ملخص

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مادة الفيزياء العملية 1

Introduction:

Mean $(\bar{x}) = \frac{1}{N} \sum_{i=1}^{N} xi$

Standard deviation $\sigma = \sqrt{\frac{\sum_{i=1}^{N}(xi-\bar{x})^2}{N}}$

Where d_i (x_i-x) is the deviation of the i_{th} value from the mean.

For a small number of measurements (ten or less):

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(xi-x)^2}{N-1}}$$

Accuracy and precision :

- The micrometer is more accurate than the caliper which is more accurate than the meter stick.
- An instrument must be properly calibrated before it can be used.

Types of errors:

1) Personal errors
2) Systematic errors
3) Random errors

1- Personal errors: examples:

-errors in performing a series of measurements

-errors in reading scales [parallax]; change the position of eye during taking the reading.

2- systematic errors:

Associated with particular measuring instruments.

Examples:

-an improperly zeroed instrument.

*أن تكون الأداة غير مصفَّرة عند بداية القياس، من المحتمل أن تحدث هذه الأخطاء عند استخدام الميزان والأميتر.

-an improperly calibrated thermometer

-a meter stick that reads higher due to environmental conditions.

3- Random errors: examples:

-unpredictable fluctuations in temperature or voltage.

-mechanical vibration

→ reducing random errors can be made by improving experimental techniques and repeating the measurement a sufficient number of times and repeating the average value.

To express errors in our calculations:

If the acceptable value is known, then use:

1-absolute error = |accepted value-measured value|

2- relative error = $\frac{|experimental\ value - accepte\ \ \ value|}{accepted\ value} \times 100\%$

If the acceptable value is not known, then use:

3-percent difference: $\frac{|E2-E1|}{(E2-E1)/2} \times 100\%$

where E1 is 1st measurement, E2 is 2nd measurement.

For 3 or more measurements:

4- $\frac{|max\ value - min\ value|}{average} \times 100\%$

5-express errors using σ:

Error = $\sqrt{\frac{\sigma}{N}}$

Propagation of error:

1) $x \pm \Delta x \ \pm \ y \pm \Delta y$ R=Ax+By *OR* R=Ax-By

→then, $\Delta R = \sqrt{A \triangle x^2 + B \triangle y^2}$

2) $x \pm \Delta x \ \times \div \ y \pm \Delta y$ R=XY *OR* R=X/Y

→then, $\frac{\triangle R}{R} = \sqrt{(\frac{\triangle X}{X})^2 + (\frac{\triangle Y}{Y})^2}$

3) R= X^n ,then:

$\frac{\triangle R}{R} = n\frac{\triangle X}{X}$

Empirical relationships:

y= mx + b ← → y-intercept

↓ slope

when a relationship between 2 variables is not linear, it is sometimes possible to make a simple change of variables such that a linear relationship is obtained.

Example :

1) y= c x^m

Log y = log c * x^m → log y = m log x + log c

2) y= $\frac{x^m}{c}$

Log y = log x^m /c → log y = m log x - log c

➔ Uncertainty in slope = $\left|\frac{slope\ \max - slope\ min}{2}\right|$

Experiment 1

"Analysis of data"

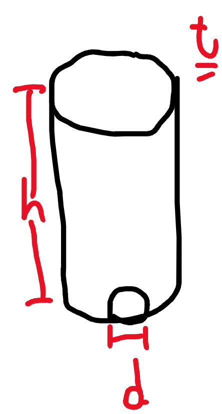
In this experiment, we want to study the relationship among three parameters:

1- the height of the water in a container. (h)

2- the diameter of a hole in the bottom of the container. (d)

3-the time needed to empty the container. (t)

- The parameters h and d can change freely without ant constraint, and so, they are called independent parameters.
- On the other hand, once we have specific values of h and d, we will get a specific value of t. so, t is called a dependent parameter.



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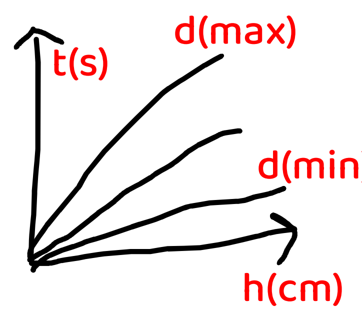
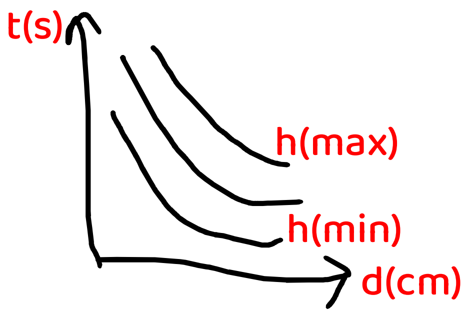
1) time versus height for different values of diameters.

-conclusion: we see that for a specific value of d the relationship between h and t is direct.

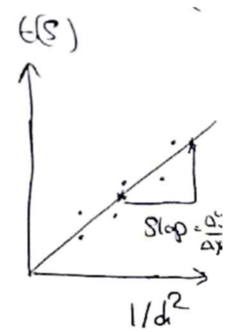


2) we want to plot the time versus the diameter for different values of height.

-conclusion: the relationship between *d* and *t* is inverse.



3) for h=10 cm, we want to plot *t* versus *1/d²*

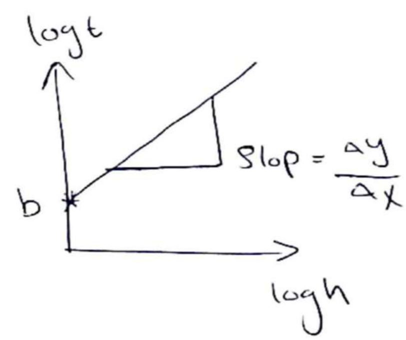


Here b=0, Find the slope:

$t = m/d^2 + b \rightarrow m = \Delta t/\Delta(1/d^2)$ s.m²

{ $t = m/d^2$, h=10 cm } → this represents an empirical relationship between t and $1/d^2$ when h=10 cm.

4) we want to plot log t versus log h for d=3mm



m= Δlog t / Δlog h

b → y-intercept

log t= m log h +b

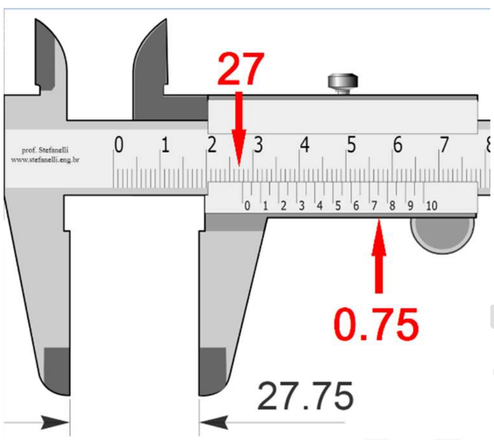
{ $t = h^m \times 10^b$ } → empirical relationship between t and h at d=3mm

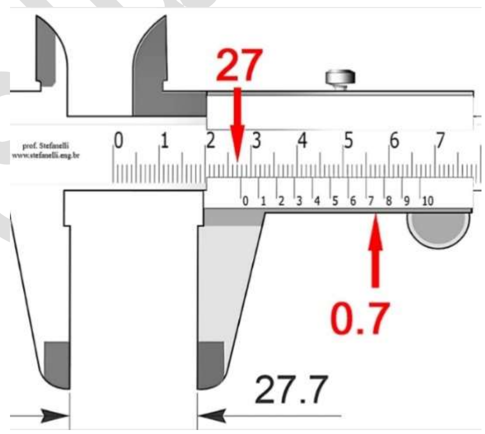
Experiment 2

“Measurement and uncertainties”

The objective is to estimate the density of a cylindrical piece of brass using measurements of its mass, diameter, and height.

1) vernier caliper





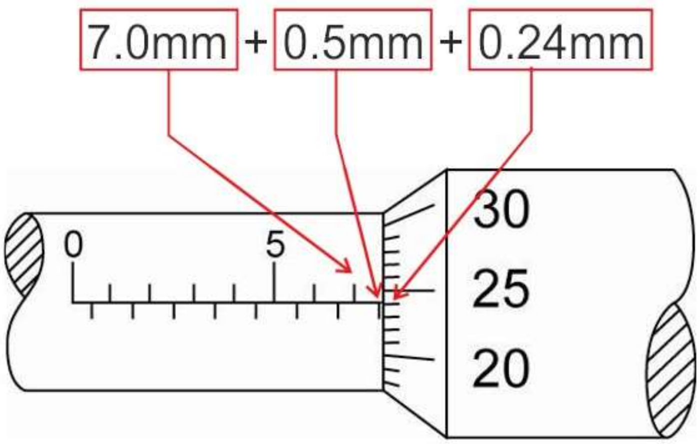
-factor = 1mm/20 = 0.05 mm → smallest length can be measured using this caliper.

-uncertainty = ±0.5 × factor = 0.5 × 0.05 = ±0.025 mm

-factor = 1mm/10 = 0.1 mm → smallest length can be measured using this caliper.

-uncertainty = ±0.5 × factor = 0.5 × 0.1 = ±0.05 mm

2) micrometer



-factor = 0.5 mm / 50 = 0.01 mm

-uncertainty = ±0.5 × factor = ±0.005 mm

3) ordinary ruler:

-factor =1mm

-uncertainty= ±0.5 mm

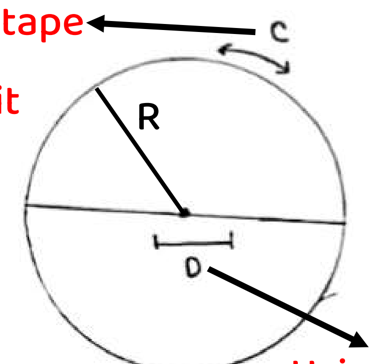
Part 1 – estimating π

Use a paper tape to measure it

C≡circumference

D≡ diameter

R ≡radius



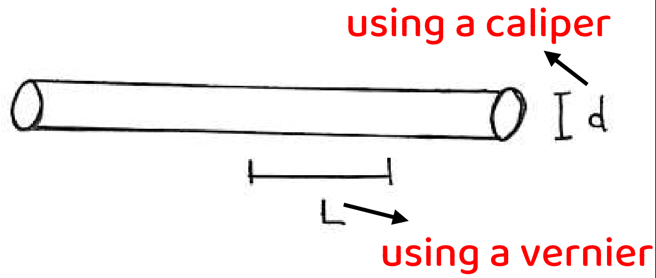
Using a vernier

C = 2 π R = π D

So, $\pi = \frac{C}{D}$ $\qquad \frac{\triangle \pi}{\pi} = \sqrt{\left(\frac{\triangle C}{C}\right)^2 + \left(\frac{\triangle D}{D}\right)^2}$

Part two – determining the density of a brass rod

$\rho = \frac{m}{v}$ ↘ using the balance



The rod has a cylindrical shape:

Volume = $\pi \times (\frac{d^2}{4}) \times L$ ← مساحة القاعدة ← الارتفاع

$\rho = \frac{m}{\pi \times (\frac{d^2}{4}) \times L}$ → use measured values $m, \bar{d}, \bar{L}, \bar{\pi}$

$$\frac{\triangle \rho}{\rho} = \sqrt{\left(\frac{\triangle m}{m}\right)^2 + \left(\frac{\triangle L}{L}\right)^2 \left(\frac{\triangle \pi}{\pi}\right)^2 + \left(\frac{2\triangle d}{d}\right)^2}$$

-all results between $(\rho - \triangle \rho)$ and $(\rho + \triangle \rho)$ are possible.

Percent error $\equiv \left|\frac{E-A}{A}\right|$

-Most error contributes to π → compare between $\left(\frac{\triangle C}{C}\right)$ and $\left(\frac{\triangle D}{D}\right)$

-Most error contributes to ρ → compare between $\left(\frac{\triangle m}{m}\right), \left(\frac{\triangle L}{L}\right), \left(\frac{\triangle \pi}{\pi}\right), \left(\frac{2\triangle d}{d}\right)$

-errors in this experiment:

1-errors in measurements of (d,L,C,m) [personal error]

2-errors in equipment (vernier caliper, micrometer)

Experiment 3

"Vectors – Force table"

-Vectors: quantities that have both magnitudes and directions. [displacement, velocity, acceleration, force]

-two vector quantities are equal only when they have the same magnitude and the same direction.

-errors in this experiment are caused by friction.

$\vec{A}$: 

$-\vec{A}$: 

$3\vec{A}$: 

$\vec{A}/3$: 

-magnitude of $\vec{A} \equiv A \equiv |\vec{A}|$ → scaler quantity and its always positive.

-use a scale for drawing vectors, examples:

*10 km is represented by a 10 cm arrow

*500 N is represented by a 5 cm arrow

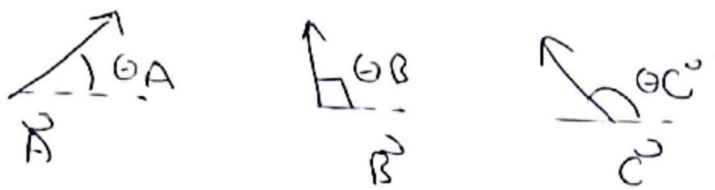
Vectors' addition and subtraction

1- graphically:

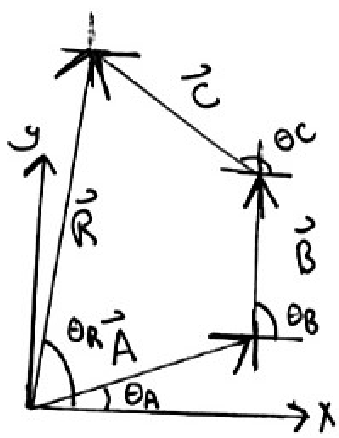
1) parallelogram method

2) head -to- tail method: 1) triangle method (for 2 vectors)

2) polygon method (for more than 2 vectors)



$\vec{A}+\vec{B}+\vec{C}=\vec{R}$

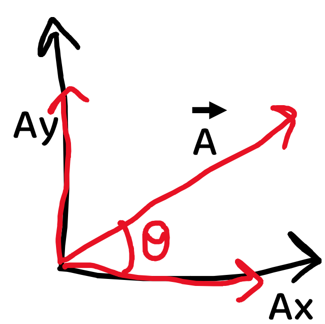


Vectors must represent the same quantity, drawn with the same scale, and have the same units

2- method of components:

$\vec{A} \equiv |A|$: magnitude

ΘA : the angle that A makes with the +x axis



A = $\sqrt{Ax^2 + Ay^2} \geq 0$

Ax= A cosΘ

Ay= A sinΘ

ΘA= $\tan^{-1}\frac{\text{Ay}}{\text{Ax}}$

Rx = Ax+Bx+Cx+....

Ry = Ay+By+Cy+....

R = $\sqrt{Rx^2 + Ry^2}$

ΘR = $\tan^{-1}\frac{\text{Ry}}{\text{Rx}}$

Experimental method:

-with the use of a third pulley and a third hanging mass, find the magnitude and direction of the equilibrium force that returns the ring to the equilibrium position.

-this third force is called the balance force; it is equal in magnitude and opposite in direction to the resultant of the two forces.

The ring is in an equilibrium position, so:

∑F = 0 → ∑Fx = 0 , ∑Fy = 0

$|\overrightarrow{\text{resultant F}}| = |\overrightarrow{\text{balance F}}| = m \times g$

The resultant force is opposite in direction to the balance force, so: θ resultant F = θ balance F – 180 → 3،4 ربع

θ resultant F = θ balance F + 180 →1،2 ربع

Experiment 4

"Kinematics of rectilinear motion"

Purpose: to study and analyze motion with variable acceleration in one dimension.

-Kinematics: is the study of the purely geometrical aspects of the motion of an object or particle, without reference to its mass or the forces acting on it.

-In this experiment you will analyze motion along a straight line, also called rectilinear or one-dimensional motion.

$\Delta x = x_f - x_i$ → displacement

$\Delta t = t_f - t_i$ → time intervals

$\bar{V} = \frac{\Delta x}{\Delta t}$ → the average velocity

$\bar{a} = \frac{\Delta v}{\Delta t}$ → the average acceleration

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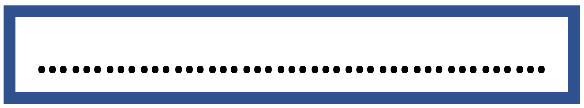
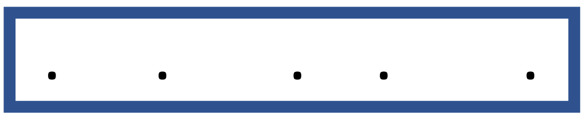
ticker time: a device for measuring time, it is an electrical device that has a little screw-shaped hammer that vibrates vertically at a rate of 50 Hz (التردد).

t= 1/50 Hz → 0.02 seconds →the distance between two successive dots on the tape is the distance covered by the tape in 0.02 s.



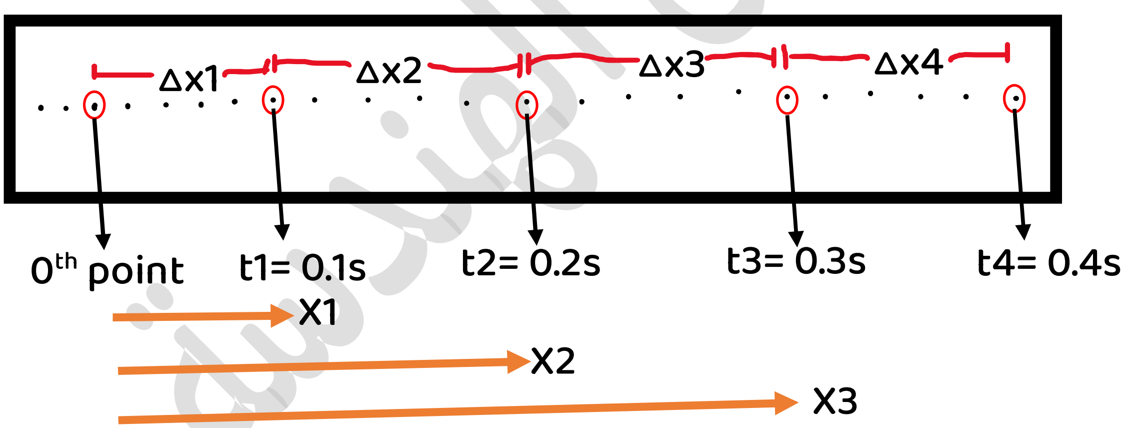
→the dots are close to each other; the object moves with a lower speed.



→the dots are far apart; the object moves with a higher speed.

-Δx is always positive, why? Because motion is always in the same forward (positive) direction. This means that the velocities are also positive in this experiment.

Analysis of the paper tape:

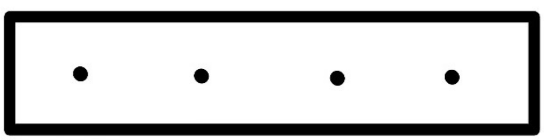


Time between two successive dots is 0.02s (very short), so take five dots , time will be (0.02) ×5 = 0.1 s.

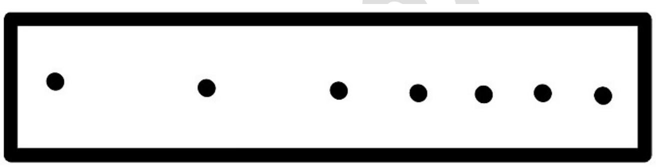
a) -maximum velocity → largest Δx أبعد نقطتين عن بعض

-minimum velocity → smallest Δx أقرب نقطتين من بعض

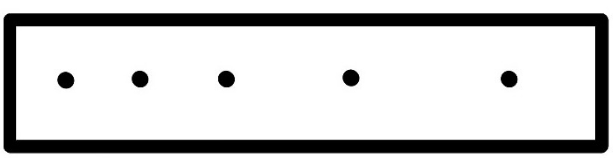
- $\Delta x = x_i - x_{i-1}$ (in this experiment its always positive)
- $\bar{V}_i = \frac{\Delta x_i}{\Delta t}$ (has the same sign as Δx_i ; is always positive)
- $\Delta \bar{V}_i = V_{i+1} - V_i$ (may be positive or negative)
- $\bar{a}_i = \frac{\Delta v_i}{\Delta t}$ (ai has the same sign as $\Delta \bar{V}_i$; can be (+) or (-) or zero)
- $\bar{a}$ → is max. when ($|\Delta V_i|$) is largest.
- $\bar{a}$ → is min. when ($|\Delta V_i|$) is smallest.
- $\bar{a}$ → is zero when ($|\Delta V_i|$) is zero.



→ dots distributed uniformly, no acceleration (uniform velocity)



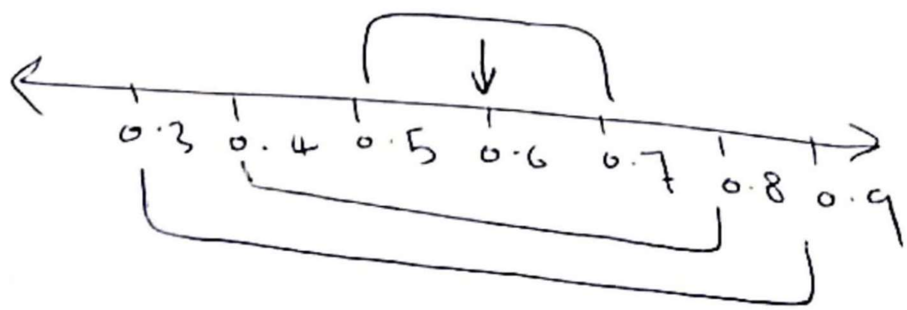
→ distance between dots decreases, There is deceleration



→ distance between dots increases, There is acceleration

b) estimating the instantaneous velocity from the approximation of $\bar{v}$:

→ want to find the [v_{inst}] at t= 0.6 s.



نحسب(v) لكل الفترات :

$\bar{v}$=
0.3-0.9
0.4-0.8
0.5-0.7

The most accurate value to [v_{inst}] at t= 0.6 s is the last one because [0.5-0.7] are the closest to 0.6s.

c) x-t graph: this graph is used to determine:

-The [v_{inst}] at any time during the motion.

-The $\bar{v}$ for any time during the motion.

-Time intervals during which the moving object is stationary, speeding up or slowing down.

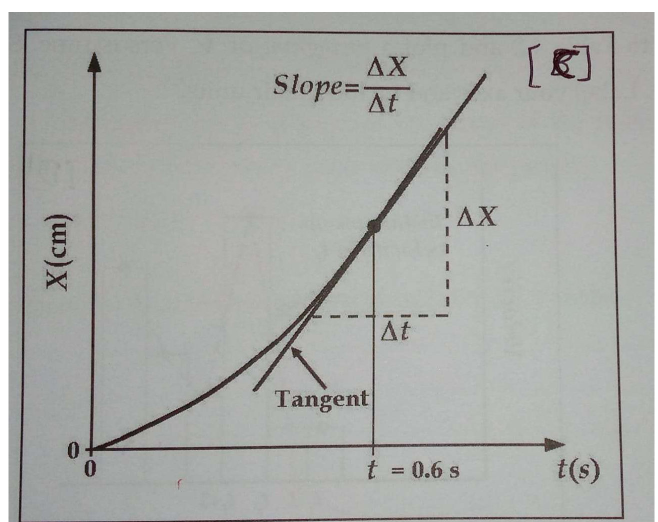


Figure 4.3: Displacement versus time (non-uniform motion).

d) $\bar{v}$-t graph: this graph is used to determine:

-the [v_{inst}] at any time.

-the total displacement from the area under the curve.

-the 'a' from the slope.

-the intervals which the 'v' is constant / increases / decreases.

($\bar{V}$ = v_{inst} at the middle of this interval)

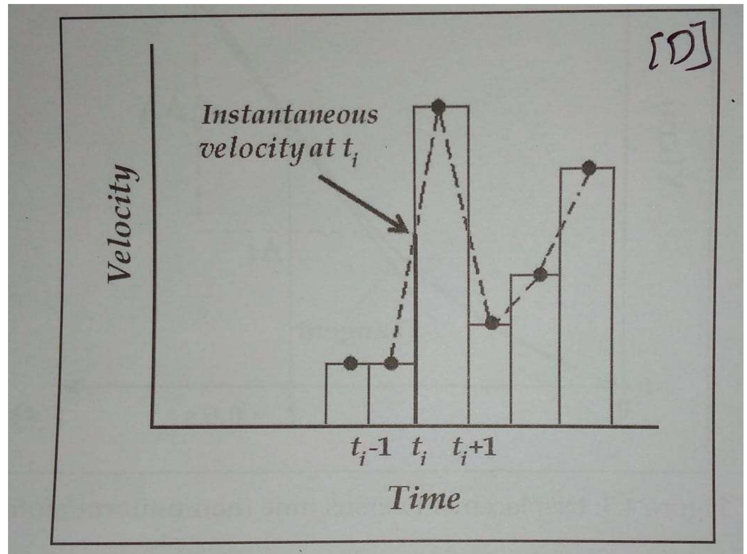
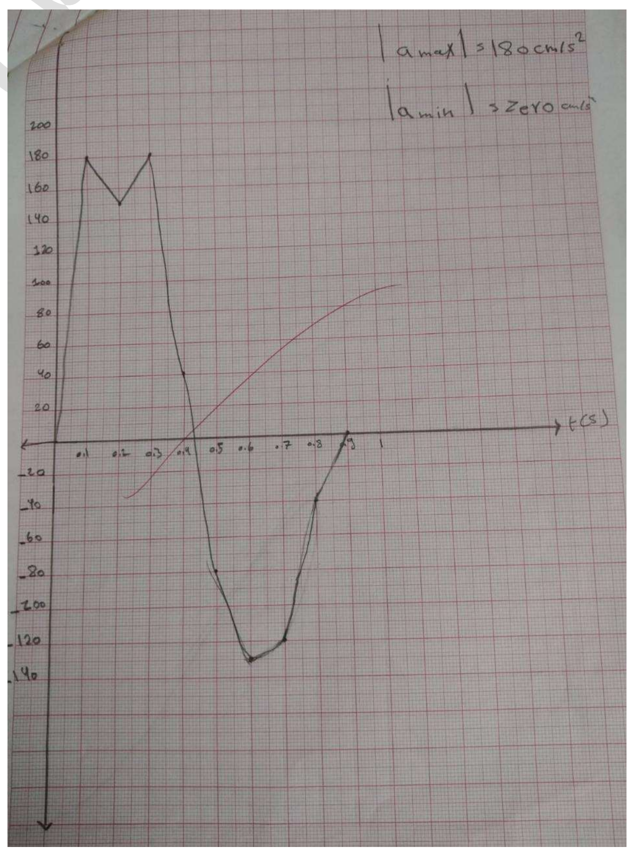


Figure 4.4: Histogram of $\overline{V}$ versus time.

e) a-t graph:

used to determine the maximum and minimum acceleration.



Experiment 5

"Force and motion"

Purpose: to verify newton's second law for a mechanical system moving in one dimension.

$\sum \vec{F}_{ext} = m\vec{a}$ $\vec{F}_{net} = \sum \vec{F}_{ext}$

-two cases will be studied:

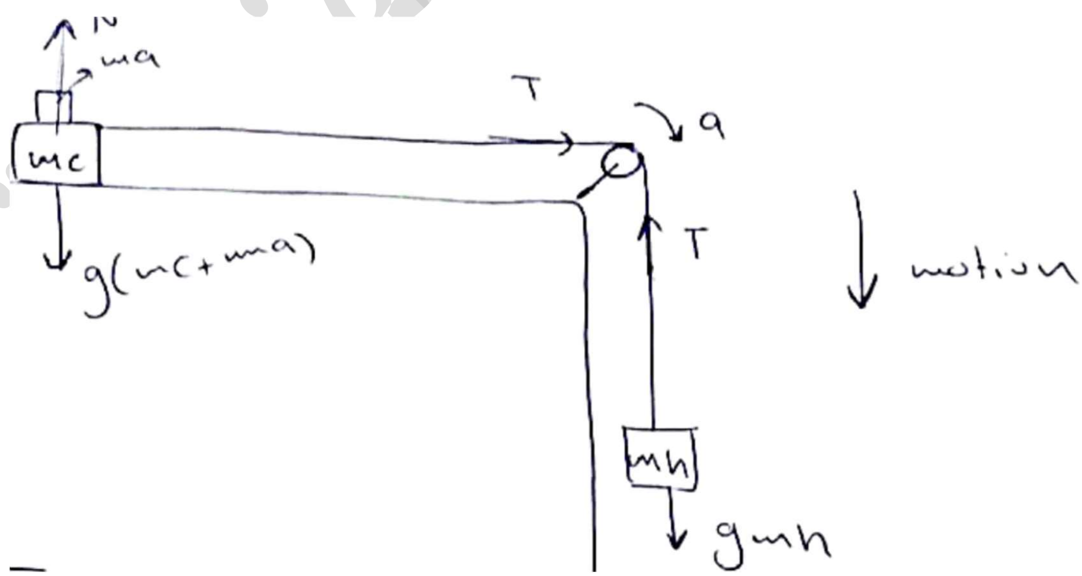
1- The net force is kept constant

2- The mass is kept constant

$\sum \vec{F}_{ext} = m\vec{a}$ → $\sum F_x = m\, a_x$

$\sum F_y = m\, a_y$

$\sum F_z = m\, a_z$



—

In this experiment we increase the inclination of the track to illuminate the friction force, and the relationship between the mass and acceleration is inverse.

1) for the cart:

$T = (m_c + m_a)\, a$ …..(1) → $N = g\,(m_c + m_a)$

2) for m_h:

$M_h\, g - T = m_h\, a$ …..(2)

-note that the tension on both sides of the pulley, has the same value, because we consider the pulley as massless and frictionless.

From equations (1), (2):

$m_h\, g = (m_c + m_a + m_h)\, a$ …..(3)→newton's second law for a system

-the only external force is the weight of the hanging mass:

$F_{net} = m_h\, g$, and tension does not appear in this equation because it is an internal force.

Since the acceleration is constant with time, $\vec{a} = a_{inst} = \frac{\Delta v}{\Delta t} = \frac{v2-v1}{t2-t1}$

- → The velocities v1 and v2 are determined with the help of two photogates located at the two positions.

Cart [metal flag with width]

V1 → photogate (1) = $\frac{\Delta x}{\Delta t}$

V2 → photogate (2)

Part (1) → ma = 0

→ ma = 25

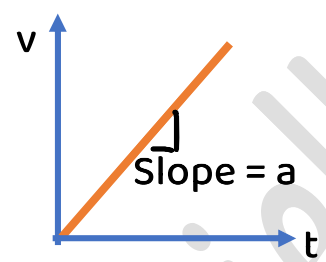
→ ma = 50

→ ma = 75

} With constant m_h = 20 g

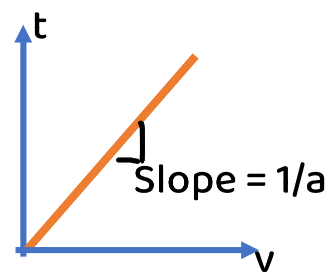
Plot *v* versus *t* → for each value of added mass.

Calculate the slope $\frac{\Delta x}{\Delta t}$ = a



a ↑ slope ↑

mass ↓



a ↓ slope ↑

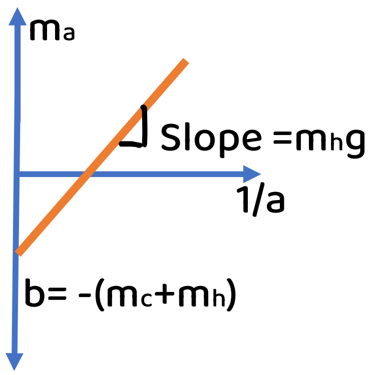
mass ↑

$m_h g = (m_c + m_a + m_h)\, a$

$m_h g = am_c + am_a + am_h$

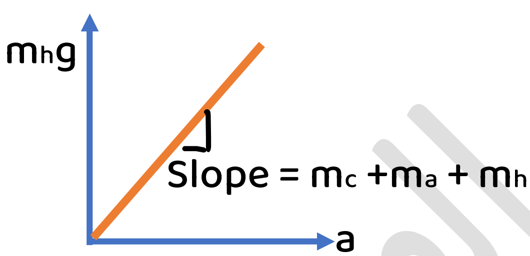
ma = $\frac{mhg - amc - amh}{a}$

ma = $m_h \frac{1}{a} - (m_h + m_c)$ → empirical formula plot (ma) versus (1/a) :



part (2) m_h (use two photogates)

plot (m_hg) versus (a)



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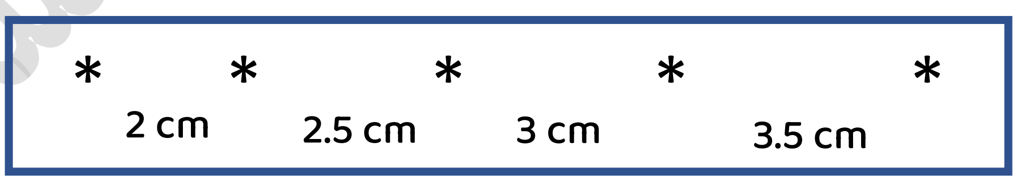
force and motion مع kinematics تداخل تجربة



m_c =800g

g=9.8

m_h g = (m_c + m_h) a
? ?

يتم إيجادها من $\frac{\triangle v}{\triangle t}$ من الشريط

Experiment 6

"Collisions in one dimension"

Purpose: to study conservation of linear momentum and kinetic energy in elastic and inelastic collisions in one dimension.

- Proof that the linear momentum is conserved in all kinds of collisions. $(P_{tot\ i} = P_{tot\ f})$

$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$

- proof that the kinetic energy is conserved JUST in the elastic collisions. $(K.E)_i = (K.E)_f$

$$\frac{1}{2} m_1v^2_{1i} + \frac{1}{2} m_2v^2_{2i} = \frac{1}{2} m_1v^2_{1f} + \frac{1}{2} m_2v^2_{2f}$$

$\{\vec{P} = m . \vec{v}\} \rightarrow$ kg. m/s

$[K.E = \frac{1}{2} m v^2] \times \frac{m}{m} \rightarrow \frac{\frac{1}{2} m^2 v^2}{m}$

$[K.E = \frac{p^2}{2m}] \rightarrow$ kg. m²/s²

Newton's second law:

$\sum F_{ext} = \frac{dP\ total}{dt} = \frac{d}{dt}(m\vec{v}) = m\frac{dv}{dt} + \vec{v}\frac{dm}{dt}$ [if m = constant then $\frac{dm}{dt} = 0$]

[$\sum F_{ext} = m\vec{a}$] → [$\sum F_{ext} = \frac{dP\ total}{dt}$] : if $\sum F_{ext} = 0$ → $\frac{dP\ total}{dt} = 0$

→ P is constant [P_{total} = constant] [isolated system]

So, IF $\sum F_{ext} = 0$ → $(P_{total})_i = (P_{total})_f$ → the law of conservation of total linear momentum of an isolated system.

IF $\sum F_{ext} \neq 0$ then → $\sum F_{ext} = \frac{dP\ total}{dt}$

This experiment is divided to three parts:

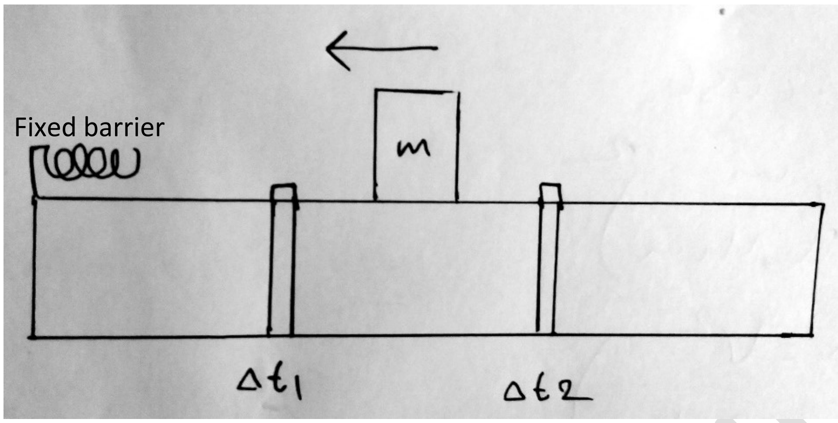
Part 1→ study an elastic collision of one cart.

Part 2 + Part 3 → study an elastic and inelastic collision between 2 carts.

- The velocities are determined with the help of the photogates installed at predefined positions along the track.

$V = \frac{\Delta x \rightarrow \text{width of a metal flag}}{\Delta t \rightarrow \text{time}}$

Part 1: elastic collision with a fixed barrier



Before collision after collision

$V_1 = \frac{\triangle x}{\triangle t1}$ (-)

$\acute{V}_1 = \frac{\triangle x}{\triangle t1}$ (+)

---

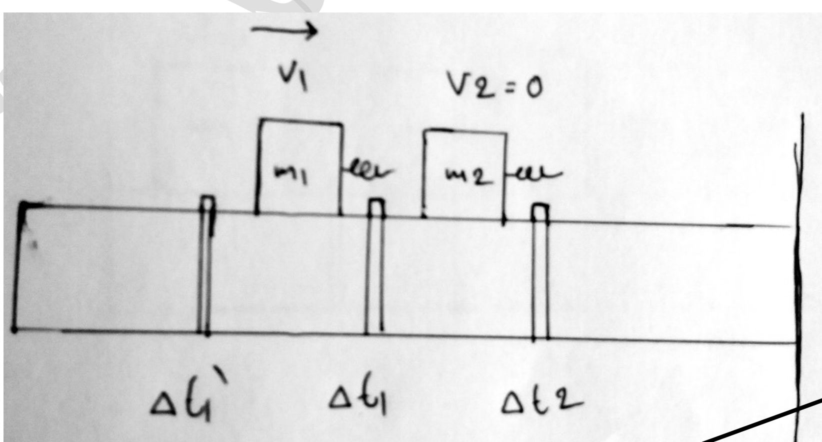
r (rebound coefficient) ($\frac{|\acute{v}1|}{|v1|}$)

- if r = 1 (elastic collision)
- if r < 1 (inelastic collision)

❖ $k_{tot\ i} = \frac{1}{2} m v_1^2$

❖ $k_{tot\ f} = \frac{1}{2} m \acute{v}_1^2$

Part 2: elastic collisions between two carts



Conservation of linear momentum

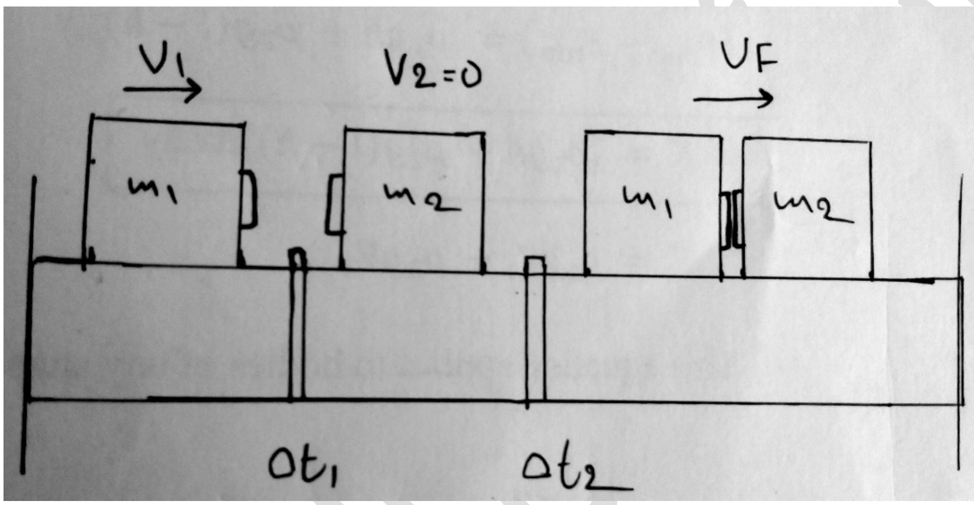
$V_1 = \frac{\triangle x}{t1}$ [$\acute{v}_1 = \frac{m1v1 - m\acute{2}v2}{m1}$] $V_2 = 0$ $\acute{V}_2 = \frac{\triangle x}{\acute{t}1}$

- $k_1 = \frac{1}{2} m_1 v_1^2$ $\quad$ $k'_1 = \frac{1}{2} m_1 v'^2_1$
- $K_2 = \frac{1}{2} m_2 v_2^2$ $\quad$ $K'_2 = \frac{1}{2} m_2 v'^2_2$

- $k_{tot\,i} = k_1 + k_2$
- $k'_{tot} = k'_1 + k'_2$

$r = \frac{k'}{k}$

Part 3: inelastic collisions



$P_i = P_f$

$K_i \neq K_f$

$V_1 = \frac{\Delta x}{t1}$ $\quad$ $V_2 = 0$ $\quad$ $V_f = \frac{\Delta x}{t2}$ $\quad$ $m_1 v_1 + m_2 v_2 = (m_1 + m_2)\, v_f$

Errors in this experiment:

-friction

-Ac track

-the precision of the timer

-errors in calculations

Experiment 7

"Simple harmonic motion- The simple pendulum"

Purpose: to study the simple harmonic motion of a simple pendulum and verify the relationship between its length and period. -you will also calculate 'g' (the acceleration of gravity).

Oscillatory motion is the type of motion in which a particle moves back and forth over the same path.

There are several types of oscillatory harmonic motions, the simple harmonic motion is the simplest.

Two important characteristics of periodic motion are its: *amplitude* and *period*.

-two common examples of the simple harmonic motion are:

(1) the vibration of a spring that has been displaced from its equilibrium position

(2) the oscillation of a simple pendulum about its (vertical) equilibrium position.

Simple harmonic motion of a spring

Consider the horizontal spring, with spring constant *k*. Its left end is fixed to a vertical wall and its right end is attached to a block of mass *m* sitting on a smooth, horizontal surface.

when we release the block, it will move under the action of the spring force (Fs), also called a restoring force; is directly proportional to the displacement (x) from the equilibrium position (x=0), and is given by hook's law:

$$F_s = -k\,x$$

The minus sign indicates that the force and the displacement are always in opposite directions.

By applying newton's second law, we have:

$$-k\,x = m\,a = m\frac{dv}{dt} = m\frac{d^2x}{dt^2}$$

→ in this equation of SMH: the acceleration *a* of a body in a simple harmonic motion is proportional to the displacement *x* and they have opposite directions.

$$\frac{d^2x}{d^2t} + \frac{k}{m}x = 0$$

We define the angular frequency of this SMH by: $\omega = \sqrt{\frac{k}{m}}$

We can rewrite this equation: $\frac{d^2x}{dt^2} + \omega^2 x = 0$

This type of equation is of special interest in physics and is called *homogenous linear second order differential equation*.

Its general solution is given by: $x(t) = A\cos(\omega t + \emptyset)$

Where *A* and $\emptyset$ are two integration constants. *x(t)* represents the position of the block at time *t*.

The time needed for the block to make one complete cycle is called the period and is denoted by (*T*).

The number of oscillations (complete cycles) that the block performs in one second is called the *frequency* and is denoted by (*f*).

$f = 1/T$

$\omega = 2\pi f = 2\pi / T$ In MKS, the units of ω are rad/s.

Simple harmonic motion of a simple pendulum

The motion of a simple pendulum is another example of simple harmonic motion.

A simple pendulum consists of a mass *m* (also called the bob) that is attached to a string or to a massless rod of length *L*.

When the bob is displaced by an angle θ , two forces act upon it:

1) the tension in the string T 2) the weight mg.

By applying newton's second law along the tangential direction: $\sum Ft$=m a_t = -m g sin θ = m $\frac{d^2s}{dt^2}$

Where s is the length of the arc subtended by the angle θ, and is given by: s = L θ , θ is in radians.

The first and second derivatives: ds/dt and d^2s/dt^2 are:

$\frac{ds}{dt}$ = L $\frac{d\theta}{dt}$, $\frac{d^2s}{dt^2}$ = L $\frac{d^2\theta}{dt^2}$

If θ is small then sin θ ≈ θ, in this case, this equation

"-m g sin θ = m $\frac{d^2s}{dt^2}$" will be → L $\frac{d^2\theta}{dt^2}$ = -g θ

Defining the constant $\omega = \sqrt{\frac{g}{L}}$ this equation "L $\frac{d^2\theta}{dt^2}$ = -g θ" will be:

$$\frac{d^2\theta}{dt^2} + \omega^2 \theta = 0$$

This is a homogenous linear second order differential equation and its solution is:

$\theta(t) = \theta_0 \cos(\omega t + \emptyset)$

where θ_o and $\emptyset$ are two integration constants. θ (t) is the angular displacement of the pendulum from the equilibrium (vertical) position at time *t*.

$\omega = 2\,\pi / T$

$T = 2\,\pi / \omega$ given that $\omega = \sqrt{\frac{g}{L}}$

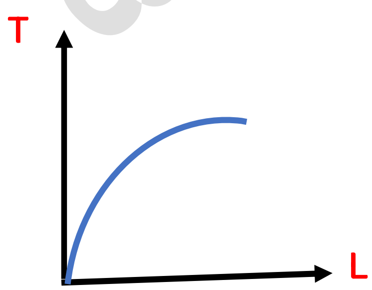
$T = \frac{2\,\pi}{\sqrt{\frac{g}{L}}}$

$T^2 = 4\,\pi^2\,\frac{L}{g}$

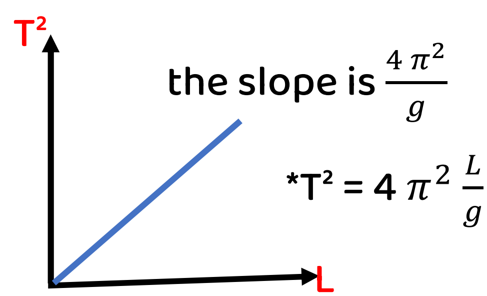
y= mx +b where $y = T^2$, $x = L$, $m = \frac{4\,\pi^2}{g}$, $b = 0$

solve for T : $T = \sqrt{4\,\pi^2\,\frac{L}{g}} \rightarrow$ $T = 2\pi\sqrt{\frac{L}{g}}$

*note that the period T doesn't depend on the pendulum's mass. It only depends on the length of the string and the "g" due to gravity at the location of the experiment.



It isn't linear, but direct



It is a linear graph

Sources of error in this experiment:

- Errors in calculations
- Errors in pendulum measurements.

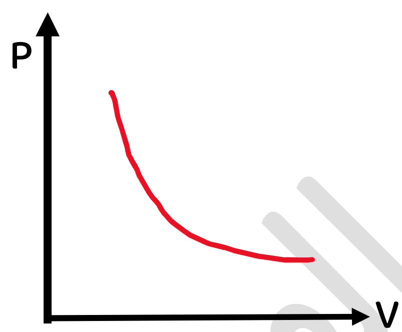
Experiment 10

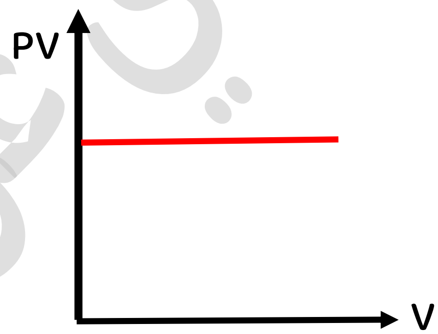
“Boyle’s law”

Purpose: to study the relationship between the pressure of the trapped gas and its volume when it is held constant.

1-Boyle’s law expresses the empirical relationship valid for gases at low densities [ideal gases] between pressure and volume for a trapped gas at constant temperature.

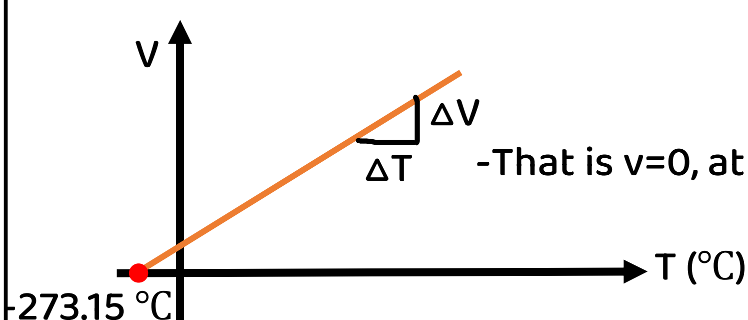
PV= constant → just when Temperature ‘T’ is constant.





2- Charles’ law expresses the empirical relationship valid for gases at low densities [ideal gases] between volume and temperature for a trapped gas at constant pressure ‘P’.

$\frac{V}{T}$ = constant → just when pressure ‘P’ is constant.



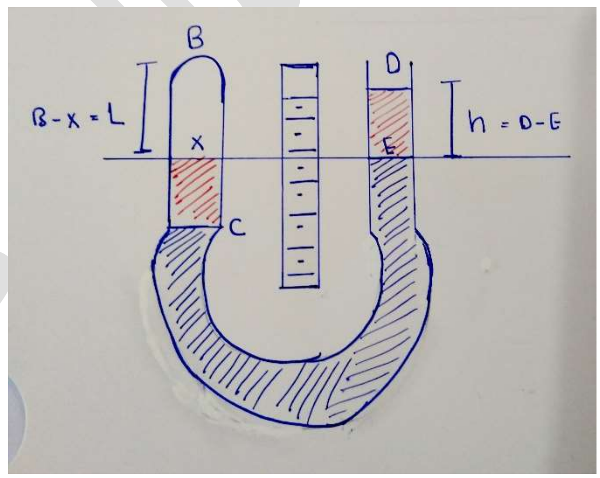
-That is v=0, at absolute zero of temperature

Boyle's law and Charles' law can be combined to produce the ideal gas law:

[PV=nRT] R= 0.0821

-We use mmHg as the unit of pressure 1 atm = 760 mmHg

-assuming that the entrapped gas behaves as an ideal gas, the: [PV=nRT] at equilibrium, the pressure at the left side equals the pressure at the right side.



$P_E = P_X = P_{atm} + h$ [P: at mmHg]

PV=nRT

$(P_{atm} + h)\, V = nRT$

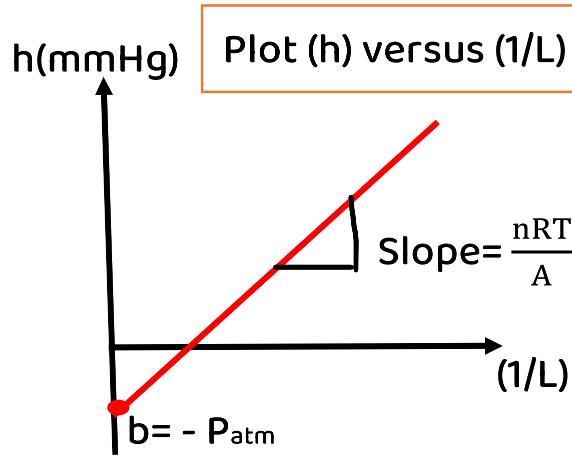
$(P_{atm} + h) = \frac{nRT}{V}$ V=AL

$P_{atm} + h = \frac{nRT}{AL}$

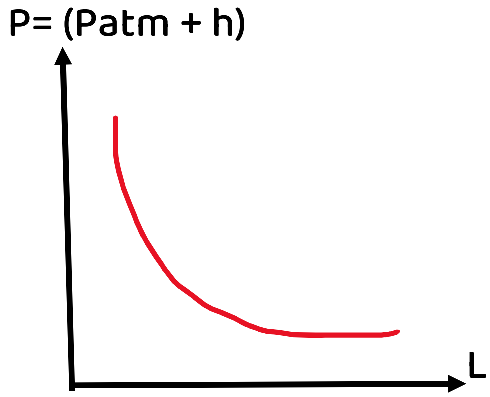
$h = \frac{nRT}{AL} - P_{atm}$

$$h = \frac{nRT}{A} \times \frac{1}{L} - P_{atm}$$

Plot (h) versus (1/L)

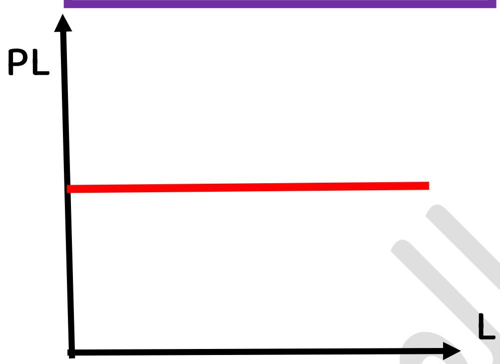


plot P (Patm + h) versus L



non linear increase Relationship

Plot PL versus L



Constant relationship and that

agrees with Boyle's law

Experiment 11

“Specific heat capacity of metals”

Purpose: to determine the specific heat capacity of a metal sample using a simple calorimeter.

-Heat (Q) is a form of energy.

Q is proportional to the temperature difference [$Q \propto \Delta T$] and the proportionality constant is called the heat capacity “C”

$Q = C\,\Delta T$ -in “MKS” the unit of heat is joule (J)

Calorie (cal): the amount of heat necessary to raise the temperature of (1g) of water from 14.5℃ to 15.5℃ at pressure of (1 atm).

1 cal = 4.18 J

So, the unit of the heat capacity is J/℃ *OR* Cal/℃

-for a substance in a given phase, at a given temperature and pressure(P) or volume(V) , we define “its specific heat capacity” “c”.

-unit of “c” → J/g . ℃ *OR* cal/g . ℃

-heat capacity "C" of "M" grams of the substance is related the specific heat capacity → $c = \frac{C}{M}$

So, we can write this equation $Q = C\Delta T$ → $Q = c\ M\ \Delta T$

-$\Delta T = T_f - T_i$

Notes:

- ❖ heat capacity (C) is an extensive property, it is affected by the magnitude of the substance.
- ❖ specific heat capacity (c) is an intensive property, it is not affected by the magnitude of the substance.
- ❖ $Q>0$: heat is added to the system.
- ❖ $Q<0$: heat is taken from the system.

In this experiment the calculations are simple and detailed in the following:

-heat flow to the calorimeter = heat from the metal

Q gained (by calorimeter) = -Q lost (by metal)

-by using the equation → $Q = c\ M\ \Delta T$

We can write → $(M_1C_1 + M_wC_w)(T_f - T_1) = (M_2C_2)(T_2 - T_f)$

M1→ mass of the container

Mw→ mass of water

M2→mass of the metal

C1→specific heat of the container

Cw→ specific heat of the water

C2→ specific heat of the metal

T1→initial temperature of calorimeter

T2→ initial temperature of metal

Tf→final temperature for (calorimeter+water+metal)

$X = M_1C_1 + M_wC_w$

$Y = T_f - T_1$

$Z = T_2 - T_f$

By using (X, Y, Z) we have →

$$C_2 = \frac{X\,Y}{M2\,Z}$$

Specific heat capacity for metal

The errors :

$$\Delta C_2 = C_2\sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2 + \left(\frac{\Delta Z}{Z}\right)^2 + \left(\frac{\Delta M2}{M2}\right)^2}$$

$\Delta X = \sqrt{(M1C1)^2 + (MwCw)^2}$, C_w, C_1 are constants

$\Delta Y = \sqrt{(\Delta T1)^2 + (\Delta Tf)^2}$

$\Delta Z = \sqrt{(\Delta T2)^2 + (\Delta Tf)^2}$ $\Delta M_2 = 0.01$ g في الميزان الرقمي قيمة الخطأ ثابتة

The possible sources of errors:

1- heat loss from the surroundings

2-personal errors

3-systematic errors

Summary:

$Q = C\,\Delta T$ C→heat capacity J/℃ *OR* Cal/℃

$Q = c\,M\,\Delta T$ c→specific heat capacity J/g . ℃ *OR* cal/g . ℃

Notes:

- In the kinematics experiment, the tape represents the distance and time
- The unit of heat capacity is calory/°C
- The unit of specific heat capacity is calory/g. °C
- the parallax is considered a personal error.
- The error in measuring the diameter of a cylindrical rod using a micrometer is 0.005 mm.
- Boyle's law represents that the pressure of gas is inversely proportional to its volume at constant temperature.
- specific heat capacity depends on the type of material
- in the force and motion experiment we increase the inclination of the track to illuminate the friction force.
- In simple harmonic motion, the angle used must be less than 50.
- In elastic collisions, the momentum and kinetic energy are conserved because the system is isolated.