Experimental Errors.

* Types of Experimental errors :-

1) Personal error :- due to observer carelessness.

2) systematic error :- from the instrument.

3) Random error :- accidental error.

Hzayen ^_^

note :- - Personal, Systematic errors can be controlled

- Random errors beyond your controll

* How to calculate errors?

[1] Error due to instrument

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

[2] Percentage Error.

For several trials with accepted value.

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

[3] Percentage difference.

for several trials with out accepted value.

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

[4] Standard mean deviation

for several trials

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

[5] Error while calculating values:

(a) addition and substraction

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

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

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

(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

$$A = B^N$$

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

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

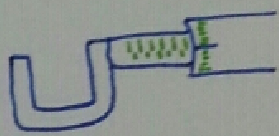
1. Pan balance :- used to measure masses
   it's smallest division is 0.01 gram

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

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

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

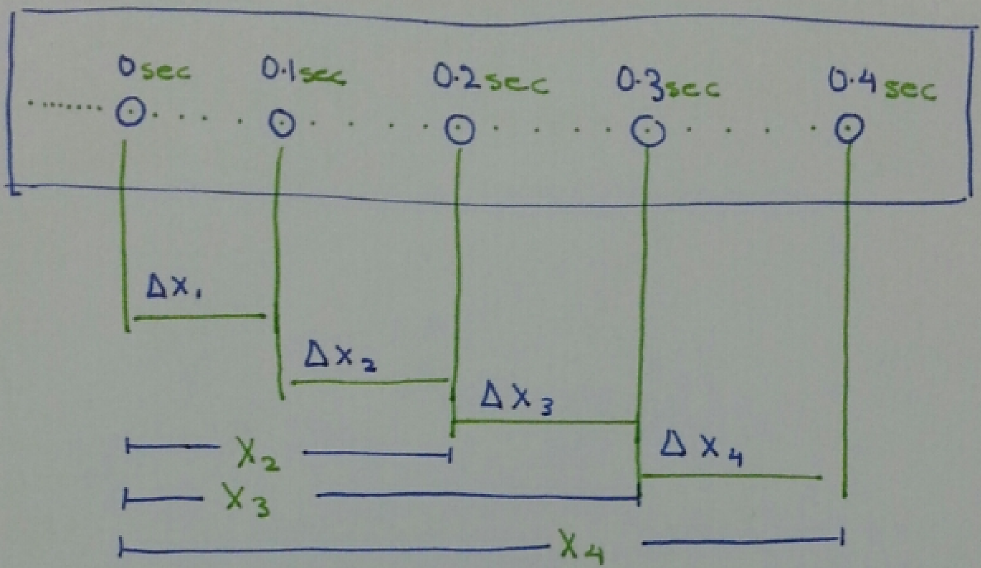
Circumference $\Longrightarrow$ $C = \pi d$

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

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

Experiment 4
kinematics of rectilinear Motion

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



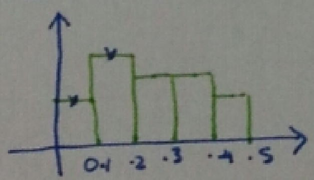
* average velocity $\Longrightarrow \frac{\Delta x}{\Delta t \to 0.1 \text{ constant}} = \bar{v}$

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

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

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

e.g.

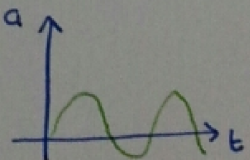


V increasing (0.05s - 0.15s)

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

$$(Q)\text{heat} = C \times m \times \Delta T$$

** note **
1 cal = 4.185 J

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

** note **
heat gained = heat lost

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

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 :-

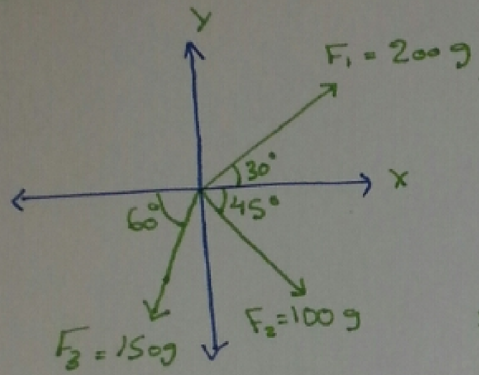
1) Experimental method :- (Force table)

2) Graphical method :-

* head to tail
* polygon

> ** note **
> $F = mg$

example :-



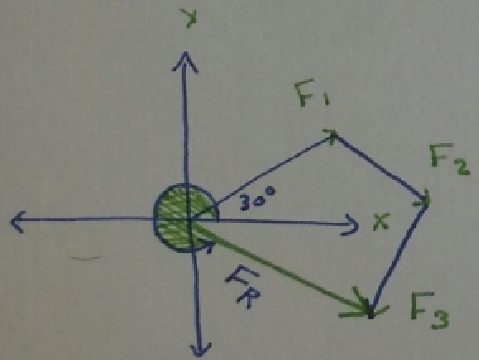
step ①

* $F_1 = mg = 200g \times 10^{-3} \times 9.8$ (g.w)
$= 200 \, g.w$

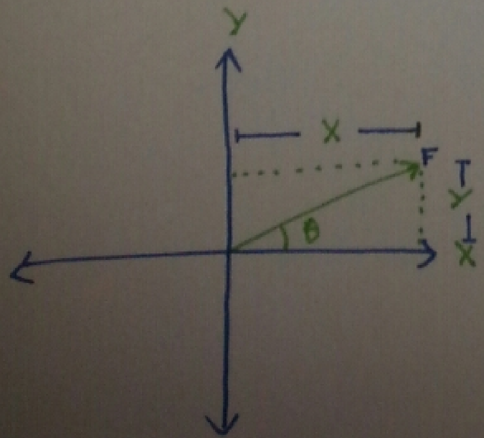
* $F_2 = mg = 100 \times 10^{-3} \times 9.8$
$= 100 \, g.w$

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

step ②



3) Method of components :-

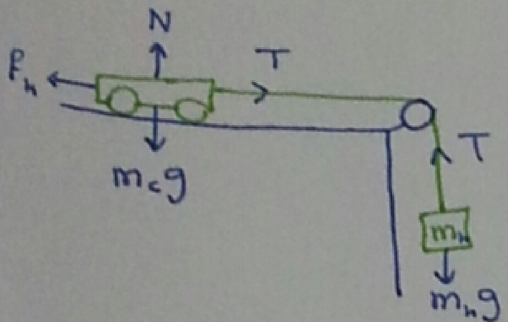


$$F_x = F \cos\theta$$

$$F_y = F \sin\theta$$

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

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

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

$$\Longrightarrow \quad m_h g = (m_c + m_h + m_a) a$$

** Note **

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

example :-

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

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

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

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

slope $= m_h g$

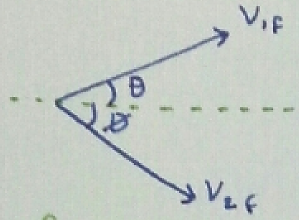
y-intercept $= -(m_c + m_h)$

x-intercept $= \dfrac{(m_c + m_h)}{m_h g}$

Experiment #6 Collisions in two dimensions

Collisions
- head-on collision (1D)
- oblique collisions (2D)

* oblique collisions (2D)



after collision

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

** note **

the type of collision in this experiment is elastic collision.

---

* momentum conservation :-

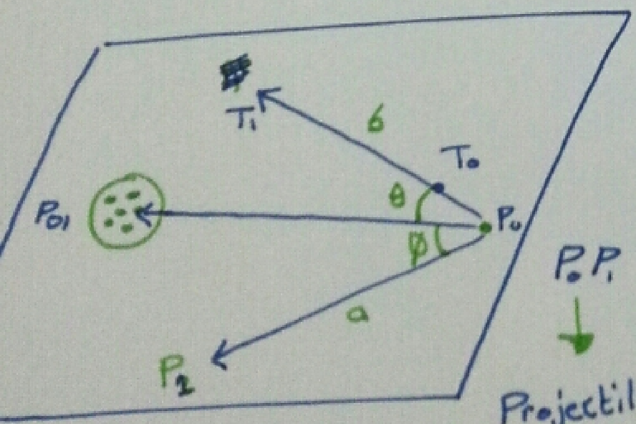
$$\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$$

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

* elastic collisions :-

$$KE_i = KE_f$$

$$\frac{1}{2}m_1 v_{1i}^2 + \frac{1}{2}m_2 v_{2i}^2 = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{2f}^2$$



$P_o P_{o1}$ = momentum before collision = V_{1i}

$P_oP_1 + T_oT_1$ = momentum after collision = $V_{1f} + V_{2f}$

P_oP_1 ↓ Projectile

T_oT_1 ↓ 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 :- $P \propto \frac{1}{V}$ $\Rightarrow$ $P = \frac{c\hat{o}nst.}{V}$

* Gas law $\Longrightarrow$ $PV = nRt$

  - P → Pressure
  - V → volume
  - n → number of moles
  - R → universal gas constant
  - t → temp.

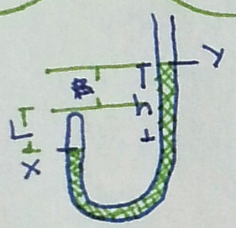
$PV = \text{constant}$

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

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

1 atm = 760 torr

1 atm = 760 mmHg



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

$(P_a + h)L = c\hat{o}nst.$

$h = Y - X$ ← فرق في طول عامودي الزئبق .

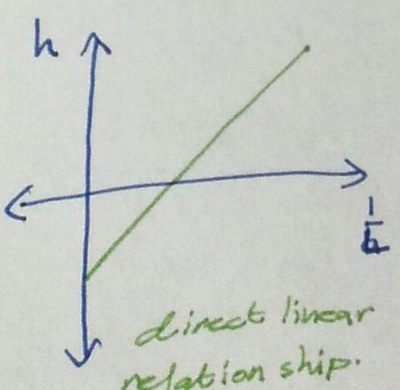
$L = B - X$ (B: const.)

L: طول عامود الغاز المحصور

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

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

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



direct linear relation ship.

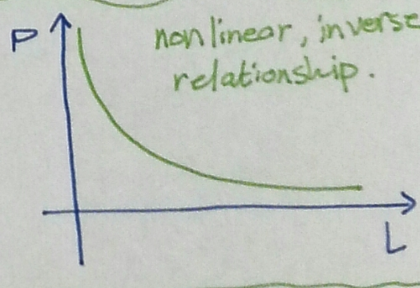
* Plot P vs L

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

$P = \left(\frac{\text{const}}{a}\right) \cdot \frac{1}{L}$ (const)

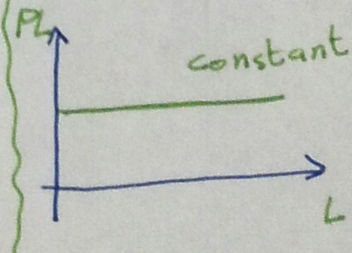
$P = \text{const} \cdot \frac{1}{L}$

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



non linear, inverse relationship.

* Plot PL vs L

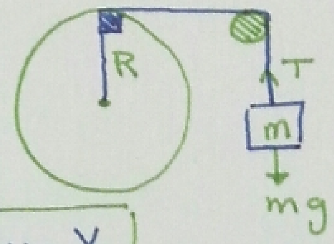


Experiment #7 Rotational Motion

[1] $F = ma$

$mg - T = ma$

$T = (g - a)m \longrightarrow ①$



[2] $\tau = R \times (\vec{F}) = I\alpha$

R ↓ البعد عن ذراع القوى

F ↓ Tension

$\boxed{\alpha = \frac{a}{R}}$ $\boxed{w = \frac{V}{R}}$

$TR = I\alpha \longrightarrow ②$

* From the two equations :-

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

$Rm(g - \alpha R) = I\alpha$ ← قسمة α

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

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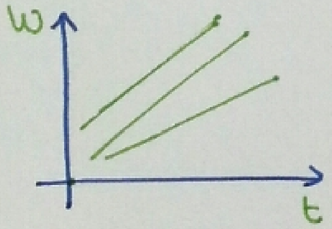
* * * note * * * when mass increases, α decreases.

---

* Plot W vs t :-



slope = α

W vs t

linear direct relationship

* How to find Torque ?

$\tau = I\alpha$

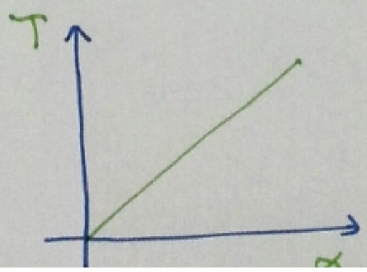
[τ] unit = (dyne·cm)

and

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

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

* Plot τ vs α

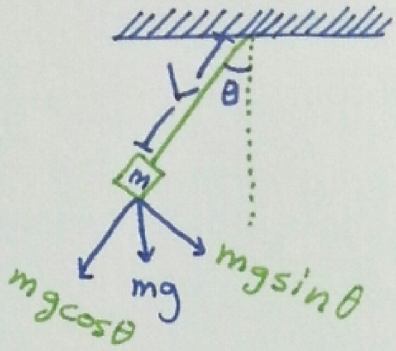


slope = I

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.

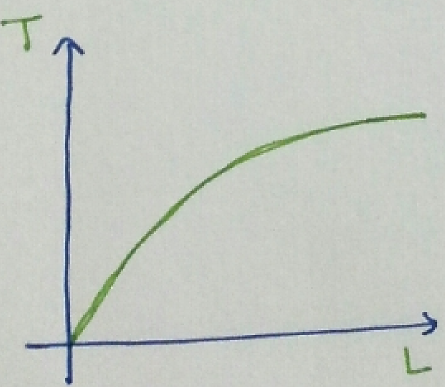
L: length

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

* Plote T vs L

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

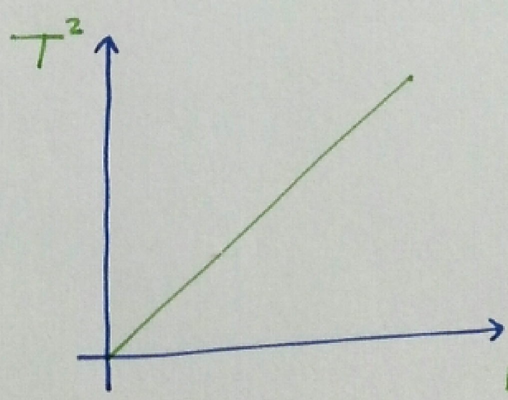
$$T \propto \sqrt{L}$$



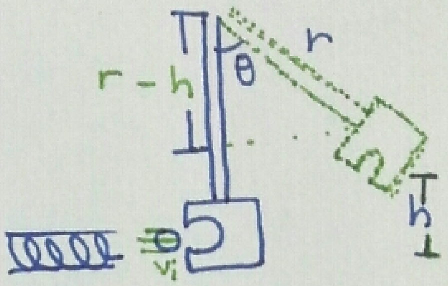
* Plote T^2 vs L

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

$$T^2 \propto L$$



Experiment # 12 Ballistic Pendulum



* $U_i = K_f$ لحظة الإفلات

$$\frac{1}{2} k x^2 = \frac{1}{2} m_b v_i^2$$

$$v_i = \sqrt{\frac{k x^2}{m_b}} \longrightarrow (1)$$

** after the ball is captured by the pendulum.

قبل التصادم $P_i = P_f$ بعد التصادم

m_b : mass of ball

m_p : mass of pendulum.

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

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

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

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

** at maximum hieght

$$U_f = K_i$$

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

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

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

Good luck ^_^