Experimental Errors.

* Types of Experimental errors :-

1) Personal error :- due to observer carelessness.

2) systematic error :- from the instrument.

3) Random error :- accidental error.

note :-

- Personal , Systematic errors $\boxed{\text{can be controlled}}$
- Random errors $\boxed{\text{beyond your controll}}$

* How to calculate errors?

$\boxed{1}$ Error due to instrument

$$= \frac{\text{smallest division}}{2}$$

$\boxed{2}$ Percentage Error.

for several trials with accepted value

$$= \left| \frac{E - A}{A} \right| \times 100\%$$

$\boxed{3}$ Percentage difference.

for several trials with out accepted value.

$$= \left| \frac{E_{max} - E_{min}}{\left(\frac{E_{max} + E_{min}}{2}\right)} \right| \times 100\%$$

$\boxed{4}$ Standard mean deviation

for several trials

$$= \sqrt{\frac{\sum (A_n - \bar{A})^2}{n(n-1)}}$$

$\boxed{5}$ Error while calculationg values:

(a) addition and substraction

e.g. $A = B + C - D$

$$\Delta A = \sqrt{\Delta B^2 + \Delta C^2 + \Delta D^2}$$

(b) multiplication and division

$A = \frac{BC}{D}$

$$\frac{\Delta A}{A} = \sqrt{\left(\frac{\Delta B}{B}\right)^2 + \left(\frac{\Delta C}{C}\right)^2 + \left(\frac{\Delta D}{D}\right)^2}$$

(c) Power

$A = B^N$

$$\frac{\Delta A}{A} = N\left(\frac{\Delta B}{B}\right)^*$$

$\Rightarrow (A \pm \Delta A)$

log vs log graph

$\Rightarrow \log A = m \log d + b$

$\Rightarrow A = d^m \cdot 10^b$

*** note *** $y = mx + b$

Exp 2 Measurements and Uncentaities

1 Pan balance :- used to measure masses
it's smallest division is 0.01 gram

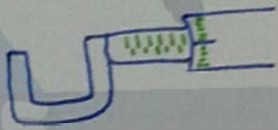
$$\Delta m = \frac{\text{smallest division}}{2} = \pm 0.005$$

[redacted]

2 meter stick :- it's smallest division is 0.1cm

$$\Delta = \frac{\text{smallest division}}{2} = \pm 0.05$$

3 Micrometer :- it's smallest division is 0.01mm



$$\Delta = \frac{\text{smallest division}}{2} = \pm 0.005$$

4 Vernier caliper :- it's smallest division is 0.1mm

$$\Delta = \frac{\text{smallest division}}{2} \pm 0.05$$

Circumference $\Longrightarrow$ $C = \pi d$

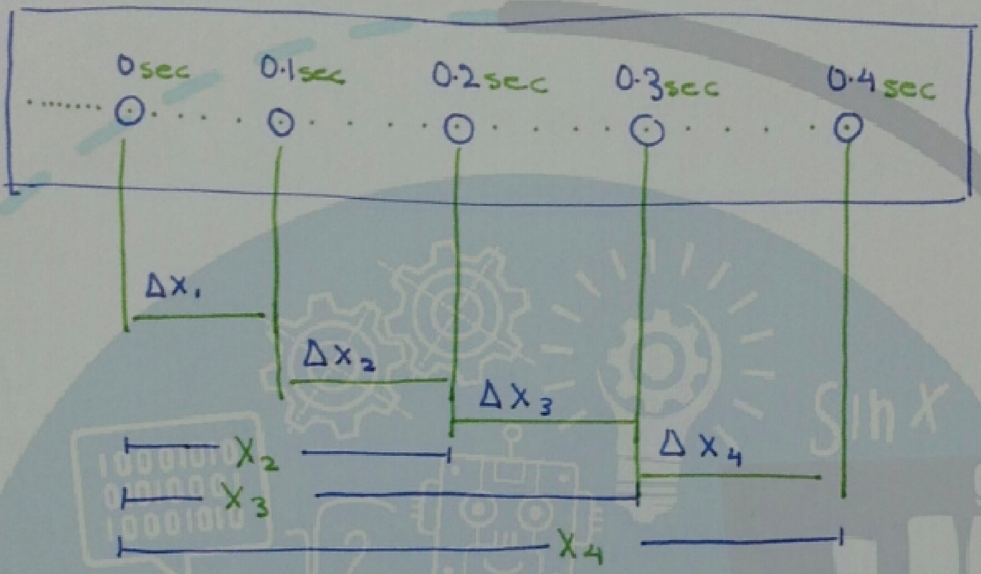
volume $\Longrightarrow$ $V = \pi \left(\frac{d}{2}\right)^2 h$

density $\Longrightarrow$ $\rho = \frac{m}{V} = \frac{m}{\pi \left(\frac{d}{2}\right)^2 h}$

[redacted]

Experiment 4
kinematics of rectilinear Motion

*ticker timer :- it makes a dot every 0.02 sec



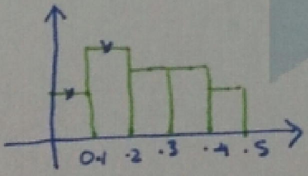
* average velocity $\Longrightarrow \dfrac{\Delta x}{\Delta t \rightarrow 0.1 \text{ constant}} = \bar{V}$

* velocity differences $\Longrightarrow \Delta V = V_f - V_i$

* acceleration average $\Longrightarrow \bar{a} = \dfrac{\Delta V}{\Delta t \rightarrow 0.1 \text{ constant}}$.

*** note *** the slope of x vs t is the ins. velocity

e.g.

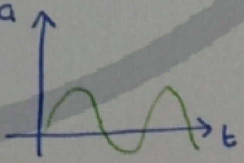


V increasing (0.05s - 0.15s)

V const. (0.25s - 0.35s)

V decreasing (0.15s - 0.25s)

e.g



the displacement

=

area under the curve.

Experiment 11 Specific heat capacity

* specific heat capacity : (it depends on the type of the substance)

- the amount of heat required to raise the temp. of 1 gram of substance by 1°C

it's unit is cal/g.°C or J/g.°C

* heat capacity :- (it depends on the type and qauntity of the substance)

- the amount of heat to raise temp. by 1°C

it's unit is J/°C or cal/°C

*heat :- the amount of energy gained or lost due to difference in temp.

(Q) heat = heat Capacity X temp. difference.

(Q) heat = specific heat capacity x mass X temp difference

(Q) heat = C x m x ΔT

note

1 cal = 4.185 J

example :- heat gained (calorimeter+water) = heat lost (metal)

$$\Rightarrow (M_1C_1 + M_wC_w)(T_f - T_1) = M_2C_2(T_2 - T_f)$$

** note **

heat gained = heat lost

T_1 : temp of water and cup

T_2 : temp of boiling water and metal.

T_f : final temp.

let : $X = (M_1C_1 + M_wC_w)$ $Y = (T_f - T_1)$ $Z = (T_2 - T_f)$ then,

$$C_2 = \frac{XY}{ZM_2}$$

Error in $C_2 \Rightarrow$ $\frac{\Delta C_2}{C_2} = \sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2 + \left(\frac{\Delta Z}{Z}\right)^2 + \left(\frac{\Delta M_2}{M_2}\right)^2}$

Experiment #3 Vectors

* to calculate the resultant force we have 3 methods :-

1) Experimental method :- (Force table)

2) Graphical method :-

* head to tail

* polygon

example :-

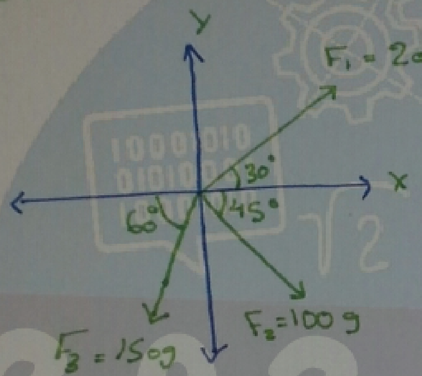
** note **
$F = mg$

step ①

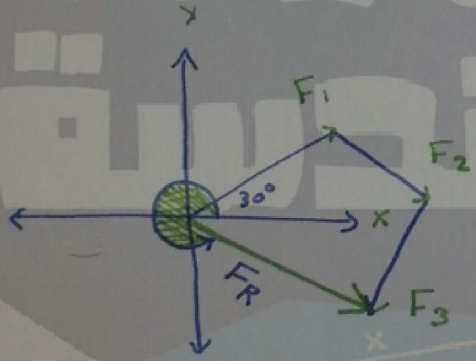
* $F_1 = mg = 200g \times 10^{-3} \times 9.8$ (9.8 is marked as $\underbrace{\quad}_{}$ g.w)
$= 200\ g.w$

* $F_2 = mg = 100 \times 10^{-3} \times 9.8$
$= 100\ g.w$

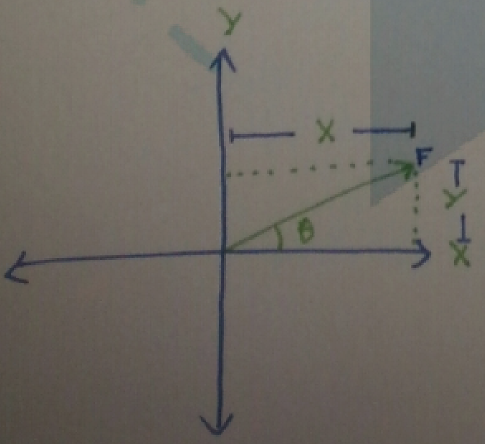
* $F_3 = mg = 150 \times 10^{-3} \times 9.8$
$= 150\ g.w$



step ②



3) Method of components :-

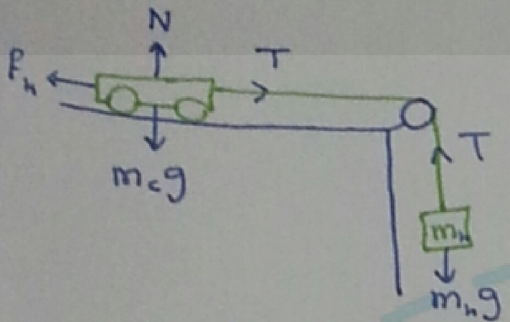


$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

$$|F_R| = \sqrt{F_x^2 + F_y^2}$$

Experiment #5 Force and motion.



$$\Sigma F = m_{tot} a$$

newton 2nd law

$$m_h g - T = m_h a$$

$$T - f_k = m_c a$$

addition

$$m_h g - f_k = (m_h + m_c) a$$

$$\Rightarrow \boxed{m_h g = (m_c + m_h + m_a) a}$$

** Note **

$f_k = 0$ when we increase the inclination of the track

example :

*For M_a vs $\frac{1}{a}$

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

$$\frac{m_a a}{a} = \frac{m_h g}{a} - \frac{(m_c + m_h)\cancel{a}}{\cancel{a}}$$

$$m_a = m_h g \cdot \frac{1}{a} - (m_c + m_h)$$

$\boxed{\text{slope} = m_h g}$

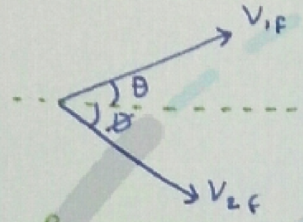
$\boxed{\text{y-intercept} = -(m_c + m_h)}$

$\boxed{\text{x-intercept} = \frac{(m_c + m_h)}{m_h g}}$

Experiment #6 Collisions in two dimensions

$$\text{Collisions}\begin{cases}\xrightarrow{} \text{head-on collision (1D)}\\ \xrightarrow{} \text{oblique collisions (2D)}\end{cases}$$

* oblique collisions (2D)



after collision

$\Rightarrow \theta + \emptyset = 90^\circ \Rightarrow$ if $m_1 = m_2$
$V_{2i} = 0$

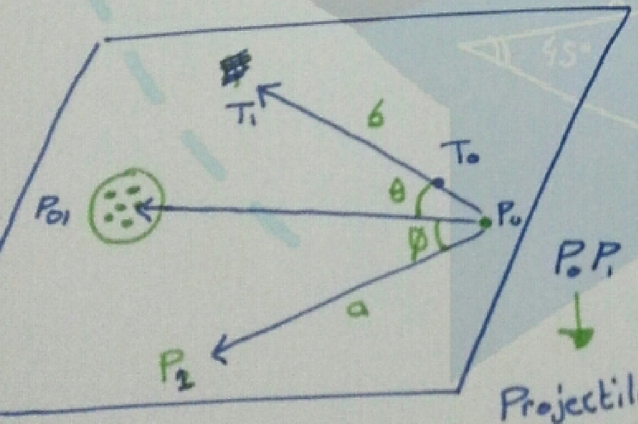
** note **
the type of collision in this experiment is elastic collision.

* momentum conservation :- $\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$

$$m_1\vec{V}_{1i} + m_2\vec{V}_{2i} = m_1\vec{V}_{1f} + m_2\vec{V}_{2f}$$

* elastic collisions :- $KE_i = KE_f$

$$\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$$



P_0P_{01} = momentum before collision = V_{1i}

$P_0P_1 + T_0T_1$ = momentum after collision = $V_{1f} + V_{2f}$

$\downarrow$ Projectile $\quad \downarrow$ target ball(2)

Experiment #9 The law of Gases

* Boyl's law :- the volume of the intrapped gas decreases with increasing pressure.

* under const. temp :- $P \propto \frac{1}{V} \Rightarrow P = \frac{\overset{n}{\text{const.}}}{V}$

number of moles

* $\boxed{\text{Gas law} \Longrightarrow PV = nRt} \rightarrow$ temp.

Pressure

volume

universal gas constant

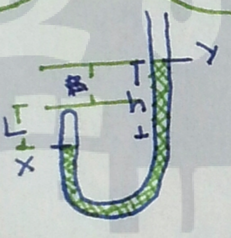
$PV = \text{constant}$

$\text{mmHg} \equiv \text{torr}$

$[\text{Pressure}] = \text{Pa}$ in SI

1atm = 760 torr

1atm = 760 mmHg



$P_{gas} = P_{atm} + h$

$(P_a + h)L = \overset{n}{\text{cost.}}$

فرق في طول عامودي الزئبق .

$h = Y - X$

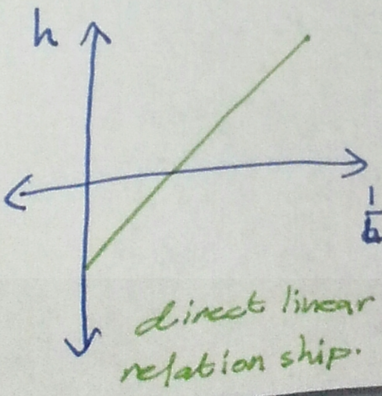
const.

طول عامود الغاز المحصور $L = B - X$

* Plot h vs $\frac{1}{L}$

$(P_a + h)L = \text{const.}$

$h = \text{const}\frac{1}{L} - P_a$



* Plot P vs L

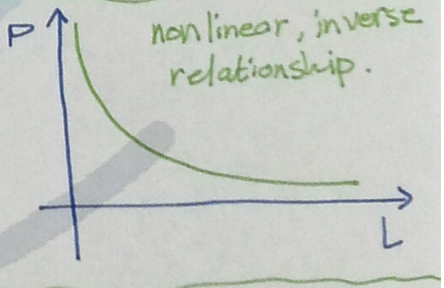
$P = \frac{\text{const.}}{V}$

const

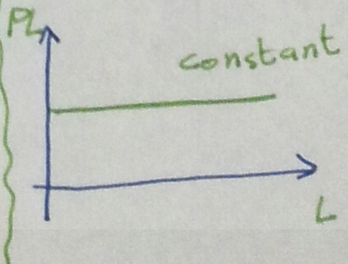
$P = \boxed{\frac{\text{const}}{a}} \cdot \frac{1}{L}$

$P = \text{const} \cdot \frac{1}{L}$

$P \propto \frac{1}{L}$



* Plot PL vs L

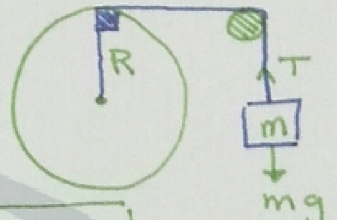


Experiment # 7 Rotational Motion

$\boxed{1}$ $F = ma$

$mg - T = ma$

$T = (g-a)m \longrightarrow ①$



$\boxed{2}$ $\underset{\text{Tension}}{\overset{}{}}$ $\tau = \underbrace{R}_{\text{البعد من ذراع القوى}} \times (\underbrace{\vec{F}}_{\text{Tension}}) = I\alpha$ $\boxed{\alpha = \frac{a}{R}}$ $\boxed{\omega = \frac{v}{R}}$

$TR = I\alpha \longrightarrow ②$

*From the two equations:-

$R(g-a)m = I\alpha$

$Rm(g-\alpha R) = I\alpha$ ← قسمة α

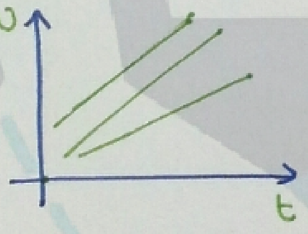
moment of Inertia $\Rightarrow$ $\boxed{Rm\left(\frac{g}{\alpha} - R\right) = I}$

---

* * * note * * * when mass increases, α decreases.

---

* Plot W vs t :-



slope = α

w vs t

linear direct relationship

* How to find Torque ?

$\tau = I\alpha$

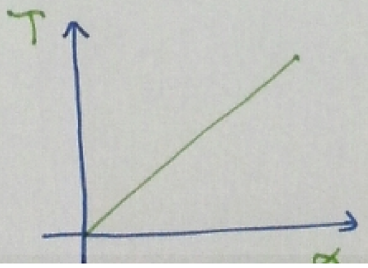
$[\tau]$ unit = (dyne.cm)

and

$I\alpha = Rm(g-\alpha R)$

$\boxed{So}$ $\tau = Rm(g-\alpha R)$

* Plot τ vs α

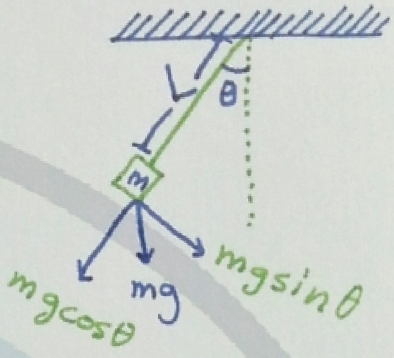


$\boxed{\text{slope} = I}$

Experiment #8 Simple harmonic motion

* simple :- no force on it .

→ harmonic :- repeats it's self over a certain
Period



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

T: time needed for 1 complete oscillation.

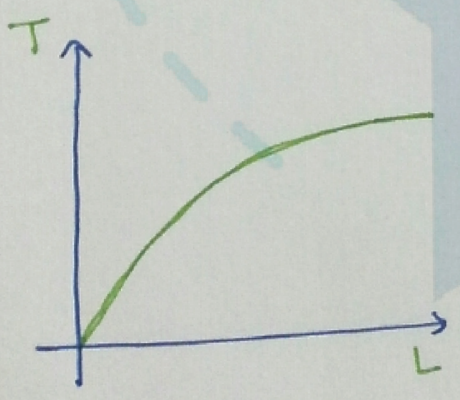
L: length

* $T \propto \sqrt{L}$ * $T \propto \frac{1}{\sqrt{g}}$

* Plote T vs L

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

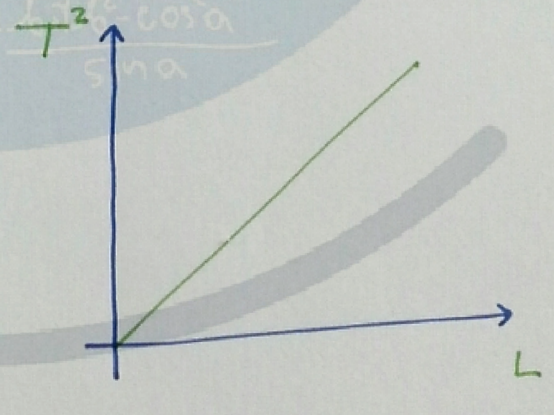
$T \propto \sqrt{L}$



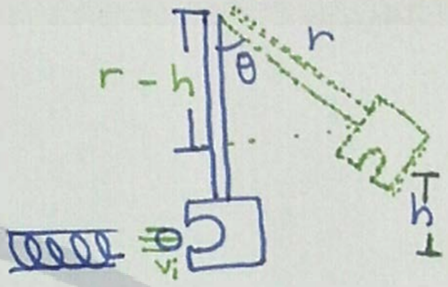
* Plote T^2 vs L

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

$T^2 \propto L$



Experiment # 12 Ballistic Pendulum



* $U_i = K_f$ لحظة الإنطلاق

$$\frac{1}{2}kx^2 = \frac{1}{2}m_b v_i^2$$

$$\boxed{v_i = \sqrt{\frac{kx^2}{m_b}}} \longrightarrow ①$$

** after the ball is captured by the pendulum.

قبل التصادم $P_i = P_f$ بعد التصادم

$$\boxed{m_b v_i = (m_b + m_p)V_f} \longrightarrow ②$$

$$V_f = \left(\frac{m_b}{m_b + m_p}\right) v_i$$

m_b : mass of ball

m_p : mass of pendulum.

$$\cos\theta = \frac{r-h}{r} = 1 - \frac{h}{r}$$

** $\boxed{h = (1 - \cos\theta) r}$ **

** at maximum hieght

$$U_f = K_i$$

$$\cancel{(m_b + m_p)} g\Delta h = \frac{1}{2}\cancel{(m_b + m_p)} V^2$$

$$V_f = \sqrt{2gr(1 - \cos\theta)}$$

$$v_i = \left(\frac{m_b + m_p}{m_b}\right)\sqrt{2gr(1 - \cos\theta)}$$