# 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

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

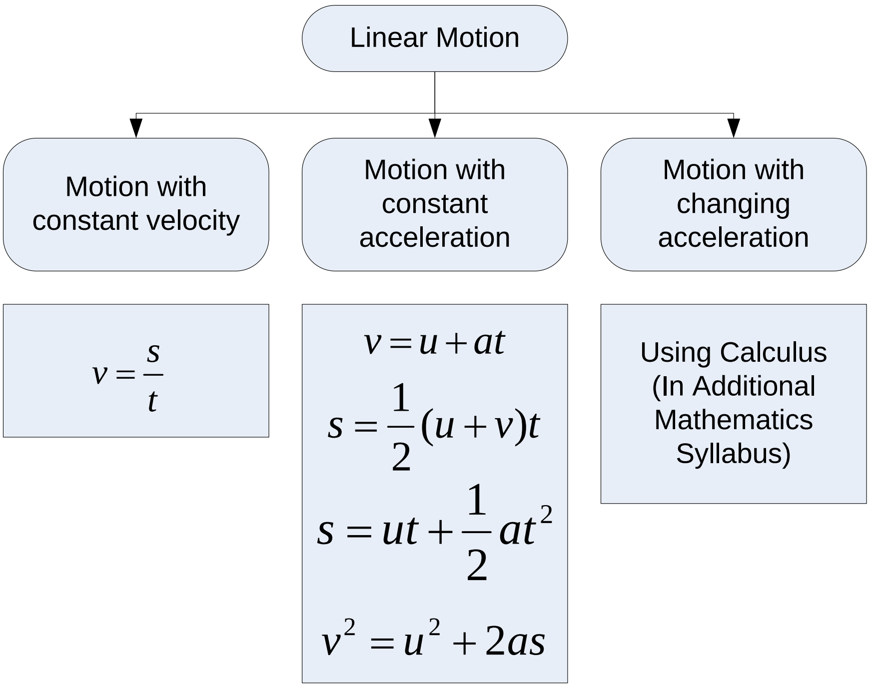
*v* = *velocity* (*ms*$^{-1}$)
*s* = *displacement* (*m*)
*t* = *time* (*s*)

## 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*)

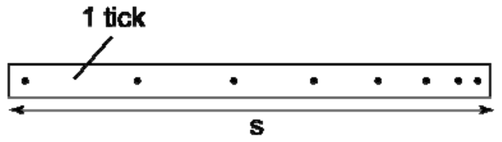
## Equation of Linear Motion




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

# Ticker Tape

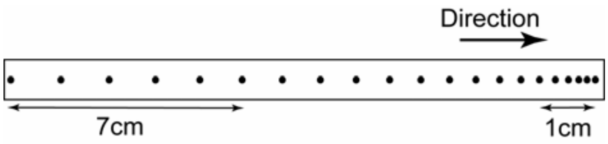
## Finding Velocity:



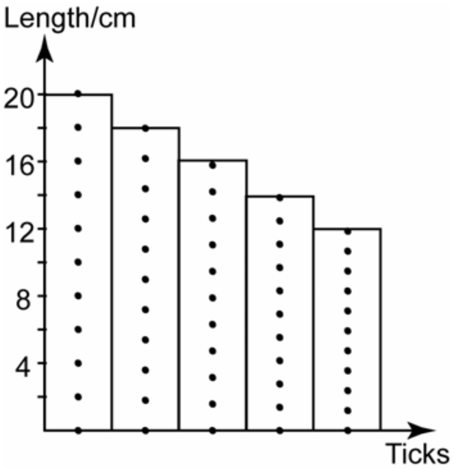

$$\text{velocity} = \frac{s}{\text{number of ticks} \times 0.02\text{s}}$$

1 tick = 0.02s

## Finding Acceleration:



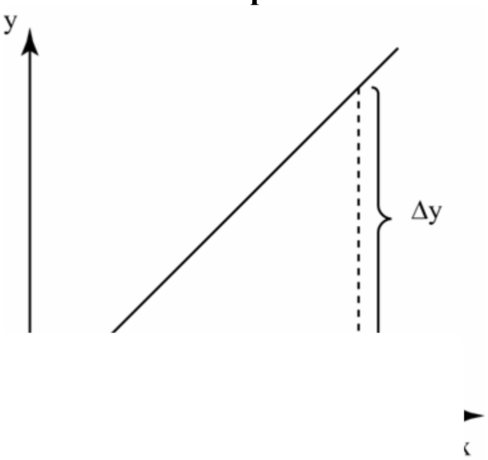

$$a = \frac{v-u}{t}$$




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

## Graph of Motion

### Gradient of a Graph

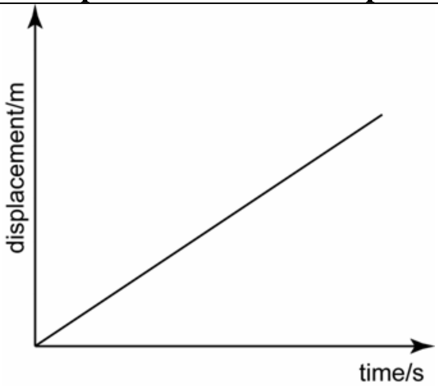
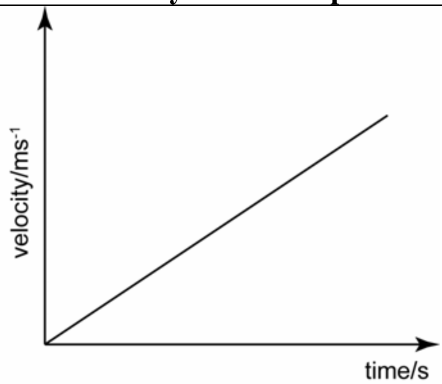



The gradient 'm' of a line segment between two points and is defined as follows:

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

*or*

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

| Displacement-Time Graph | Velocity-Time Graph |
|---|---|
|  |  |
| Gradient = Velocity ($ms^{-1}$) | Gradient = Acceleration ($ms^{-2}$)<br><br>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

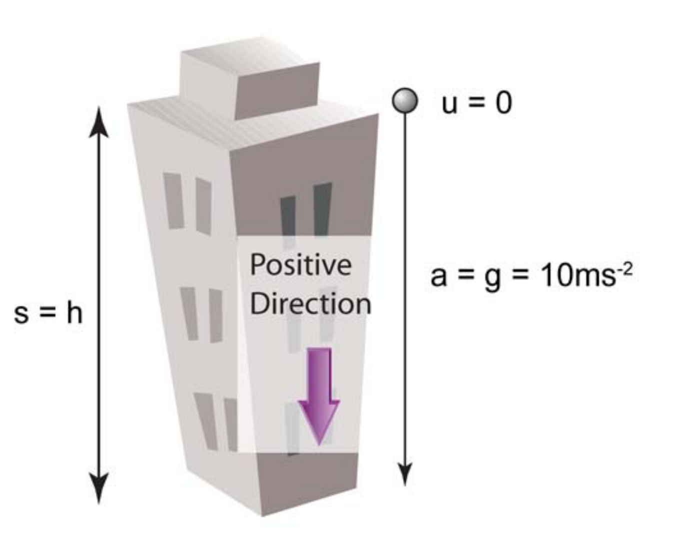
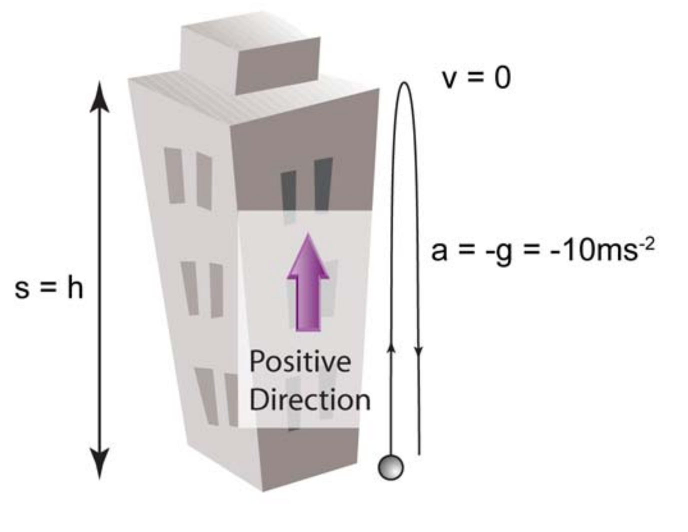
$$g = \frac{F}{m}$$

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

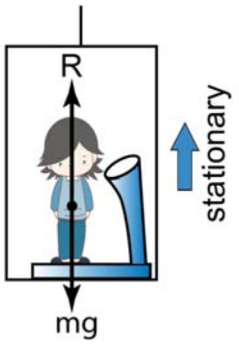
## Weight

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

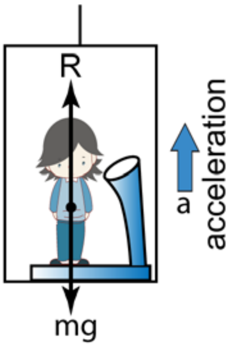
**Vertical Motion**

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

**Lift**

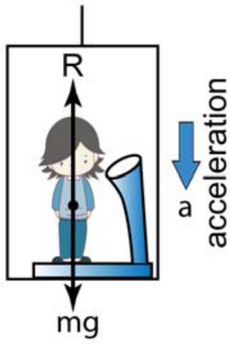
| **In Stationary** | |
|---|---|
|   $R = mg$ | • When a man standing inside an elevator, there are two forces acting on him.<br>(a) His weight, which acting downward.<br>(b) Normal reaction (R), acting in the opposite direction of weight.<br><br>• The reading of the balance is equal to the normal reaction.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

**Moving Upward with positive acceleration**



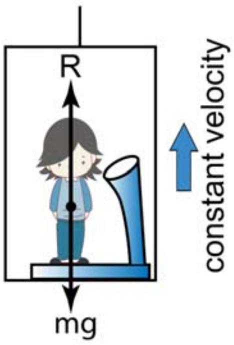

$$R = mg + ma$$

**Moving downward with positive acceleration**



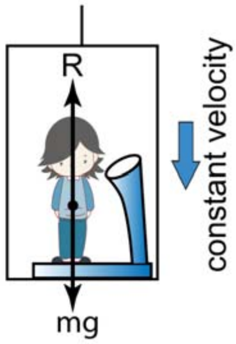

$$R = mg - ma$$

**Moving Upward with constant velocity**



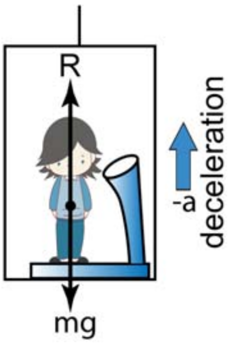

$$R = mg$$

**Moving downward with constant velocity.**



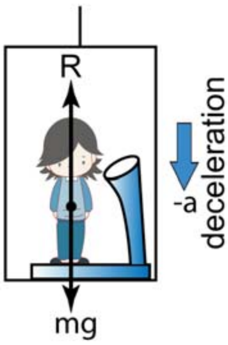

$$R = mg$$

**Moving Upward with negative acceleration**




$$R = mg - ma$$

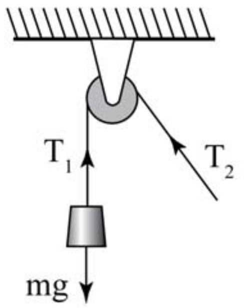
**Moving downward with negative acceleration**



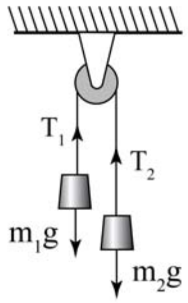

$$R = mg + ma$$

## Smooth Pulley

### With 1 Load

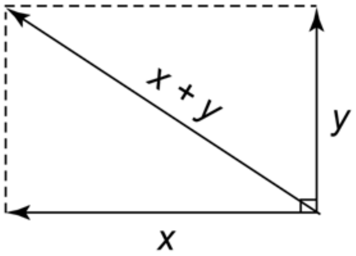
| | | |
|---|---|---|
|  | $T_1 = T_2$ | **Moving with uniform speed:** $T_1 = mg$ |
| | **Stationary:** $T_1 = mg$ | **Accelerating:** $T_1 - mg = ma$ |

### With 2 Loads

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

## Vector

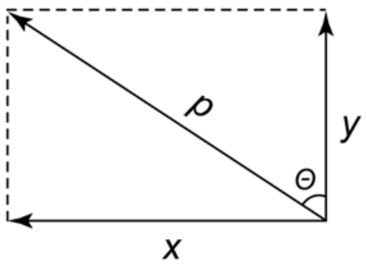
### Vector Addition (Perpendicular Vector)




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

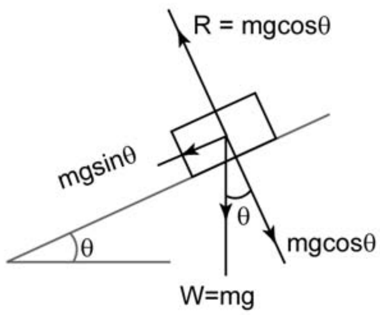
Direction = $\tan^{-1}\dfrac{|y|}{|x|}$

### Vector Resolution




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

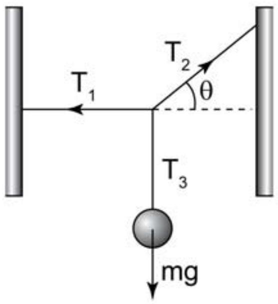
## Inclined Plane



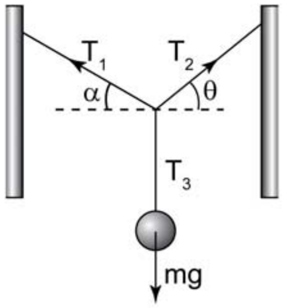

Component parallel to the plane = ***mgsinθ***

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

## Forces In Equilibrium

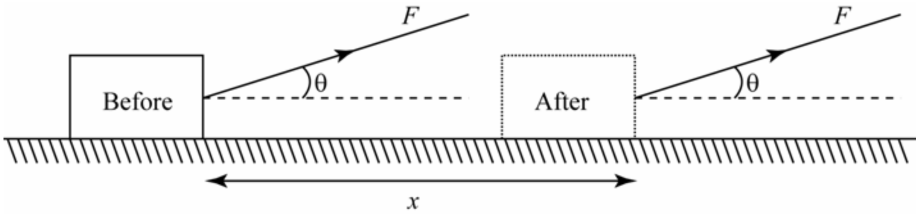



$$T_3 = mg$$
$$T_2 \sin\theta = mg$$
$$T_2 \cos\theta = T_1$$
$$T_1 \tan\theta = mg$$




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

## Work Done




$$W = Fx\cos\theta$$

*W = Work Done* *(J or Nm)*
*F = Force* *(N or kgms$^{-2}$)*
*x = displacement* *(m)*
*$\theta$ = 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

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

$\rho$ = *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*)
$\rho$ = *density* ($kg\ m^{-3}$)
*g* = *gravitational Field Strength* ($N\ kg^{-1}$)

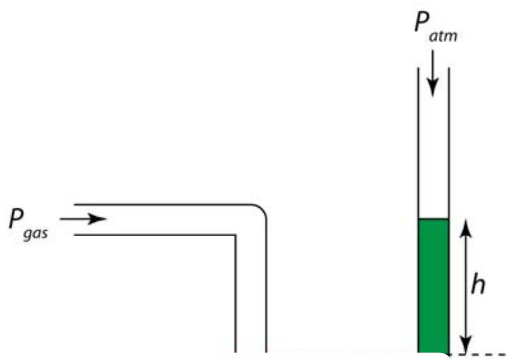
## Pressure in Liquid

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

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

## Gas Pressure

### Manometer



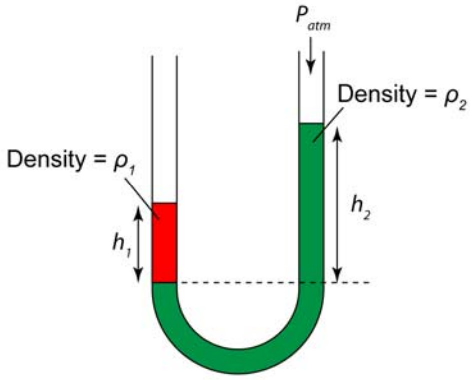

$$P = P_{atm} + h\rho g$$

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

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

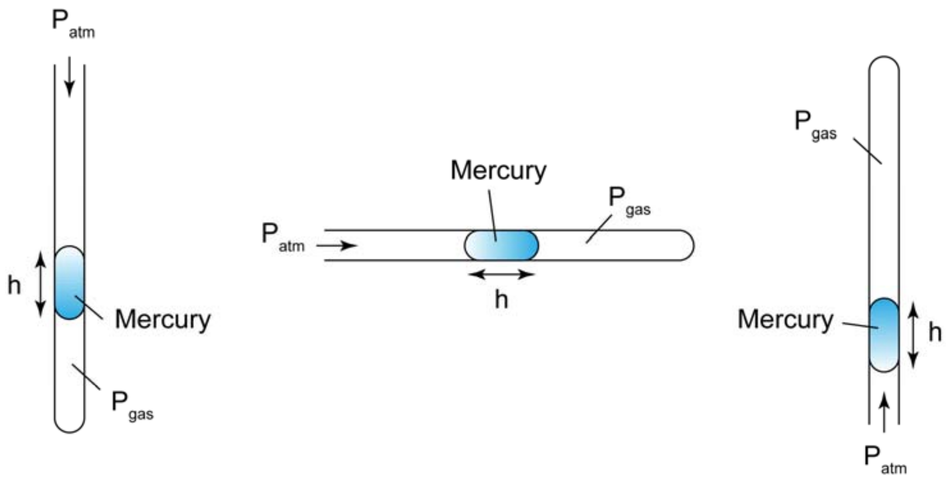
*g* = *gravitational field strength* ($N\ kg^{-1}$)

**U=tube**




$$h_1\rho_1 = h_2\rho_2$$

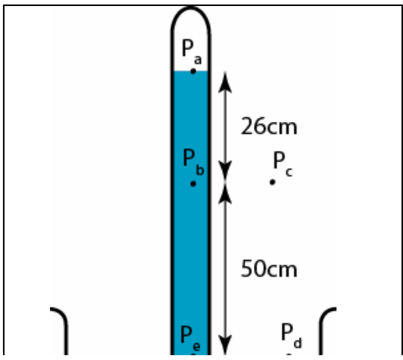
## Pressure in a Capillary Tube




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

| | |
|---|---|
| *$P_{gas}$ = 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)* |
| *$\rho$ = density of mercury* | *(kg $m^{-3}$)* |
| *g = gravitational field strength* | *(N $kg^{-1}$)* |

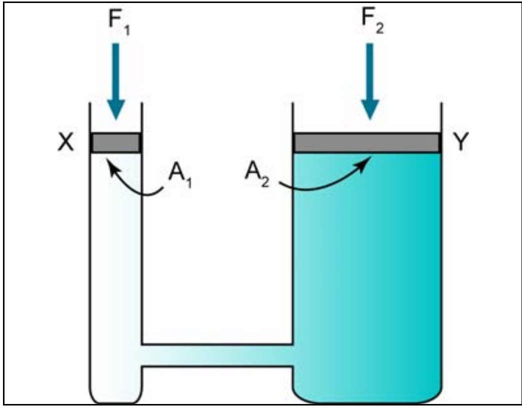
## Barometer




| Pressure in unit cmHg | Pressure in unit Pa |
|---|---|
| $P_a$ = 0 | $P_a$ = 0 |
| $P_b$ = 26 | $P_b$ = 0.26×13600×10 |
| $P_c$ = 76 | $P_c$ = 0.76×13600×10 |
| $P_d$ = 76 | $P_d$ = 0.76×13600×10 |
| $P_e$ = 76 | $P_e$ = 0.76×13600×10 |
| 84 | $P_f$ = 0.84×13600×10 |

(Density of mercury = 13600kg$m^{-3}$)

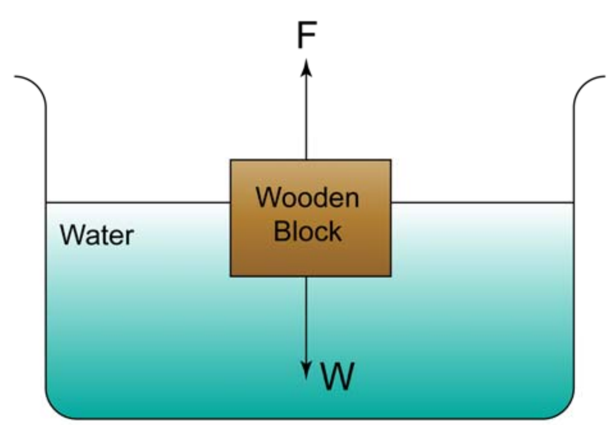
## Pascal's Principle




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

*$F_1$ = 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*

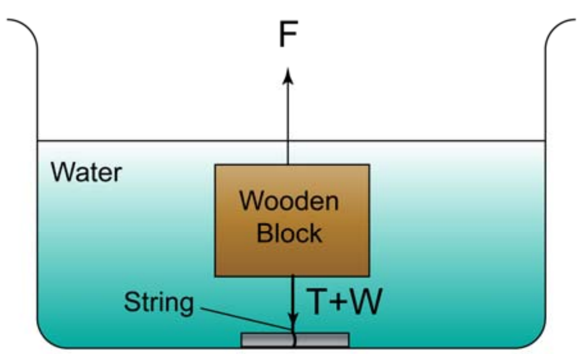
## Archimedes Principle




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

Upthrust, $F = \rho_2 V_2 g$

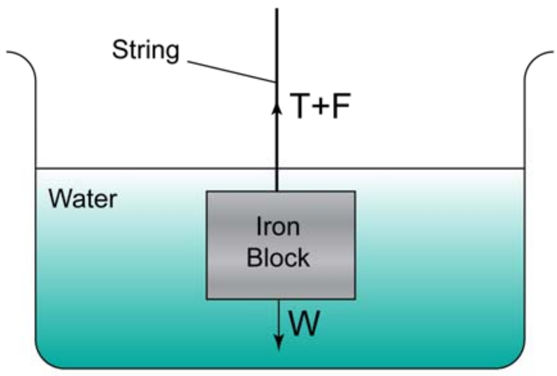
*$\rho_1$ = density of wooden block*
*$V_1$ = volume of the wooden block*
*$\rho_2$ = density of water*
*$V_2$ = volume of the displaced water*
*g = gravitational field strength*




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$^{-1}$ $^{o}$C$^{-1}$) |
| $\theta$ = temperature change | ($^{o}$) |

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

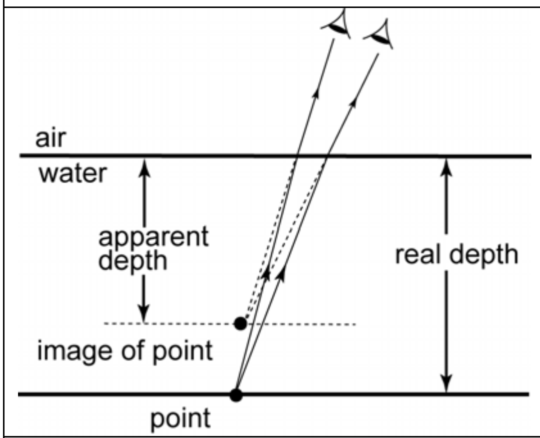
**Refractive Index**

**Snell's Law**

**Real depth/Apparent Depth**

$$n = \frac{\sin i}{\sin r}$$

*n = refractive index* (No unit)
*i = angle of incident* ($^o$)
*r = angle of reflection* ($^o$)




$$n = \frac{D}{d}$$

*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* ($^o$)

**Power**

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

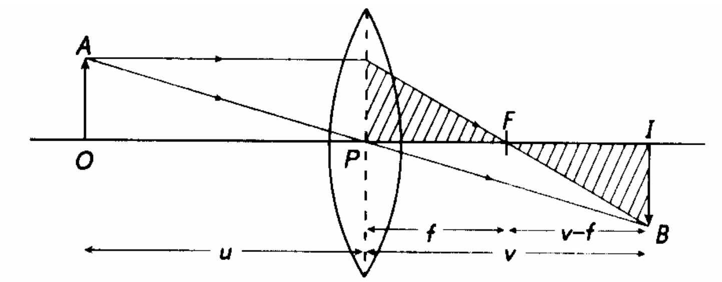
| | |
|---|---|
| $P$ = *Power* | *(D(Diopter))* |
| $f$ = *focal length* | *(m)* |

**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*