Physics 111 (final Summary)
Birziet University (Nedaa Hamamra)

① Measurements and uncertainity:

* Random errors: - caused By taking different readings for the same measurements.

- Related to the uncertainity in the sample (σ_s) and the uncertainity in the mean (σ_m).

- $\sigma_m = \frac{\sigma_s}{N}$ where N is the # of measurements.

- Any number or measurement should be written as ⇒ $x = \bar{x} \pm \Delta x$

  where $\bar{x}$: is the average value.

  Δx : is σ_m for x values.

- Δx should always be written to one significant figure and $\bar{x}$ should follow Δx in decimal places ⇒ Ex: $x = 3.52 \pm 0.04$ cm

- if the leading figure in Δx is <u>one</u> like 0.134 we keep another digit after the one

  Ex: $x = 3.52 \pm 0.13$ cm

⇒ Δx can be found from the least number a tool can read.

Ex: ① if ~~answer~~ the smallest measurement a ruler can read is 1 mm then $\Delta x = 1mm$.

② if the smallest measurement a voltmeter can read is 0.5 volt then $\Delta V = 0.5$ volt.

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* systematic errors :-
- caused by the uncalibration of the measuring tool.
- related to the average value.
- high systematic error means that the average value is far from the true value.

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* Remember ⇒
- The propability that the average value is different from the true value by σ_m is $\frac{2}{3}$

$$\Rightarrow x_{true} - \sigma_m \le \bar{x} \le x_{true} + \sigma_m$$

$$\Rightarrow \bar{x} \in [x_{true} - \sigma_m , x_{true} + \sigma_m]$$

} same meaning

- The propability that any single measurement x_i is different from the average value by σ_s is $\frac{2}{3}$

$$\Rightarrow \bar{x} - \sigma_s \le x_i \le \bar{x} + \sigma_s$$

$$\Rightarrow x_i \in [\bar{x} - \sigma_s , \bar{x} + \sigma_s]$$

* Precision and accuracy :

⇒ Small random error Δx ⇒ high precision.

⇒ Small systematic error $|\bar{x} - x_{true}|$ ⇒ high accuracy.

Ex: $g_A = 9.78 \pm 0.14 \ m/sec^2$

$g_B = 9.89 \pm 0.03 \ m/sec^2$

$g_{true} = 9.80 \ m/sec^2$

which is more precise and which is more accurate?

Answer: $\Delta g_B = 0.03 < \Delta g_A = 0.14$

* g_B is more precise.

$D_A = |g_A - g_{true}| = 0.02$

$D_B = |g_B - g_{true}| = 0.09$

* g_A is more accurate.

$D_A \overset{?}{\leq} 2 * 0.14$ Acceptable.

$0.02 \leq 0.28$ ✓

$D_B \overset{?}{\leq} 2 * 0.03$

$0.09 \leq 0.06$ X Not acceptable.

② Significant figures : (~~Average~~

$x = 3,52 \Rightarrow$ 3 significant figures.

$x = 0.3520 \Rightarrow$ 4 significant fig.

$x = 3,05200 \Rightarrow$ 6 sig. fig.

$x = 1,000 \Rightarrow$ 4 sig. fig.

$x = 1000 \Rightarrow$ 1 sig. fig

$x = 010 \Rightarrow$ 1 sig. fig.

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* Rounding :-

$x = 3,527 \Rightarrow$ 4 sig. fig

$x = 3,53 \Rightarrow$ 3 sig. fig

$x = 3.5 \Rightarrow$ 2 sig. fig.

⇒ if the next digit > 5 ⇒ Round up.

⇒ if the next digit < 5 ⇒ Round down.

⇒ if the next digit = 5

⇒ odd number Round up.

⇒ even number Round down.

exp: ① $x = 3,25$ (3 sig. fig)
⇓
3,2 (2 sig fig)

② $x = 3,35 \Rightarrow 3,4$

⇒ Significant figures in Calculations

* Addition and Subtraction :

⇒ the result should have the least number of decimal places.

Ex: A = 3,521 (4 Sig. fig) ⇒ 3 decimal places

B = 14,61 (4 Sig. fig) ⇒ 2 decimal places

R = A+B = 18,131 ⇒ 18,13 (2 decimal places)

* multiplication and Division :

⇒ the result should have the least number of Significant figures

Ex: A = 2,5 (2 sig. fig)

B = 5,041 (4 sig. fig)

R = A * B = 12,6025 (calculator Result)

R = 13

* other functions :

Result should have the same # of Sig. fig. as the inside of the function ⇒

θ = 3,5° (2. Sig. fig)

R = Sin(θ) = Sin(3,5) = 0.061

⇒ Uncertainities in functions.

⇒ +/-

$x = \bar{x} + \Delta x$

$y = \bar{y} \pm \Delta y$

$R = x + y \Rightarrow \bar{R} = \bar{x} + \bar{y}$

$\Delta R = \Delta x + \Delta y$

⇒ * / ÷ (multiplication and division)

$R = \frac{x}{y} \Rightarrow \frac{\Delta R}{\bar{R}} = \frac{\Delta x}{\bar{x}} + \frac{\Delta y}{\bar{y}}$

$\bar{R} = \frac{\bar{x}}{\bar{y}}$

⇒ Constant multiplier

$R = 2x$

$\Delta R = 2\Delta x$

⇒ raising to power

$R = \frac{x^a y^b}{z^c}$

$\frac{\Delta R}{R} = a\frac{\Delta x}{x} + b\frac{\Delta y}{y} + c\frac{\Delta z}{z}$

⇒ General Rule

if R is a function of x, y, z ⇒ R (x, y, z)

then $\Delta R = \left(\frac{dR}{dx}\right)\Delta x + \left|\frac{dR}{dy}\right|\Delta y + \left(\frac{dR}{dz}\right)\Delta z$

Ex: $R = x^2 y^3 \sin(x+z)$

$\frac{dR}{dx} = y^3 \left(2x \sin(x+z) + x^2 \cos(x+z)\right)$

$\frac{dR}{dy} = 3y^2 x^2 \sin(x+z)$

$\frac{dR}{dz} = x^2 y^3 \cos(x+z)$

$\Delta R = \Delta x \left|\left(2y^3 x \sin(x+z) + x^2 y^3 \cos(x+z)\right|\right.$

$+ \Delta y \left|3y^2 x^2 \sin(x+z)\right|$

$+ \Delta z \left|x^2 y^3 \cos(x+z)\right|$

Ex: if $R = \sin(\theta)$ $\theta = 80° \pm 1°$

$\Delta R = \Delta\theta \sin(\theta)$ ⟶ Note $\Delta\theta$ should Be in Radian

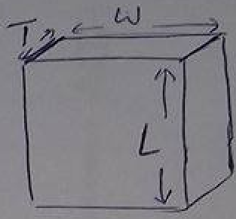
$\Delta R = 1° * \frac{\pi}{180} \sin(80°)$

Experiments

Exp. 1

Density of Metals

* $V = L \times W \times T \; (cm^3)$
  Volume



density

* $\rho = \frac{M \text{ (mass)}}{V \text{ (volume)}} = g/cm^3$

* $\frac{\Delta V}{\bar{V}} = \frac{\Delta L}{\bar{L}} + \frac{\Delta W}{\bar{W}} + \frac{\Delta T}{\bar{T}}$

* $\frac{\Delta \rho}{\bar{\rho}} = \frac{\Delta M}{\bar{M}} + \frac{\Delta V}{\bar{V}}$

* $a \Rightarrow$ density between atoms

$$a = \sqrt{\frac{A_w}{\rho N_A}}$$

$A_w \Rightarrow$ Atomic weight
$N_A \Rightarrow$ Avocadros number.

Exp. 2

Conservation of linear momentum

$$R = \frac{P_a}{P_b} = \frac{m_1 U_{1a} + m_2 U_{2a}}{m_1 U_{1b}}$$

$$= \frac{m_1 X_{1a} + m_2 X_{2a}}{m_1 X_{1b}}$$

a: after Collision

b: befor Collision

$$\frac{\Delta R}{R} = \frac{\Delta P_a}{\overline{P_a}} + \frac{\Delta P_b}{\overline{P_b}}$$

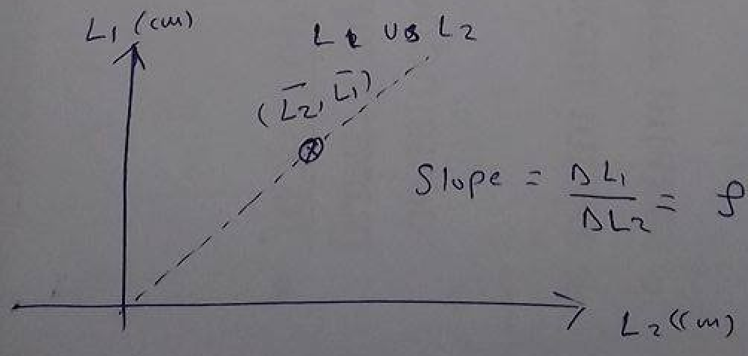
Exp. 3

Density of liquids

water $\leftarrow \rho_1 L_1 = \rho_2 L_2$

$\rho_1 = 1$

$$L_1 = \rho_2 L_2$$



$$\text{Slope} = \frac{\Delta L_1}{\Delta L_2} = \rho$$

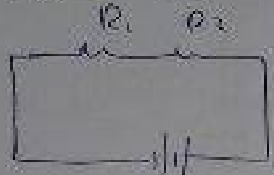
$$\frac{\Delta \rho}{\overline{\rho}} = \frac{\Delta L_1}{\overline{L_1}} + \frac{\Delta L_2}{\overline{L_2}}$$

Exp. 4

D.C circuit

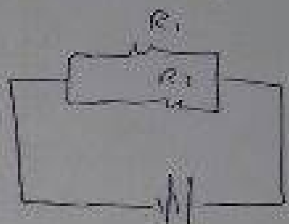
$$R_{(\Omega)} = \frac{V \text{ (volt)}}{I \text{ (A)}}$$

* In series



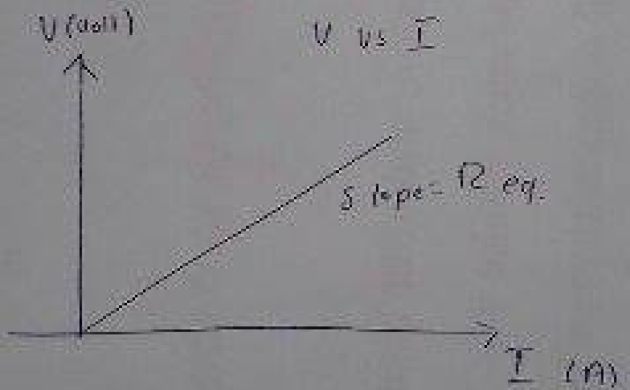
$R_{eq} = R_1 + R_2$

* In parallel



$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

=>

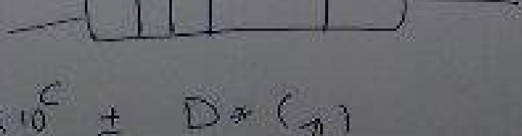


⇒ Voltmeter: very large resistance
↳ on parallel

⇒ Ammeter: very small resistance
↳ on series.

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

* Colour code



$R = AB \times 10^{C} \pm D * (\ )$

Exp. 5

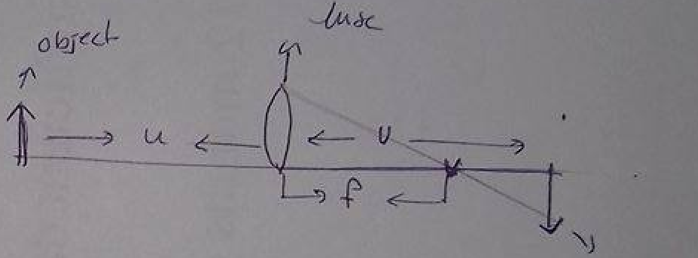
focal length.

$$\Rightarrow \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$f \Rightarrow$ focal length.

$u \Rightarrow$ Distance between the object and lens

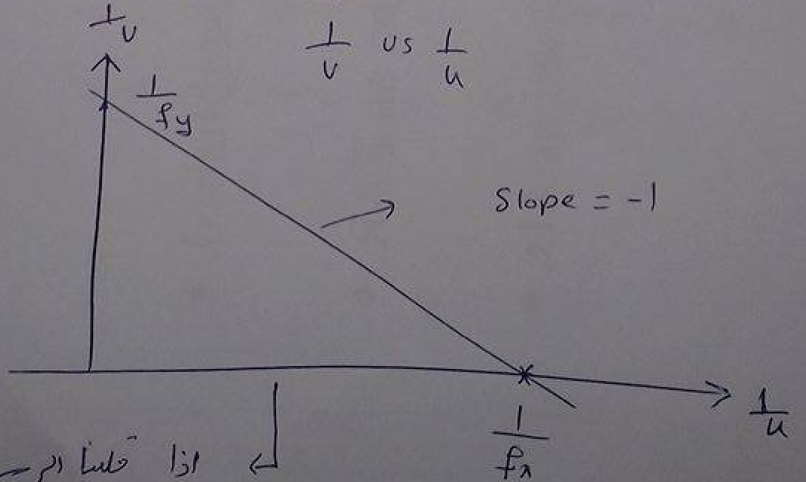
$v \Rightarrow$ Distance between the lens and Image



The focal length: the distance at which the light converges.

$$\frac{\Delta f}{\bar{f}^2} = \frac{\Delta u}{\bar{u}^2} + \frac{\Delta v}{\bar{v}^2}$$

$\frac{1}{v}$ vs $\frac{1}{u}$



اذا قلبنا الرسم؛ نحصل على
نفس الإجابة.

Exp. 6 (Index of refraction)

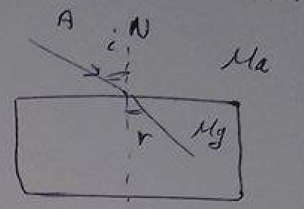
$$\mu = \frac{c}{v}$$

μ → Index of refraction.

c → speed of light in air.

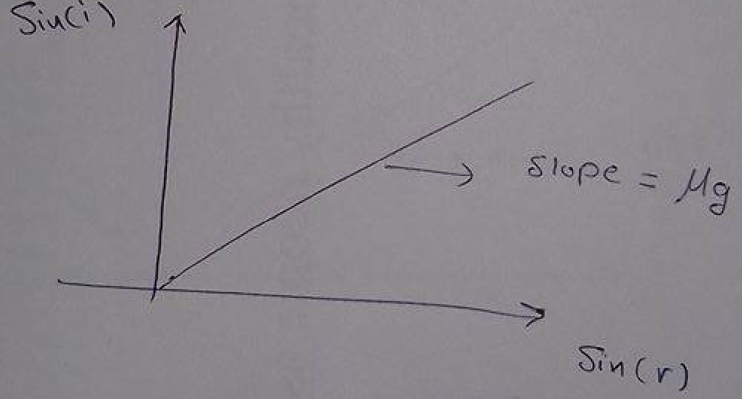
v → speed of light in the medium.

$$\mu_a \sin(i) = \mu_g \sin(r)$$



$\mu_a = 1$

$$\frac{\Delta \mu_g}{\bar{\mu}_g} = \left|\frac{\cos(\bar{i})}{\sin(\bar{i})}\right| \Delta i + \frac{\cos(\bar{r})}{\sin(\bar{r})} \Delta r$$



⇒ we used least square method

But don't remember the equations By heart.

Exp. 7: Measuring $\underline{\underline{g}}$

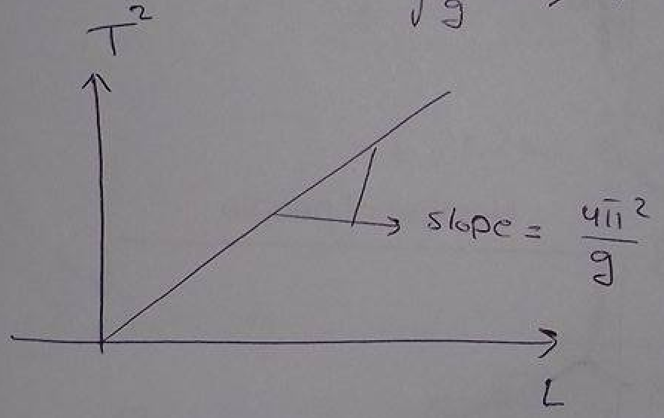
$$\omega = 2\pi f = \frac{2\pi}{T}$$

ω: Angular frequancy

f = frequancy

T = period

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



L: length of the String.

$$\frac{\Delta g}{g} = \frac{\Delta \text{ slope}}{\text{slope}}.$$

Exp. 8 : Half-life ...

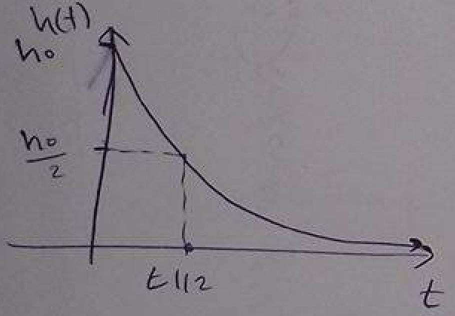
$$\frac{dh}{dt} = -\lambda dt$$

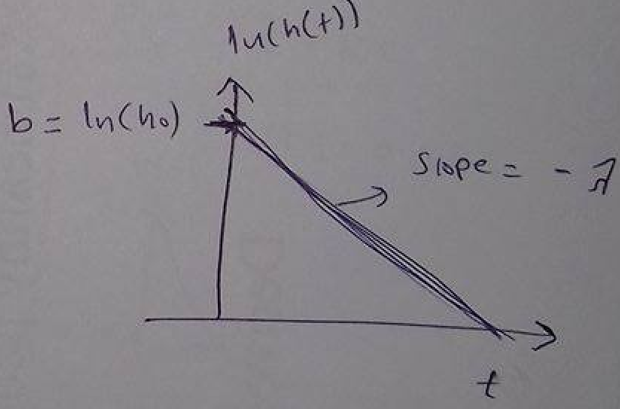
$$h(t) = h_0 e^{-\lambda t}$$

λ => decay constant

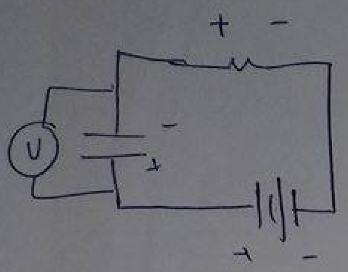
$t_{1/2}$ = half-life time

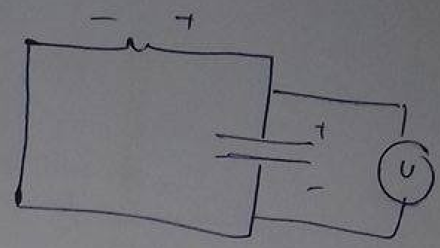
$$t_{1/2} = \frac{\ln(2)}{\lambda}$$





Exp. 9 : RC circuit





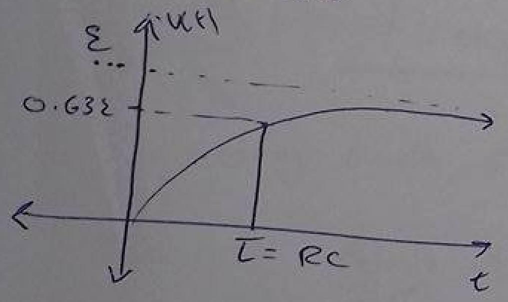
⇒ Charging

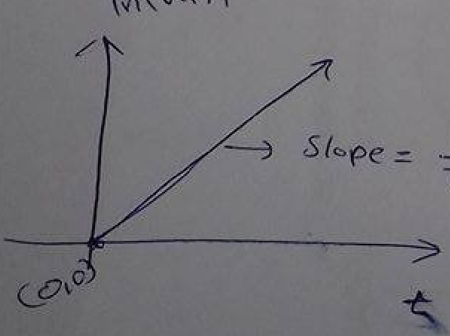
⇒ $Q(t) = \mathcal{E}C(1 - e^{-t/RC})$

$U(t) = \mathcal{E}(1 - e^{-t/\tau})$

$\tau = RC \Rightarrow \frac{\Delta C}{C} = \frac{\Delta \tau}{\tau} + \frac{\Delta R}{R}$ → نفس الشيء

$U(\tau) = 0.63\,\mathcal{E}$





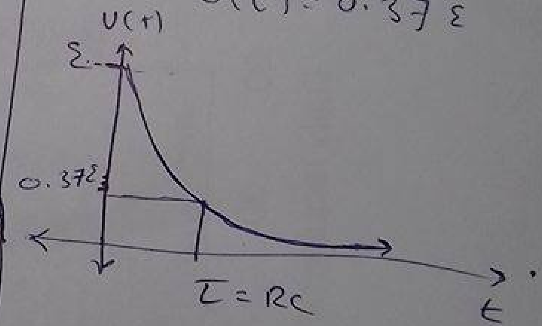
⇒ Discharging

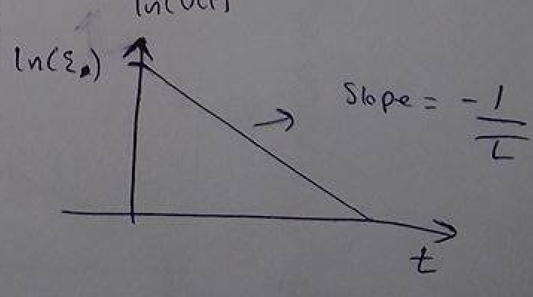
⇒ $Q(t) = \mathcal{E}C e^{-t/\tau}$

⇒ $U(t) = \mathcal{E} e^{-t/RC}$

$\tau = RC$

$U(\tau) = 0.37\,\mathcal{E}$





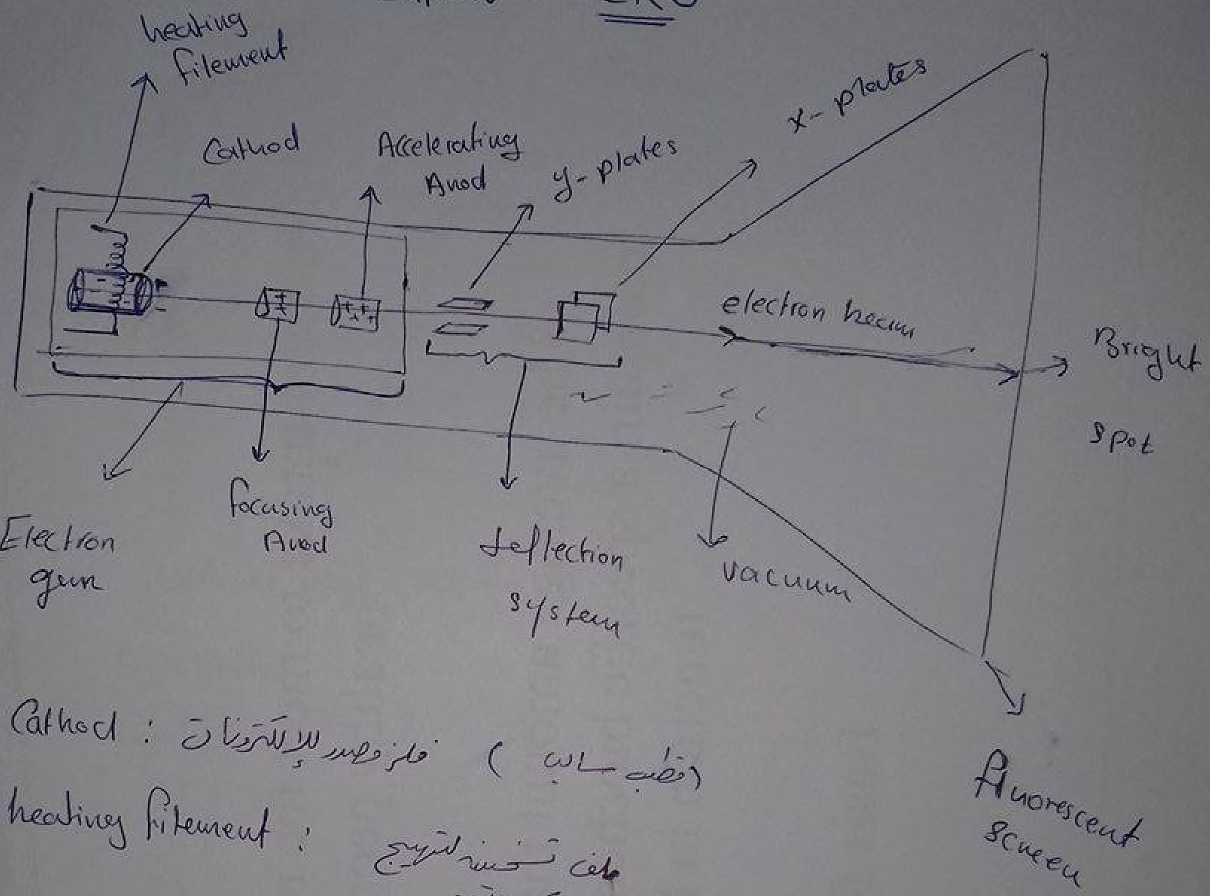
τ ⇒ time Constant

Big τ ⇒ slow Charging

small τ ⇒ fast Charging

⇒ $t_{1/2} = \ln(2) * \tau$

Exp. 10 : CRO



→ Cathod : فلز مصدر للإلكترونات (قطب سالب)

→ heating filement : ملف تسخين لتهييج الإلكترونات

→ Accelerating Anode ⇒ قطب موجب مسارع للإلكترونات

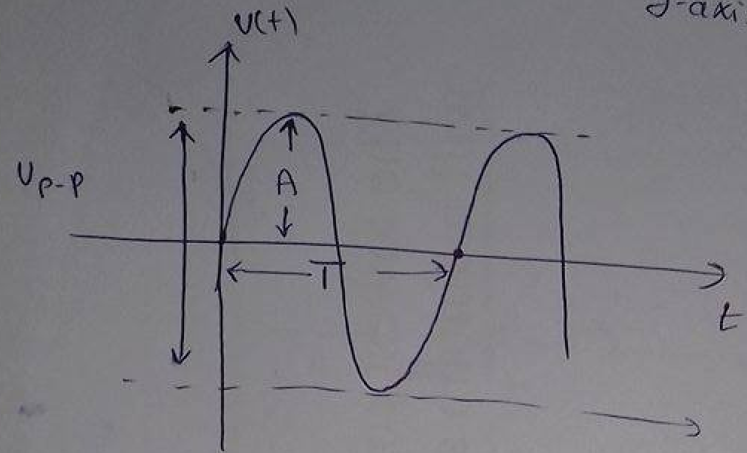
→ focusing Anode ⇒ قطب موجب مركز للإلكترونات

⇒ y-plates , x-plates ⇒ صفائح للتحكم باتجاه شعاع الإلكترونات

⇒ flouorscent screen ⇒ شاشة فلورسنتية مضيئة

⇒ Internal Mode : V vs t

V → y-axis, t → x-axis



V_{p-p} : peak to peak Voltage.

A : Amplitude.

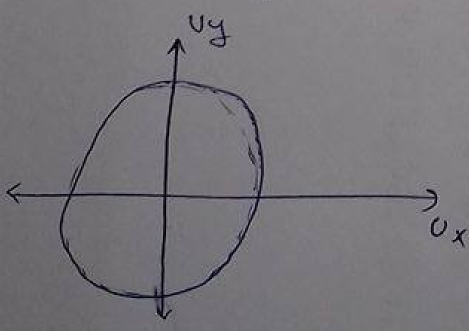
T : period

$f = \frac{1}{T}$

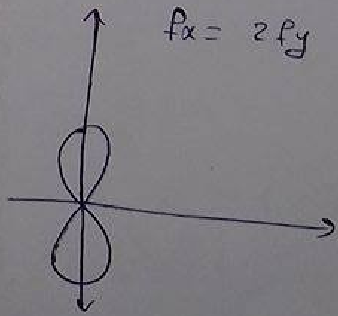
⇒ External Mode V_y vs V_x

V_y → y-axis, V_x → x-axis

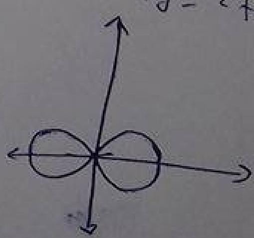
$f_x = f_y$



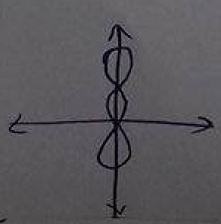
$f_x = 2f_y$



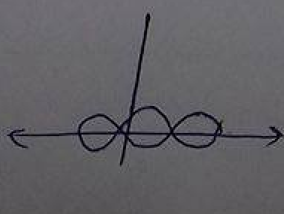
$f_y = 2f_x$



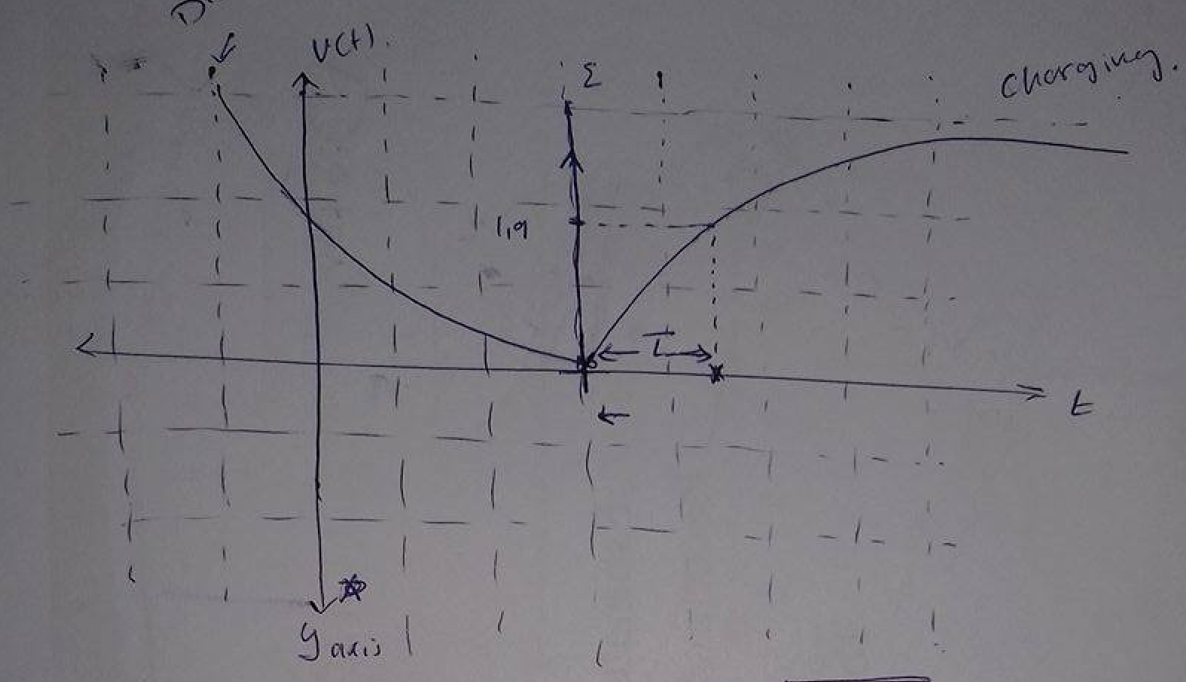
$f_x = 3f_y$



$f_y = 3f_x$



Exp. 11 RC- Circuit



$\Rightarrow$ if $C = 0.1\,\mu F$

0.5 volt/Div

5 msec/Div.

$\tau = 3$ squares

$0.63 * 3 = 1,9$ $\Rightarrow$ for charging

$\tau = 1,5$ squares

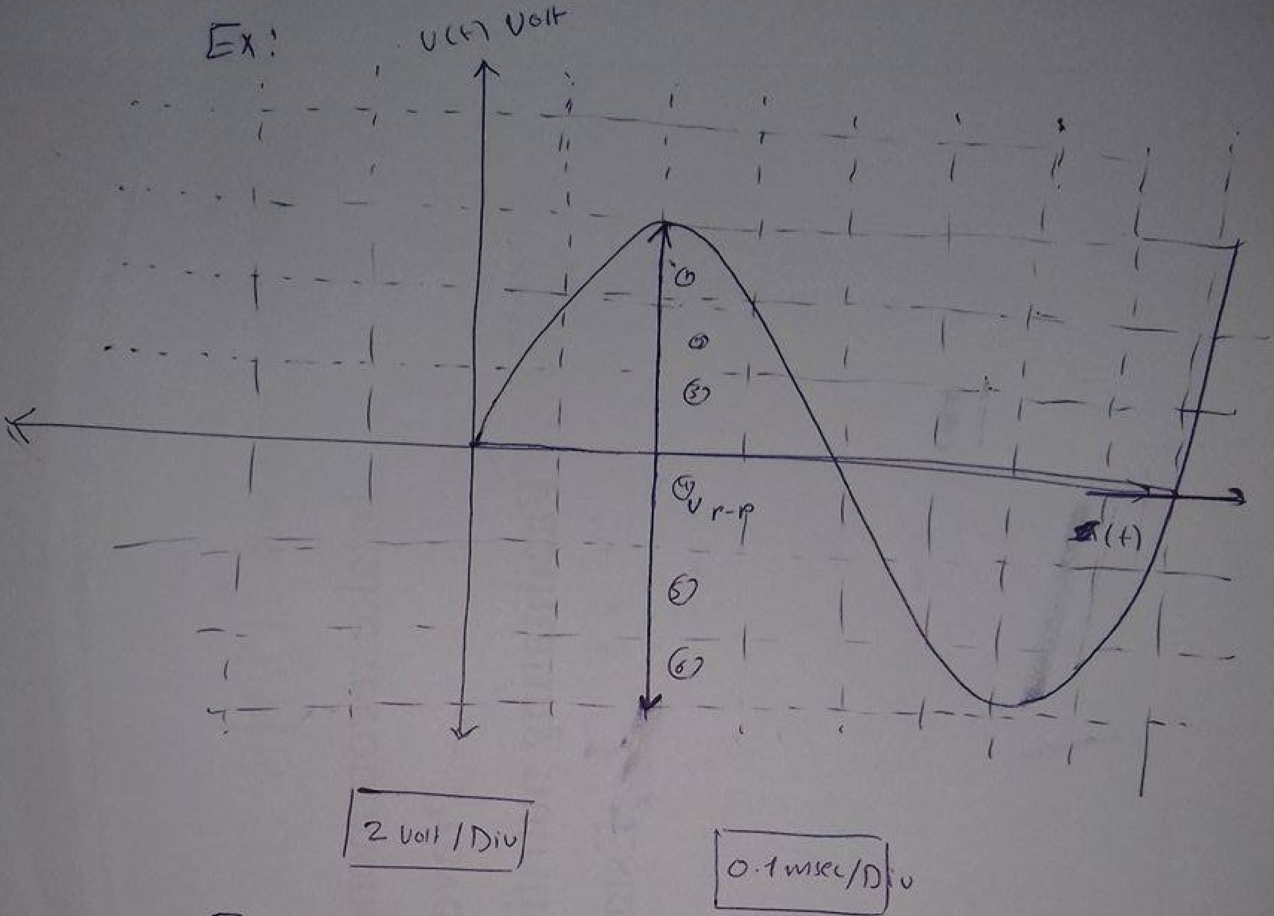
$1,5 * 5\,msec = 7,5\ m(sec)$

$\Rightarrow$ find R $\Rightarrow$ $\tau = RC$

$7,5 * 10^{-3} = R * 0.1 * 10^{-6}$

$R = 75 * 10^{3} = 75\ K\Omega$

Ex:



Find ① V_{P-P} :

② Amplitude

③ fuequency

① ⇒ 6 squares

$V_{P-P} = 6 * 2$ volt / Div = 12 volt

② Amplitude = $\frac{V_{P-P}}{2}$ = 6 volt.

③ T = period = 8 * 0.1 msec = 0.8 msec

$f = \frac{1}{T} = \frac{1}{0.8 * 10^{-3}} = \frac{1000}{0.8} = 1250$ Hz