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 $(\frac{1}{100} m)$

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

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

Force and Motion

Average Speed

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

Velocity

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

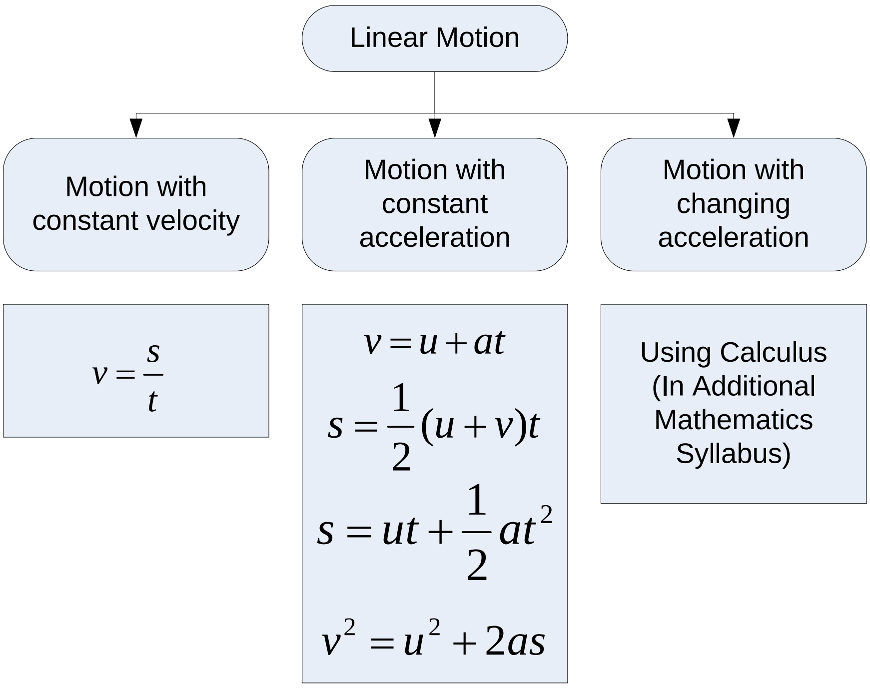
v = velocity	*(ms^{-1})*
s = displacement	*(m)*
t = time	*(s)*

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)*

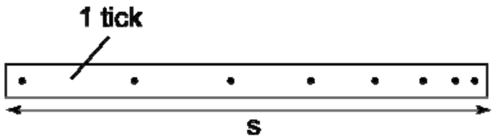
Equation of Linear Motion



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

Ticker Tape

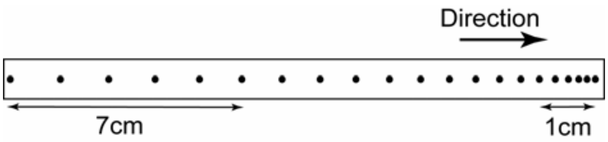
Finding Velocity:



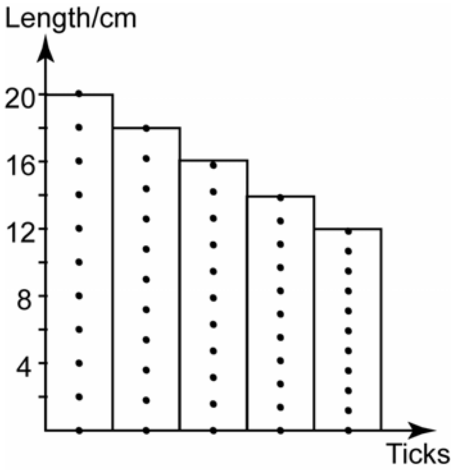
$$\text{velocity} = \frac{s}{\text{number of ticks} \times 0.02\text{s}}$$

1 tick = 0.02s

Finding Acceleration:



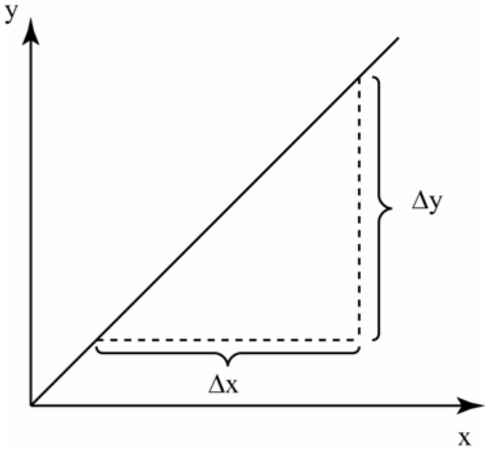
$$a = \frac{v-u}{t}$$



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

Graph of Motion

Gradient of a Graph

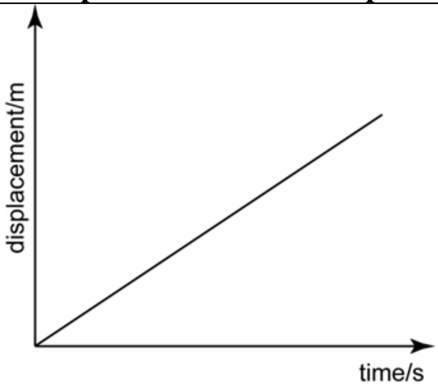
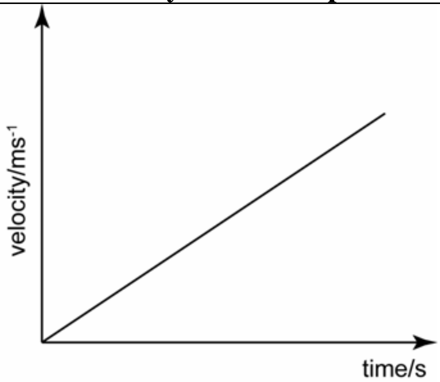


The gradient 'm' of a line segment between two points and is defined as follows:

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

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

$$\text{Impulse} = Ft$$

F = force	*(N)*
t = time	*(s)*

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

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

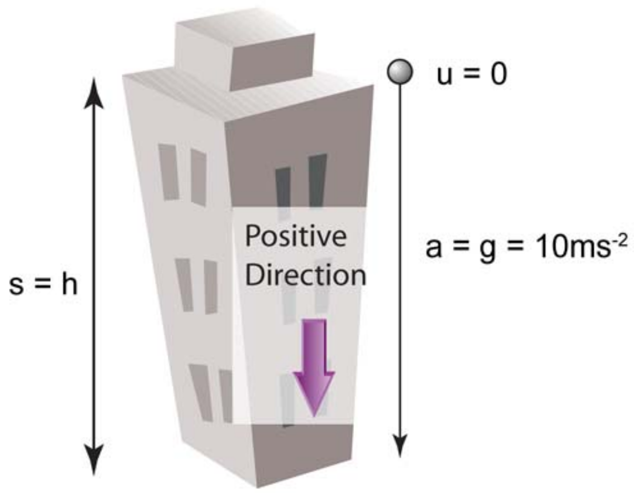
$$g = \frac{F}{m}$$

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

Weight

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

Vertical Motion

<table>
<tr>
<td>
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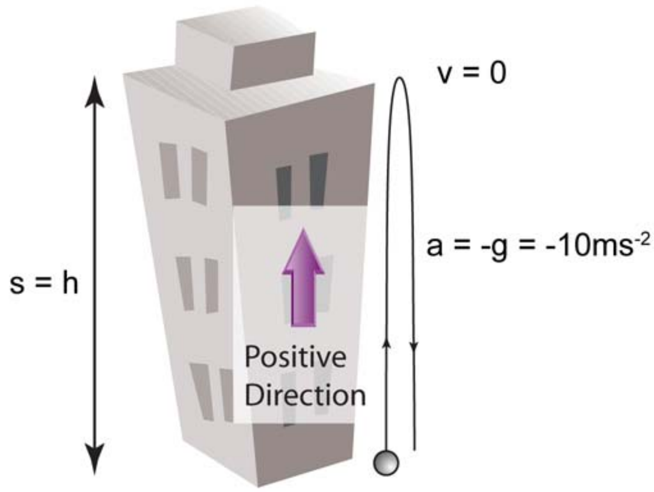
<td>
</td>
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<td>

- 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.

</td>
<td>

- 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.

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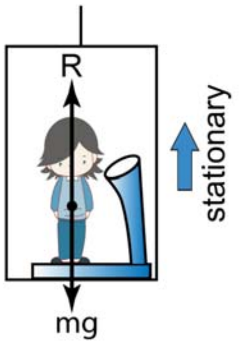
</table>

Lift

<table>
<tr>
<td>In Stationary</td>
<td></td>
</tr>
<tr>
<td>

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

- 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.

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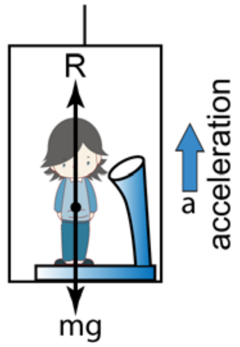
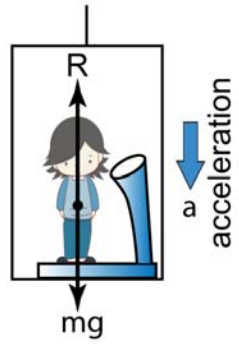
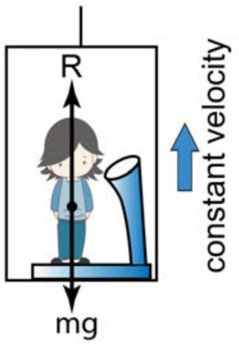
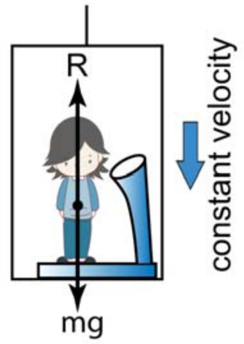
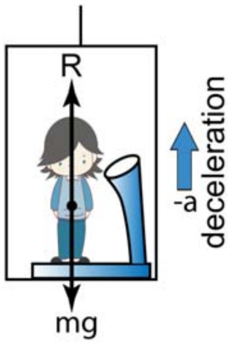
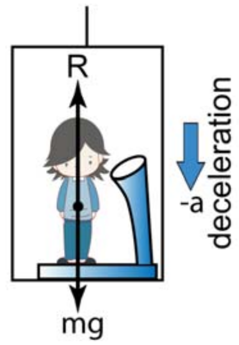
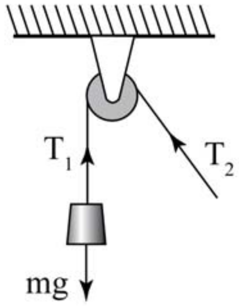
</table>

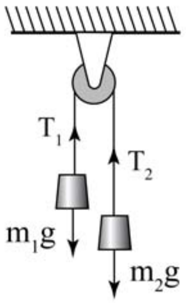
Moving Upward with positive acceleration	Moving downward with positive acceleration
 $R = mg + ma$	 $R = mg - ma$
Moving Upward with constant velocity	**Moving downward with constant velocity.**
 $R = mg$	 $R = mg$
Moving Upward with negative acceleration	**Moving downward with negative acceleration**
 $R = mg - ma$	 $R = mg + ma$

Smooth Pulley

With 1 Load

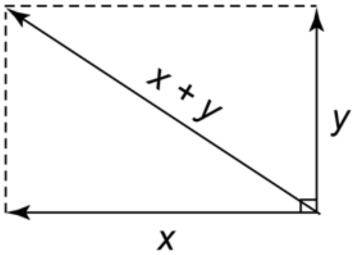
<table>
<tr><td rowspan="2"></td><td>$T_1 = T_2$</td><td>Moving with uniform speed:
$T_1 = mg$</td></tr>
<tr><td>Stationary:
$T_1 = mg$</td><td>Accelerating:
$T_1 - mg = ma$</td></tr>
</table>

With 2 Loads

<table>
<tr><td rowspan="2"></td><td>Finding Acceleration:
(If $m_2 > m_1$)
$m_2g - m_1g = (m_1 + m_2)a$</td></tr>
<tr><td>Finding Tension:
(If $m_2 > m_1$)
$T_1 = T_2$
$T_1 - m_1g = ma$
$m_2g - T_2 = ma$</td></tr>
</table>

Vector

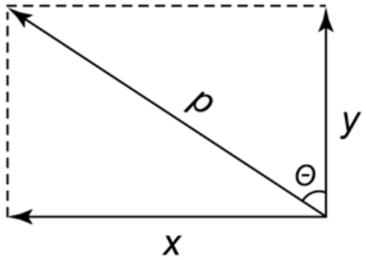
Vector Addition (Perpendicular Vector)



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

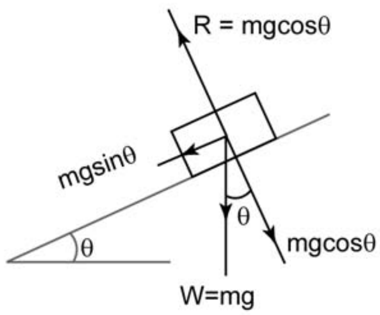
Direction = $\tan^{-1}\frac{|y|}{|x|}$

Vector Resolution



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

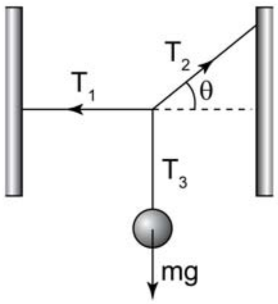
Inclined Plane



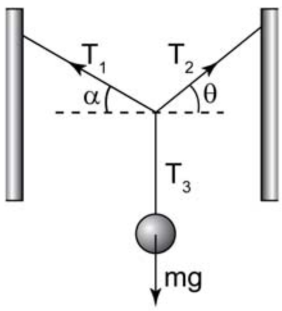
Component parallel to the plane = ***mgsin*θ**

Component perpendicular to the plane = ***mgcos*θ**

Forces In Equilibrium

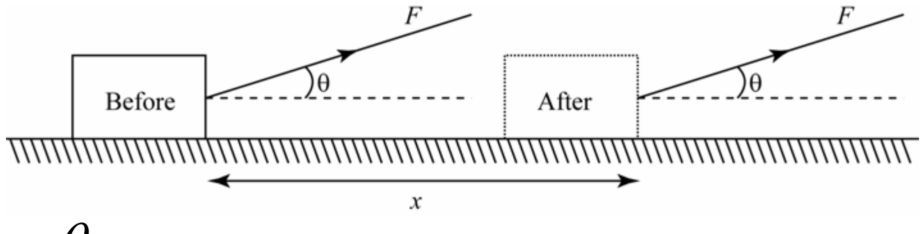


$$T_3 = mg$$
$$T_2 \sin\theta = mg$$
$$T_2 \cos\theta = T_1$$
$$T_1 \tan\theta = mg$$



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

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.

$$W = Fs$$

W = Work Done *(J or Nm)*
F = Force *(N or kgms^{-2})*
s = displacement *(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 = Potential Energy (J)
k = spring constant ($N\ m^{-1}$)
x = extension of spring (m)

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

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 ($N\ m^{-1}$)
x = 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})

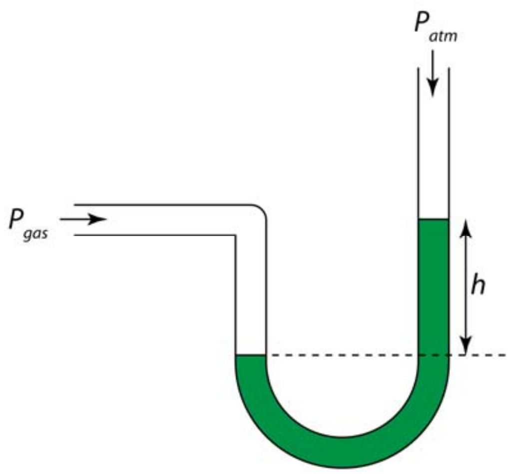
Pressure in Liquid

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

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



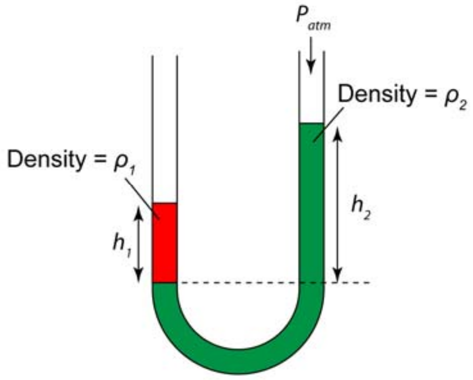
$$P = P_{atm} + h\rho g$$

P_{gas} = Pressure (Pa or N m^{-2})

P_{atm} = Atmospheric Pressure (Pa or N m^{-2})

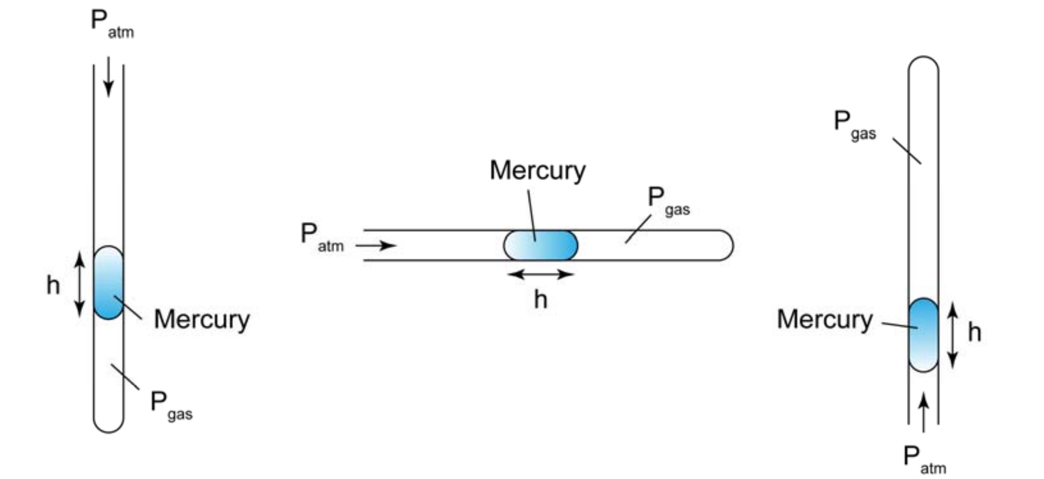
g = gravitational field strength (N kg^{-1})

U=tube



$$h_1\rho_1 = h_2\rho_2$$

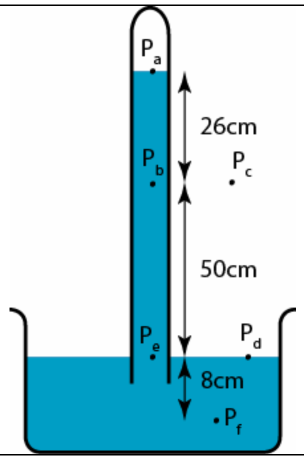
Pressure in a Capillary Tube



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

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})*

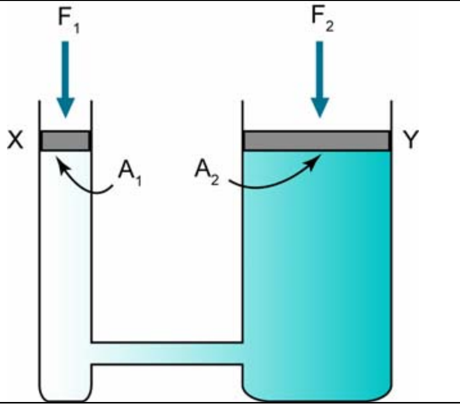
Barometer



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

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

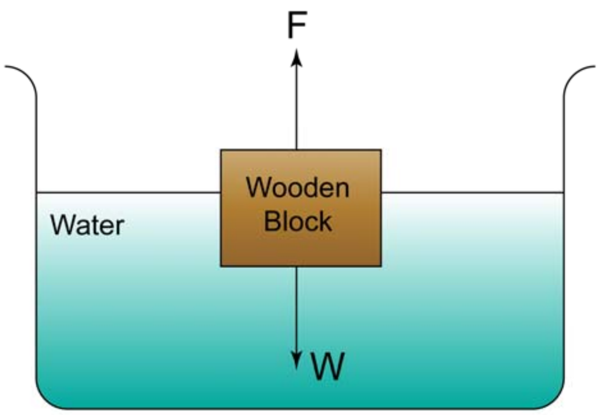
Pascal's Principle



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

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

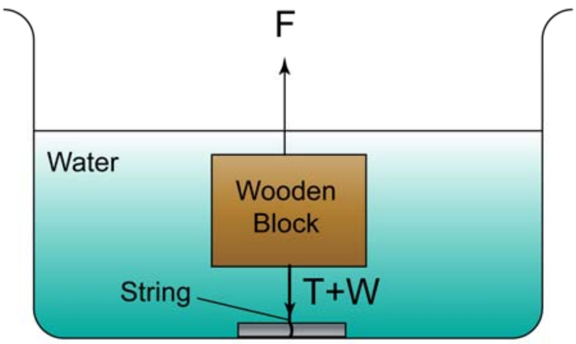
Archimedes Principle



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

Upthrust, $F = \rho_2 V_2 g$

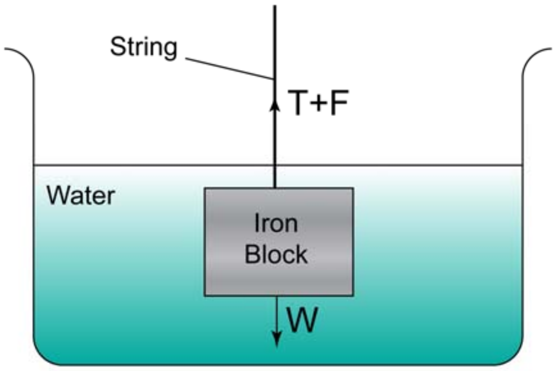
ρ_1 = density of wooden block
V_1 = volume of the wooden block
ρ_2 = density of water
V_2 = volume of the displaced water
g = gravitational field strength



Density of water > Density of wood

F = T + W

$$\rho V g = T + mg$$



Density of Iron > Density of water

T + F = W

$$\rho V g + T = mg$$

Heat

Heat Change

$$Q = mc\theta$$

m = mass (kg)
c = specific heat capacity ($J\ kg^{-1}\ {}^oC^{-1}$)
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* ($J\ kg^{-1}\ {}^oC^{-1}$) 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

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

(Requirement: Volume is constant)

Charles's Law

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

(Requirement: Pressure is constant)

Universal Gas Law

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

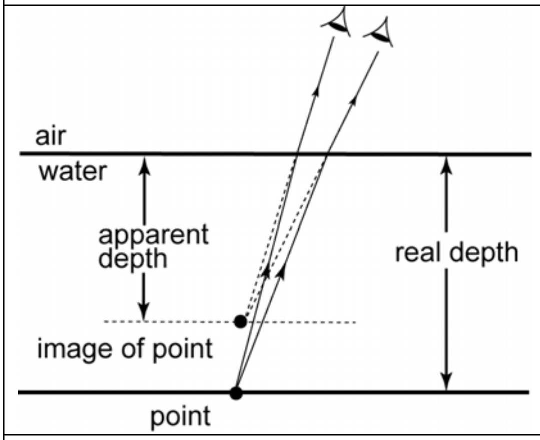
P = Pressure (Pa or cmHg …….)
V = Volume (m^3 or cm^3)
T = Temperature (MUST be in K(Kelvin))

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, glass …) (ms^{-1})*	**Total Internal Reflection** $n = \frac{1}{\sin c}$ *n = refractive index (No unit)* *c = critical angle (°)*

Lens

Power

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

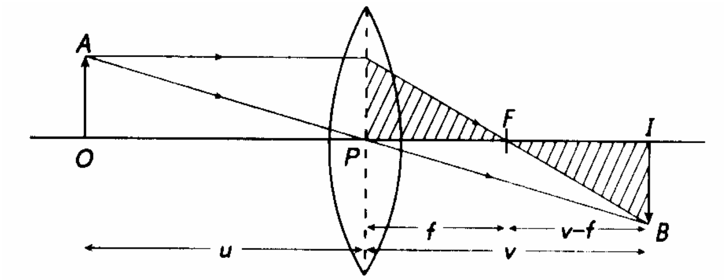
P = Power	*(D(Diopter))*
f = focal length	*(m)*

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,

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

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

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

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*