تلخيص

lab phsics 1

لاب فيزياء 1

改善
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TEAM

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

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

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

(d) standard daviation

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

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 ~~gro~~ 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 الـ error لقيمة قمنا بقياسها مثل الإزاحة أو ~~...~~ 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 $= \Delta m = \pm 0.005\,g$

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

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

* Rules → قواعد حساب الخطأ

x, y are measured values

1. $R = x + y$ <u>or</u> $R = x - y$

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

2. $R = x * y$ <u>or</u> $R = x / y$

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

$\frac{\Delta R}{R} \equiv$ 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 (عمود الماء في الاسطوانة) مع الزمن t

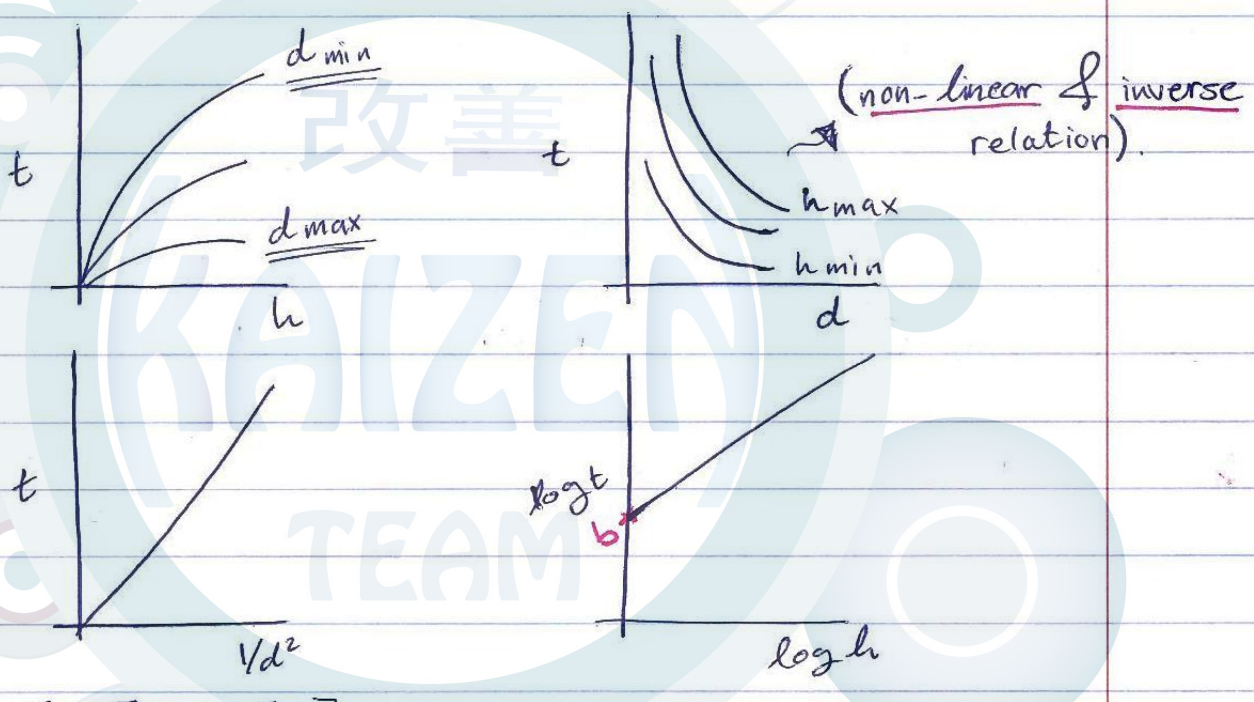
→ Relation $\boxed{t \propto \frac{1}{d^2}}$ (مع تثبيت h)

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

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

متغير تابع
dependent variable: t

graphs



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

$= C h_0^{\alpha}$

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

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

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

(1) constant d : $d = d_0$

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

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

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

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

$$y = \underset{\uparrow\,\text{y-intercept}}{b} + \underset{\uparrow\,\text{slope}}{a}x \longrightarrow b = \log C'$$

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

$a = \alpha$

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

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

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

---

(2) h constant $h : h = h_0$

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

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

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

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

Experiment # 2:-

→ **Purpose:-** - ~~to~~ Measure length, and mass the use it to Calculate volume, & density.

- Calculate the value of (π)

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

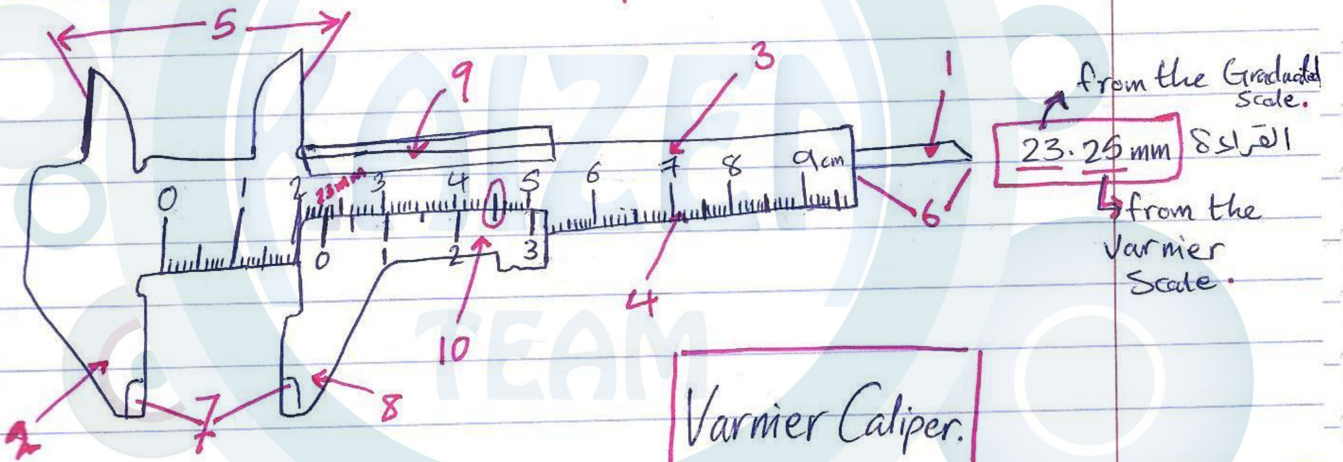
$$C = \pi d$$

C: Circumfrance of the disk.

→ Can be measured using ~~Varnier~~ Paper tape & meter stick.

d: ~~r~~ diameter of the disk.

→ Can be measured using Varnier Caliper.

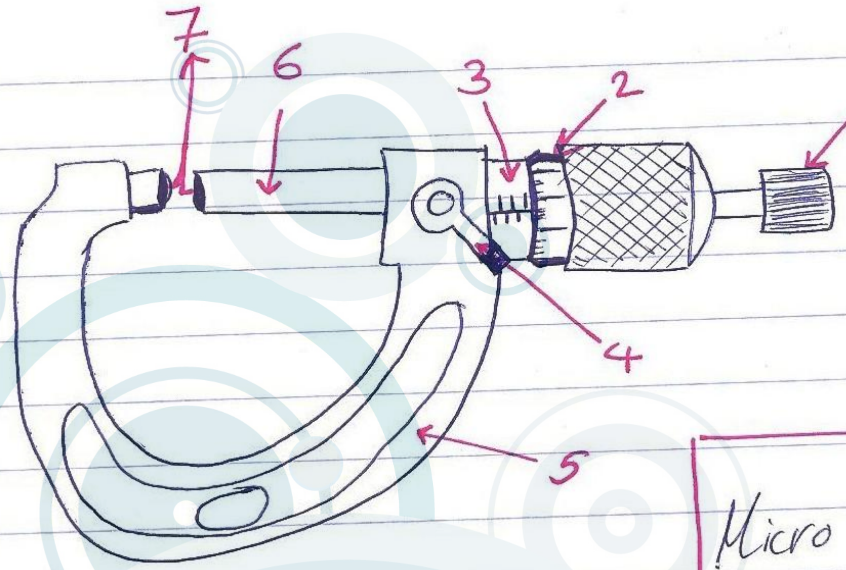


Varnier Caliper.

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)

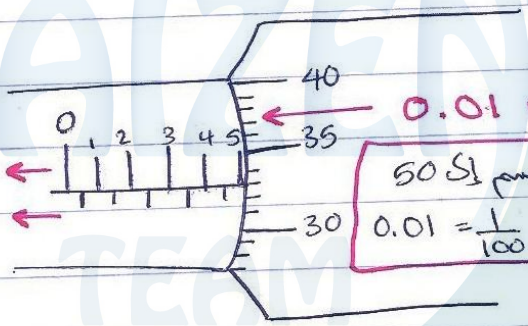
Micro meter.



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

أصغر وحدة قياس 0.01mm

error = ± 0.005 mm



0.01 mm كل تدريج

كل تدريج 1 mm

كل تدريج 0.5mm

لأنه 0.5 كل مقسم إلى 50 جزء

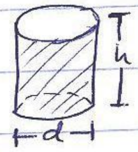
$0.01 = \frac{1}{100} = \frac{0.5}{500}$

القراءة: 5.33

exp → #2

- Calculating density of Brass ρ :-

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



m :- mass ; ~~data~~ measured using Pan Balance
Δm ↳ error = ± 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.

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

القيمة المتعارف عليها ≈ 3.14

Stage # 2 (calculating ρ)

1. $\Delta m = \pm 0.005\ g$

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

2. $\cancel{H} = h = \dfrac{h_1 + h_2 + \dots + h_n}{n} + \sqrt{\dfrac{(h_1-\bar{h})^2 + (h_2-\bar{h})^2 + \dots + (h_n-\bar{h})^2}{n(n-1)}}$

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

4. $\bar{\rho} = \dfrac{m}{\bar{h} * \bar{\pi} (\bar{d}/2)^2}$

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

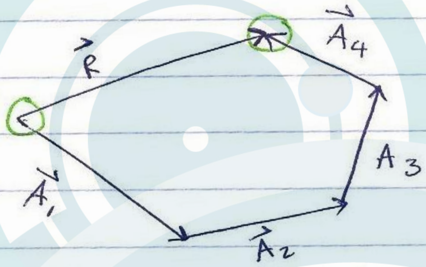
6. $\rho = \bar{\rho} \pm \Delta\bar{\rho}$

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:

المحصلة ترسم راس مع راس وذيل مع ذيل



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 (~~Algebric~~ Algebric)

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

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

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

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

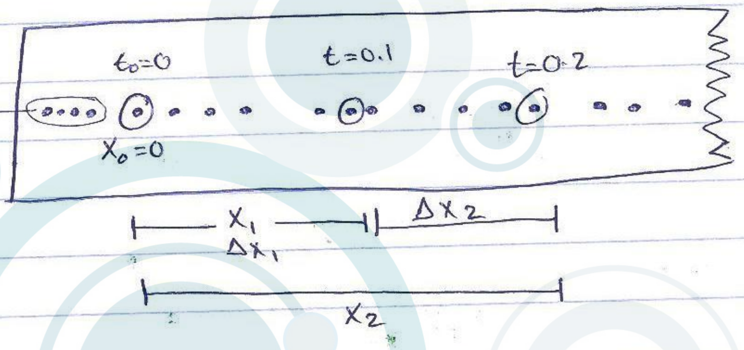
C) Experimental Method (Force table).

⇒ (from manual)

Experiment #4: kinematic of rectilinear motion.

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

The first few dots are neglected



→ 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~~ بحساب ΔX لكل فترة زمنية (0.1s) 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 $t = 0.05 = 5.9/0.1 = \underline{59 \text{ cm/s}}$

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

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

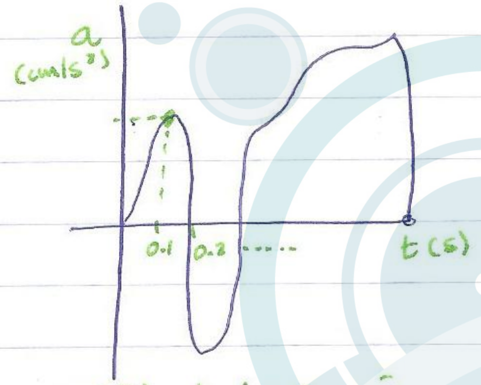
الأكثر دقة

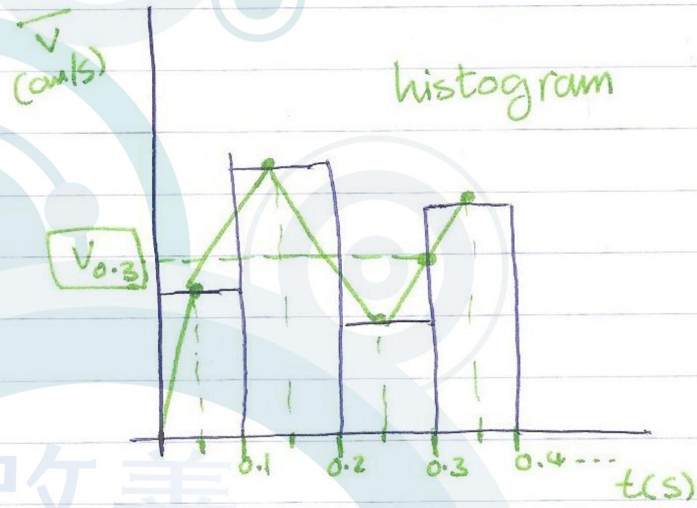
$\bar{V}_{a-b} = \dfrac{X_b - X_a}{\Delta t}$

* مقاسة من $X_0 = 0$ (من المرجع) X

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

→ $\boxed{\text{Graphs}}$

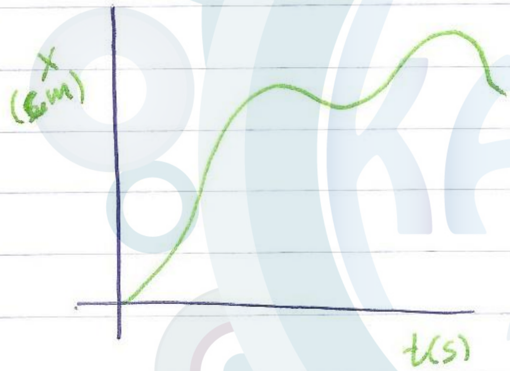




قيم a عند t = 0.1 و 0.2 ....

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

$(V_{i+1} - V_i)/\Delta t$



slope of tangent line at t = a

$= V_{inst}(a)$

Experiment 6:- collision in two dimensions.

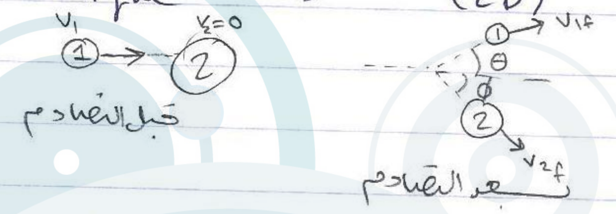
* Purpose :- to proove the conservation of momentum by simulating 2D elastic collision.

* Introduction :-

Collisions

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

↳ Oblique " (2D)



$\theta + \phi = 90^\circ$

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 :-

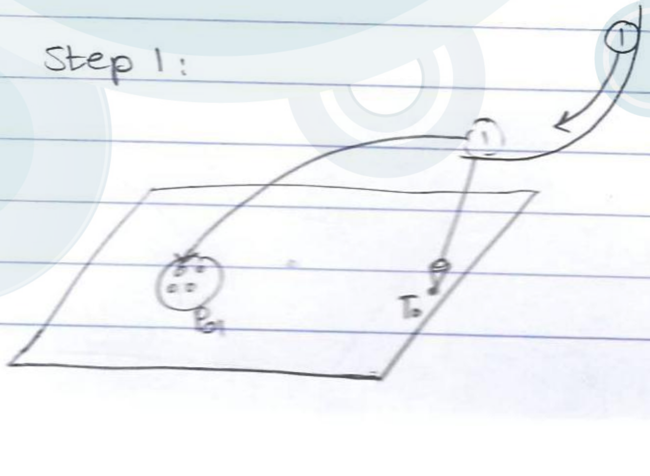
$$K.E_i = K.E_f$$

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

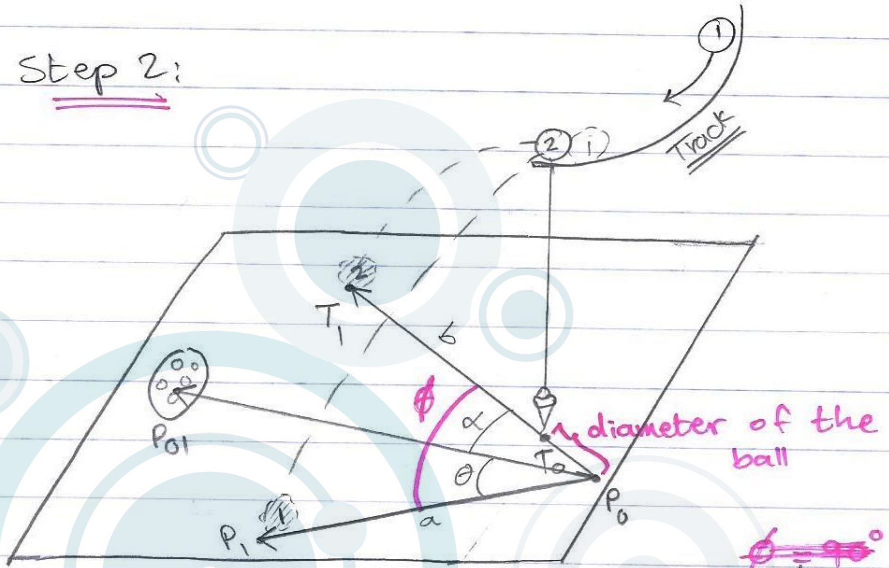
$$v_{1i}^2 + v_{2i}^2 = v_{1f}^2 + v_{2f}^2 \quad \text{--- (2)}$$

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

Step 1:



Step 2:



~~$\phi = 90°$ must be~~

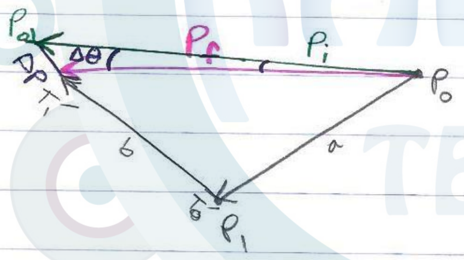
$\underbrace{P_0P_{01}}_{\text{(Projectile) ball 1}} \equiv$ momentum before collision $\equiv (V_{1i} + \cancel{V_{2i}}^{\,0}) = V_{1i}$

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

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

momentum after collision (P_f)

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 & $m_1 = m_2$ &

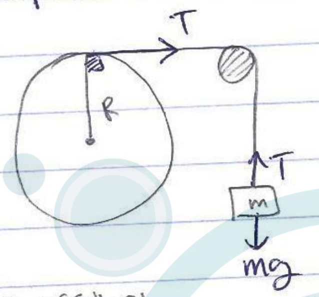
$V_2 = 0$

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

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 $\rightarrow$ we can find I

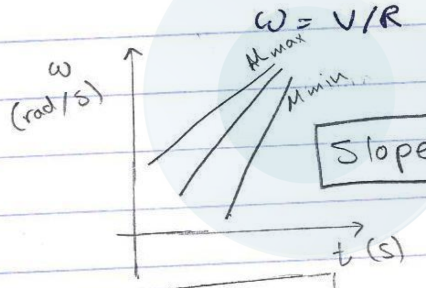
Part 1:-

variable:- M (mass of the disk)

الخطوات :-

(1) * نقوم بحساب السرعة V عند قيم مختلفة لـ(M) من خلال قراءات الأشرطة الورقية ومن ثم حساب ω من العلاقة

$\omega = V/R$



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

$\Rightarrow$ 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

const. = disk radius.

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

α → variable

$$\Longrightarrow \boxed{M \propto \frac{1}{\alpha} \propto I} \qquad [I] = g.cm^2$$

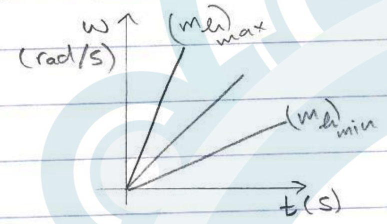
Part #2 :-

Variable :- m_h (hanging mass)

* الخطوات :-

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

$\boxed{slope = \alpha}$



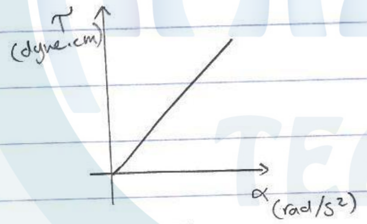
→ when m_h increases, α (slope) increases.

$m_h \propto \alpha$

② نقوم بحساب τ من خلال القانون

$$\tau = I\alpha$$

$$\tau = Rm(g - \alpha R) \qquad [\tau] = (dyne.cm)$$



slope = I

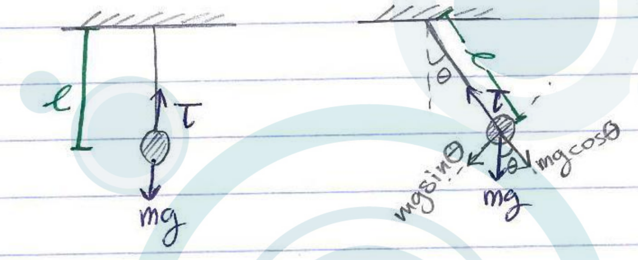
لحساب نسبة الخطأ في I نقوم باستخدام قانون percent differance لأنه لدينا قيمتين لـ I من دون قيمة مرجعية

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

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

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

الزمن الدوري (اللازم لانهاء دورة واحدة) مع طول البندول.

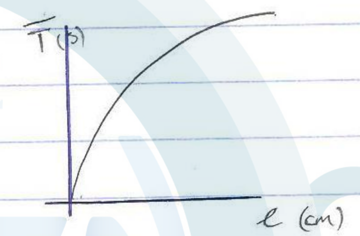


$$F_r = \frac{mv^2}{r} \quad \text{(القوة المركزية)}$$

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

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

* $T(l) = 2\pi\sqrt{\frac{l}{g}}$ →

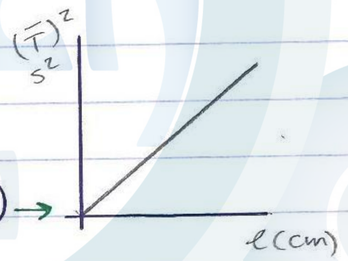


T: period of oscillation (s)

l: length of the pendulum (m)

$$T^2 = \underbrace{\left(\frac{4\pi^2}{g}\right)}_{\text{constant = slope}} l$$

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



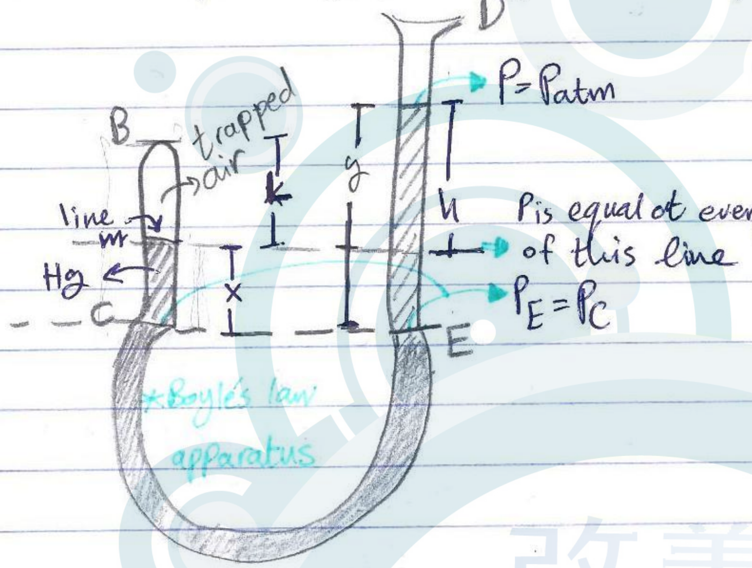
$$\text{Slope} = \frac{4\pi^2}{g}$$

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

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

Experiment ※9:- The laws of gases:-

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



النقاط التي لها نفس الخط يكون الضغط عليها متساوي

* Boyle's law:-

Part 1:→ we have constant quantity of trapped gas at constant temp.

P & V are variables (for the trapped Air)
الضغط الحجم volume

$[P]$ = pascal

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

(W: وزن السائل weight; A: المساحة; $\frac{V}{A} = h$)

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

ρ: density

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

at the line m

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

P_{gass}: الغاز المحصور, the right side — $P_{atm} + \rho_{Hg} g h$: 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′ نتعامل كطول (mm Hg)

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

constant

$\ell = B - X$ ↳ طول عمود الغاز المحصور

$h = y - x$ ↳ الفرق في طول عمودي الزئبق

from ideal gas law

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

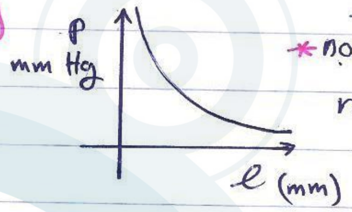
$P = \dfrac{\text{const}}{V}$

$P = \dfrac{\text{const.}}{A\,\ell}$ const.

$P = \text{const.} * \dfrac{1}{\ell}$

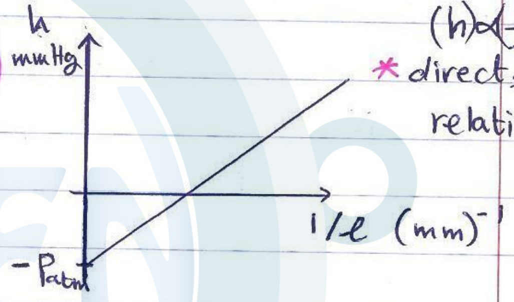
$\therefore P \propto \dfrac{1}{\ell}$

$\boxed{1}$



*non linear, inverse relation

$\boxed{2}$



$(h) \propto \left(\dfrac{1}{\ell}\right)$

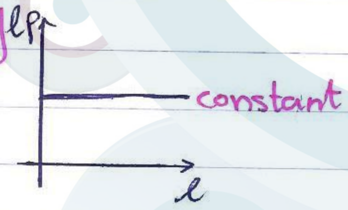
* direct, linear relation

plug in ①...

slope y-intercept

ضغط بدلالة الطول mmHg ← $h = (\text{const.}) \cdot \dfrac{1}{\ell} \left(- P_{atm}\right)$

$\boxed{3}$



experiment # 11: Specific heat capacity

⇝ specific heat capacity (C)

* $[C] = cal/(g \cdot c^\circ)$

مهم التمييز بينهم *

⇝ Heat capacity $= mC = [cal/c^\circ]$

⇝ Heat $= Q = m\underset{=}{\overset{\text{constant}}{C}}\Delta T$ ⇒ 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.

let $x = \Delta T_w = \Delta T_c$

$y = (m_w C_w + m_c C_c)$

$z = \Delta T_b$

$\therefore y x = m_b C_b z$

$C_b = \dfrac{yx}{z m_b}$ ...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 ث بالقراءتين/نفس الجهاز)

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

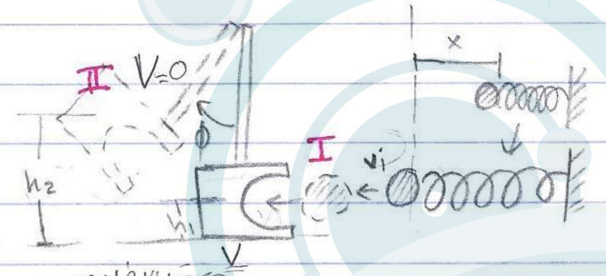
* Possible sources of error:-

* 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

بعد الإطلاق مباشرة

→ Potenial E_i = Kinetic E_f

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

$$V_i = \sqrt{\frac{kx^2}{m}} \quad \text{——} (2)$$

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

※ لحظة قبل التصادم $P_i = P_f$ → لحظة بعد التصادم

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

m: mass of the ball

M_{tot}: total mass of the pendulum

لحظة الالتحام

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

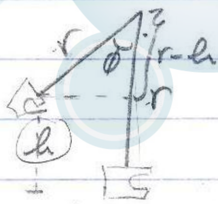
$$\frac{1}{2}(m+M)V^2 = (m+M_{tot})\, g \,\Delta h$$

$$V = \sqrt{2gr(1-\cos\phi)}$$

h

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

h →



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

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

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_o ثم تغيير الكتلة المضافة للبندول M_a.

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

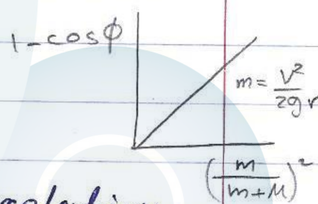
قيم متغيرة

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

slope = α

$\therefore \underbrace{1-\cos\phi}_{y} = \underbrace{\boxed{\frac{V_i^2}{2gr}}}_{\text{constants}} \underbrace{\left(\frac{m}{m+M}\right)^2}_{x}$ V_i: محسوبة عند X_o من Part 1

$y = \alpha x$



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

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

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

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