KARNATAK UNIVERSITY'S

KARNATAK SCIENCE COLLEGE, DHARWAD

Laboratory Manual

B.Sc. V Semester (NEP)

Classical Mechanics and Quantum Mechanics

S.No.	Name of the Experiment
1	(i) To determine 'g', the acceleration due to gravity, at a given place, from the L – T^2 graph, for a simple pendulum (ii) Studying the effect of mass of the bob on the time period of the simple pendulum (iii) Studying the effect of amplitude of oscillation on the time period of the simple pendulum
2	To study the spectral characteristics of a photo-voltaic cell (Solar cell) using different filters
3	To study I- V characteristics of solar cell and determine its fill factor
4	To study the tunnelling in Tunnel Diode using I-V characteristics
5	Determine energy Eigen value of particle electron/proton in a finite potential well
6	Study of op amp as an Differentiator
7	Study of op amp as an Integrator
8	FET as common source amplifier

Simple Pendulum

Aim:

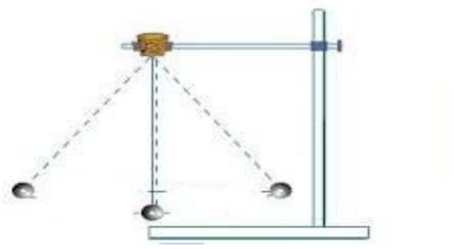
Expt. No.1. To determine the acceleration due to gravity at a place by plotting L-T^2 graph

Expt.No.2. To Study the effect of mass of the bob on the time period of the simple pendulum by keeping the length of the pendulum same

Expt.No.3. Studying the effect of amplitude of oscillation on the time period of the simple pendulum

Apparatus: Pendulum bobs of different masses, screw gauge, vernier calipers, metal stand, stop clock, inextensible thread

Diagram:



Formula:

$$g = 4\pi^2\left(\frac{L}{T^2}\right)$$

Observations:

Least count of the vernier calipers:

Diameter of the bob = (i)   cm (ii)   cm (iii)   cm

Radius of the bob=   cm

Length of the hook =   cm

Least count of the stop clock =   s

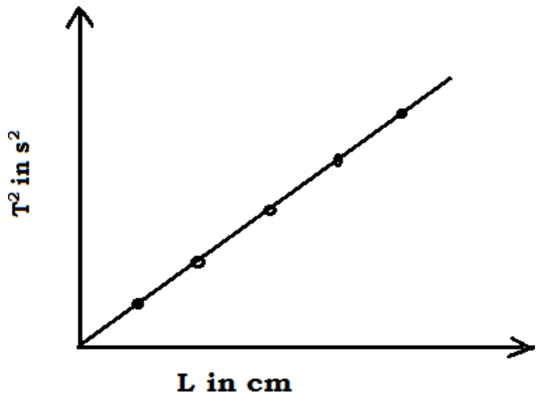
Effective length L =Length of the string from the hook to the point of suspension+ radius of the bob+ length of the hook =   cm

Number of oscillations= 30

(Ex.No1) Tabular Column: Vary the length of the pendulum (10-15cm) by keeping mass of the bob and the angle of oscillation same

S. No.	Effective length L in cm	Time for 30 oscillations in s			Time Period T in s

Nature of graph: L against T^2



Result:

Expt.No.2:

Least count of the vernier calipers=

Diameter of the bob = (i) cm (ii) cm (iii) cm

Radius of the bob= cm

Length of the hook = cm

Least count of the stop clock = s

Effective length L =Length of the string from the hook to the point of suspension (l) + radius of the bob+ length of the hook = cm

Number of oscillations= 30

Tabular Column: Vary the mass of the bob by keeping length and the angle of oscillation of the pendulum same

<table>
<tr><td rowspan="2">S. No.</td><td colspan="2">Effective length L in cm</td><td rowspan="2">Mass of the bob in kg</td><td colspan="3">Time for 30 oscillations in s</td><td rowspan="2">Time Period T in s</td></tr>
<tr><td>l in cm</td><td>L in cm</td><td></td><td></td><td></td></tr>
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</table>

Result:

Expt.No.3:

Least count of the vernier calipers=

Diameter of the bob = (i) cm (ii) cm (iii) cm

Radius of the bob= cm

Length of the hook = cm

Least count of the stop clock = s

Effective length L =Length of the string from the hook to the point of suspension (l) + radius of the bob+ length of the hook = cm

Number of oscillations= 30

Tabular Column 3: Vary the angle of oscillation by keeping length ofthe pendulum and mass of the bob same

S. No.	Effective length L in cm		Angle of oscillation of the pendulum in degree	Time for 30 oscillations in s			Time Period T in s
	l in cm	L in cm					
			5°				
			10°				
			15°				
			20°				

Result:

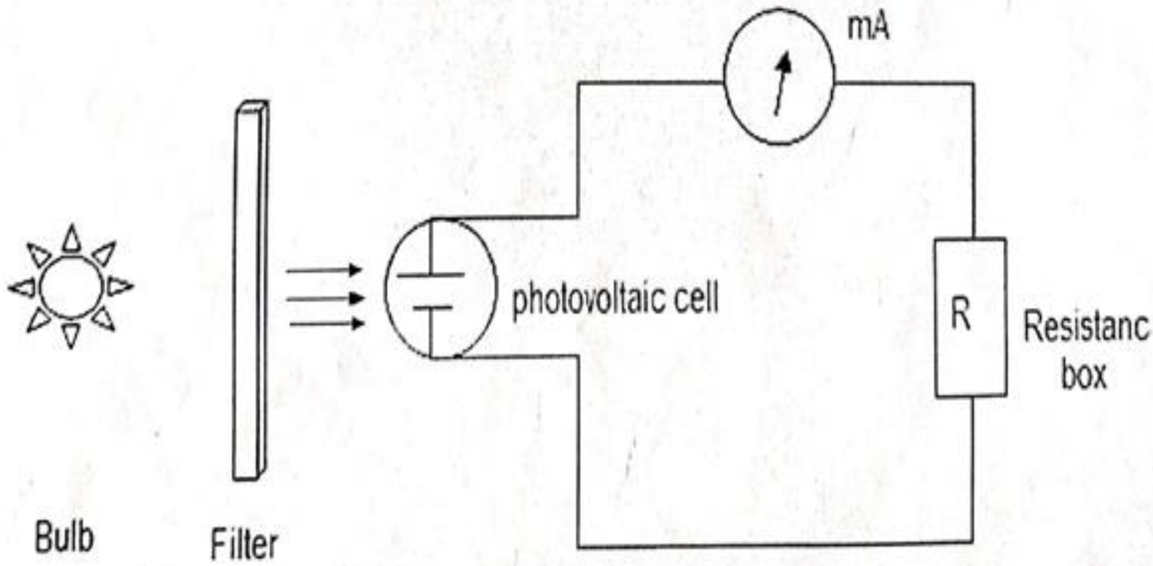
SPECTRAL SENSITIVITY OF PHOTOVOLTAIC CELL

AIM: Study the spectral characteristics of a photovoltaic cell using different wavelength filters. Hence draw spectral response curve.

APPARATUS: light source, photovoltaic cell, filter, milliammeter, resistance box etc.

PRINCIPLE: The experiment is based on the study of photo electric devices. It consists of a layer of semiconductor on a metal base plate. Generally copper oxide is deposited on the base plate of semiconductor, electrons are raised from valence band to conduction band , giving current which flows in the external circuit through a load. The reverse flow of electrons from the metal to semiconductor is prevented by the surface barrier set up in the semiconductor. As long as the illumination continues , there is a continuous flow of current in the external circuit.

CIRCUIT DIAGRAM:



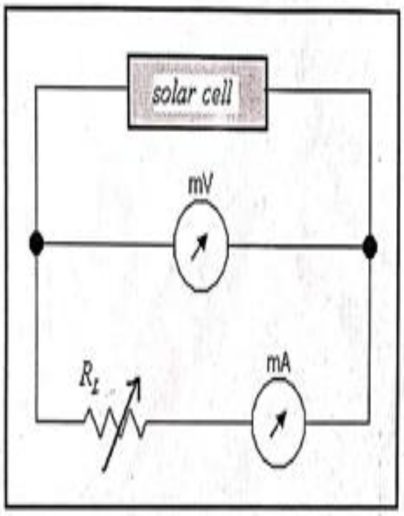
SOLAR CELL

AIM: Calculate the fill factor of solar cell for given distance between solar cell and source of a light with the help of I.V. Characteristics.

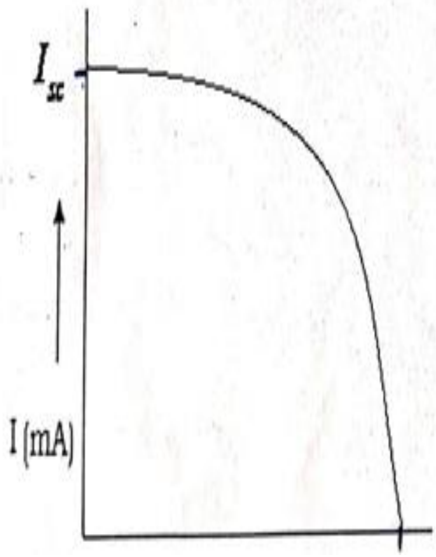
FORMULA

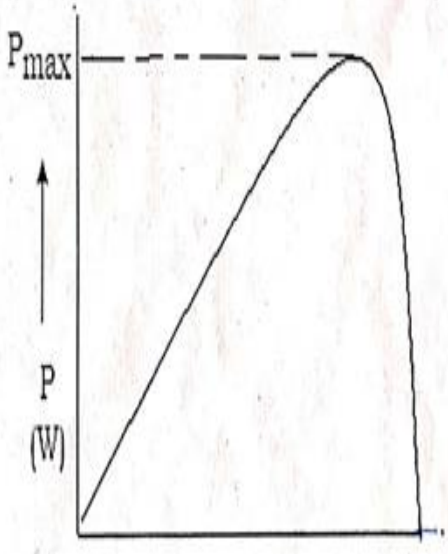
$$FF = \frac{I_{max} V_{max}}{I_{sc} V_{oc}}$$

CIRCUIT DIAGRAM



NATURE OF GRAPH





SOLAR CELL

OBSERVATIONS:

1. Open circuit voltage V_{oc} (when R_L and milliammeter is disconnected) = __________volts
2. Short circuit current I_{sc} (R = 0 Ω) = _______mA
3. Distance between source and solar cell 'D' = _______cms

TABULATION

Sl.No.	R (Ω)	V(mV)	I (mA)	P = V*I (W)
	0		I_{sc}	
	1			
	2			
	5			
	10			
	20			
	1000			

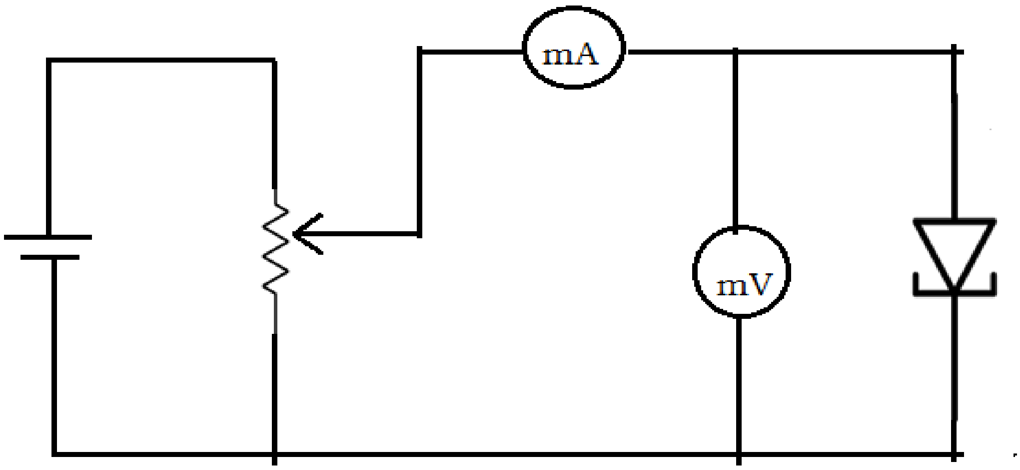
RESULT: The VI characteristics of the solar cell has been studied and the fill factor has been found FF = ____________

Tunnel Diode Characteristics

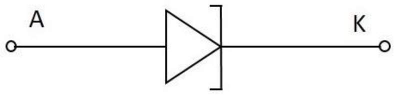
Aim: To study the I-V characteristics of Tunnel diode

Apparatus: Tunnel diode**,** Power supply, Rheostat, Voltmeter, Ammeter

Circuit Diagram:



Tunnel Diode Symbol



Nature of graph:

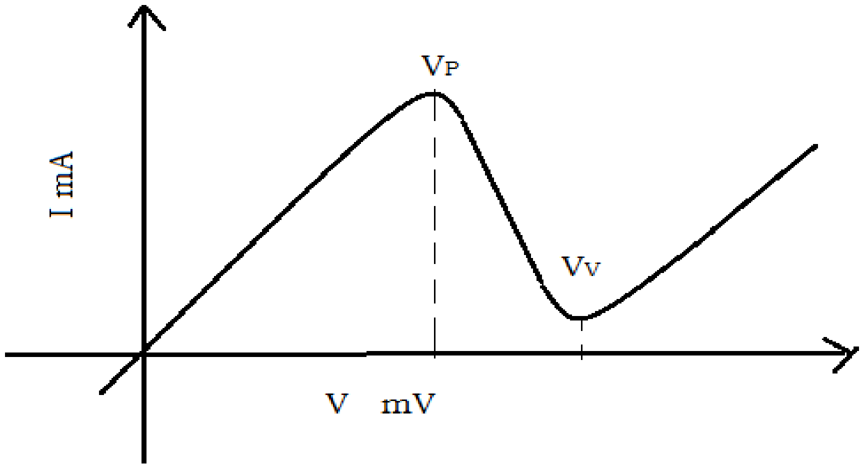


Fig. 1

V_P: Peak voltage

V_V: Valley voltage

Tabular Column:

S.No.	Current I in mA	Voltage V in mV

Theory:

Tunnel diode is a heavily doped pn junction which is 1000 times more doped than the normal diode. Its depletion layer is very narrow. The heavy doping provides large number of carriers. There is a much drift activity in p and n section and many valence electrons are raised to the conduction region. Hence it starts conducting even for a small applied voltage. The flow of electrons from valence band to conduction band without any applied forward voltage is known as tunnelling.

I-V characteristic of tunnel diode is shown in the Fig.1. As the forward voltage across the tunnel is increased, electrons from “n” region tunnel through the potential barrier to “p” region. As the forward voltage increases diode current increases up to peak point, up to this peak point diode exhibits positive resistance. As the voltage is increased tunnelling action decreases and diode current decreases up to valley point. Between peak point and valley point, diode exhibits negative resistance. When tunnel diode is operated in a negative resistance region, it can be used as a switch or as an oscillator.

ENERGY EIGEN VALUES OF A PARTICLE IN A FINITE SQUARE WELL POTENTIAL

Theory:

Energy Eigen Values for a particle in a square well potential with finite walls.

Particle of mass m is moving inside a potential well with Finite barriers of height V_0

$V(x) = V_0$	$x < -a$	Region-I
$V(x) = 0$	$-a < x < a$	Region-II
$V(x) = V_0$	$x > a$	Region-II

Schrodinger Wave Equation for the Region II is

$$\frac{d^2\psi}{dx^2} + k^2\psi = 0 \qquad (1)$$

Where $$k^2 = \frac{2mE}{\hbar^2} \qquad (2)$$

Solution to Eq. (1) is $\psi(x) = ASin(kx) + BCos(kx)$ (3)

By applying the boundary conditions at $x=\pm a$,

$$ASin(ka) + BCos(ka) = 0 \qquad (4)$$
$$-ASin(ka) + BCos(ka) = 0 \qquad (5)$$

From Eq. (4) and Eq. (5)

$BCos(ka) = 0$

and $ASin(ka) = 0$

The solution A=0, B=0 leads to physically unacceptable solution $\psi=0$

Other condition are (i) $A=0$, $B\neq 0$ and $A\neq 0$ $B=0$

For $A=0$, $B\neq 0$

For $A=0$, $B\neq 0$

$Cos(ka) = 0$ $\qquad ka = \frac{n\pi}{2}$

n=1, 3, 5, ….

$$k^2 = \frac{2mE}{\hbar^2} = \frac{n^2\pi^2}{4a^2} \qquad (6)$$

$$E_n = \frac{k^2\hbar^2}{2m} = \frac{\pi^2\hbar^2 n^2}{8ma^2}, \quad n=1, 3, 5 \ldots\ldots \qquad (7)$$

The eigen function corresponding to this energy eigenvalue is

$$\psi_n(x) = B\cos\left(\frac{n\pi x}{2a}\right)$$ n=1, 3, 5, ……. (8)

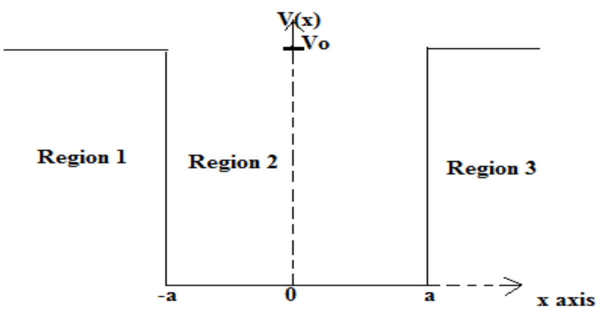
For $A \neq 0$ and B=0

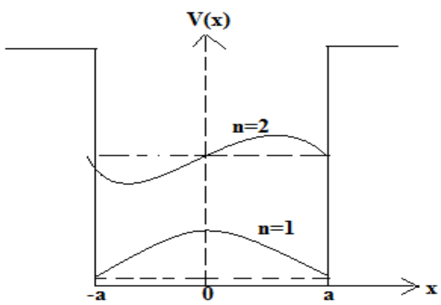
$$E_n = \frac{\pi^2\hbar^2 n^2}{8ma^2}$$ n=2, 4, 6, …….

$$\psi_n(x) = A\sin\left(\frac{n\pi x}{2a}\right)$$ (9)

Schrodinger wave equation In Region I and Region III

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V_0\psi = E\psi$$ (10)





For (i) E<V0

$$\frac{d^2\psi}{dx^2} = \beta^2\psi \qquad \beta^2 = \frac{2m}{\hbar^2}(V_0 - E)$$

And the Solution is

$$\varphi(x) = Ce^{-\beta x} + De^{-\beta x}$$ (11)

β is positive, C and D are constants, If D is not zero, ψ(x) → ∞, as x→∞(R-III) which is not acceptable solution. Similarly C=0 in R-I

The wave function for different regions will be

$\psi(x) = De^{\beta x}$ x< -a (12)

$\psi(x) = ASin(kx) + BCos(kx)$ -a<x<a (13)

$\psi(x) = Ce^{-\beta x}$ x>a (14)

Symmetric and antisymmetric wave function in R-II must be matched with wave function of R-I and R-III, Hence solution in R-II is divided into Symmetric and Antisymmetric function

For Symmetric function in R-II, A=0, The continuity condition on ψ and its derivative at $x = \pm a$

$$De^{-\beta a} = B\cos(ka) \text{ and } D\beta e^{-\beta a} = Bk\sin(ka) \quad (15)$$

$$Ce^{-\beta a} = B\cos(ka) \qquad C\beta e^{-\beta a} = Bk\sin(ka) \quad (16)$$

C=D and ka tan (ka) =βa (17)

Asymmetric function in R-II, B=0, The continuity condition on ψ and its derivative at $x = \pm a$

$$De^{-\beta a} = -A\sin(ka) \text{ and } D\beta e^{-\beta a} = Ak\cos(ka) \quad (18)$$

$$Ce^{-\beta a} = A\sin(ka) \qquad -C\beta e^{-\beta a} = Bk\cos(ka) \quad (19)$$

From Eq. (18) and Eq. (19) C= -D

ka cotka= -βa (20)

The energy eigenvalues can be determined by solving Eq. (17) and Eq. (20) graphically

ka =α

βa =γ

Hence α tanα =γ

α cotα=-γ

$$\alpha^2 = (ka)^2 = \frac{2mEa^2}{\hbar^2} \quad (21)$$

$$\gamma^2 = (\beta a)^2 = \frac{2m(V_0 - E)a^2}{\hbar^2} \quad (22)$$

$$\alpha^2 + \gamma^2 = \frac{2mV_0 a^2}{\hbar^2} \quad (23)$$

Eq. (23) is a equation of circle with radius

$$r = \sqrt{\frac{2mV_0a^2}{\hbar^2}}$$

$$\gamma = \sqrt{r^2 - \alpha^2}$$

The number of bound states for a given particle depends on the height and width of the potential well, which can be determined by plotting the graph of $\alpha\tan\alpha$ against α and Abs α $\cot\alpha$ against α. As α and γ can only positive values, intersection of two curves in the first quadrant gives the energy levels for n=1,3,5 … and also for n=2,4,6…..

Given data:

1. Mass of the Electron = m= 9.1×10^{-31} kg
2. Planck's constant $\hbar = \frac{h}{2\pi} = 1.054 \times 10^{-34}$ J-S
3. Depth of the potential well $= V_0 = 5$ eV
4. Half width of the potential well = a = 5 Å = 5×10^{-10} m.

$$r^2 = \frac{2mV_0a^2}{\hbar^2} = 32.8$$

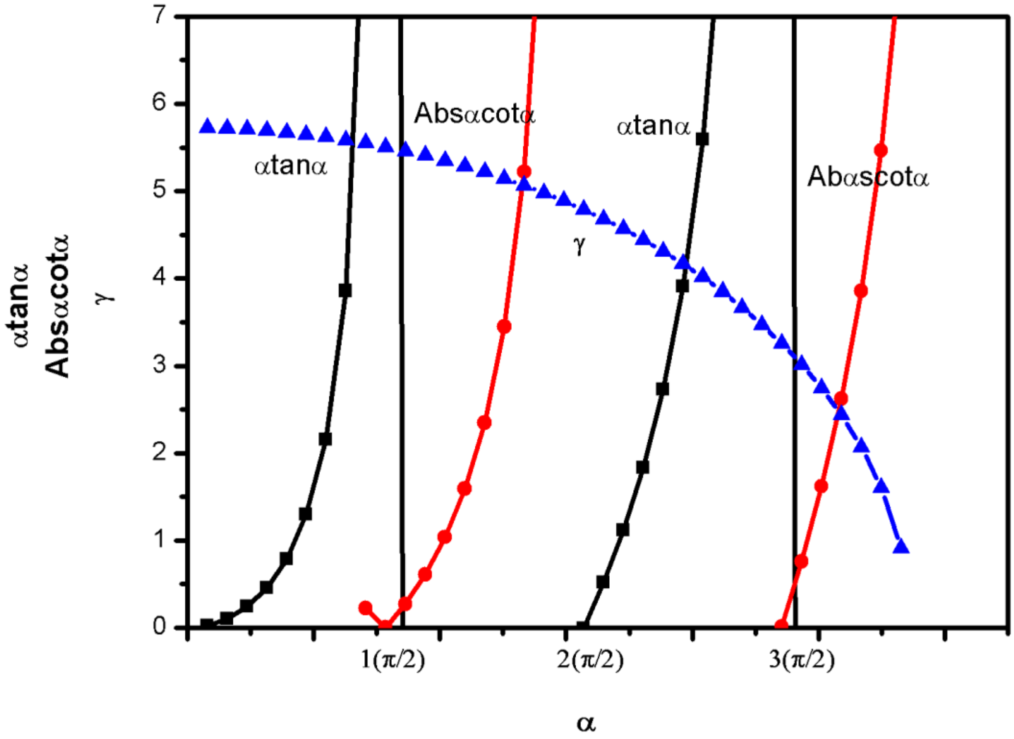
$$\gamma = \sqrt{r^2 - \alpha^2}$$

Nature of graph

Plot γ Vs α

Plot $\alpha\tan\alpha$ Vs α

Plot $|\alpha cot\alpha|$ Vs α



Tabular Column :

S.No.	α	γ	αtanα	$|\alpha cot\alpha|$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

S.NO	α Interval	Point of the intersection α_n (Even case)	Point of the intersection α_n (Odd case)
1	(0.π/2 -1. π/2)		
2	(1.π/2 -2. π/2)		
3	(2.π/2 -3. π/2)		
4	(3.π/2 -4. π/2)		

Energy Eigen Value

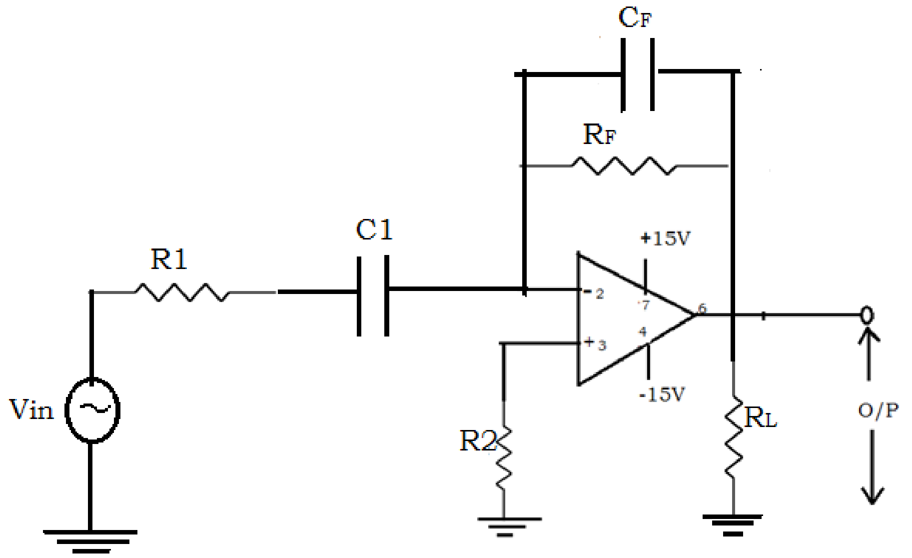
$$E'_n = \left(\frac{\alpha_n}{r}\right)^2 V_0$$

OP-AMP IC-741 as a Differentiator

Aim: To set the Differentiator circuit using OP-Amp IC-741

Apparatus: Dual Power supply, function generator, CRO, breadboard, capacitors, resistors

Circuit Diagram:



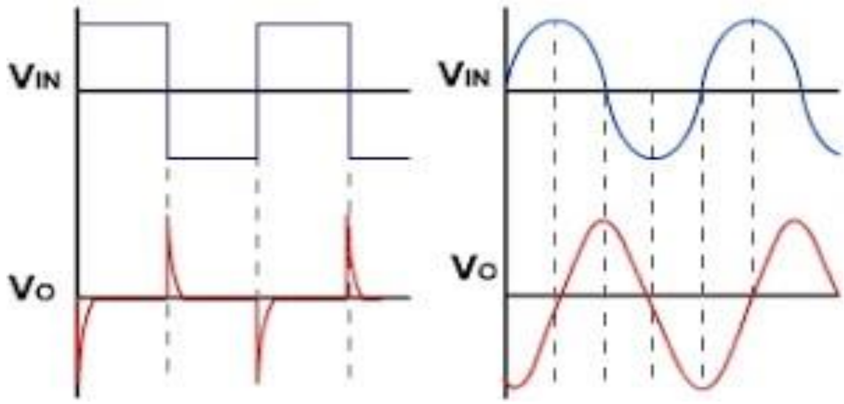
R_F=1.5kΩ, R_2=1.5kΩ, R_1= 82Ω, R_L=10kΩ, C_F=0.005μF, C_1=0.1μF,

Formula:

$$V_0 = R_F C_1 \left(\frac{dV_{in}}{dt} \right)$$

Procedure:

1. Set up the differentiator circuit as shown in figure. Give a rectangular wave of ±5V(peak-peak) and 1 kHz frequency atthe input and observe the input and output
2. Repeat the experiment for triangular wave and sine wave at the input and observe the output.

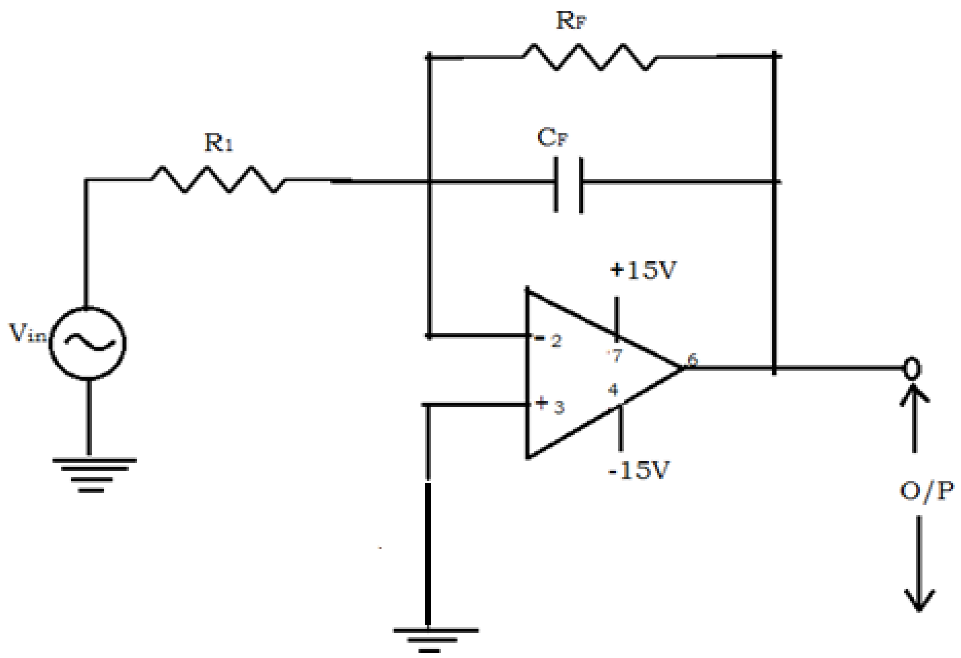


OP-AMP IC-741 as an Integrator

Aim: To set an integrator circuit using OP-Amp IC-741

Apparatus: Dual Power supply, function generator, CRO, breadboard, capacitors, resistors

Circuit Diagram:



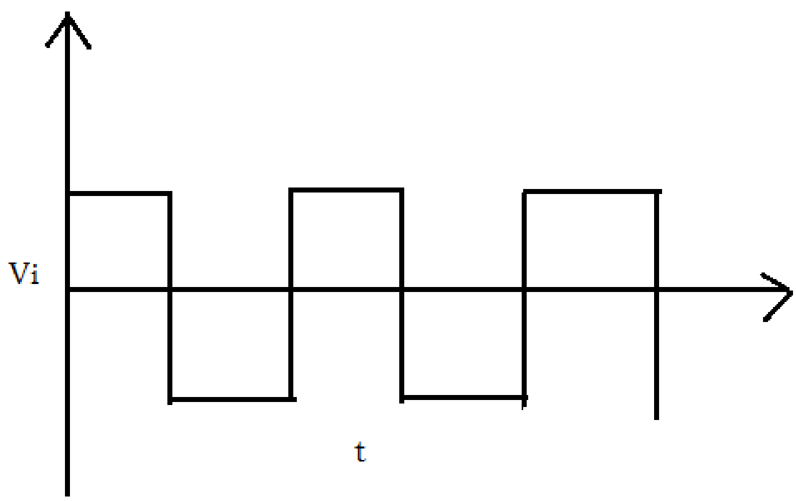
R_F=100kΩ, R_1=10kΩ, C_F= 0.1μF

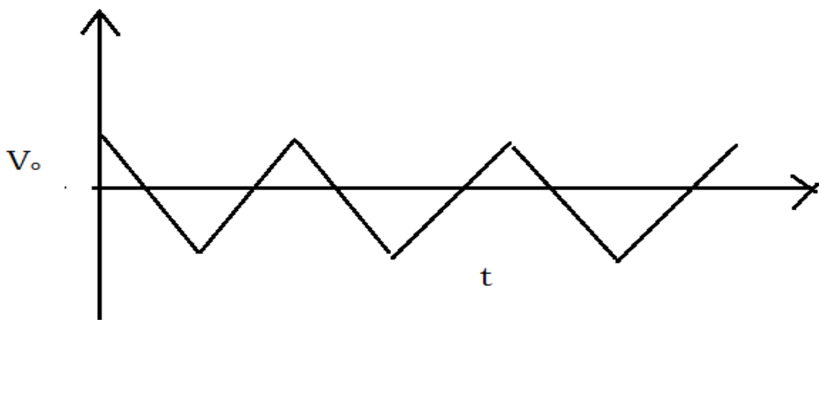
Formula

$$V_0 = \frac{1}{R_1 C_F} \int V_{in} dt$$

Procedure:

1. Set up the integrator circuit as shown in figure. Rectangular wave of ±5V pp, 1 kHz frequency is set the input and observe the output wave form on CRO.
2. Repeat the experiment for triangular wave and sine wave at the input and observe the output.



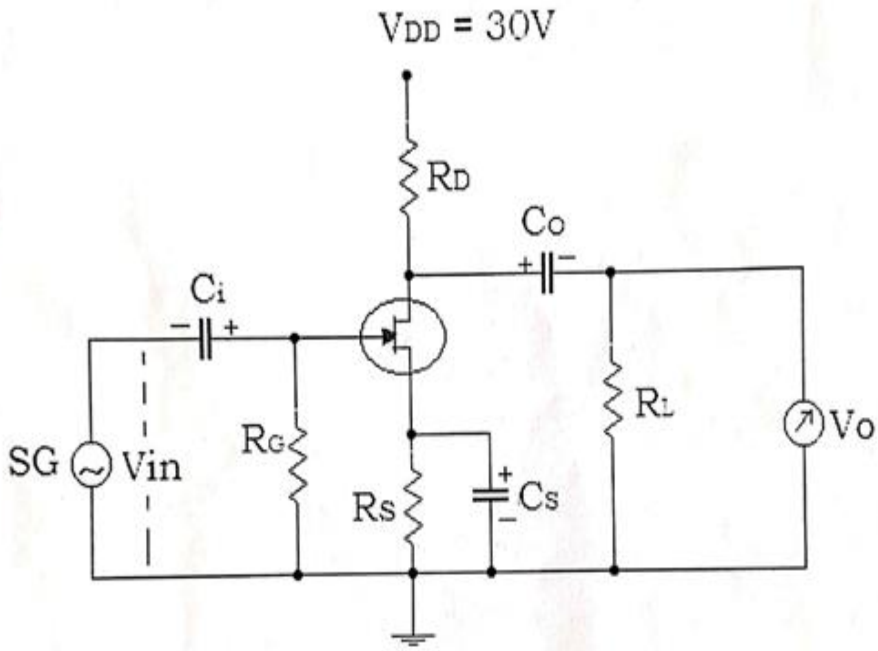


FET AMPLIFIER

AIM: Set up FET amplifier. Draw frequency response curve and hence obtain band width of amplifier.

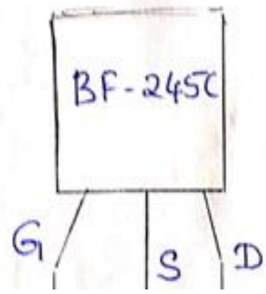
APPARATUS: FET, capacitors, resistors, power supply, AC millivoltmeter, connecting wires etc.

CIRCUIT DIAGRAM:



FET- BF245C	R_G = 1 MΩ	Ci = 22μF	SG – signal generator
Rd = 10KΩ	R_L = 22KΩ	Co = 22μF	Vo – AC millivoltmeter
Rs = 3880Ω	V_{DD} = 30 V	Cs = 22μF	

Base diagram



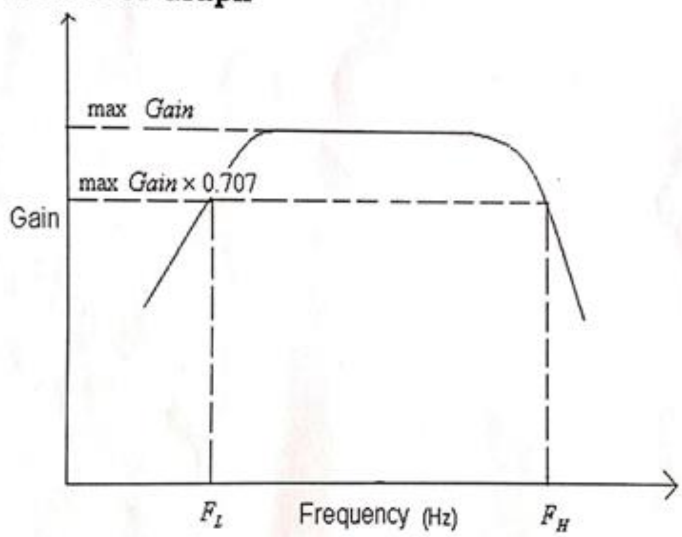
FET AMPLIFIER

OBSERVATIONS & TABULATION:

Input voltage V_{in} = 20 mV constant for all frequencies.

Obs no	Frequency (Hz)	Output V_o (Volt)	Gain= $\frac{V_o}{V_{in}}$

Nature of Graph



Max Gain = ______

Band Width = $F_H - F_L$ = ________Hz

Result :

1. Maximum gain = ________
2. Lower cutoff frequency F_L = _______Hz
3. Upper cutoff frequency F_H = ______Hz
4. Band Width = $F_H - F_L$ = ________Hz