Laser Diffraction: → [deviation $\propto \lambda$]
→ Bending of waves around the edges of an obstacle } → to observe diffraction ⇓ size of obstacle should be comparable with the λ of the light.

As c & λ → are of same order (10^{-6}m) ↓ diffraction takes place within grating.

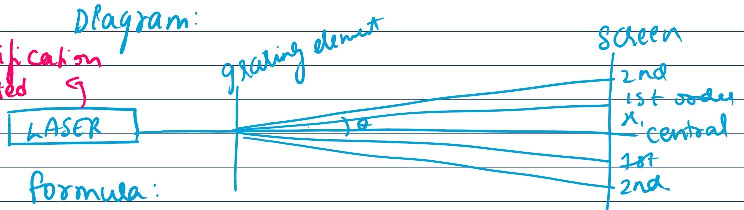
Aim → determine λ.

Apparatus → Laser source, optical bench, metre scale
→ monochromatic: source with single λ.
→ polychromatic: source w/ diff. λ.

Obs →

Diagram:

Light amplification by stimulated emission of Radiation
⇓
characteristics
1) high intensity
2) high coherence (same phase)
3) high monochromaticity
4) high directionality
5) less divergence



Formula:

Wavelength of light source: $\lambda = \dfrac{c\sin\theta_n}{n}$

c → grating constant; n → order of the maximum
θ → angle of diffraction

$c = \dfrac{1\text{ inch}}{\text{no. of lines per inch}} = \dfrac{2.54\times10^{-2}\text{ m}}{500} = 5.08\times10^{-5}\text{ m}$

Dispersion: splitting of the components of composite radiation when passed through a medium. [deviation $\propto \frac{1}{\lambda}$]

→ Distance b/w grating and the screen ⇒ d = ____ cm

→ Error formula:

$$\lambda = \frac{c\sin\theta_n}{n}$$

$$\log\lambda = \log\left(\frac{c}{n}\right) + \log(\sin\theta)$$

Simplifying we get relative uncertainity

$$\frac{\delta\lambda}{\lambda} = \frac{\delta x_n}{x_n} + \frac{x_n\,\delta x_n + d\,\delta d}{x_n^2 + d^2} \approx \frac{\delta x_n}{x_n}$$

Population Inversion: $N_2 > N_1$ → can be achieved in active medium
needed by stimulated emission.
done by pumping.
⇓
process in which atoms are excited to higher energy states by supplying energy.

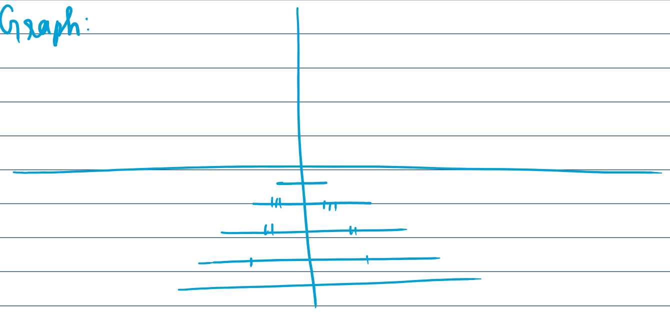
Optical Resonator → action gives directionality of laser beam and amplifies it

Table:

diffraction order (n)	distance $2x_n$ (cm)	distance x_n(cm)	diffraction angle $\theta_n = \tan^{-1}(x_n/d)$	wavelength $\lambda = \frac{c\sin\theta_n}{n}$	Fractional error $(\delta\lambda/\lambda)$
take 5 values					$\frac{0.1}{x_n}$

Avg wavelength of the laser and fractional error $\lambda =$ $\frac{\delta\lambda}{\lambda} =$

Graph:



Calculations: $\theta = \tan^{-1}(x_n/d)$ → } do for all 5.

$\lambda = \frac{C \sin\theta_n}{n}$ → }

λ_{avg}.

Result: → wavelength of laser light is ______ nm

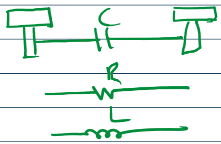
→ relative error (or fractional error) in λ is ______

Black Box:

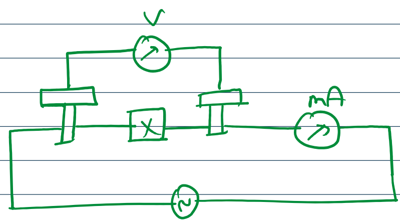
Aim: identify electrical components.

Apparatus: Black box, audio freq. oscillator, ac multi-meter, ac voltmeter.

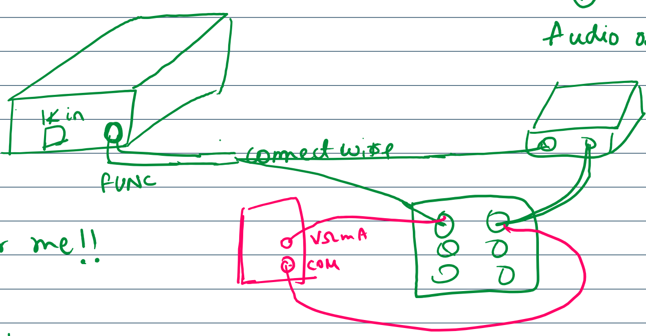
Obs: Diagram:



Circuit:



Audio oscillator



for me!!

Table: ↪ 3 needed.

freq (Hz)	voltage V (V)	current I (mA)	Component value
100 to 600.		I const (resistor)	$R = \frac{V}{I}$ (kΩ)
		I↑ (capacitor)	$C = \frac{1}{2\pi f X_C} = \frac{I}{2\pi f V}$ (μF)
		I↓ (Inductor)	$L = \frac{V}{2\pi f I}$ (H)

Calc: do **Avg:**

Result: → component ______ of value ______ is connected across ______ & ______

Numerical Aperture.

Aim: Part A: to determine NA
Part B: measure α → attenuation coefficient.

Apparatus: Laser, power supply, NA setup with screen optical fibre cables. (1.5m & 3m) obs: Diagram:

Part A:

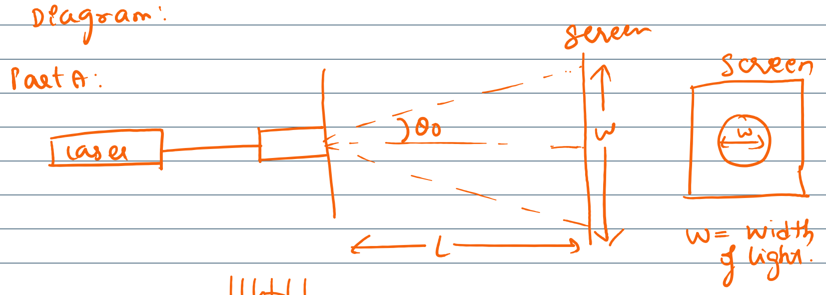
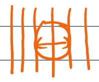


Table:



A) Sl.no L(m) W(mm) $NA = \sin\theta_0 = \frac{W}{\sqrt{4L^2+W^2}}$ acceptance angle. $\theta_0 = \sin^{-1}(NA)$

5 values

Avg: NA θ_0

B)

length (m)	attenuation of A (mW)	length (m)	attenuation of B (mW)
1.5	0.47 [Pin]	3	0.07 [Pout]

Pin > Pout.

calc: $\alpha = \frac{-10 \times \log[Pout/Pin]}{L}$ dB/m

Result: → NA is ______

→ θ_0 is ______ °

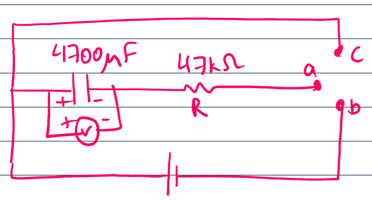
→ α is ______ dB/m.

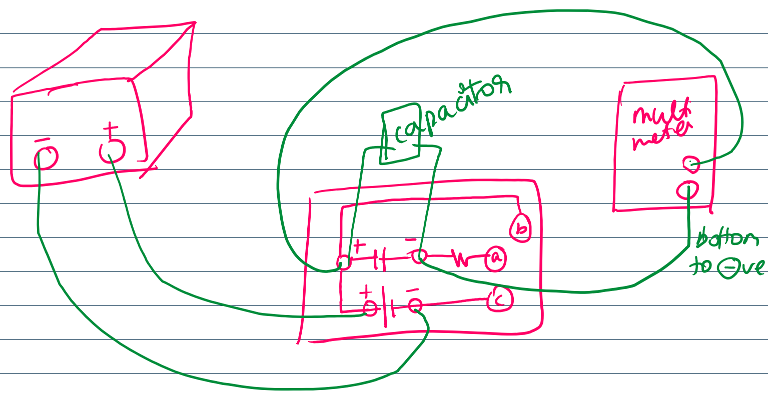
Dielectric constant:

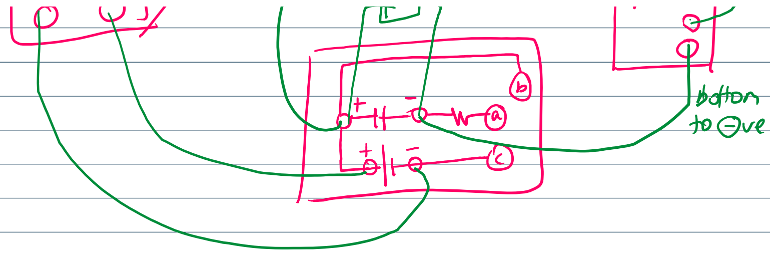
Aim:

Apparatus: Battery of 10V, electrolytic capacitor, multimeter, 2 way key, stop clock.

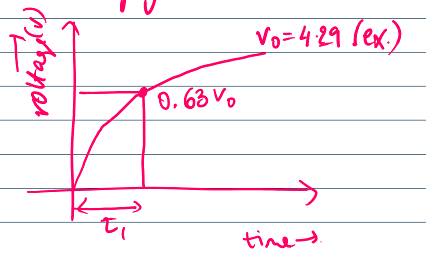
obs: circuit:







charging curve.



discharging curve

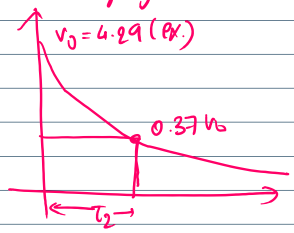


Table:

Time (s)	voltage during charging (V)	voltage during discharging (V)
0	0	4.29
30		
⋮	till 4 const/ same value.	⋮
	⋮	till
	4.29 4 time	0.01

→ charging time const, τ_1 = ______

→ discharging time const, τ_2 = ______

→ Avg time const, $\tau = \frac{\tau_1 + \tau_2}{2}$ = ______

→ Capacitance, $C = \frac{\tau}{R}$ = ______ (R → 47k)

→ Thickness of dielectric medium, $d = 80\mu m$

→ Area of each plate, $A = 70.5 m^2$

→ $\varepsilon_r = \frac{Cd}{\varepsilon_0 A}$

- ε_r → dielectric const
- C → capacitance
- d → thickness of dielectric medium
- A → area
- ε_0 → absolute permitivity of free space.

calc: → find ε_r.

graph: → draw 2 graphs.

Result: → capacitance is ______ μF

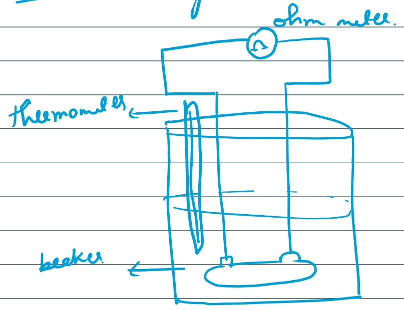
→ dielectric const is ______

Band Gap

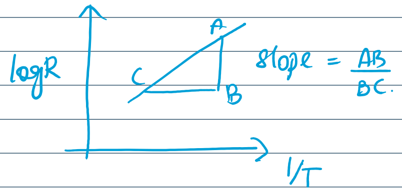
Aim: Eg of thermistor

Apparatus: glass beaker, thermistor, multimeter, thermometer.

Obs: diagram:



model graph:



$\rightarrow$ $E_g = \frac{4.606 \times K \times m}{1.6 \times 10^{-19}}$ eV

$\downarrow$

energy gap of thermistor

K $\rightarrow$ Boltzmann const

$\hookrightarrow = 1.381 \times 10^{-23}$ J/K

m $\rightarrow$ slope of graph.

Table:

Sl no	Temp (°C)	Temp (K)	R (Ω)	log R	1/T ($\times 10^{-3}$)

15 values

graph: draw.

calc: $m = \frac{AB}{(BC) \times 10^{-3}}$ = ______

E_g = ______ eV

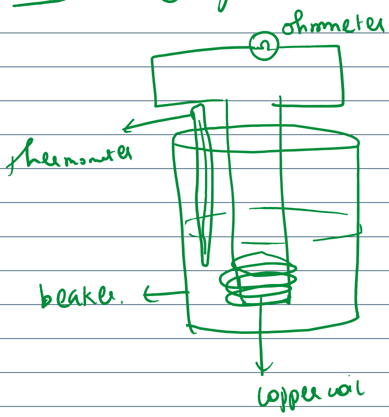
Result: $\rightarrow$ E_g is ______ eV

Fermi energy

Aim:

Apparatus: Beaker, thermometer, multimeter, copper wire

obs: Diagram:



Formula:

$\rightarrow$ $E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho A m}{l}}$ J

$E_F = \dfrac{1.36 \times 10^{-15} \sqrt{\frac{\rho A m}{l}}}{1.6 \times 10^{-19}}$ eV

$E_F \rightarrow$ fermi energy
$A \rightarrow$ area of cross section $= 3.14 \times 10^{-8}\ m^2$
$l \rightarrow$ length of Cu wire $= 15m$
$\rho \rightarrow$ density of Cu $= 8960\ kg/m^3$
$m \rightarrow$ slope of R vs T graph

$\rightarrow$ slope (m) $= \dfrac{n \Sigma xy - (\Sigma x)(\Sigma y)}{n \Sigma x^2 - (\Sigma x)^2}$

$\rightarrow$ Intercept (c) $= \dfrac{(\Sigma y)(\Sigma x^2) - (\Sigma x)(\Sigma xy)}{n(\Sigma x^2) - (\Sigma x)^2}$

Table:

Sl no.	Temp(°C) [x]	R(Ω) [y]	x^2	xy

8 values

$\Rightarrow n = 8$ $\quad \Sigma x \quad \Sigma y \quad \Sigma x^2 \quad \Sigma xy$

point	Temp(x)	Resistance (y)
P	30	use (mx+c) to find.
Q	80	

graph: draw R vs T

calc: $\rightarrow$ find m & c

$\rightarrow$ find pt P & Q

$\rightarrow$ slope using points P & Q on graph
↳ must match the m value calculated.

$\rightarrow$ find E_F

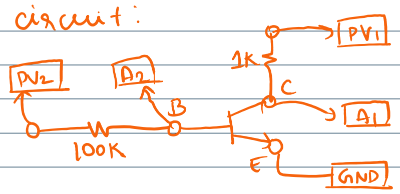
Result: $\rightarrow$ Fermi energy is ______ J
______ eV

Transistor Characteristics

Aim:

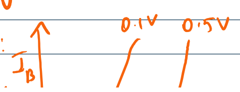
Apparatus: expeyes kit, Transistor SL100, connecting wires
1K and 100K Ω resistors, breadboard.

Obs: circuit:

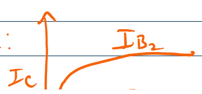


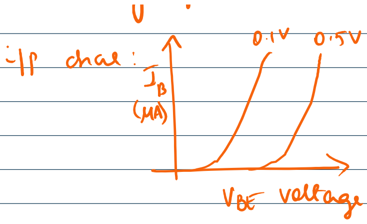
model graph:

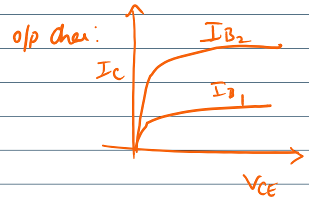
i/p char:



o/p char:







formulas:

$$\beta = \frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}}$$ } → collector currents (in mA) } → base currents (in μA)

$$\alpha = \frac{\beta}{\beta+1}$$

Table:

i/p char. o/p char

$V_{CE} = 0.1V$		$V_{CE} = 0.5V$		$I_{B_1} =$		$I_{B_2} =$	
V_{BE} (V)	I_B (μA)	V_{BE} (V)	I_B (μA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)

graph: do

calc: β, α

Result: curren gain in:

→ common emitter config (β) = ____

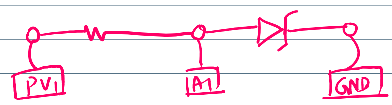
→ common base config (α) = ____

Zener diode:

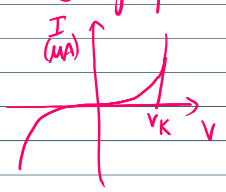
Aim:

Apparatus: expeyes -17 hardware, zenu diode, resistor, wires.

Obs: circuit



model graph:



formula:

→ Static resistance, Dynamic resistance,

$R_f = \frac{V_f}{I_f}$ forward $r_f = \frac{\Delta V_f}{\Delta I_f}$

$R_r = \frac{V_r}{I_r}$ Reverse $r_r = \frac{\Delta V_r}{\Delta I_r}$

calc:

forward bias
x
y
slope

reverse bias
x
y
slope

static
R_f/R_R = pts from graph.

dynamic
$r_f/r_R = \frac{1}{slope}$

graph: plot on expeyes.

→ open in terminal → type gnuplot

→ set timestamp
set zeroaxis
set title 'Zener ....'
set xlabel 'Voltag in Volts'
set ylabel 'Current in mA
plo 'zener.txt' w lp

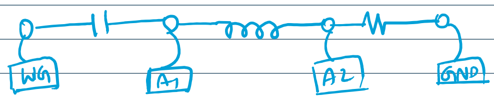
Result: F B
Knee voltage = x "
f. st. res. = "
f. dy. res. = –

Series LCR:

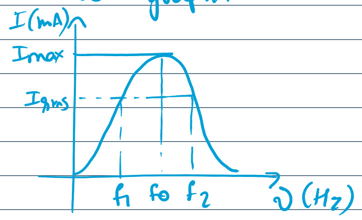
Aim:

Apparatus: expeyes-17 hardware, resistance box, capacitor, inductor.

obs: circuit:



model graph:



formula:

1) I_{max} =
2) $I_{rms} = \frac{I_{max}}{\sqrt{2}}$
3) Resonant freq. (f_0)
4) lower freq (f_1)
5) higher freq (f_2)
6) Bandwidth ($\Delta f = f_1 - f_2$)
7) Quality factor (Q) $= \frac{f_0}{\Delta f}$
8) capacitance (C) = 474 μF.

7) Quality factor (Q) = $\frac{f_0}{\Delta f}$

8) capacitance (C) = 474μF.

9) Inductance (L) = $\frac{1}{4\pi^2 f_0^2 C}$

graph: → set timestamp.
set title 'LCR'
set xlabel 'freq. in Hz'
set ylabel 'Current in mA'
plot 'lcr.txt' w lp

calc: All the formulas

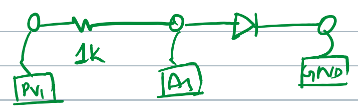
Result: → f_0, L, Q, BW

Wavelength of LED

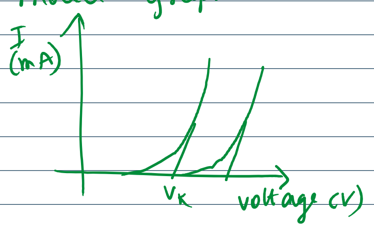
Aim:

Apparatus: expeyes-17 hardware, LEDs, 1kΩ resistor, wires

obs: circuit



model graph:



formula:

→ Energy of photon emitted by LED

$$E = \frac{hc}{\lambda} = eV_K$$

wavelength of LED ⇒ $\lambda = \frac{hc}{eV_K}$

table:

colour of LED	knee voltage (V_K)	wavelength (in nm)

4 values.

calc: λ →

Result: Studied I-V graphs and λ of LEDs are determined.

graph: → plot. using gnuplot.