البندول البسيط - Simple pendulum

* Aim: determination the gravity of acceleration

* Theory: the simple pendulum consists of metalic ball of mass m connected to a string of fixed end at (A) amplitude. the motion of this pendulum is called S.H.M.

* Apparatus:

1- metalic ball 2- string 3- Stand 4- Stop wa

5- Ruler

* Steps:

1) measure the length of the string

2) move the ball by small angel which is less than 15°

3) measure the period Time of 10 oscillations by Stop watch the dived it by 10 to get the period time

4) Repeat steps 2 and 3 by changing the length of string

* Results:

L (cm)	T_{10} (sec)	$T = \frac{T_{10}}{10}$ (sec)	T^2 (Sec^2)
30	10.96	1.096	1.201
35	11.71	1.171	1.371
40	12.31	1.231	1.515
45	12.96	1.296	1.679
50	13.95	1.395	1.946

Results

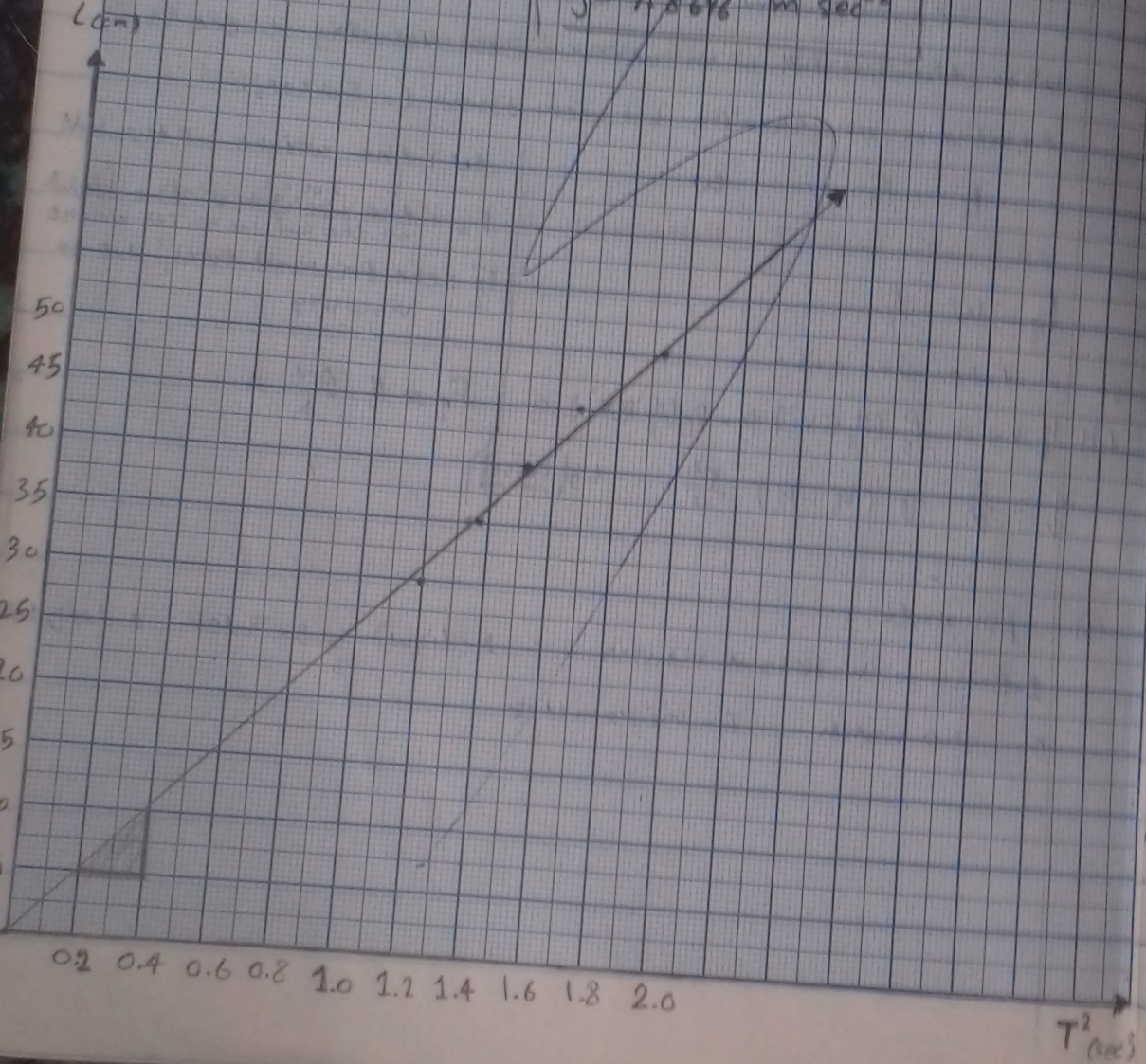
$$\text{Slope} = \frac{\Delta l}{\Delta T^2} = \frac{10.5}{0.4 - 0.2} = \frac{5}{0.2} = 25$$

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \rightarrow T^2 = 4\pi^2 \frac{l}{g}$$

$$g = 4\pi^2 \frac{l}{T^2} = 4\pi^2 \cdot \text{Slope} = 4\pi^2 \times 25$$

$$g = 986.96 \text{ cm sec}^{-2}$$

$$g = 9.8696 \text{ m sec}^{-2}$$



① Aim: Determination of viscosity coefficient of a liquid: η

② theory:

Viscosity: is the resistance of liquid to flow

Viscosity coefficient: Tangential force between two layers of flowing liquid have the same area of the surface and the velocity gradient between them is one.

* when ball fall in liquid there are three forces affect on it.

upward force — downward force

* when the ball fall with uniform velocity there is equilibrum or equality between these to forces.

$F_b + F_\eta = W$

$F_\eta = W - F_b$

W: the weight of the ball

F_b: the force of the liquid on the ball due to its weight

F_η: the frictional force due to viscosity

So in tube we get:

$6\pi \eta r v = \rho_s (\frac{4}{3}\pi r^3) g - \rho_L (\frac{4}{3}\pi r^3) g$

$\eta = \frac{2}{9} g (\rho_s - \rho_L) \frac{r^2}{v}$ by Poise

$F_\eta = \eta \frac{\Delta v}{d} A$

③ Apparatus:

1- Balls with different rituses 2- liquid 3- Ruler 4- long tube

5- stop watch 6- micrometer

STEPS:

① measure the radius of each ball by micrometer.

② Using two marks (A) and (B) on the tube then measure it as constant to get velocity later x:-

③ Drop the ball and start the stop watch when it reaches mark (A) then stop the when it reaches mark (B).

④ by knowing the time and the distance calculate the velocity. $v = \frac{d}{t} = \frac{x}{t}$

⑤ Repeat the steps ③ and ④ to different balls and make a table.

⑥ Calculate the slope of relationship $r^2 \propto v$ and get η value.

Result :

Sphere number	D (cm) قطر	r (cm) نصف قطر	r^2 (cm^2)	t (sec)	$v = \frac{x}{t}$ ($cm\,sec^{-1}$)
1	0.6	0.3	0.09	4.55	10.981
2	0.4	0.2	0.04	9.91	5.0454
3	0.3	0.15	0.0225	17.91	2.7917

$$\eta = \frac{2}{9} g (\rho_s - \rho_L) \frac{r^2}{v} = \frac{2}{9} g (\rho_s - \rho_L) \times \text{Slope}$$

givens:

$g = 980\ cm\,sec^{-2}$

$\rho_s = 7.7\ g/cm^3$

$\rho_L = 1.26\ g/cm^3$

$x = 50\ cm$

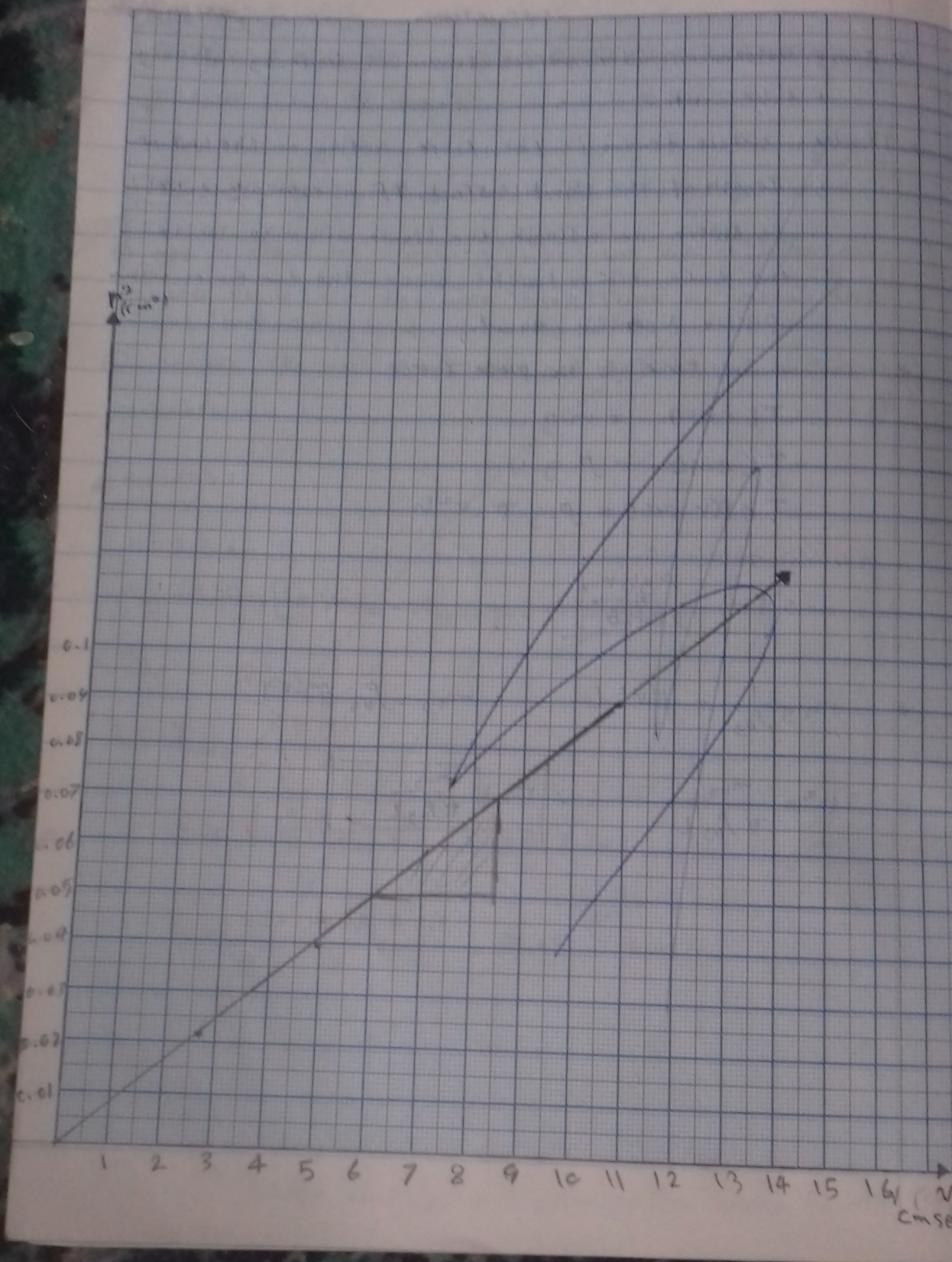
$\frac{r^2}{v} = ?$

$\text{Slope} = \frac{\Delta r^2}{\Delta v} = \frac{0.07 - 0.05}{8.5 - 6}$

$\text{Slope} = 8 \times 10^{-3}\ cm\,Sec$

$$\eta = \frac{2}{9} \times (980)(7.7 - 1.26) \times 8 \times 10^{-3}$$

$\eta = 11.219\ cm^{-1}\,g\,sec^{-1} = 11.2199$ poise


0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
cmse

Surface-Tension

Aim: Determination the surface tension of liquid by capillary tube method

Theory: surface tension is the force acting on the unit of length of the liquid surface. If a capillary tube is dipped in a liquid the liquid will rise inside the tube till a height when the two forces with opposite direction equal.

upward force = downward force

$$T L \cos\theta = m \cdot g$$

$$T L \cos\theta = \rho \cdot g \cdot V$$

$$T \cdot 2\pi r \cos\theta = \rho \cdot g \cdot \pi \cdot r^2 h$$

$$\therefore \boxed{T = \frac{\rho g h r}{2 \cos\theta}}$$

$$m_{Hg} \cdot \frac{1}{\rho_{Hg}} = \pi r^2 \cdot l \qquad m_{Hg} = \rho_{Hg} \pi r^2 L$$

$$r^2 = \frac{m_{Hg}}{\pi \rho_{Hg} L} \qquad \therefore \boxed{r = \sqrt{\frac{m_{Hg}}{\pi \rho_{Hg} L}}}$$

Apparatus

① Vessel of water ② capillary tube ③ mercury
④ Ruler ⑤ balance

Steps:

① get a clean dry capillary tube and put it inside the water vessel till the water stop rising at certain height and note It.

② measure the mass of mercury and It's height in capillary tube.

Results:

$h = 2.5$ cm

$M_{Hg} = 1.5$ g $M_{Total} - M_{Vessel} = 2 - 0.5 = 1.5$ g

$\rho_{water} = 1$ g/cm³

$\gamma_w = T_{water} = \frac{r \rho g h}{2}$

$r = \sqrt{\frac{1.5}{\pi * 13.6 * 8}} = 0.0662$ cm

$\gamma_w = \frac{0.662 * 980 * 2.5}{2} = 81.15$ dyne/cm

Hook's Law

(*) Aim: ① verifaction of Hook's law
② Determination of specific weight of solid.

(*) Theory: - Hook's law: "within elastic region the ΔL is directly proportional with force effects on the body" while ΔL is the increase on the spring length.

$$F \propto \Delta L \Rightarrow F = K \Delta L$$

$$K = F \frac{1}{\Delta L} = m \cdot g \frac{1}{\Delta L} \quad \boxed{K = \frac{m}{\Delta L} \cdot g}$$

- while K is the Hook's or spring constant which is different from material of spring to another.

(*) Apparatus:
1- spring 2- weights 3- scale 4- solid body
5- vessel of water

* Steps: (Proofing Hook's law)
1- determine the zero read for the spring on the scale.
2- add a mass of 5 or grams then note the change in length of the spring in a table.
3- Repeat step 2 for other masses till 50 grams
4- Draw the graph of proportional $m \propto \Delta L$

(Determination of S.W)
1- put the solid body on the spring and note the elgonate.
2- put the solid body in water vessel without touching it walls or body while attatching it to the spring.

* Results

Δm (kg gram)	ΔL (kg cm)
10 g	0.5 cm
20 g	1 cm
30 g	1.5 cm
40 g	2 cm
50 g	2.5 cm

$$Slope = \frac{55 - 45}{2.75 - 2.25} = 20 \ g\,cm^{-1}$$

$K = Slope * g = 20 * 980$

(1) $K = 19600 \ dyne.cm^{-1}$

$\Delta L_a = 3.5$ cm $\Rightarrow$ the elongation for the body in air

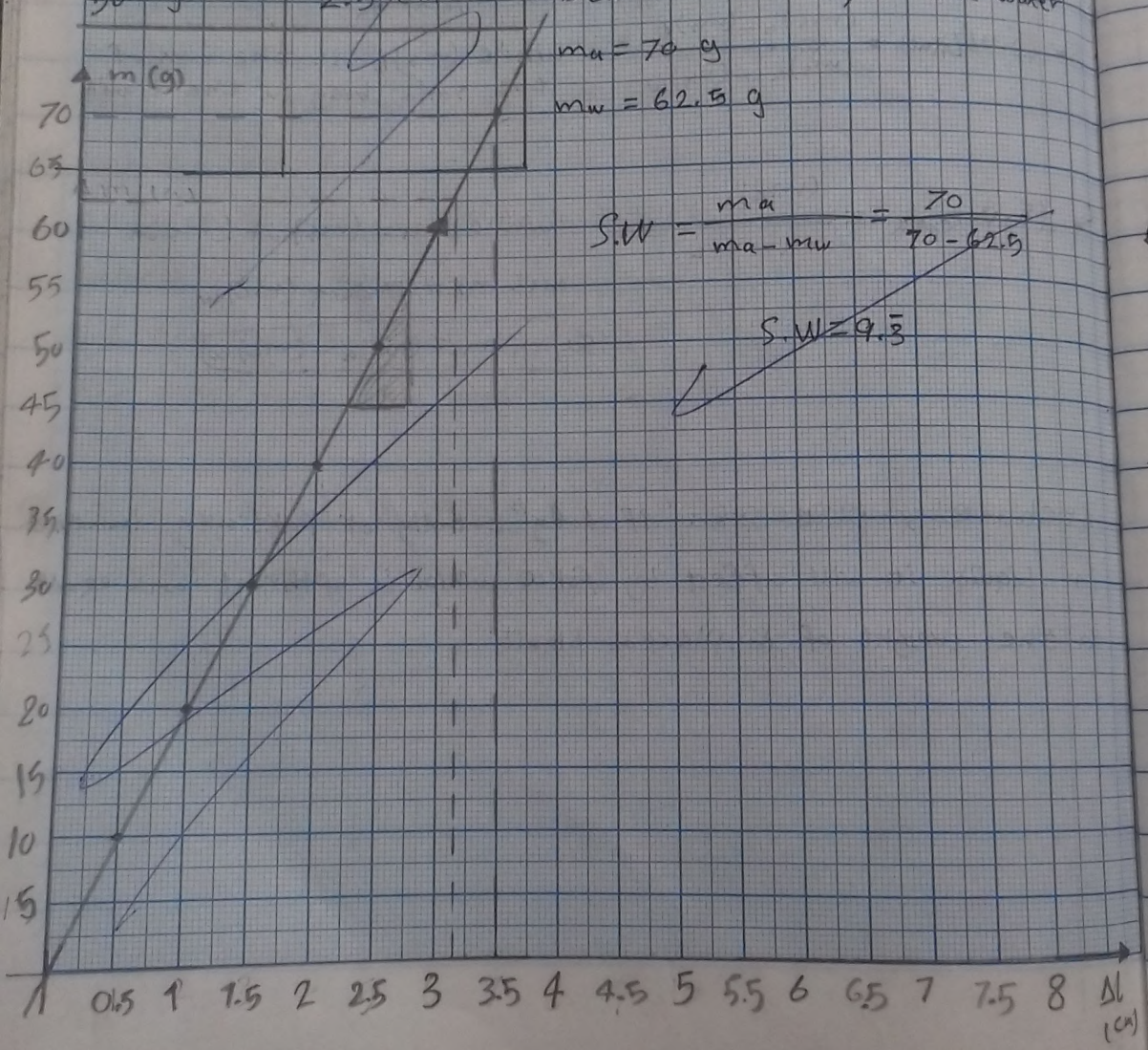
$\Delta L_w = 3.1$ $\Rightarrow$ in the water

$m_a = 70$ g

$m_w = 62.5$ g

$$S.W = \frac{m_a}{m_a - m_w} = \frac{70}{70 - 62.5}$$

$S.W = 9.\overline{3}$



Archimedes principle

Aim: determination the specific weight of
* solid * liquid * cork

Theory:

specific weight = S.W = $\frac{\text{weight of certain volume of matter}}{\text{weight of same volume of water}} = \frac{m_{\text{matter}}}{m_w}$

A- $(S.W)_{solid} = \frac{(m_s)_a}{(m_s)_a - (m_s)_w}$

while $(m_s)_a$ & $(m_s)_w$ is the mass of the solid body in air and water respectively.

B- $(S.W)_{liquid} = \frac{(m_s)_a - (m_s)_l}{(m_s)_a - (m_s)_w}$

While $(m_s)_l$ is the mass of the solid body in the liquid

C- $(S.W)_{cork} = \frac{(m_c)_a}{m_1 - m_2}$

while $m_1 = (m_s)_w + (m_c)_a$

and $m_2 = (m_s)_w + (m_c)_w$

So $\boxed{m_1 - m_2 = (m_c)_a - (m_c)_w}$

Archimedes principle: "if body is totally or partially immersed in liquid it will affect by force which is upthrust and equal to the weight of displaced liquid"

Apparatus

① Balance ② Solid ③ Liquid ④ cork ⑤ bridge
⑥ weights (0.1g → 0.5)

Steps

① find the values of the solid and cork masses in air [$m_{s/a}$ and $m_{c/a}$]
② find $(m_s)_w$ and $(m_s)_L$ by adding the bridge with out touching the balance and immerse the solid in the water once and the liquid once. then note the values you get
③ and to get m_1 & m_2 values first but the solid as it was in step ② and but the cork under the bridge on the balance then determine the weight which is m_1, then bind the cork and the solid together and sink it in water then determine the weight which is m_2.

④ Subtitute in A & B & C laws and get the specific weight values

Results

givens

$(m_s)_a = 15.2\ g$ $\quad (m_c)_a = 1.75\ g$

$(m_s)_w = 14.25\ g$ $\quad m_1 = 16\ g$

$(m_s)_L = 12\ g$ $\quad m_2 = 13.8\ g$

① solid specific weight $= \frac{(m_s)_a}{(m_s)_a - (m_s)_w} = \frac{15.2}{17.2 - 14.25}$

$$SW_s = \frac{15.2}{2.95} = 5.152 \quad (R_1)$$

② Liquid specific weight $= \frac{(m_s)_a - (m_s)_L}{(m_s)_a - (m_s)_w} = \frac{17.2 - 12}{2.95}$

$$SW_L = \frac{5.2}{2.95} = 1.762 \quad (R_2)$$

③ cork specific weight $= \frac{m_c a}{m_1 - m_2} = \frac{1.75}{16 - 13.8}$

$$SW_c = \frac{1.75}{2.2} = 0.7954 \quad (R_3)$$

vertical-spring: الزنبرك الرأسي (b) جهاز

*Aim:

① Determination of spring constant (K) by using a vertical spring

② Determination of the mass of ~~of spring~~ a pan holding masses (m')

*Theory:

* Simple Harmonic motion (S.H.M): "Motion in which the restoring force is directly proportional to the displacement from equilibrium position but in opposite direction".

* in case of vertical motion equation of S.H.M:

$$y'' + \omega^2 y = 0 \implies \omega = \sqrt{\frac{K}{m}}$$

* (ω) is the angular frequency or velocity:

"scalar measure of rotation rate"

"the angular displacement per unit time"

$$\omega = \frac{\Delta\theta}{\Delta t} \qquad \omega = \frac{2\pi}{T} = 2\pi f = \sqrt{\frac{K}{m}}$$

(T) Peridic time: time ~~for~~ complete oscillation. (sec)

(f) frequency: Number of cycles per unit time Sec^{-1} or Hz

$M = m + m'$ (m) masses attached to the pan

(m') mass of the pan

Apparatus :

① Spring ② Pan ③ Known masses ④ Stopwatch

Steps :

① put the first mass m (10g) on the pan, then let the spring to oscillate about its equilibrium position.

② by using the stopwatch calculate the time of 10 oscillations.

③ Tabulate your results as shown.

m	T_{10} (sec)	$T = \frac{T_{10}}{10}$	T^2
10			
20			
30			
⋮	⋮	⋮	⋮

⑤ Draw the relation between $m \propto T^2$ while m is the independent Variable, then determine k & m_i.

determine k from the slope and m_i from the extension of the Line.

Results:

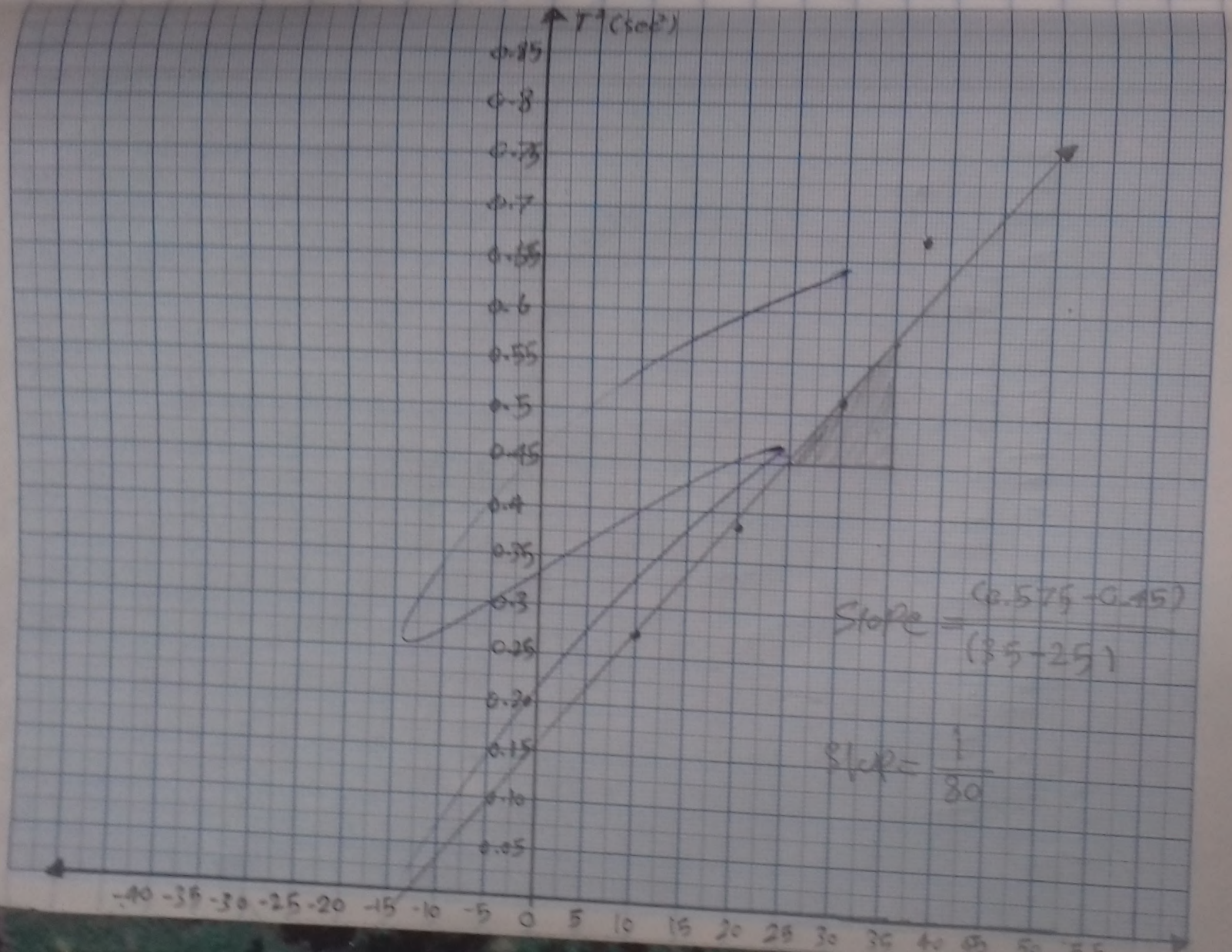
m (gm)	T_{10} (sec)	$T_1 = \frac{T_{10}}{10}$ (sec)	T^2 (sec^2)
10	5.23	0.523	0.273
20	6.2	0.62	0.384
30	7.21	0.72	0.519
40	8.22	0.822	0.6756

$$\omega = \sqrt{\frac{K}{m}} \qquad T = \frac{2\pi}{\omega} = 2\tilde{\pi}\sqrt{\frac{m}{K}}$$

$$T^2 = 4\tilde{\pi}^2 \frac{m}{K} \longrightarrow \boxed{K = \frac{4\tilde{\pi}^2 m}{T^2} = 4\tilde{\pi}^2 * \frac{1}{\text{slope}}}$$

$$K = 4\tilde{\pi}^2 * 80 = 3158.2 \text{ dyne cm}^{-1}$$

$$\boxed{m' = 12.59}$$


T² (sec²)
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.20
0.15
0.10
0.05
-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40
Slope = (0.575 - 0.45) / (35 - 25)
Slope = 1/80

convex lens أو العدسة المحدبة

① Aim: Determination of the power of the convex lens.

② theory: * Lens: "It is a transparent medium that refract rays incident on it"

* convex lens: "geometrically formed from the intersection of two spheres".

or "It is the converging lens"

* optical axis: "It is the axis which passes through the centers of the two spheres which the lens made up of it.

* Focal point: "It is the point of crossing refracted rays when it incident parallel to the optical axis"

* Focal length (f): "the distance between the focal point and the center of the lens".

* Power of the convex lens (P): "the ability of the lens to converge rays"

by meter $P = \frac{1}{f}$

③ Apparatus: (A) optical beneh (B) convex lens
(C) Mirror (D) optical source
(E) Ruler (F) screen

④ Steps: to determine the power there are three methods to get it

1st method the parallel Rays method

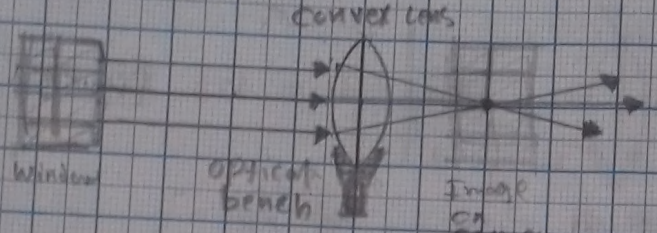


figure 1.1

① put the items like figure 1.1
② move the screen till you get the clearest Image of the window
③ measure the distance from lens center to the Image note the value as focal length.
④ Power = $\frac{1}{\text{focal length}}$ = ... D or diopeter or m^{-1}

2nd method the coincidence method

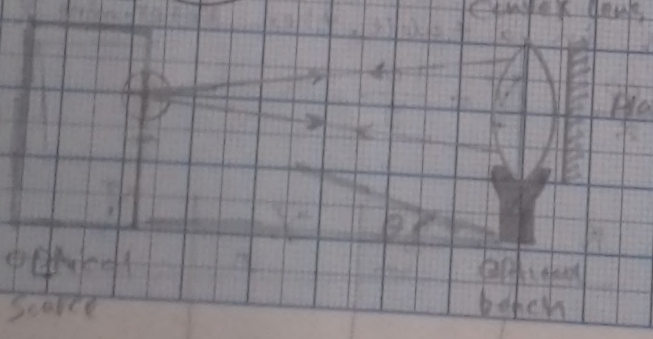


figure 1.2

① Put the items like in figure 1.2

② move group of the convex lens and mirror till you get the clearest Image on the source.

③ measure the distance between the lense and the Image as focal length.

④ power $= \frac{1}{\text{focal length}}$

3rd method

general method

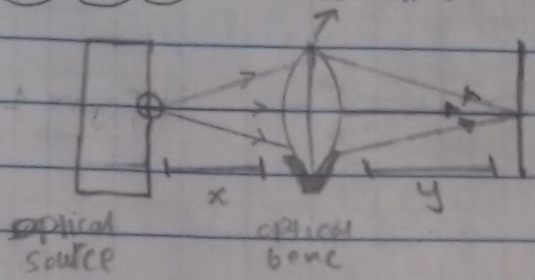


figure 1.3

① put the items like in figure 1.3 while $x > 2f$ so x is variable $x_1, x_2, x_3, x_4 \ldots$

② move the screen while the lens doesn't move. when you find the clearest image in the screen note y_1 value and x_1

③ Repeat the ① and ② steps by changing the values of x constants and note x and y values in a table. then determine X (Y

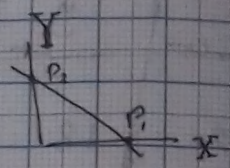
$$X = \frac{100}{x} \qquad Y = \frac{100}{y}$$

table sample

x cm	y cm	X Δ	Y Δ

④ Draw the graph and find the Power of Lens from

equation ⇒ $P = \frac{P_1 + P_2}{2} \ldots\ldots \Delta$



while P_1 is the cross value with Y

and P_2 ~ ~ ~ ~ ~ X

Results:

① 1st method

$f = 10$ cm $\Rightarrow P = \frac{100}{10} = 10\ m^{-1}$

$P = 10\ \Delta$

② 2nd method

$f = 10$ cm $\Rightarrow P = \frac{100}{10} = 10\ m^{-1}$

$P = 10\ \Delta$

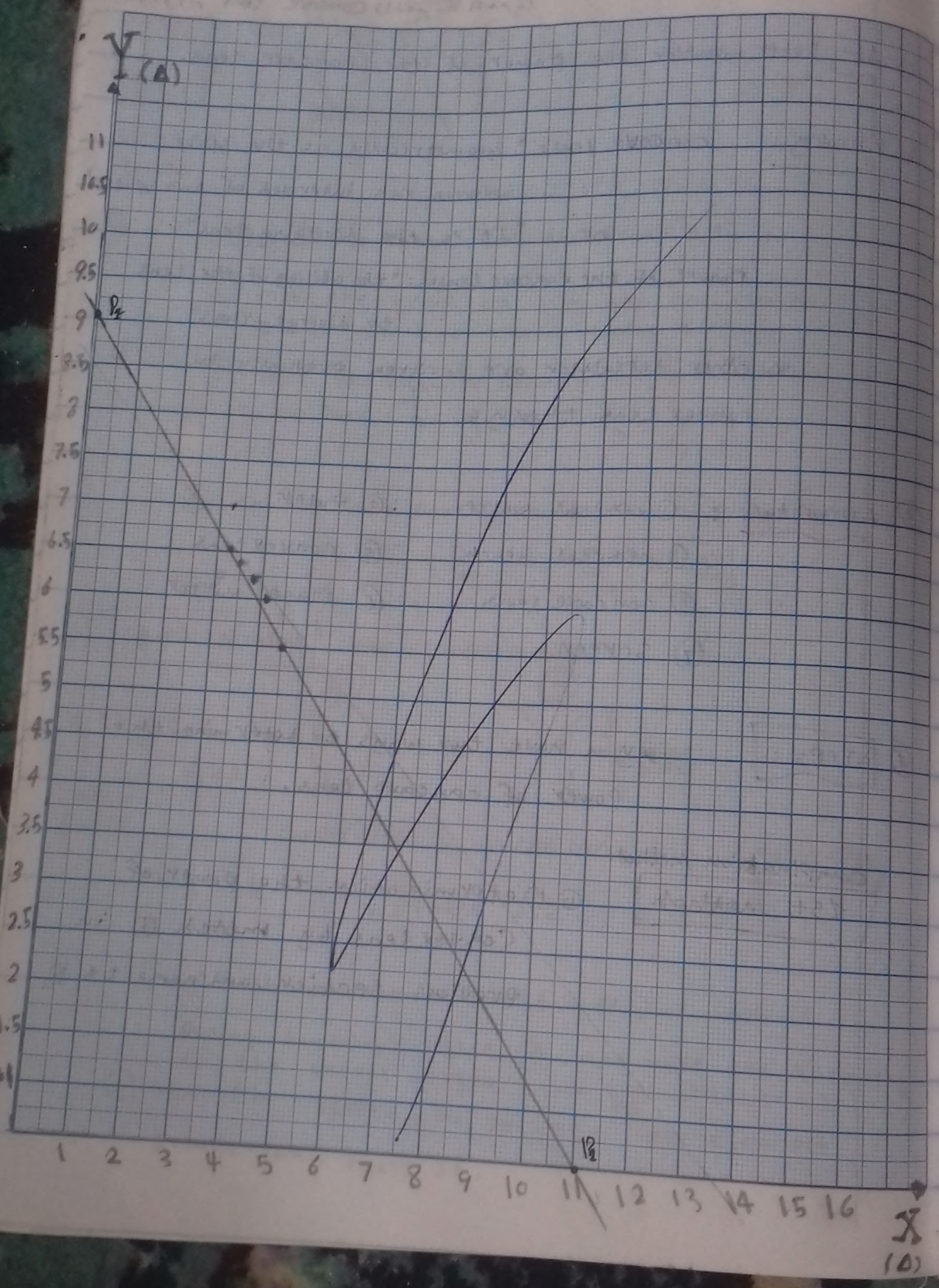
(5) 3rd method

x cm	y cm	X Δ	Y Δ
22	18	4.545	5.5
24	16.5	4.166	6
26	16	3.846	6.25
28	15.5	3.571	6.45
30	15	3.333	6.6

$P_2 = 11\ \Delta$

$P_1 = 9\ \Delta$

$$P = \frac{9+11}{2} = 10\ \Delta$$


Y
(A)
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
X
(A)

(أ) تجربة عن العدسة المقعرة Concave lens (2) تجربة

① Aim: Determination the power of the concave lens.

② theory: concave lens: "geometrically is the space between non intersted of two sphere"
or "It is the diverging lens"
Power of the concave lenses: "the ability of the lens to diverge rays"
* other definition are written previously in convex lens theory.

③ Apparatus: ① optical source ② Ruler
③ optical bench ④ convex lens
⑤ concave lens ⑥ plane mirror
⑦ screen

④ Steps: * you have two ways to determine the power of concave lens.

combination method
1st method ① Determination the power of convex lens by meted ② in previous section. and name it P_c

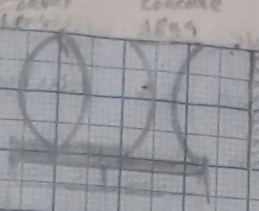


figure 2.1

② put the Items like the figure 2.1

③ move the group till you get the clearest Image In the optical source surface.

④ note the distance between ~~them~~ It and the surface as f_g. so $P_g = \frac{1}{f_g}$

⑤ calculate the power of concave lens by relation

$$P_g = P_c + P_d \Longrightarrow \boxed{P_d = P_g - P_c}$$

2nd method, the Direct method

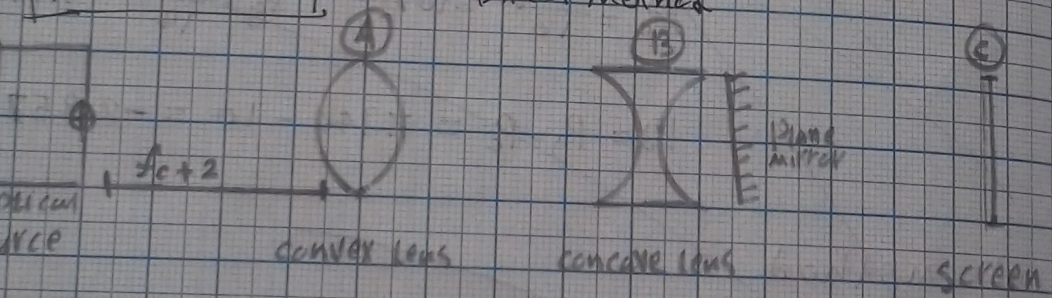


figure 2.2

① put the ~~em~~ Items like figure, but without puting Anything In site ⑬, and make the distance to the convex lens equal to (focal Length + 2). It's

② Move the screen till you get the clearest Image and Pause It.

(3) the Put the concave lens with plan mirror in site (B) and move it till you get the clearer Image on source

(4) measure the distance by the Ruler from site (C) and site (B) while this distance equal the focal Length of the concave lens (f_d).

(5) $P_d = \frac{-100}{f_{d(cm)}} = \dots\dots \Delta$ It will be negative value because of the diverging facility

Result s

1st method

$f_c = 10\ cm$ $f_g = 14\ cm$

$P_c = \frac{100}{10} = 10\ \Delta$ $P_g = \frac{100}{14} = 7.142\ \Delta$

$P_d = P_g - P_c = 7.142 - 10 = -2.858\ \Delta$

2nd method

$f_d = 35\ cm$ $P_d = \frac{-100}{35} = -2.857\ \Delta$

Concave Mirror

Aim: Determination of the power of the concave mirror

Theory:

① Mirror: It is an surface capable of reflecting all the incident rays on it.

② Concave Mirror: is an curved mirror formed by a part of a hollow sphere with the reflecting surface on the hollow side.

③ Radius of curvature: It is the distance between the center of hollow sphere and the center of the mirror. (pole)

④ power of the mirror(P): "It is the ability of the (concave) converging mirrors to converge the rays and (convex) diverging mirrors to diverge the rays"

* Other defination were written previously In 1st section.

Apparatus: ① optical source ③ optical bench
② concave mirror ④ Ruler
⑤ screen

*Steps.

there are three methods 1st and 2nd are typically the 1st and 2nd methods of convex lens power section by changing the lens with concave mirror.

the last method is slightly different to 3rd method in the same section. by adding the screen ~~screen the ...~~ between the source and the mirror

then y = distance from mirror to screen

and x = distance from source to screen

~~*~~ Result →

1st method $f = 20$ cm $\quad P = \frac{100}{20} = 5$ D

2nd method $R = 40$ $\quad f = \frac{40}{2} = 20$ cm

$$P = \frac{100}{20} = 5 \text{ D}$$

3rd Method

x	y	X	Y
42	35	2.3809	2.8571
44	34	2.2727	2.9411
46	33	2.1739	3.0303
48	32	2.0833	3.1250
50	31	2	3.2258

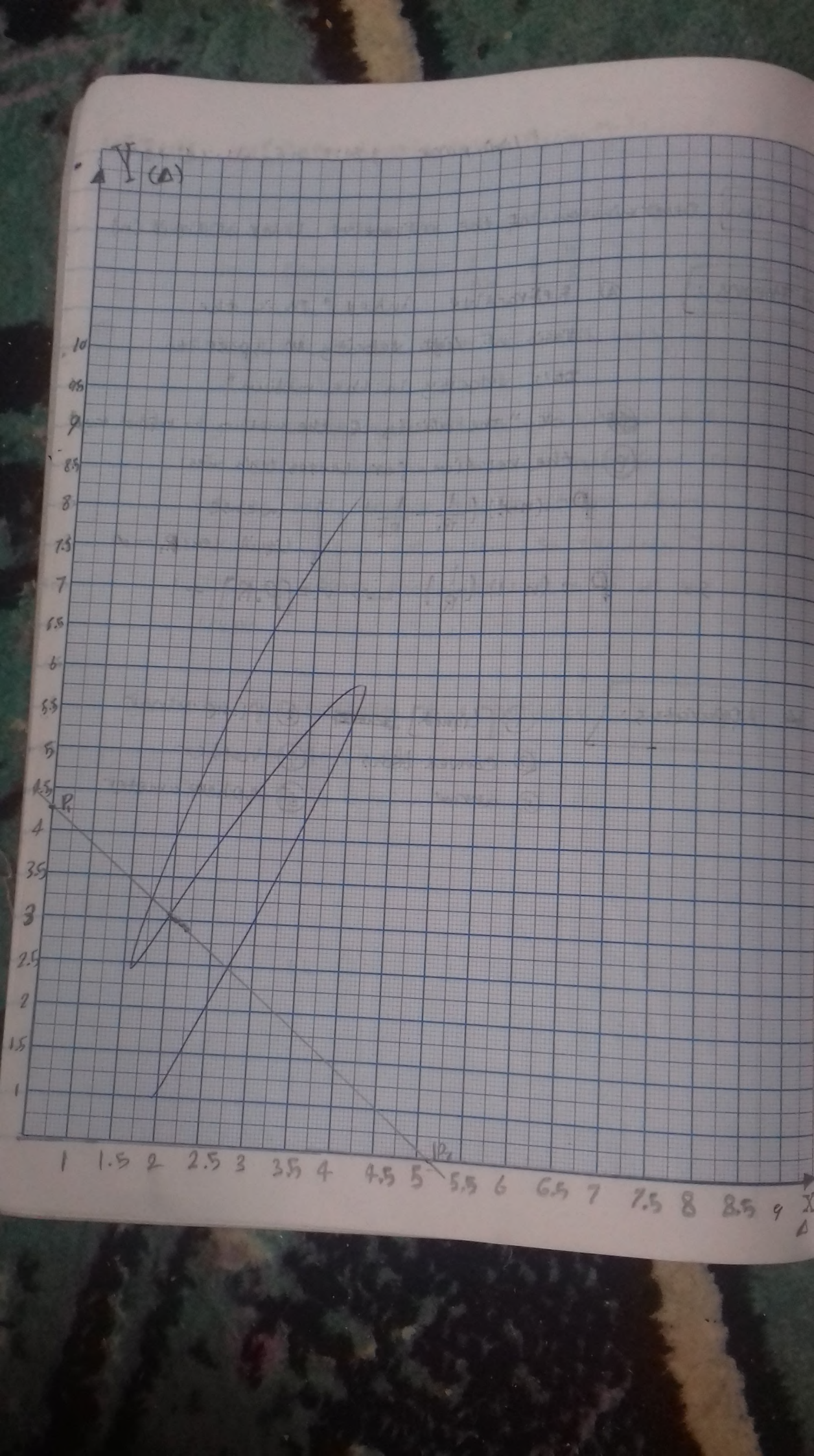
$P_1 = 4.25\,\Delta$

$P_2 = 5.25\Delta$

$$P = \frac{P_1 + P_2}{2} = \frac{4.25 + 5.25}{2}$$

$$P = \frac{9}{2}$$

$$\boxed{P = 4.75\,\Delta \simeq 5\,\Delta}$$


Y (A)
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
P1
P2
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
X
Δ

(Liquid mirror) عدسة سائلة : (4) تجربة

Aim: Determination of the refractive index of Liquid (n)

Theory:

(A) Refractive index: "It is the ratio of light velocity in space to It's velocity in the medium"

or "The ability of the medium to refract rays"

(B) the relation for Lenses (thin ones)

$$P = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

in case Liquid Lens $R_1 = \infty$

So $$P = (n-1)\left(\frac{1}{R}\right) \Rightarrow n = [P.R] + 1$$

Apparatus:

1. [Liquid]
2. Plane Mirror
3. convex lens
4. holder
5. arrow
6. spherometer

Steps: 1st [Determination the Radius]

(1) use the spherometer to get the redius by equation $R = \frac{a^2}{6h} + \frac{h}{2}$

2nd [Determination Power of Liquid lens]

(1) by combination method that you have studied in second section we can get focal length but we will measure the ~~the~~ length from glcmp to abody not a lens. So the body Image in the mirror should be the same as the real by length.

(2) then subtitute in the equation

$$n = P.R + 1$$

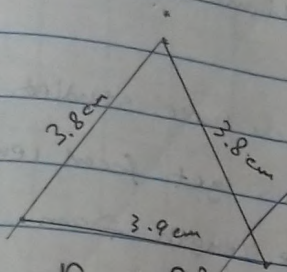
Results

$f_c = 18$ cm

$f_g = 31.6$

~~$P_c = 12.5\ \Delta$~~ $P_c = 5.55\ \Delta$

~~$P_g = 6.25\ \Delta$~~ $P_g = 3.164\ \Delta$



$P_L = P_g - P_c = 3.16 - 5.55$

$P_L = 2.39\ \Delta$

$R = \frac{a^2}{6h} + \frac{h}{2}$

$h = 1.35\ mm = 1.35 \times 10^{-3}\ m$

$a = \frac{3.8 + 3.8 + 3.9}{3} = 3.8\ cm = 3.8 \times 10^{-2}\ m$

$R = \frac{[3.8 \times 10^{-2}]^2}{6 * 1.35 \times 10^{-3}} + \frac{1.35 * 10^{-3}}{2}$

$R = 0.178271604 + 6.75 \times 10^{-4} = 0.1789 \simeq \boxed{0.179\ m}$

$n = R * P + 1 = 0.179 * 2.39 + 1 = 1.4$

Refraction of Light Through the Prism

* Aim: ① to trace the path of the rays of light through the glass prism
② determination the refractive index of glass

* Theory:

* Prism: " a transparent polyhedron optical object with triangular base and three rectangular lateral surfaces which refract (bend) and resolve the white light "

* the angle of deviation (D): " an angel between the incident ray of light entering the first face of the prism and the refracted ray that emerges from the second face of the prism.

* the angle of prism (A): " the angle between two refracting faces of the prism "

* the refraction: " Light changes its speed when it move from one medium to another. ~~For example~~ this speed changes cause that ligt refract and Enter the new medium with new angle.

* in case of minimum deviation Ex.

$$n_{glass} = \frac{\sin[(A+D_m)/2]}{\sin[A/2]}$$

while (A) : angle of Prism D_m: angle of Deviation minimum

* Apparatus: ① Prism ② pencil
③ Protractor ④ Paper (white sheet)

* STEPS

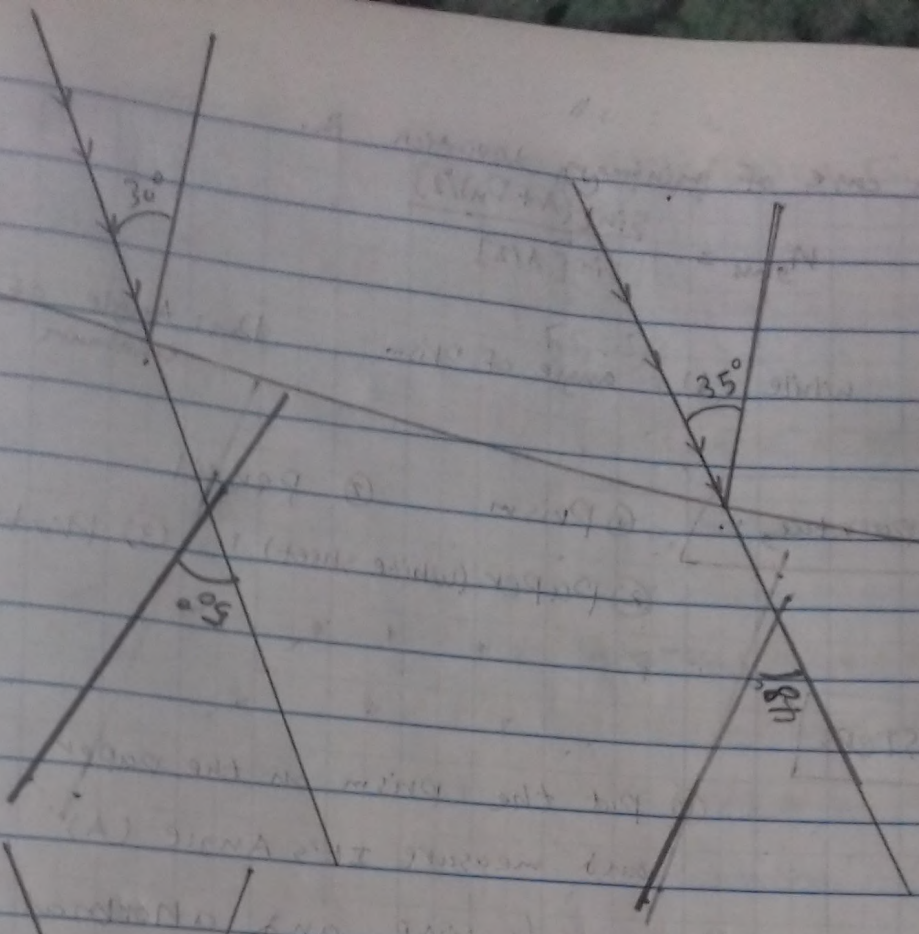
① Put the prism on the paper and measure It's Angle (A)

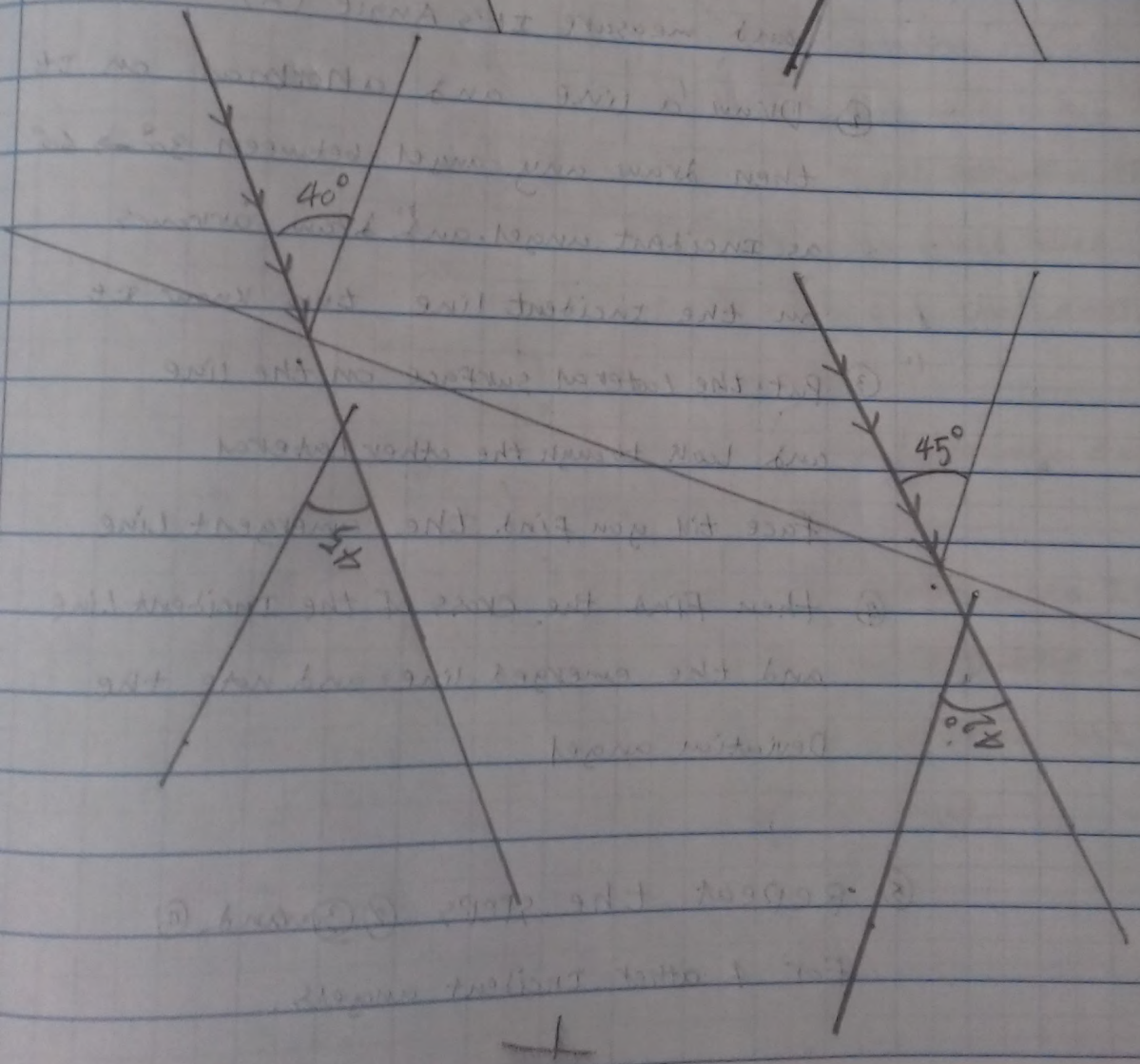
② Draw a line and a normal on it then draw any angel between 30° → 60° as Incident angel and draw arrows on the Incident line two know it

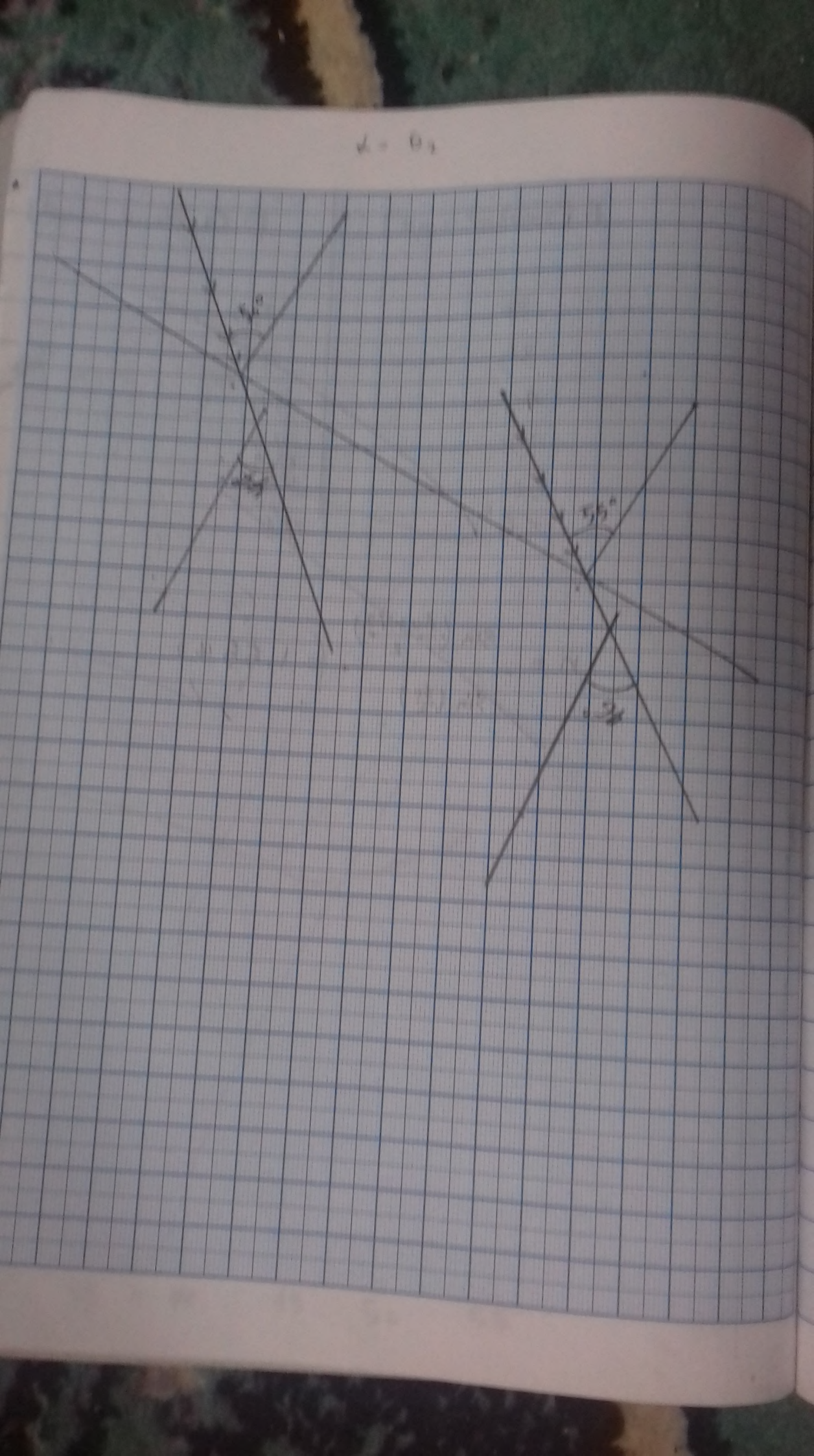
③ Put the Lateral surface on the line and look trough the other Lateral face till you find the emergent Line

④ then find the cross of the Incident Line and the emerged line and note the Deviation angel

⑤ Repeat the steps ② ③ and ④ For 4 other Incident angels.


30°
35°


40°
45°



θ [Incident angle]	D [deviation angle]
30	50
35	48
40	45
45	42
50	44
55	46

$$n = \frac{\sin\left(\frac{60+42}{2}\right)}{\sin\left(\frac{60}{2}\right)} = 1.5542$$