2)

1 m^3 $= 10^6$ cm^3 (1,000,000 cm^3)

1 cm $= 10^{-2}$ m $\left(\frac{1}{100} m\right)$

1 cm^2 $= 10^{-4}$ m^2 $\left(\frac{1}{10,000} m^2\right)$

1 cm^3 $= 10^{-6}$ m^3 $\left(\frac{1}{1,000,000} m^3\right)$

Force and Motion

Average Speed

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

Velocity

$$v = \frac{s}{t}$$

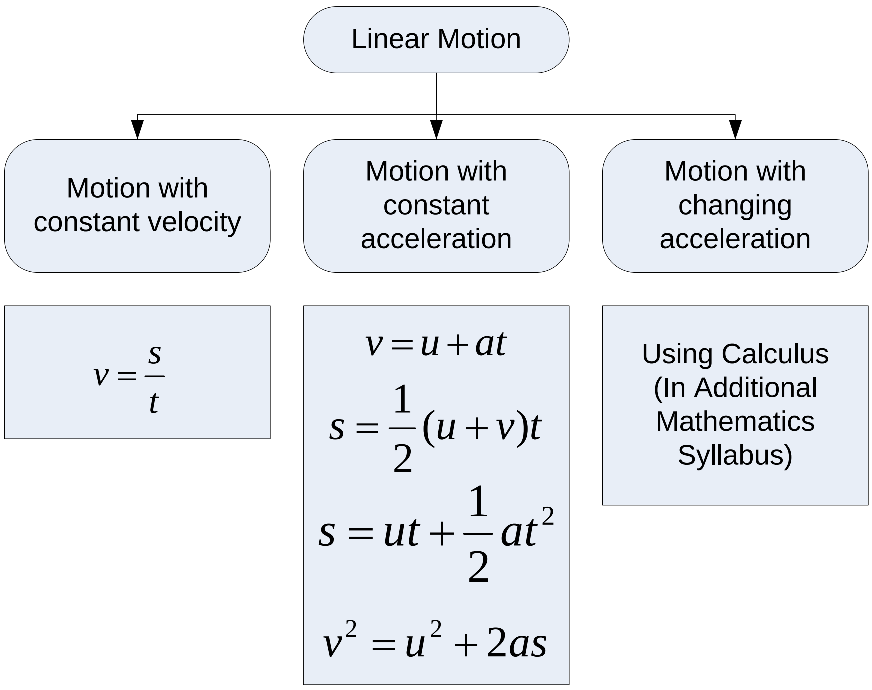
v = velocity (ms^{-1})
s = displacement *(m)*
t = time *(s)*

Acceleration

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

a = acceleration (ms^{-2})
v = final velocity (ms^{-1})
u = initial velocity (ms^{-1})
t =time for the velocity change *(s)*

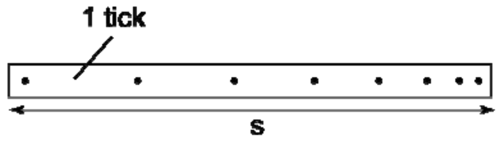
Equation of Linear Motion



u = initial velocity (ms^{-1})
v = final velocity (ms^{-1})
a = acceleration (ms^{-2})
s = displacement *(m)*
t = time *(s)*

Ticker Tape

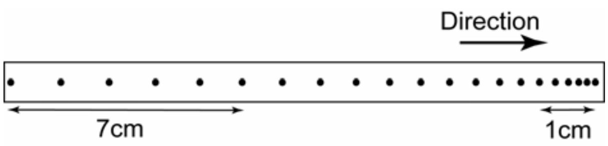
Finding Velocity:

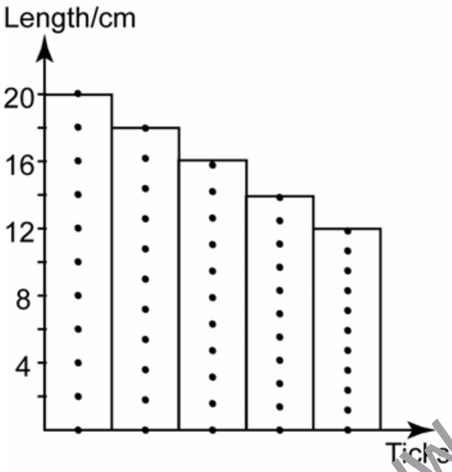


$$\text{velocity} = \frac{s}{\text{number of ticks} \times 0.02\text{s}}$$

1 tick = 0.02s

Finding Acceleration:





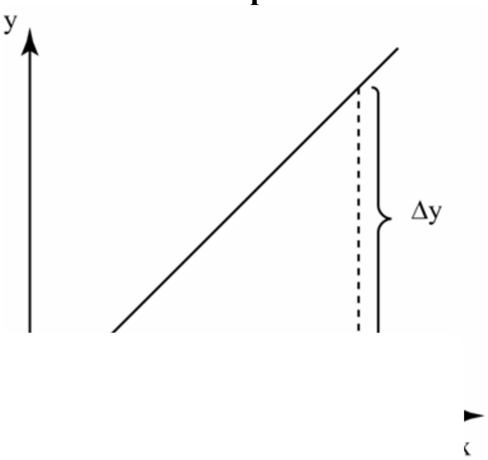
$$a = \frac{v - u}{t}$$

a = acceleration *(ms⁻²)*

a = acceleration	(ms^{-2})
v = final velocity	(ms^{-1})
u = initial velocity	(ms^{-1})
t = time for the velocity change	(s)

Graph of Motion

Gradient of a Graph

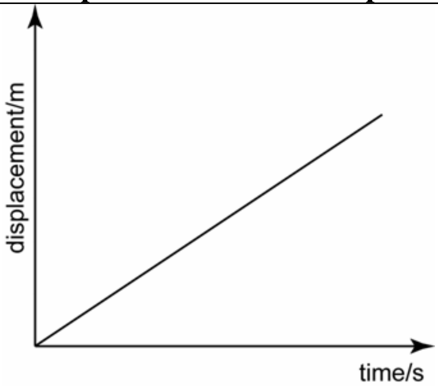
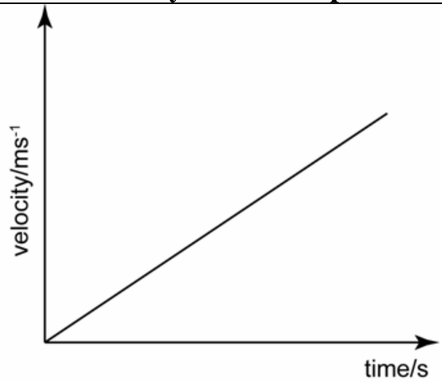


The gradient 'm' of a line segment between two points and is defined as follows:

$$\text{Gradient, } m = \frac{\text{Change in y coordinate, } \Delta y}{\text{Change in x coordinate, } \Delta x}$$

or

$$m = \frac{\Delta y}{\Delta x}$$

Displacement-Time Graph	Velocity-Time Graph
	
Gradient = Velocity (ms^{-1})	Gradient = Acceleration (ms^{-2}) Area in between the graph and x-axis = Displacement

Momentum

$$p = m \times v$$

p = momentum (*kg* ms^{-1})
m = mass (*kg*)
v = velocity (ms^{-1})

Principle of Conservation of Momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

m_1 = *mass of object 1* (*kg*)
m_2 = *mass of object 2* (*kg*)
u_1 = *initial velocity of object 1* (ms^{-1})
u_2 = *initial velocity of object 2* (ms^{-1})
v_1 = *final velocity of object 1* (ms^{-1})
v_2 = *final velocity of object 2* (ms^{-1})

Newton's Law of Motion
Newton's First Law

In the absence of external forces, an object at rest remains at rest and an object in motion continues in motion with a constant velocity (that is, with a constant speed in a straight line).

Newton's Second Law

$$F \alpha \frac{mv - mu}{t}$$

$$F = ma$$

The rate of change of momentum of a body is directly proportional to the resultant force acting on the body and is in the same direction.

F = Net Force	*(N or $kgms^{-2}$)*
m = mass	*(kg)*
a = acceleration	*(ms^{-2})*

Implication

When there is resultant force acting on an object, the object will **accelerate** (moving faster, moving slower or change direction).

Newton's Third Law

Newton's third law of motion states that for every force, there is a reaction force with the same magnitude but in the opposite direction.

Impulse

$$\text{Impulse} = Ft$$

$$\text{Impulse} = mv - mu$$

F = force	*(N)*
t = time	*(s)*
m = mass	*(kg)*
v = final velocity	*(ms^{-1})*
u = initial velocity	*(ms^{-1})*

Impulsive Force

$$F = \frac{mv - mu}{t}$$

F = Force	*(N or $kgms^{-2}$)*
t = time	*(s)*
m = mass	*(kg)*
v = final velocity	*(ms^{-1})*
u = initial velocity	*(ms^{-1})*

Gravitational Field Strength

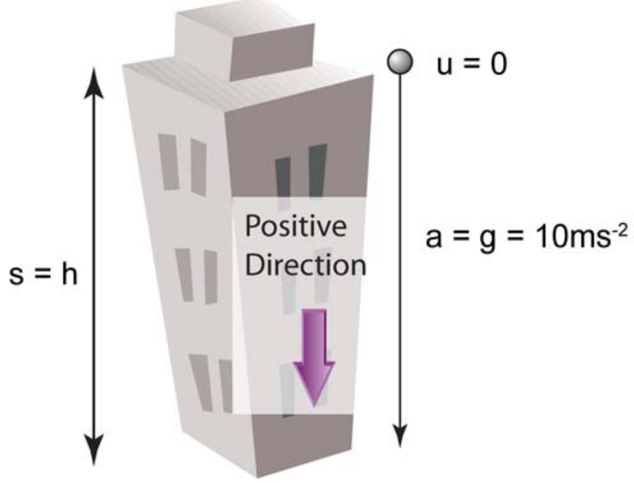
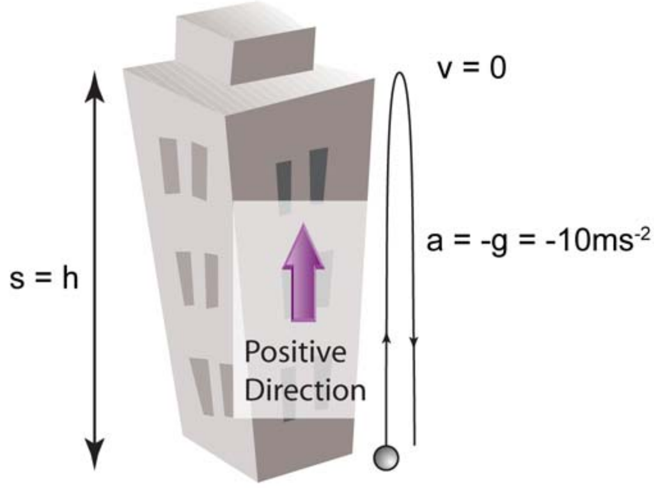
$$g = \frac{F}{m}$$

g = gravitational field strength	*(N kg^{-1})*
F = gravitational force	*(N or $kgms^{-2}$)*
m = mass	*(kg)*

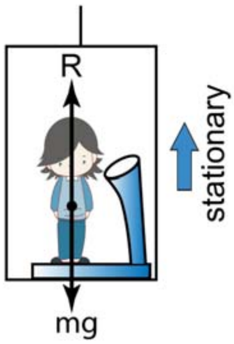
Weight

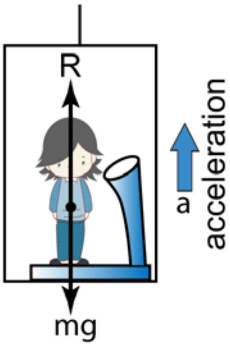
W = Weight	*(N or $kgms^{-2}$)*
m = mass	*(kg)*
g = gravitational field strength/gravitational acceleration	*(ms^{-2})*

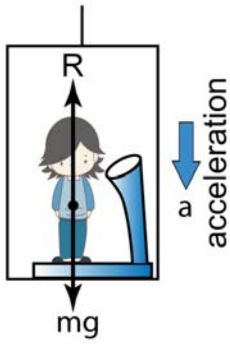
Vertical Motion

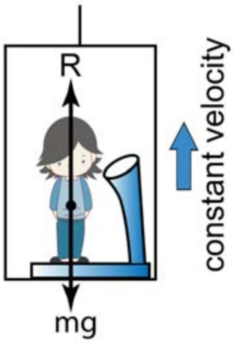
	
• If an object is release from a high position: • The initial velocity, u = 0. • The acceleration of the object = gravitational acceleration = $10ms^{-2}$(or $9.81\ ms^{-2}$). • The displacement of the object when it reach the ground = the height of the original position, h.	• If an object is launched vertically upward: • The velocity at the maximum height, v = 0. • The deceleration of the object = -gravitational acceleration = $-10ms^{-2}$(or $-9.81\ ms^{-2}$). • The displacement of the object when it reach the ground = the height of the original position, h.

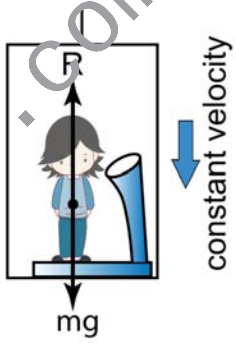
Lift

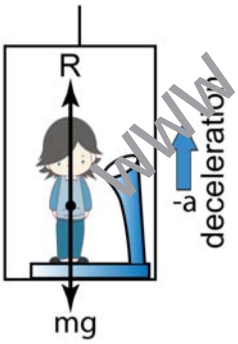
In Stationary	
 $R = mg$	• When a man standing inside an elevator, there are two forces acting on him. (a) His weight, which acting downward. (b) Normal reaction (R), acting in the opposite direction of weight. • The reading of the balance is equal to the normal reaction.

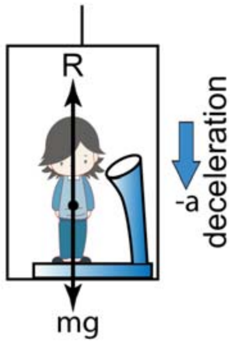
<table>
<tr><td>Moving Upward with positive acceleration</td><td>Moving downward with positive acceleration</td></tr>
<tr><td>

$$R = mg + ma$$</td><td>

$$R = mg - ma$$</td></tr>
<tr><td>Moving Upward with constant velocity</td><td>Moving downward with constant velocity.</td></tr>
<tr><td>

$$R = mg$$</td><td>

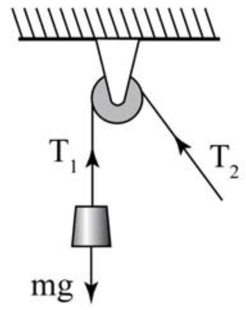
$$R = mg$$</td></tr>
<tr><td>Moving Upward with negative acceleration</td><td>Moving downward with negative acceleration</td></tr>
<tr><td>

$$R = mg - ma$$</td><td>

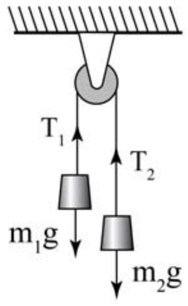
$$R = mg + ma$$</td></tr>
</table>

Smooth Pulley

With 1 Load

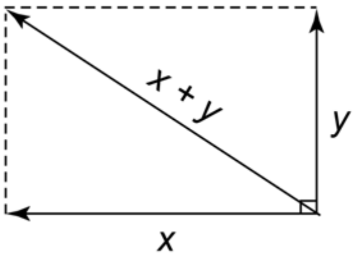
	$T_1 = T_2$	**Moving with uniform speed:** $T_1 = mg$
	Stationary: $T_1 = mg$	**Accelerating:** $T_1 - mg = ma$

With 2 Loads

	**Finding Acceleration:** (If $m_2 > m_1$) $m_2g - m_1g = (m_1 + m_2)a$
	Finding Tension: (If $m_2 > m_1$) $T_1 = T_2$ $T_1 - m_1g = ma$ $m_2g - T_2 = ma$

Vector

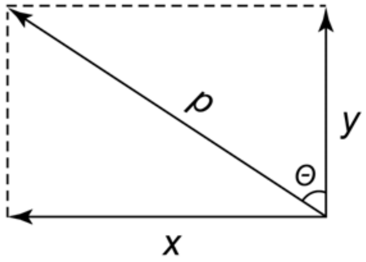
Vector Addition (Perpendicular Vector)



Magnitude = $\sqrt{x^2 + y^2}$

Direction = $\tan^{-1}\frac{|y|}{|x|}$

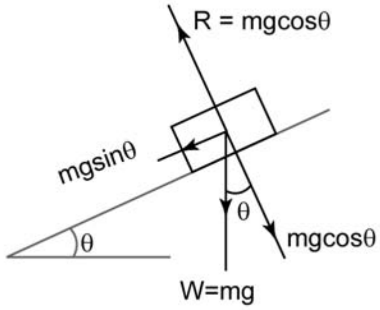
Vector Resolution



$|x| = |p|\sin\theta$

$|y| = |p|\cos\theta$

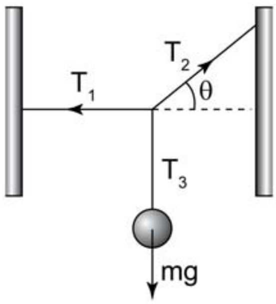
Inclined Plane



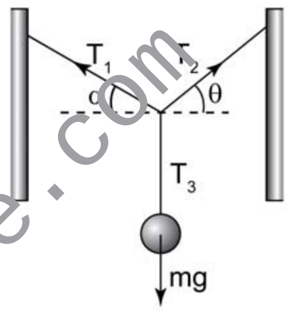
Component parallel to the plane = ***mgsinθ***

Component perpendicular to the plane = ***mgcosθ***

Forces In Equilibrium

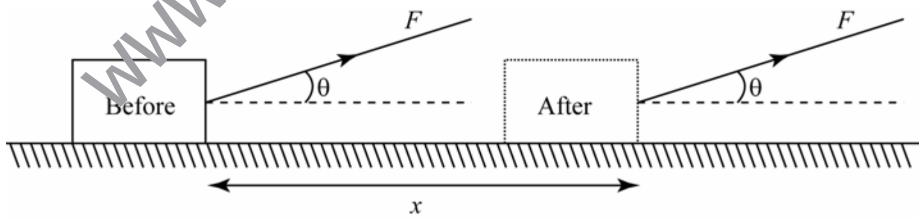


$$T_3 = mg$$
$$T_2 \sin\theta = mg$$
$$T_2 \cos\theta = T_1$$
$$T_1 \tan\theta = mg$$



$$T_3 = mg$$
$$T_2 \cos\theta = T_1 \cos\alpha$$
$$T_2 \sin\theta + T_1 \sin\alpha = mg$$

Work Done



$$W = Fx\cos\theta$$

W = Work Done *(J or Nm)*
F = Force *(N or kgms^{-2})*
x = displacement *(m)*
θ = angle between the force and the direction of motion *(^{o})*

When the force and motion are in the same direction.

Work Done *(J or Nm)*
Force *(N or kgms^{-2})*
lisplacement *(m)*

Energy

Kinetic Energy

$$E_K = \frac{1}{2}mv^2$$

E_K = Kinetic Energy	(J)
m = mass	(kg)
v = velocity	(ms^{-1})

Gravitational Potential Energy

$$E_P = mgh$$

E_P = Potential Energy	(J)
m = mass	(kg)
g = gravitational acceleration	(ms^{-2})
h = height	(m)

Elastic Potential Energy

$$E_P = \frac{1}{2}kx^2$$

$$E_P = \frac{1}{2}Fx$$

E_P = Potential Energy	(J)
k = spring constant	($N\,m^{-1}$)
x = extension of spring	(m)
F = Force	(N)

Power and Efficiency

Power

$$P = \frac{W}{t}$$

$$P = \frac{E}{t}$$

P = power	(W or Js^{-1})
W = work done	(J or Nm)
E = energy change	(J or Nm)
t = time	(s)

Efficiency

$$\text{Efficiency} = \frac{\text{Useful Energy}}{\text{Energy}} \times 100\%$$

Or

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} \times 100\%$$

Hooke's Law

$$F = kx$$

F = Force	(N or $kgms^{-2}$)
k = spring constant	($N\,m^{-1}$)
extension or compression of spring	(m)

Force and Pressure

Density

$$\rho = \frac{m}{V}$$

ρ = density	(kg m^{-3})
m = mass	(kg)
V = volume	(m^3)

Pressure

$$P = \frac{F}{A}$$

P = Pressure	(Pa or N m^{-2})
A = Area of the surface	(m^2)
F = Force acting normally to the surface	(N or kgms^{-2})

Liquid Pressure

$$P = h\rho g$$

h = depth	(m)
ρ = density	(kg m^{-3})
g = gravitational Field Strength	(N kg^{-1})

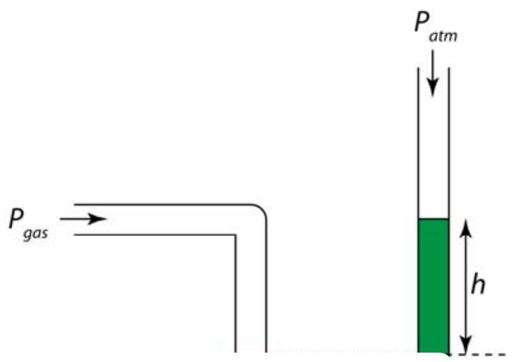
Pressure in Liquid

$$P = P_{atm} + h\rho g$$

h = depth	(m)
ρ = density	(kg m^{-3})
g = gravitational Field Strength	(N kg^{-1})
P_{atm} = atmospheric Pressure	(Pa or N m^{-2})

Gas Pressure

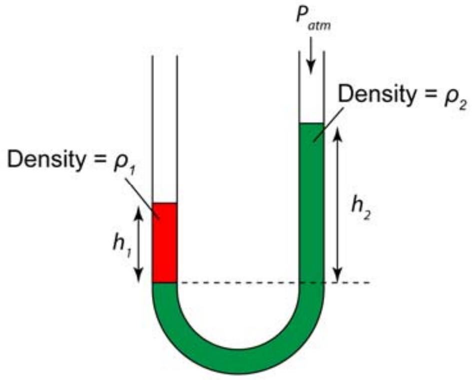
Manometer



$$P = P_{atm} + h\rho g$$

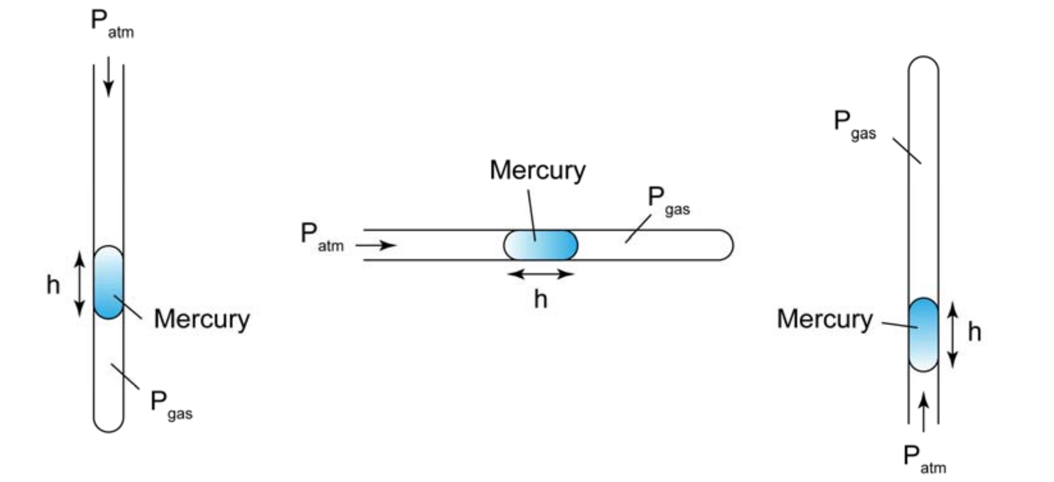
P_{gas} = Pressure	(Pa or N m^{-2})
P_{atm} = Atmospheric Pressure	(Pa or N m^{-2})
g = gravitational field strength	(N kg^{-1})

U=tube



$$h_1\rho_1 = h_2\rho_2$$

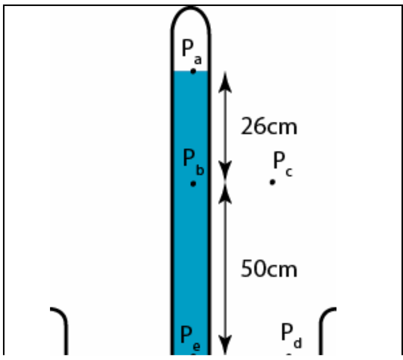
Pressure in a Capillary Tube



$P_{gas} = P_{atm} + h\rho g$ $\quad$ $P_{gas} = P_{atm}$ $\quad$ $P_{gas} = P_{atm} - h\rho g$

P_{gas} = gas pressure in the capillary tube (Pa or N m^{-2})
P_{atm} = atmospheric pressure (Pa or N m^{-2})
h = length of the captured mercury (m)
ρ = density of mercury (kg m^{-3})
g = gravitational field strength (N kg^{-1})

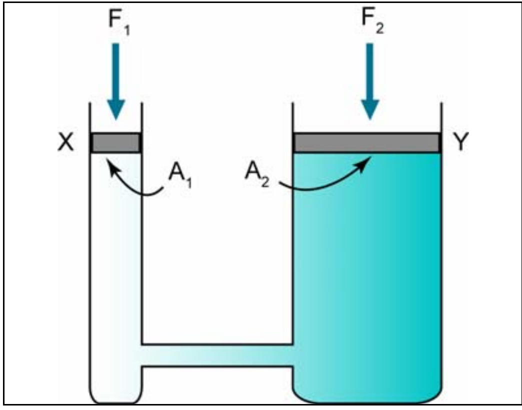
Barometer



Pressure in unit cmHg	Pressure in unit Pa
$P_a = 0$	$P_a = 0$
$P_b = 26$	$P_b = 0.26\times13600\times10$
$P_c = 76$	$P_c = 0.76\times13600\times10$
$P_d = 76$	$P_d = 0.76\times13600\times10$
$P_e = 76$	$P_e = 0.76\times13600\times10$
84	$P_f = 0.84\times13600\times10$

(Density of mercury = 13600kgm^{-3})

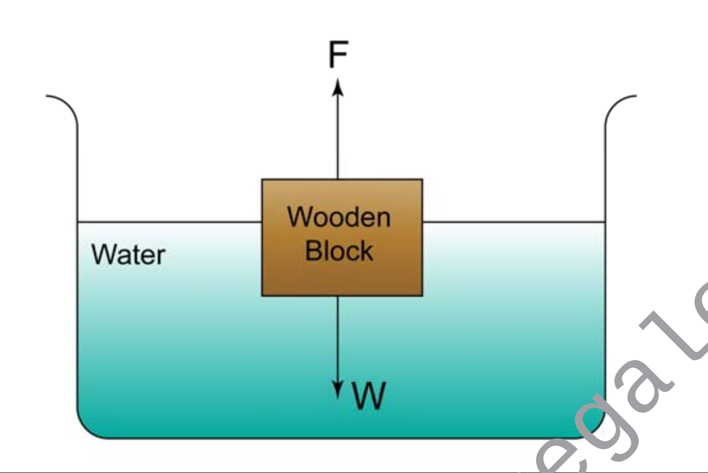
Pascal's Principle



$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

F_1 = *Force exerted on the small piston*
A_1 = *area of the small piston*
F_2 = *Force exerted on the big piston*
A_2 = *area of the big piston*

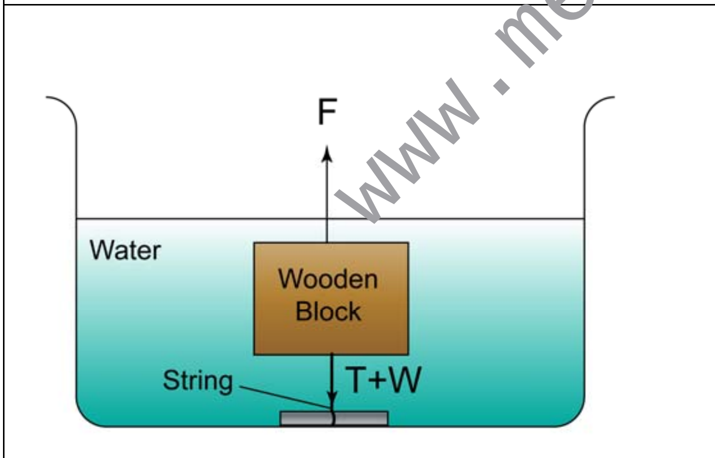
Archimedes Principle

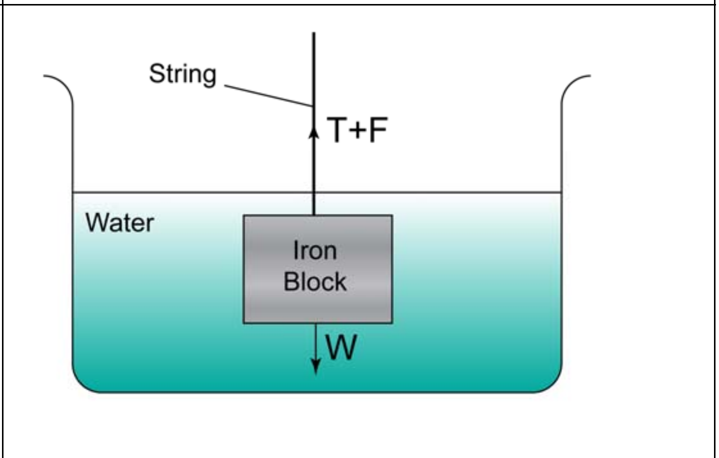


Weight of the object, $W = \rho_1 V_1 g$

Upthrust, $F = \rho_2 V_2 g$

ρ_1 = *density of wooden block*
V_1 = *volume of the wooden block*
ρ_2 = *density of water*
V_2 = *volume of the displaced water*
g = *gravitational field strength*





Density of water > Density of wood

F = T + W

$$\rho Vg = T + mg$$

Density of Iron > Density of water

T + F = W

$$\rho Vg + T = mg$$

Heat

Heat Change

$$Q = mc\theta$$

m = mass	*(kg)*
c = specific heat capacity	*(J kg^{-1} ^{o}C^{-1})*
θ = temperature change	*(^{o})*

Electric Heater	Mixing 2 Liquid
Energy Supply, $E = Pt$ Energy Receive, $Q = mc\theta$ Energy Supply, E = Energy Receive, Q $Pt = mc\theta$ *E = electrical Energy (J or Nm)* *P = Power of the electric heater (W)* *t = time (in second) (s)* *Q = Heat Change (J or Nm)* *m = mass (kg)* *c = specific heat capacity (J kg^{-1} ^{o}C^{-1})* *θ = temperature change (^{o})*	Heat Gain by Liquid 1 = Heat Loss by Liquid 2 $m_1c_1\theta_1 = m_2c_2\theta_2$ *m_1 = mass of liquid 1* *c_1 = specific heat capacity of liquid 1* *θ_1 = temperature change of liquid 1* *m_2 = mass of liquid 2* *c_2 = specific heat capacity of liquid 2* *θ_2 = temperature change of liquid 2*

Specific Latent Heat

$$Q = mL$$

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

Boyle's Law

$$P_1V_1 = P_2V_2$$

(Requirement: Temperature in constant)

Pressure Law

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

Charles's Law

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

(Requirement: Pressure is constant)

Universal Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

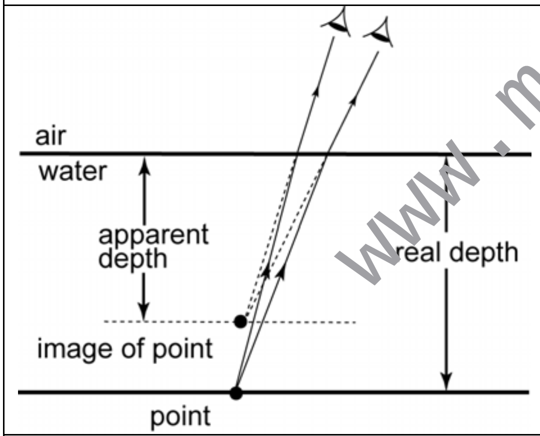
P = Pressure *(Pa or cmHg …….)*
V = Volume *(m^3 or cm^3)*
T = Temperature *(MUST be in K(Kelvin))*

Light

Refractive Index

Snell's Law

Real depth/Apparent Depth

	$$n = \frac{\sin i}{\sin r}$$ *n = refractive index (No unit)* *i = angle of incident (°)* *r = angle of reflection (°)*
	$$n = \frac{D}{d}$$ *n = refractive index (No unit)* *D = real depth (m or cm…)* *d = apparent depth (m or cm…)*
Speed of light $$n = \frac{c}{v}$$ *n = refractive index (No unit)* *c = speed of light in vacuum (ms^{-1})* *v = speed of light in a medium (like water,*	**Total Internal Reflection** $$n = \frac{1}{\sin c}$$ *n = refractive index (No unit)* *c = critical angle (°)*

Lens

Power

$$P = \frac{1}{f}$$

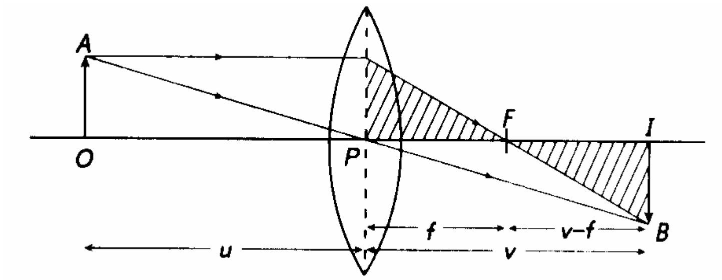
P = Power	*(D(Diopter))*
f = focal length	*(m)*

Linear Magnification

$$m = \frac{h_i}{h_o} \qquad m = \frac{v}{u} \qquad \frac{h_i}{h_o} = \frac{v}{u}$$

m = linear magnification	*(No unit)*
u = distance of object	*(m or cm…)*
v = distance of image	*(m or cm…)*
h_i *= heigth of image*	*(m or cm…)*
h_o *= heigth of object*	*(m or cm…)*

Lens Equation



$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Conventional symbol

	positive	negative
u	Real object	Virtual object
v	Real image	Virtual image
f	Convex lens	Concave lens

Astronomical Telescope

Magnification,

$$m = \frac{P_e}{P_o} \qquad m = \frac{f_o}{f_e}$$

m = linear magnification
P_e = Power of the eyepiece
P_o = Power of the objective lens
f_e = focal length of the eyepiece
f_o = focal length of the objective lens

Distance between eye lens and objective lens

$$d = f_o + f_e$$

d = Distance between eye lens and objective lens
f_e = focal length of the eyepiece
f_o = focal length of the objective lens

Compound Microscope

Magnification

$$m = m_1 \times m_2$$
$$= \frac{\text{Height of first image}, I_1}{\text{Height of object}} \times \frac{\text{Height of second image}, I_2}{\text{Height of first image}, I_1}$$
$$= \frac{\text{Height of second image}, I_2}{\text{Height of object}, I_1}$$

m = Magnification of the microscope
m_1 = Linear magnification of the object lens
m_2 = Linear magnification of the eyepiece

Distance in between the two lens

$$d > f_o + f_e$$

d = Distance between eye lens and objective lens
f_e = focal length of the eyepiece
f_o = focal length of the objective lens