تلخيص

لاب فيزياء 1

zenon

Calculating error & uncertainty :-

1. Percent error.

* يُحسب percent error في التجارب التي تهدف لحساب قيمة متعارف عليها مثل π ، g.

$$* \text{ Percent error} = \frac{|E - A|}{|A|} * 100\%$$

E: experimental value (قد تكون معدل) القيمة المحسوبة من التجربة

A: accepted value. القيمة المتعارف عليها.

* when A (accepted value) is not known we calculate:-

2. percent differance.

two measurements.

$$\text{percent diff.} = \frac{|E_2 - E_1|}{\underbrace{(E_2 + E_1)/2}_{\text{Avg}}} * 100\%$$

* for 3 or more measurements:

الفرق بين أكبر وأصغر قيمة

$$\text{Percent diff} = \frac{\text{absolute differance } \cancel{\text{betw}} \text{ of the extreme values}}{\text{avg}}$$

* Average or (mean) value ($\bar{x}$):-

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n} = \frac{1}{n} \sum_{i=1}^{N} x_i$$

* لحساب تشتّت القيم المقاسة عن المعدل $\bar{x}$ نستخدم الانحراف المعياري

(d) standard daviation

$$d_i = \underbrace{x_i}_{\text{القيمة المقاسة}} - \overset{\text{المعدل}}{\bar{x}} \Leftarrow$$

لحساب الانحراف المعياري لقيمة واحدة من القيم المقاسة

$$\delta = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \dots (x_n - \bar{x})^2}{n}}$$

لحساب الانحراف المعياري لمجموعة من القيم المقاسة.

$$= \sqrt{\frac{d_1 + d_2 + \dots + d_n}{n}}$$

* when we have a <u>Small number</u> of measurements it's better to use:-

$$\delta = \sqrt{\frac{d_1+d_2+\dots+d_n}{n-1}}$$

→ we can use standard daviation δ to calculate the precision or <u>error</u> in the mean of a ~~gp~~ set of measured values.

$$\underbrace{\Delta \bar{x}}_{\text{error in } x} = \frac{\delta}{\sqrt{n}} = \sqrt{\frac{(x_1-\bar{x})^2+(x_2-\bar{x})^2+\dots+(x_n-\bar{x})^2}{n(n-1)}}$$

n ← عدد القيم المقاسة

* هذا القانون يستخدم لحساب ال error لقيمة قمنا بقياسها مثل الإزاحة أو ~~ال~~ الزاوية ....

* بعض القيم مثل الكتلة تقاس بأدوات تكون نسبة الخطأ بها محددة وتساوي نصف أصغر قراءة يستطيع الجهاز قراءتها.

مثلاً في الميزان أصغر قراءة = $(0.01)g$

$\therefore$ error = Δm = $\pm 0.005\,g$

* بعض القيم الأخرى تقوم بحسابها من خلال عدة قيم مقاسة مثلاً:

$$V = \frac{\pi D^2 H}{4}$$

* Rules → قواعد حساب الخطأ

1. $R = x+y$ or $R = x-y$ — x, y are measured values

$$\Delta R = \sqrt{(\Delta x)^2+(\Delta y)^2}$$

2. $R = x*y$ or $R = x/y$

$$\Delta R = \bar{R}\sqrt{\left(\frac{\Delta x}{x}\right)^2+\left(\frac{\Delta y}{y}\right)^2}$$

$\frac{\Delta R}{R} \equiv$ fractional error

3. $R = x^n$

$$\frac{\Delta R}{R} = n\left(\frac{\Delta x}{x}\right) \rightarrow \Delta R = nR\left(\frac{\Delta x}{x}\right)$$

Experiment #1:-

* Purpose:- إيجاد العلاقة بين d (قطر الثقب في قعر الاسطوانة) و h (عمق الماء في الاسطوانة) مع الزمن t

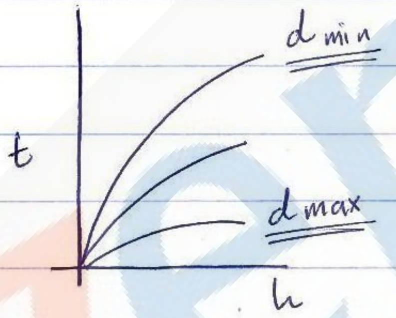
→ Relation $\boxed{t \propto \frac{1}{d^2}}$ (مع تثبيت h)

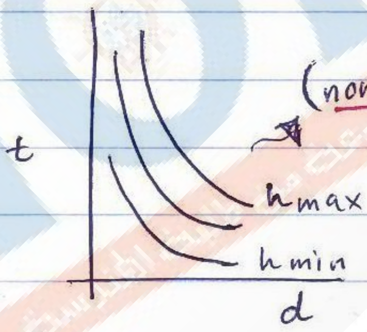
$\boxed{\log t \propto \log h}$ (مع تثبيت d)

متغير مستقل
Independent variable: d و h (المتغير اللي بتغيره وعلى اساسه بتغير المتغير التابع ...)

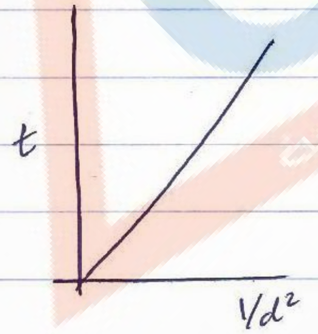
متغير تابع
dependent variable: t

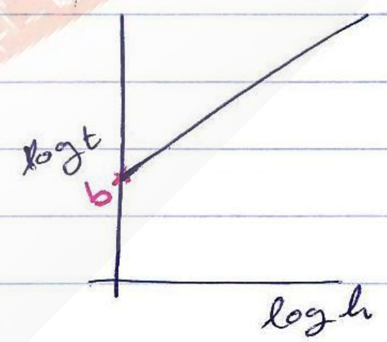
graphs





(non-linear & inverse relation).





$[\text{Slope}] = \frac{s}{\frac{1}{m^2}} = [s.m^2]$

$= c h_0^{\alpha}$

$b = \log(C d_0^{\beta})$

$[\text{Slope}] = [\alpha] = \left(\frac{s}{cm}\right)$

$t(d,h) = \underline{C}\, h^{\underline{\alpha}} d^{\underline{\beta}}$ → constants!

① constant d : $d = d_0$

$$t = \left(C\, d_0^{\beta}\right) h^{\alpha} \quad \ldots ①$$

$$t = C' h^{\alpha}$$

$$\log t = \underbrace{\log C'}_{\text{constant}} + \log h^{\alpha}$$

$$\underbrace{\log t}_{y} = C_2 + \alpha \underbrace{\log h}_{x}$$

y-intercept, slope

$$y = \underline{\underline{b}} + \underline{\underline{a}}\, x \longrightarrow b = \log C'$$

$$C' = 10^{b}$$

$$\underbrace{C d_0^{\beta}} = 10^{b}$$

$a = \alpha$

$b = \log(d_0^{\beta} C)$

plug in ① ∴ $t = 10^{b} h^{\alpha}$ → slope

---

② h constant h : $h = h_0$

$$t = \left(C\, h_0^{\alpha}\right) d^{\beta}$$

$$t = \underbrace{C'}_{\text{slope}} d^{\beta} \qquad \boxed{\beta = -2} \rightsquigarrow t \propto \frac{1}{d^2} \rightsquigarrow t \propto d^{-2}$$

$b = 0.85$ / $\alpha = 0.52$ / $\beta = -2$ / $C h_0^{\alpha} = 166.67$

$$t = 10^{0.85}\, h^{0.52}$$

Experiment # 2:-

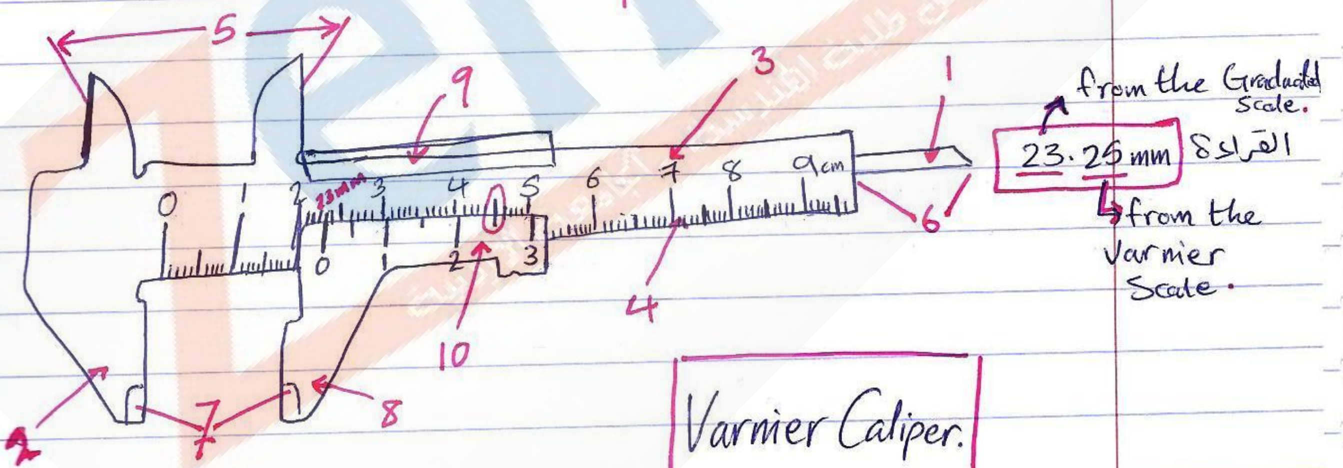
→ **Purpose:-** - ~~Eo~~ Measure length, and mass the use it to Calcutate volume, & density.
- Calculate the value of (π)

→ **Procedure:-** - Calculate value of π using a disk!

$$C = \pi d$$

C: Circumfrance of the disk.
→ Can be measured using ~~Varnier~~ Paper tape & meter stick.

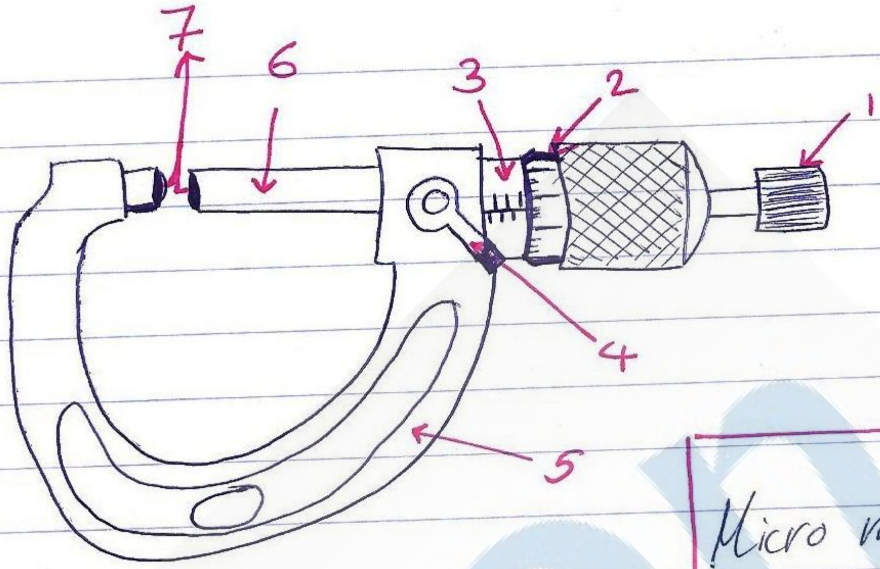
d: ~~ur~~diameter of the disk.
→ Can be measured using Varnier Caliper.



Varnier Caliper.

1 Depth measurment.
2 Fixed jaw blade.
3 Guide bar.
4 Graduated Scale.
5 Knife-edge measuring faces for inside measurements.
6 Measuring faces for Depth measurement.
7 Measuring faces for Outside measurement.
8 Movable jaw blade.
9 Slide.
10 Varnier.

error in measurement = ± 0.025mm
(لأن أصغر وحدة يقيسها 0.05mm)

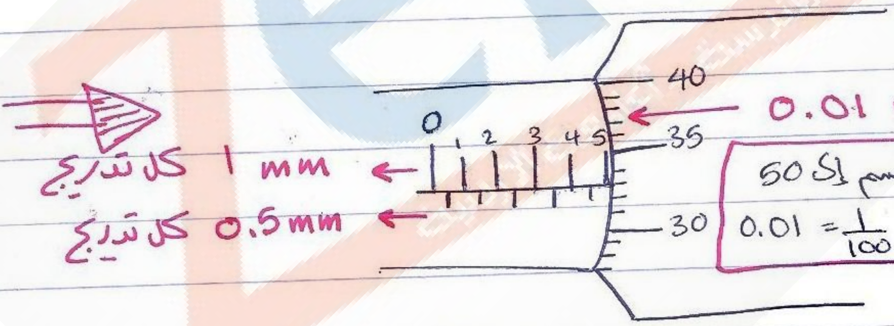


Micro meter.

1- ratchit Knob.
2- Thimble (Varnier Scale).
3- main / Graduated Scale.
4- lock.
5- frame
6- Spindle
7- Anvel.

اصغر وحدة قياس 0.01mm

error = ± 0.005 mm



كل تدريج 0.01 mm

كل تدريج 1 mm

كل تدريج 0.5mm

لأنه 0.5 كل تقسم إلى 50 جزء

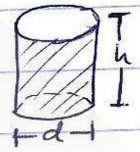
$0.01 = \frac{1}{100} = \frac{0.5}{500}$

القراءة: 5.33

exp → #2

- Calculating density of Brass ρ :-

$$\rho = \frac{m}{V} \longrightarrow V = h * \pi (d/2)^2$$



m :- mass ; measured using Pan Balance

Δm ↳ error = $\pm 0.005\, g$

h :- length of the rod ; measured using Varnier Caliper

Δh ↳ error = ± 0.05 mm

d :- diameter " " ; measured using Micrometer

Δd ↳ error = ± 0.01 mm

Calculating errors :-

* Stage # 1 (calculating π)

(diameter) 1. $\bar{d} = \frac{d_1 + d_2 + \cdots + d_n}{n}$

2. $\Delta \bar{d} = \pm \sqrt{\frac{(d_1 - \bar{d})^2 + (d_2 - \bar{d})^2 + \cdots + (d_n - \bar{d})^2}{n(n-1)}}$

3. $d = \bar{d} \pm \Delta \bar{d}$

repeat the same steps for (c)

(π) 4. $\bar{\pi} = \frac{\bar{c}}{\bar{d}}$

5. $\Delta \bar{\pi} = \bar{\pi} \sqrt{\left(\frac{\Delta \bar{d}}{\bar{d}}\right)^2 + \left(\frac{\Delta \bar{c}}{\bar{c}}\right)^2}$

6. $\pi = \bar{\pi} \mp \Delta \bar{\pi}$

7. which ~~value~~ error contributes most to π.

we calculate $\left(\frac{\Delta \bar{d}}{\bar{d}}\right)^2$ & $\left(\frac{\Delta \bar{c}}{\bar{c}}\right)^2$ and the higher value contribute most to π.

القيمة المتعارف عليها = 3.14

8. Calculate experimental error = $\left|\frac{\pi_{measured} - \pi_{known}}{\pi_{known}}\right| * 100\%$

Stage * 2 (calculating ρ)

1. $\Delta m = \pm 0.005\,g$
2. $h = \frac{h_1 + h_2 + \dots + h_n}{n} + \sqrt{\frac{(h_1-\bar{h})^2 + (h_2-\bar{h})^2 + \dots + (h_n-\bar{h})^2}{n(n-1)}}$

   بنجيد نفس خطوات d و $\Delta\bar{d}$ و $\bar{d}$ ...

3. $d = \bar{d} + \Delta\bar{d}$
4. $\bar{\rho} = \frac{m}{\bar{h} * \pi (\bar{d}/2)^2}$
5. $\Delta\bar{\rho} = \bar{\rho}\sqrt{\left(\frac{\Delta m}{m}\right)^2 + \left(\frac{\Delta\bar{h}}{\bar{h}}\right)^2 + \underbrace{\left(\frac{\Delta\bar{\pi}}{\bar{\pi}}\right)^2}_{\text{from stage * 1}} + \left(\frac{2\Delta\bar{d}}{\bar{d}}\right)^2}$
6. $\rho = \bar{\rho} \pm \Delta\bar{\rho}$

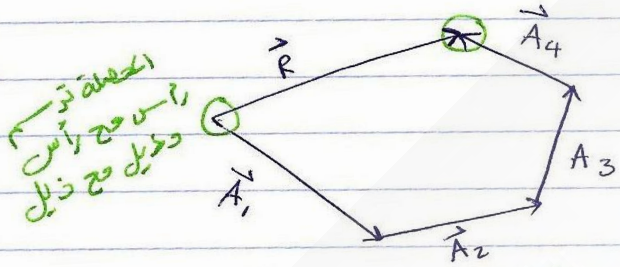
Experiment #3:- Vectors (Force Table).

→ Purpose:- to calculate resultant force using:-

1) $\boxed{\text{graphical}}$ 2) $\boxed{\text{experimental}}$ 3) $\boxed{\text{Algebrical}}$

methods.

A) Graphical Method:



Polygon Method

* we should use a convinient scale.
* $|\vec{R}|$ is determined using a ruler

→ direction of $\vec{R}$ is determined using Protractor.

→ magnitude should be multiplyed by the chosen scale factor.

B) Method of Components (~~Algebraic~~ Algebric)

$$\vec{A}_{x_1} = |\vec{A}_1| \cos\theta_1 \, \hat{i} \qquad \vec{A}_{y_1} = |\vec{A}_1| \sin\theta_1 \, \hat{j}$$

$$\vec{A}_x = \sum_1^n A_{x_i} \, \hat{i} \qquad \vec{A}_y = \sum_1^n \vec{A}_{y_i}$$

$$|\vec{R}| = \sqrt{(A_x)^2 + (A_y)^2}$$

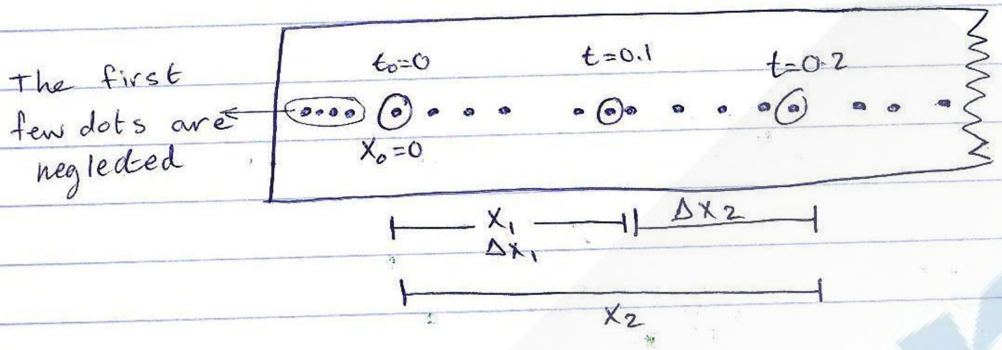
$$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

C) Experimental Method (Force table).

⇒ (from manual)

Experiment #4: kinematic of rectilinear motion.

→ Purpose:- study irregular motion (made by hand).



→ ticker timer marks a dot on the ticker tape each (1/50)s so we take every 5 dots to represent (0.1)s.

→ Average Speed $\bar{V}_i = \Delta X_i / \underbrace{\Delta t}_{=0.1s}$ cm/s

→ Average Acceleration $\bar{a}_i = \Delta v_i / \Delta t$ cm/s^2

* نقوم بحساب ΔX لكل فترة زمنية (0.1) ثم نحسب $\bar{V}_i$ لكل فترة

مثلاً :-

from $t = 0 \rightarrow 0.1$ s

$\Delta X_1 = 5.9$ cm

$\therefore \bar{V}_1 = 5.9/0.1 = 59$ cm/s

$V_{instantanous}$ at $t = 0.05 = 5.9/0.1 = \underbrace{59 \text{ cm/s}}$

$\therefore \underset{a\ t(mid)}{V_{inst}} = \underset{at\ t}{\bar{V}_{avg}}$

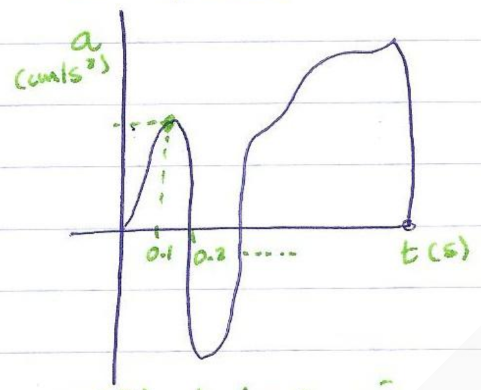
$\bar{V}_{2-10}$ / $\bar{V}_{3-9}$ / $\bar{V}_{4-8}$ / $\boxed{\bar{V}_{5-7}}$

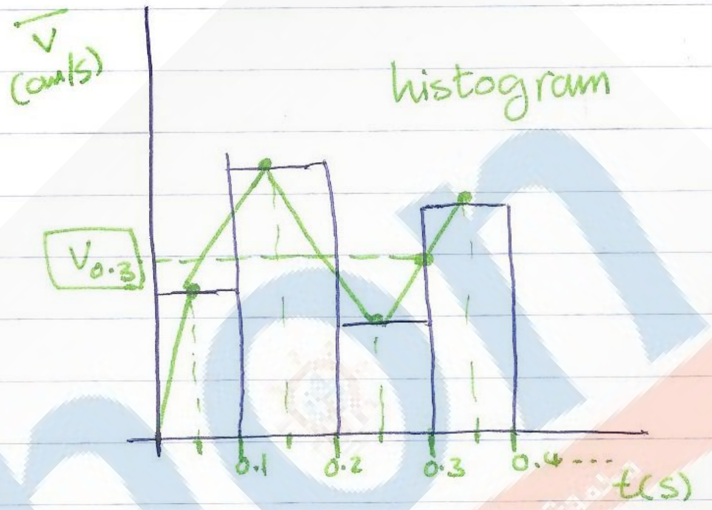
الأكثر دقة

$\bar{V}_{a-b} = \dfrac{X_b - X_a}{\Delta t}$ ← X * مقاسة من $X_0 = 0$ (من المرجع)

* V is highest when spaces between dots are longest & vice versa.

→ Graphs

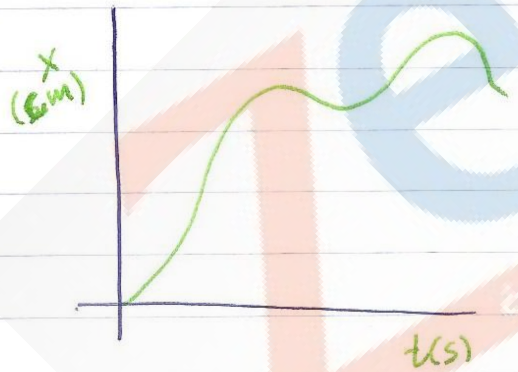




.... قيم a عند $t = 0.1 \& 0.2$

$\bar{a}_{avg} = \Delta v_i / \Delta t$

$(v_{i+1} - v_i)/\Delta t$



slope of tangent line at $t = a$

$= V_{inst}(a)$

Experiment 6:- collision in two dimensions.

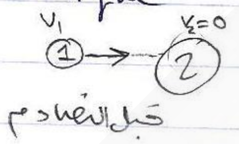
* purpose :- to proove the conservation of momentum by simulating 2D elastic collision.

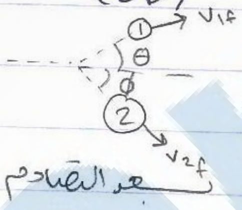
* Introduction:-

Collisions

↳ head-on collision (1D) تصادم في بعد واحد

↳ Oblique " (2D)





$\theta + \phi = 90°$

if $m_1 = m_2$

$v_{2i} = 0$

→ from momentum conservation:-

$$(\vec{P}_1)_i + (\vec{P}_2)_i = (\vec{P}_1)_f + (\vec{P}_2)_f$$

$$\cancel{m_1}\vec{v}_{1i} + \cancel{m_2}\vec{v}_{2i} = \cancel{m_1}\vec{v}_{1f} + \cancel{m_2}\vec{v}_{2f} \quad \text{... if } m_1 = m_2$$

$$\vec{v}_{1i} + \vec{v}_{2i} = \vec{v}_{1f} + \vec{v}_{2f} \quad \text{--- ①}$$

→ in an elastic collision:-

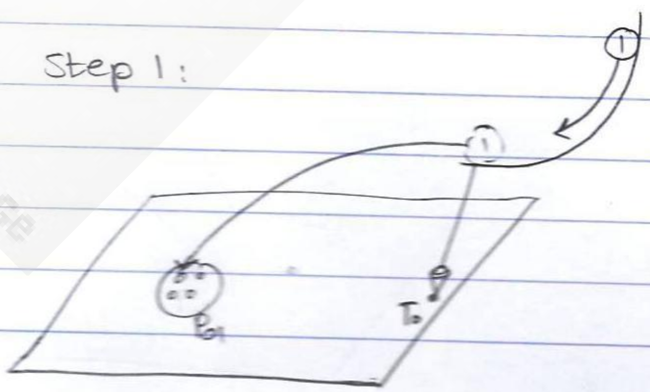
$$K.E_i = K.E_f$$

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

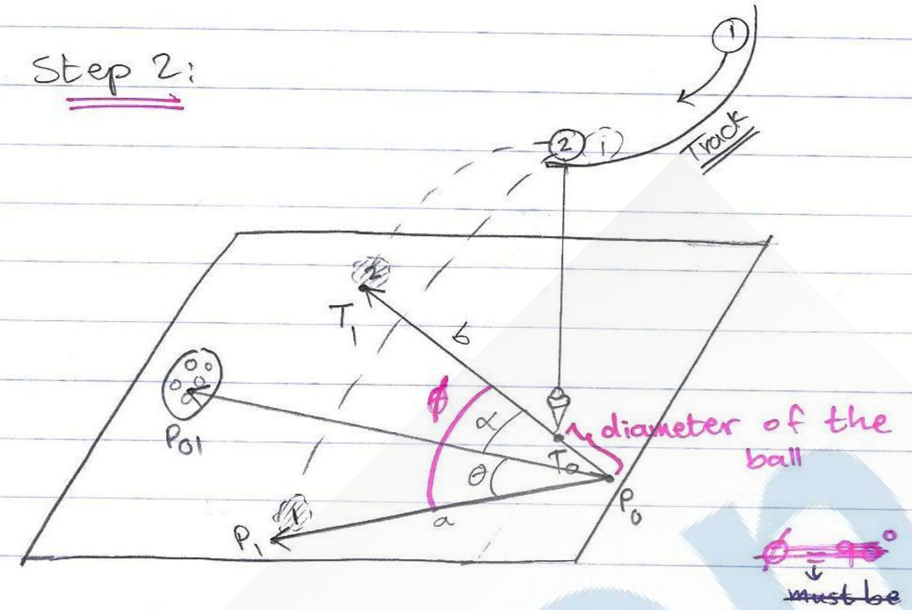
$$v_{1i}^2 + v_{2i}^2 = v_{1f}^2 + v_{2f}^2 \quad \text{--- ②}$$

* من التجربة نريد اثبات تساوي طرفي كل من ① و② حتى نثبت أن الزخم محفوظ وأن التصادم (elastic).

Step 1:



Step 2:



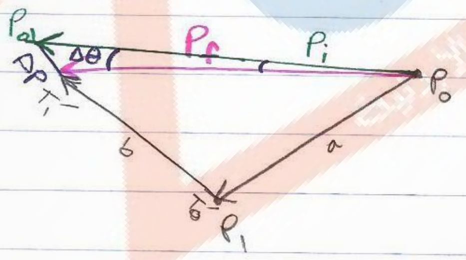
$\underbrace{P_0P_{01}}_{\text{(Projectile) ball 1}} \equiv$ momentum before collision $\equiv (V_{1i} + \cancel{V_{2i}}) = V_{1i}$

$\underbrace{P_0P_1}_{\text{Projectile (1)}} + \underbrace{T_0T_1}_{\text{target (ball 2)}} \equiv$ momentum after collision $\equiv (V_{1f} + V_{2f})$

momentum after collision (P_f)

لحساب قيمة $\boxed{P_0P_1 + T_0T_1}$ نقوم بجمع الاتجاهين عن طريق الرسم

عبر رسم الاتجاه T_0T_1 من رأس P_0P_1



$P_i \approx P_f$ $\therefore$ momentum is conserved

from ② before after

$(V_{1i}^2) \overset{?}{=} (V_{1f}^2 + V_{2f}^2)$ K.E conservation

$(P_0P_{01})^2 \overset{?}{=} (P_0P_1^2) + (T_0T_1)^2$

$(P_0P_{01})^2 \simeq (P_0P_1)^2 + (T_0T_1)^2$ $\therefore$ K.E is conserved & the collision is elastic

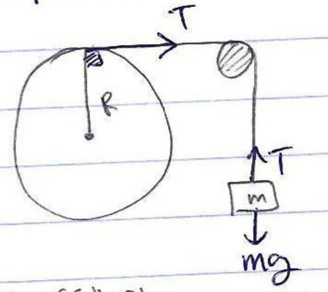
$\phi_A = 90$ because collision is elastic & $m_1 = m_2$ &
$V_2 = 0$

$\phi = \alpha + \theta \rightsquigarrow$ T_0T_1 & P_0P_1 الزاوية بين

$$\text{Percent error} = \left| \frac{\phi - \phi_A}{\phi_A} \right| * 100\%$$

Experiment # 7: Rotational motion:

* Purpose:- (I: moment of inertia) حساب -



[1] $F = ma$

$mg - T = ma$

$T = m(g-a)$ ...①

بعد القوة عن المحور

$\vec{F} = \vec{T}$ (tension)

[2] $\vec{\tau} = \vec{r} \times \vec{F} = I * \alpha \rightarrow \alpha = a/R$

$TR = I\alpha$

from ①

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

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

$mR\left(\frac{g}{\alpha} - R\right) = I$

$$\boxed{I = m\left(\frac{gR}{\alpha} - R^2\right)}$$

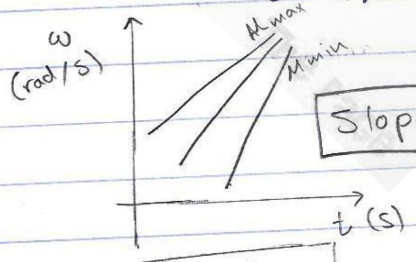
* if we have α, m, R → we can find I

Part 1:-

الخطوات :-

variable:- M (mass of the disk)

① * نقوم بحساب السرعة V عند قيم مختلفة لـ(M) من خلال قراءات الأشرطة الورقية ومن ثم حساب ω من العلاقة $\omega = V/R$



$\boxed{\text{Slope} = \alpha} = \frac{\Delta\omega}{\Delta t}$

⇒ when M increases, α decreases

$M \propto \frac{1}{\alpha}$

$\omega \propto t$
linear, direct relation

② حساب I ← moment of inertia لقيم M المختلفة من خلال القانون

$$I = \underset{\text{const.}}{m}\left(\frac{gR}{\alpha} - R^2\right)$$

R → const. = disk radius.
α → variable

$$\Longrightarrow \boxed{M \propto \frac{1}{\alpha} \propto I}$$

$[I] = g.cm^2$

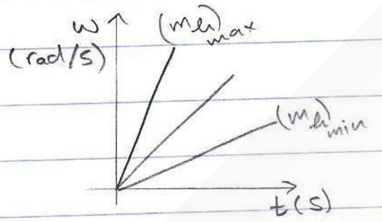
Part #2 :-

Variable :- m_h (hanging mass)

* الخطوات :-

① نقوم بحساب السرعة v للقيم المختلفة لـ (m_h) من خلال الأشرطة الورقية ثم نحسب ω.

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



→ when m_h increases, α (slope) increases.

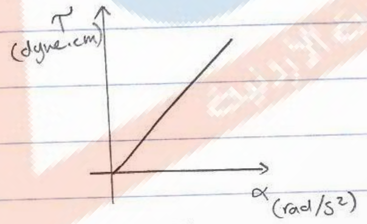
$m_h \propto \alpha$

② نقوم بحساب τ من خلال القانون

$$\tau = I\alpha$$

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

$[\tau] = (\text{dyne.cm})$



slope = I

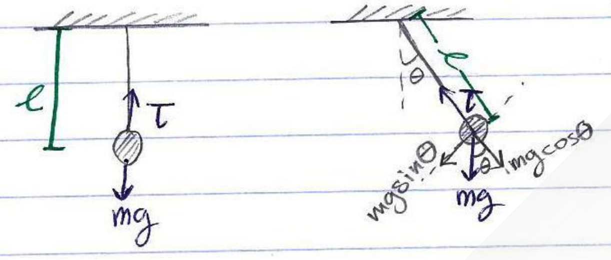
لحساب نسبة الخطأ في I نقوم باستخدام قانون percent differance لأنه لدينا قيمتين لـ I من دون قيمة مرجعية A

$$\text{percent differance} = \frac{|I_1 - I_2|}{(I_1 + I_2)/2} * 100\%$$

Experiment #8: Simple harmonic motion (simple pendulum).

*Purpose: حساب قيمة g من خلال دراسة Simpe harmonic motion ودراسة العلاقة بين $(\ell \,\&\, \bar{T}^2) / (\ell \,\&\, \bar{T})$

الزمن الدوري (اللازم لإنهاء دورة واحدة) و ℓ طول البندول

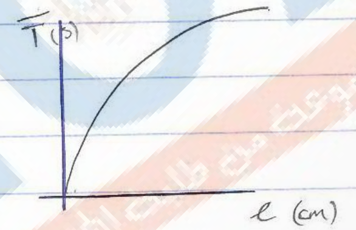


$$F_r = \frac{mv^2}{r} \quad \text{(القوة المركزية)}$$

$$T - mg\cos\theta = \frac{mv^2}{\ell} \quad \text{---}①$$

$$F_{tangential} = mg\sin\theta \quad \text{---}②$$

$$* \; T(\ell) = 2\pi\sqrt{\frac{\ell}{g}} \longrightarrow$$



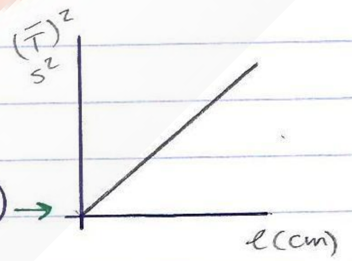
T: period of oscillation (s)

ℓ: length of the pendulum (m)

constant = slope

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

$\therefore T^2 \propto \ell$ (direct, linear relation) →



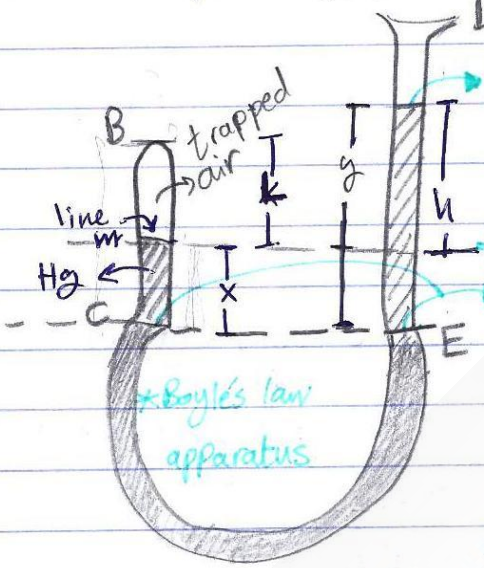
$$\text{Slope} = \frac{4\pi^2}{g}$$

$$\therefore g = \left(\frac{4\pi^2}{\text{slope}}\right) = E \quad \text{expiremental value}$$

$$\text{Percent error in } (g) = \left|\frac{E - A}{A}\right| * 100\% \qquad A = 980 \text{ cm/s}^2$$

Experiment ※9:- The laws of gases:-

*purpose :- حساب الضغط الجوي Patm من خلال العلاقة بين الضغط pressure و الحجم Volume (حجم الهواء المحصور) عند درجة حرارة ثابتة (حرارة الغرفة).



$P = P_{atm}$

P is equal at every point of this line — النقاط التي لها نفس العمود يكون الضغط عليها متساوي

$P_E = P_C$

*Boyle's law:-

Part 1:→ we have constant quantity of trapped gas at constant temp. P & V are variables (for the trapped Air)

الضغط ← P ، الحجم volume ← V

[P] = pascal

$$P_{fluid} = \frac{W}{A} = \frac{mg}{A} = \frac{\rho V g}{A} = \rho g h$$

W: weight وزن المائع ، A: المساحة ، V = Ah

$$\boxed{\vec{P} = \rho g h}$$

ρ: density

* في الجزء (I) نثبت BC و نحرك DE
* نعتمد النقطة B كنقطة مرجع.
* عند تحريك DE في كل مرة نأخذ قياسات x و y.

at the line m

$$\left(P_{gass} = P_{atm} + \rho_{Hg}\, g\, h\right) / \rho_{Hg}\, g$$

gass: الغاز المحصور — the right side = the left side

$$\frac{P_g}{\rho_{Hg}\, g} = h + \frac{P_{atm}}{\rho_{Hg}\, g}$$

$$P'_g = h + P'_{atm} \quad \ldots ① \Rightarrow$$

هنا P' تعامل كطول (mm Hg)

* بعد أخذ قياسات X,Y لارتفاعات مختلفة للأنبوب PE مع ثبات (BG)

$\underline{l} = \overset{\text{constant}}{B} - X$ — طول عمود الغاز المحصور

$\underline{h} = Y - X$ — الفرق في طول عمودي الزئبق

from ideal gas law

* $P \cdot V = \text{constant}$ (at the same temperature)

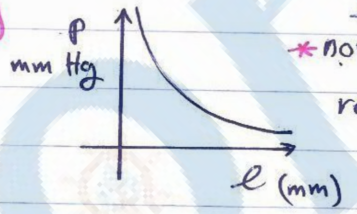
$P = \frac{\text{const}}{V}$

$P = \frac{\text{const.}}{A\, l}$ (const.)

$P = \text{const.} * \frac{1}{l}$

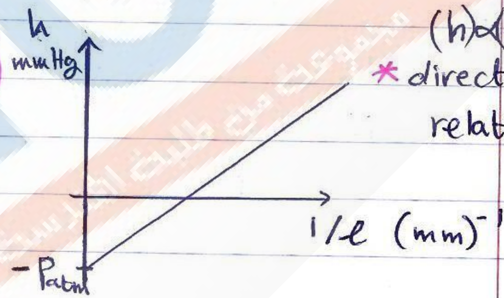
$\therefore P \propto \frac{1}{l}$

$\boxed{1}$



* non linear, inverse relation

$\boxed{2}$



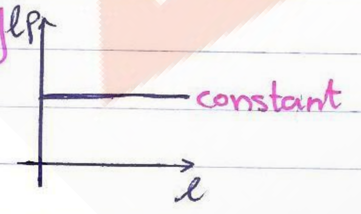
$(h) \propto (\frac{1}{l})$

* direct, linear relation

Plug in (1)...

ضغط بدلالة الطول mmHg $\leftarrow h = \underbrace{(\text{const.})}_{\text{slope}} \cdot \frac{1}{l} \underbrace{\left(- P_{atm}'\right)}_{\text{y-intercept}}$

$\boxed{3}$



experiment # 11: Specific heat capacity

~> specific heat capacity (C)

* *[C] = cal /(g . c°)

مهم التمييز بينهم

~> Heat capacity = m C = [cal / c°]

~> Heat = Q = $m \overset{\text{constant}}{\underline{\underline{C}}} \Delta T$ ⇒ كمية الطاقة اللازمة لرفع درجة حرارة m غرام من مادة سعتها الحرارية C بمقدار ΔT درجة من دون تغيير حالتها الفيزيائية.

[Q] = cal

* **Note**:- (1 cal = 4.18 Joules)

⇒ heat absorbed by one part of a system = heat ~~gained~~ lost by the other part of the same system

$$Q_{\text{gained by water \& calorimeter}} = Q_{\text{lost by brass}}$$

$$m_w C_w \underbrace{\Delta T_w}_{=|T_f - T_1| \text{ موجبة}} + m_c C_c \underbrace{\Delta T_c}_{\Delta T_c = \Delta T_w} = m_b C_b \underbrace{\Delta T_b}_{|T_2 - T_f|}$$

T_1 = initial temperature of water + Calorimeter.

T_2 = " " " brass.

T_f = equilibrium temperature.

<u>let</u> $x = \Delta T_w = \Delta T_c$

$y = (m_w C_w + m_c C_c)$

$z = \Delta T_b$

$\therefore y x = m_b C_b z$

$C_b = \dfrac{y x}{z m_b}$ ...①

error in $C_b = \Delta C_b$

$$\Delta C_b = C_b \sqrt{\left(\frac{\Delta y}{y}\right)^2 + \left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta z}{z}\right)^2 + \left(\frac{\Delta m}{m}\right)^2}$$

$$\Delta x = \sqrt{(\Delta T)^2 + (\Delta T)^2} = \sqrt{2}\,\Delta T$$

$$\Delta y = \sqrt{(\Delta m_w)^2 + (\Delta m_c)^2}$$

$\Delta z = \sqrt{2}\,\Delta T$ (في حال كان ΔT ثـ بتطلع القراءتين/نفس الجهاز)

$\Delta m = \dfrac{\pm \text{أصغر قراءة للميزان}}{2} = \pm 0.005\ g$

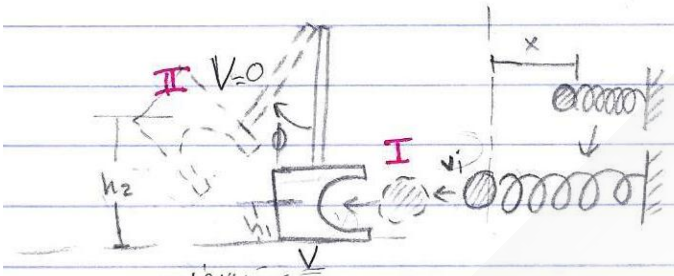
* possible sources of error:-

* ① energy (heat) lost with the surroundings.

② error in readings by the observer.

Experiment 12 : Ballistic Pendulum.

* Purpose:- حساب g (تسارع الجاذبية) من خلال تطبيق مبدأ حفظ الطاقة ومبدأ حفظ الزخم



قبل الإطلاق

$\Rightarrow$ Potenial E_i = Kinetic E_f → بعد الاطلاق مباشرة

$$\frac{1}{2}kx^2 = \frac{1}{2}mv_i^2 \quad \dots ①$$

$$V_i = \sqrt{\frac{kx^2}{m}} \quad ②$$

* after ball is captured by the pendulum, we can calculate their speed using the conservation of momentum & energy.

※ كمية الحركة قبل التصادم $P_i = P_f$ ← كمية الحركة بعد التصادم

$$mV_i = V(m + M_{tot}) \quad \dots ③$$

m: mass of the ball

M_{tot}: total " " pendulum

طاقة الحركة

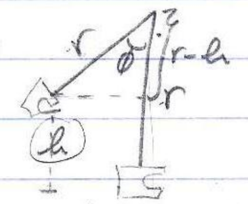
\# $K.E_{I} = P.E_{II}$ عند أعلى ارتفاع (II is at the maximum height, V=0 → K.E=0)

$$\frac{1}{2}(m+M)V^2 = (m + M_{tot})\, g\, \Delta h$$

$$V = \sqrt{2g\underbrace{r(1-\cos\phi)}_{h}}$$

$\therefore$ from ③ $\quad v = \frac{m+M}{m}\sqrt{2gr(1-\cos\phi)}$

$h \rightarrow$



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

$\therefore h = (1-\cos\phi)r$

Procedure:-

*Part 1:-

* تثبيت الكتلة المضافة للبندول مع تغيير الإزاحة (X).

← عند قيم مختلفة لـ(X) نقوم بحساب V من القانون ①

$$V = \sqrt{\frac{kx^2}{m}}$$

when x increases v increases.

non-linear relation $x \propto v$

* Part 2:-

* تثبيت الإزاحة عند قيمة X_0 ثم تغيير الكتلة المضافة للبندول Ma.

$$v = \frac{m+M}{m}\sqrt{2gr(1-\cos\phi)}$$ ← من القانون

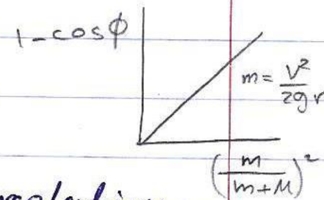
قيم متغيرة

$$V^2 = \left(\frac{m+M}{m}\right)^2 (2gr(1-\cos\phi))$$

$$\therefore \underbrace{1-\cos\phi}_{y} = \overbrace{\underbrace{\boxed{\frac{V_i^2}{2gr}}}_{\text{constants}}}^{\text{slope} = \alpha} \underbrace{\left(\frac{m}{m+M}\right)^2}_{x}$$

V_i: محسوبة عندي من Part 1

$$y = \alpha x$$



$$(1-\cos(\phi)) \propto \left(\frac{m}{m+M}\right)^2$$ direct-linear relation.

since ... $\text{slope} = \frac{V_i^2}{2gr}$

$$\therefore \boxed{g} = \frac{V_i^2}{2r * \text{slope}} = E$$ ← experimental value

percent error in (g) = $\left|\frac{E-A}{A}\right| * 100\%$ $\quad A = 9.80\ m/s^2$