SOLUTIONS: PHYSICS(042)			
Code: 55/4/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	**(C)** decreases by 4.55×10^{-23} kg	**1**	**1**
2.	**(C)** R^3	**1**	**1**
3.	**(B)** a semicircular path in XY plane	**1**	**1**
4.	**(C)** 60^0	**1**	**1**
5.	**(B)** Sodium Chloride	**1**	**1**
6.	**(A)** $10\sqrt{2}$A	**1**	**1**
7.	**(D)** 3.33×10^{-6}T	**1**	**1**
8.	**(B)** Concave and real	**1**	**1**
9.	**(C)** Photons of light and electrons both exhibit dual nature	**1**	**1**
10.	**(B)** The red beam has more numbers of photons than the blue beam	**1**	**1**
11.	**(A)** Sn	**1**	**1**
12.	**(C)** Concentric horizontal circles around the wire	**1**	**1**
13.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	**1**	**1**
14.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	**1**	**1**
15.	**(C)** Assertion (A) is true but Reason (R) is false.	**1**	**1**
16.	**(B)** Both Assertion (A) and Reason (R) are true but reason (R) is not the correct explanation of the Assertion (A)	**1**	**1**
	SECTION-B		
17.	(a) (i) Comparison of brightness of bulbs P and Q with bulb S ½ Justification ½ (ii) Comparison of brightness of bulb S with Q ½ Justification ½ (i) Brightness of the bulb 'S' will be more than bulbs 'P' and 'Q' The current flowing through the bulb 'S' is twice of the current in bulbs 'P' and 'Q'. (ii) Brightness of the bulb 'S' and 'Q' will be same The current flowing through both bulbs is same. **Alternatively-** (i) Brightness of the bulb 'S' will be more than bulbs 'P' and 'Q' The potential difference across 'S' is twice than the potential	 ½ ½ ½ ½	

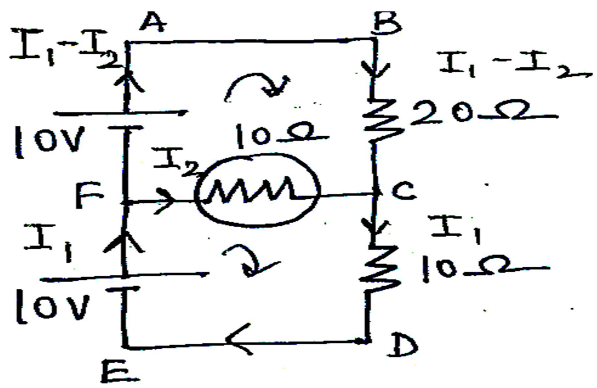
difference across bulbs ‘P’ and ‘Q’

(ii) Brightness of both bulbs ‘S’ and ‘Q’ is same.
The potential difference across ‘S’ and ‘Q’ will be same.

OR

(b)

Finding the current through the bulb ‘B’	2



½

By applying Kirchhoff’s loop rule to closed loops ABCFA and FCDEF ½

$2I_1-3I_2=1$----(1) ½

$I_1+I_2=1$-----(2)

On solving,

Current through the bulb,

$I_2=\frac{1}{5}A$ ½ **2**

18.

Finding the angle of diffraction for first secondary maximum.	2

$\theta=(2n+1)\frac{\lambda}{2a}$ ½

For first secondary maxima n=1

$\theta=\frac{3\lambda}{2a}$ ½

$\theta=\frac{3\times550\times10^{-9}}{2\times0.55\times10^{-3}}$ ½

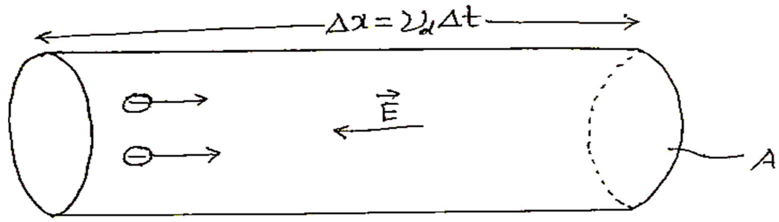
$\theta=1.5\times10^{-3}\text{radian}=0.086\text{ degree}$ ½ **2**

19.

Calculation of radius of curvature	2

$\frac{1}{f}=(n_{21}-1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$ ½

	$R_1 = R$ and $R_2 = -R$ $\frac{1}{15} = (1.55-1)\left[\frac{2}{R}\right]$ R = 16.5 cm	½ ½ ½	2
20.	Calculation of mass of an α -particle in u 2 $1u = \frac{1}{12}$ mass of carbon atom $= \frac{1.9926\times10^{-26}kg}{12} = 1.66\times10^{-27}\,kg$ mass of an electron $= 9.1\times10^{-31}$kg mass of two electrons $= \frac{2\times9.1\times10^{-31}}{1.66\times10^{-27}}$ $= 0.00109638$ u mass of α-particle = mass of the normal helium atom - mass of two electrons =4.0026030 - 0.00109638 =4.00150662 u	½ ½ ½ ½	2
21.	(a) (i) Identifying the type of dopant ½ (ii) Identifying the type of extrinsic semiconductor ½ (b) Calculating the electron concentration 1 (a) (i) Trivalent (ii) p – type semi conductor (b) Electron concentration $n_e = \frac{n_i^2}{n_h}$ $n_e = \frac{(5\times10^8)^2}{8\times10^{12}}$ $n_e = 3.125\times10^4 m^{-3}$	½ ½ ½ ½	2
	SECTION-C		
22.	**(a)** (i) Deriving the expression for resistivity of a conductor 2 (ii) Comparison of charges Q_1 and Q_2 1		



Total charge transported along E is

$$I\Delta t=\frac{e^2A}{m}\tau\, n\Delta tE$$ ½

$$\frac{I}{A}=\frac{ne^2}{m}\,\tau E$$ ½

$$J=\frac{1}{\rho}E$$ ½

$$\rho=\frac{m}{ne^2\tau}$$ ½

Alternatively-

Current in the conductor-

$$I=neAv_d$$

$$\frac{I}{A}=ne\frac{eE}{m}\tau$$

$$J=\frac{ne^2\tau}{m}E$$

$$J=\frac{1}{\rho}E$$

$$\rho=\frac{m}{ne^2\tau}$$

(ii) From given graph

$$\frac{Q_1}{Q_2}=\frac{A_1\text{ (Area of rectangle)}}{A_2\text{ (Area of triangle)}}$$ ½

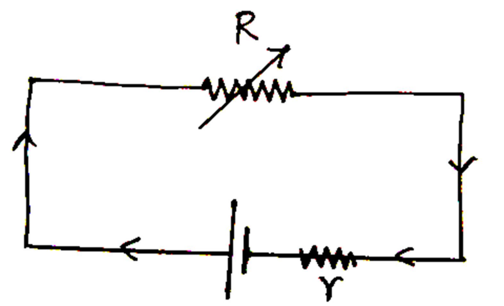
$$\frac{Q_1}{Q_2}=\frac{2}{3/2}$$

$$Q_1>Q_2$$ ½

OR

(b)

(i) (I)	
• Obtaining the expression for current	½
• Finding value of maximum current	½
(II) Obtaining terminal voltage V and its maximum possible value	1
(ii) Obtaining the internal resistance of the battery	1



- $V = E - Ir$

  $IR = E - Ir$

  $I = \dfrac{E}{R+r}$ ½

  For maximum value of current R=0

$I_{max} = \dfrac{E}{r}$ ½

(II) $V = V_{+} + V_{-} - Ir$ ½

$V = E - Ir$

$V_{max} = E$, when I=0 ½

(ii) $I_1R_1 + I_1r = I_2R_2 + I_2r$ ½

$r = \dfrac{I_2R_2 - I_1R_1}{I_1 - I_2}$ ½ **3**

23.

(a) Vector form of Biot – Savart Law	1
(b) Finding ,	
• Magnitude of resultant magnetic field	1½
• Direction of resultant magnetic field	½

(a) $d\vec{B} = \dfrac{\mu_o}{4\pi}\dfrac{I(\vec{dl}\times\vec{r})}{r^3}$ 1

	(b) As $B = \frac{\mu_o}{4\pi}\frac{2I}{a}$ ∴ B_1 = Magnetic field due to current carrying wire along X X' $\vec{B}_1 = \frac{\mu_o}{4\pi}\frac{2I}{a} = \frac{2\times2\times10^{-7}}{5} = (8\times10^{-8}\ T)(\hat{k})$ B_2 = Magnetic field due to current carrying wire along YY' $\vec{B}_2 = \frac{\mu_o}{4\pi}\frac{2I}{a} = \frac{2\times2\times10^{-7}}{4} = 10\times10^{-8}T\ (-\hat{k})$ $\vec{B}_{net} = \vec{B}_2 + \vec{B}_1$ $= 2\times10^{-8}T\,(-\hat{k})$ • Direction of resultant magnetic field along –Z axis.	½ ½ ½ ½	3
24.	Finding direction of induced current in coil and justification (a) coil '2' is moving toward coil '1' ½+½ (b) coil '2' is moving away from coil '1' ½+½ (c) Resistance connected with coil '2' is increased keeping both the coils stationary ½+½ (a) Induced current will be clockwise. Due to the direction flow of current in coil 2, the face approaching to coil 1 behaves like south pole. Induced polarity on coil 1 viewed from the side of coil 2 will be south pole (b) Induced current will be Anticlockwise Due to direction of flow of current in coil 2, face going away from coil 1 behaves like south pole. Induced polarity on coil 1 viewed from the side of coil 2, will be north pole. (c) Induced current will be Anticlockwise Till the resistance in coil 2 is increasing, the magnetic flux associated with coil 1 is decreasing. Hence according to Lenz's law current will induce in coil 1, momentarily and after that no induced current in coil	½ ½ ½ ½ ½ ½	3
25.	(a) Three characteristics of electro- magnetic wave **1½** (b) Explanation of displacement current, • how **1** • Where it exists ½ (a) (Any three) • Electromagnetic wave carries energy. • Electromagnetic wave carries momentum. • Electromagnetic wave moves with velocity of light in vacuum. • In electromagnetic wave, electric field vector, magnetic field vector	½ ½ ½	

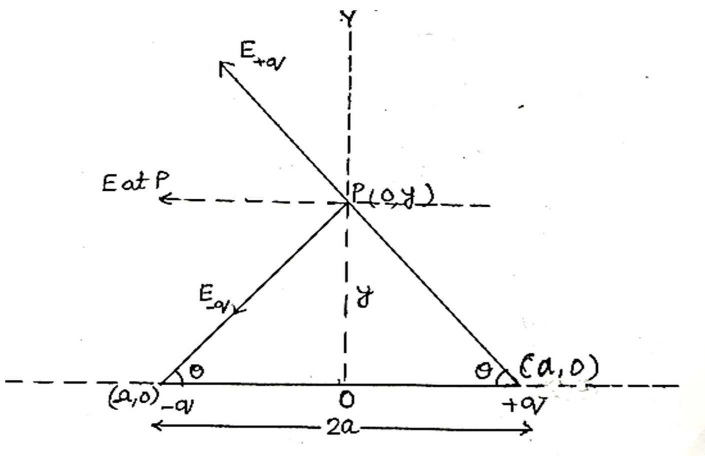
	and direction of propagation, all are mutually perpendicular. • Electromagnetic waves are transverse in nature. • Electromagnetic waves do not require a physical medium to propagate and can travel through a vacuum. • Electromagnetic waves consist of oscillating electric and magnetic fields. (b) • During charging of capacitor, time varying electric field / electric flux between the plates of capacitor induces the displacement current. • Displacement current exists between the plates of capacitor.	1 ½	**3**
26.	Effect on (a) Speed, frequency and wavelength of light 1½ (b) Fringe width, shape of fringes and shift of position of central maximum 1½ (a) • Speed of light will decrease • Frequency remains unaffected • Wavelength decreases (b) • Fringe width decreases • Shapes does not change • Position of central maxima does not change.	½ ½ ½ ½ ½ ½	**3**

27.	Explanation of (a) Photoelectric emission 1 (b) Dependency of maximum kinetic energy on frequency only 1 (c) Explanation of slope of cut off voltage versus frequency graph 1		
	(a) Einstein Photo electric equation $h\nu = h\nu_o + K_{max}$ $K_{max} = h(\nu - \nu_o)$	½	
	For $\nu < \nu_o$, K_{max} will be negative Hence, Photoelectric emission is not possible.	½	
	(b) According to Einstein Photoelectric equation $K_{max} = h(\nu - \nu_o)$	½	
	Hence $K_{max} \alpha \nu$ It shows K_{max} depends upon frequency only and not depends upon intensity.	½	
	(c) $eV_o = h\nu - h\nu_o$ $V_o = \frac{h}{e}\nu - \frac{h}{e}\nu_o$	½	
	This equation represents the equation of straight line (y = mx + c) with the slope $\frac{h}{e}$.	½	3
28.	(a) Majority and minority charge carriers in p-type and n-type semiconductor 2 (b) Brief explanation for formation of diffusion current and drift current 1		
	(a) In p-type semiconductor		
	Majority charge carriers - holes	½	
	Minority charge carriers - electrons	½	
	In n-type semiconductors		
	Majority charge carriers - electrons	½	
	Minority charge carriers – holes	½	
	(b) Diffusion current – during the formation of p n junction , and due to the concentration gradient across p and n – sides , holes diffuse from p side to n	½	

	side ($p \rightarrow n$) and electrons diffuse from n – side to p – side ($n \rightarrow p$). This motion of charge carriers gives rise to diffusion current across the junction. Drift current –Due to electric field at junction, an electron on p – side of the junction moves to n- side and a hole on n – side of the junction moves to p-side. This motion of charge carriers due to electric field gives drift current.	½	3
	SECTION-D		
29.	(i) (C) $\frac{2\varepsilon_o KL^2}{d}$ (ii) (B) $\frac{\varepsilon_o VKL^2}{d}$ (iii) (A) $\frac{V}{d}$ (iv) (a) (C) $\frac{d}{2K}$ OR (b) (D) Zero	1 1 1 1	 4
30.	(i) (C) $\sqrt{\frac{Ke^2}{mr}}$ (ii) (B) $\frac{-Ke^2}{2r}$ (iii) (C) $-2.48, 2.48$ (iv) (a) (D) $\frac{1}{n^3}$ OR (b) (C) $1.59\,\mathring{A}$	1 1 1 1	 4

31. **(a)**

(i) Finding electric field at a far off point (y>>a)	3
(ii) Calculation of work done in shifting the charges	2



½

Magnitude of electric field due to the two charges +q and -q are given by

$$E_{+q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$ ½

$$E_{-q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$ ½

Components normal to the dipole axis cancel out.

The components along the dipole axis add up.

The total electric field is opposite to the dipole moment will be given by-

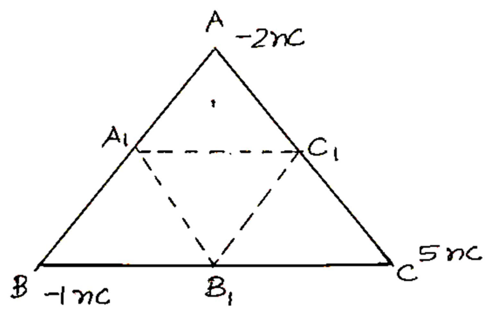
$$\vec{E} = -\,(E_{+q}+E_{-q})\cos\theta\,\hat{p}$$ ½

$$= -\,\frac{2qa}{4\pi\varepsilon_o(y^2+a^2)^{3/2}}\hat{p}$$ ($\hat{p}$ is a unit vector along dipole moment) ½

At large distance (y>>a)

$$\vec{E} = \frac{-2qa}{4\pi\varepsilon_o y^3}\hat{p}$$ ½

(ii)



Initial electrostatic potential energy of the system

$$U_1 = \frac{1}{4\pi\varepsilon_o}\left(\frac{q_A q_B}{AB} + \frac{q_C q_A}{AC} + \frac{q_C q_B}{BC}\right)$$ ½

$$= \frac{9\times10^9}{0.2}\left[(-2\times-1)+(-2\times5)+(-1\times5)\right]\times10^{-18}$$ ½

$U_1 = -5.85\times10^{-7}$ J

$$U_2 = \frac{1}{4\pi\varepsilon_o}\left(\frac{q_{A_1} q_{B_1}}{A_1B_1} + \frac{q_{C_1} q_{A_1}}{A_1C_1} + \frac{q_{c_1} q_{B_1}}{B_1C_1}\right)$$ ½

$U_2 = -11.7\times10^{-7}$ J ½

$W = U_2 - U_1 = -5.85\times10^{-7}$ J

OR

(b)

(i)

- Showing consistency of Gauss's theorem with Coulomb's law 1
- Derivation for electric field due to uniformly charged thin spherical shell at (I) $y > r$ (II) $y < r$ 2

(ii) Finding type and magnitude of charge 2

(i)

- Gauss's theorem is based on the inverse square dependence on distance contained in the coulomb's law. **1**

  Alternatively-

  According to Gauss's theorem

$$\oint \vec{E}.d\vec{s} = \frac{q}{\varepsilon_o}$$ ½

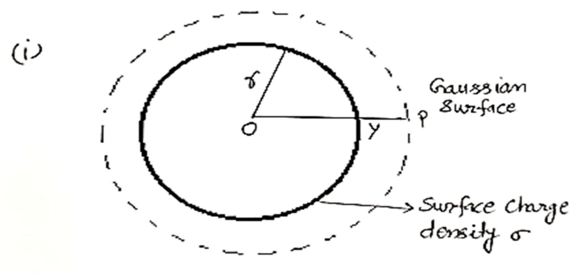
$$E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$$

According to Coulomb's law, force on charge q_o in this field

$$F = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}$$ ½

Therefore, Gauss's law is consistent with Coulomb's law

- (I) For y > r



Electric flux through Gaussian surface $E \times 4\pi y^2$

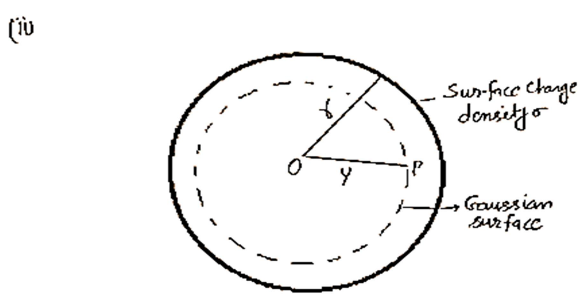
The charge enclosed by the surface $\sigma \times 4\pi r^2$

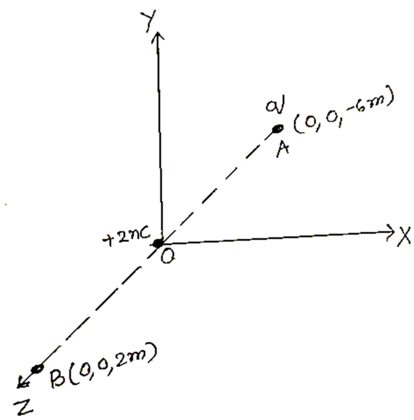
Using Gauss theorem ½

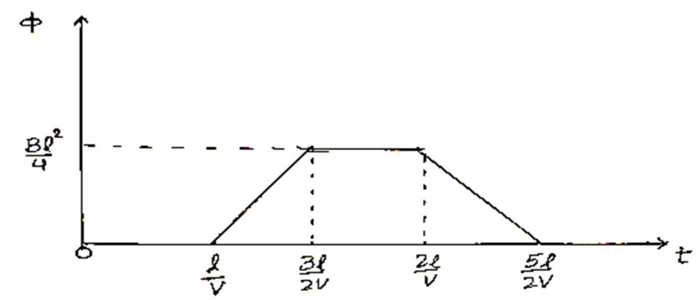
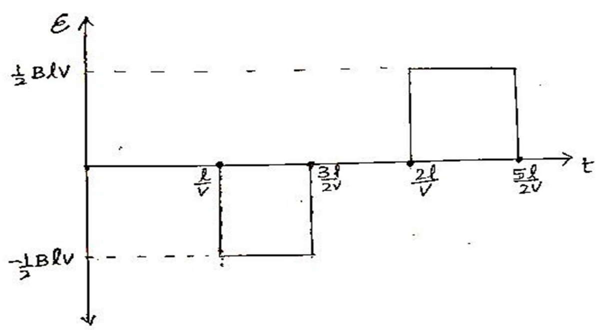
$$E(4\pi y^2) = \frac{\sigma 4\pi r^2}{\varepsilon_o}$$

$$\vec{E} = \frac{q}{4\pi\varepsilon_0 y^2}\hat{r}$$ ½

(II) For y < r



	The charge enclosed by Gaussian surface = 0 Using Gauss theorem Electric flux $= E(4\pi y^2) = 0$ i.e. $E = 0 \quad (y < r)$ (ii)  Let the charge is kept at A be q Potential at point B due to charge at the origin O and charge (q) at A $V = V_1 + V_2$ $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{2\times10^{-9}}{2} + \frac{q}{6+2}\right]$ $\frac{1}{4\pi\varepsilon_0}\left[10^{-9} + \frac{q}{8}\right] = 0$ $q = -8\times10^{-9}C$	½ ½ ½ ½ ½ ½	 5
32.	**(a)** (i) • Statement of Lenz's law ½ • Explaining, how this law is a consequence of law of conservation of energy ½ (ii) (I) Direction of induced current when loop enters and loop leaves ½+½ (II) Plots showing variation of magnetic flux (ϕ) with time (t), 1 induced emf (E) with time (t) and 1 relevant values E, (ϕ) and t on the graph 1		

	Lenz's law – Polarity of the induced emf is such that it tends to produce a current, which opposes the change in magnetic flux that produces it.	½	
	When magnet is moved closer/ away from the loop, same/ opposite pole is developed on the approaching face of the loop. So mechanical work is required to move a magnet which gets converted into electrical energy which is consistent with the law of conservation of energy.	½	
	(ii) (I) • Anticlockwise	½	
	• Clockwise	½	
	(II) 	1½	
		1½	
	OR (b) (i) Difference between Peak value and rms value of ac — 1 Relation — ½ (ii) (I) Identification of elements X and Y by phasor diagram — 1 (II) Obtaining • Resonance condition — 1 • Expression for resonant frequency — 1 • Impedance value — ½		

(i)

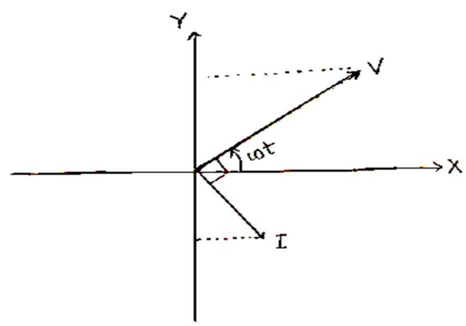
Peak value - It is the maximum value of Alternating current.
rms value – It is the equivalent dc current that would produce the same average power loss as alternating current. **1**

Alternatively-

Peak value - It is the maximum value of Alternating current.
rms value- It is the effective value of an ac representing the equivalent dc, that would produce the same heating effect in same resistor in same time period.

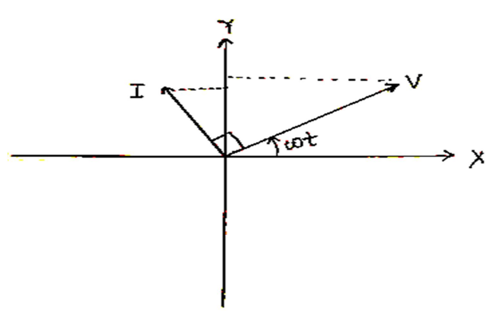
Relation $I_{rms} = \frac{I_o}{\sqrt{2}}$ ½

(ii) (I) X- Inductor (L)



½

Y- Capacitor (C)



½

	(II) Impedance of the circuit		
	$Z = (X_L - X_C)$	½	
	At resonance $Z = 0$		
	$X_L = X_C$	½	
	$\omega L = \frac{1}{\omega C}$	½	
	$\omega^2 = \frac{1}{LC}$, $\omega = \frac{1}{\sqrt{LC}}$	½	
	$\nu = \frac{1}{2\pi\sqrt{LC}}$		
	Impedance at resonance Z=0	½	5
33.	**(a)**		
	(i) Calculation of focal length of concave lens 3 (ii) Calculation of • Angle of minimum deviation 1 • Angle of incidence 1		
	For real image form by Convex lens		
	$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$	½	
	$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{(-30)}$		
	$v_1 = 15\,cm$	½	
	For Combination of lenses, let the focal length of combination of lens is f_3		
	$\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$		
	$\frac{1}{f_3} = \frac{1}{(15+45)} + \frac{1}{30}$	½	
	$f_3 = 20cm$		
	Let the focal length of concave lens is f_2	½	
	$\frac{1}{f_3} = \frac{1}{f_1} + \frac{1}{f_2}$	½	
	$\frac{1}{f_2} = \frac{1}{20} - \frac{1}{10}$		

	$f_2 = -20cm$	½	
	(ii) Angle of minimum deviation $\mu = \dfrac{\text{Sin}\dfrac{(A+\delta_m)}{2}}{\text{Sin}\dfrac{A}{2}}$	½	
	$\sqrt{3} = \dfrac{\text{Sin}\dfrac{(60^\circ+\delta_m)}{2}}{\text{Sin }30}$		
	$\dfrac{\sqrt{3}}{2} = Sin\dfrac{(A+\delta_m)}{2}$ $60^\circ = \dfrac{(A+\delta_m)}{2}$ $\delta_m = 60^o$	½	
	Angle of incidence $i + e = A + \delta$ $2i = A + \delta_m$	½	
	$i = \dfrac{A+\delta_m}{2}$ $i = 60^\circ$	½	
	OR		
	(b)		
	(i) (I) Finding the slit separation 1½ (II) Calculation of distance between central maximum and first minimum 1½ (ii) Calculation of distance between first order minima on both sides of central maxima 2		
	(i) (I) Slit separation $\beta = \dfrac{D\lambda}{d}$	½	

	$d=\frac{D\lambda}{\beta}$ $=\frac{633\times10^{-9}\times5}{5\times10^{-3}}$ $=633\times10^{-6}m$ $=633\mu m$ (II) Distance of first minimum from central maximum $x_n=\frac{(2n-1)\lambda D}{2d}$ n =1 $x=\frac{633\times10^{-9}\times5}{2\times5\times10^{-3}}$ $x=316.5\times10^{-6}m$ $x=316.5\mu m$ (ii) Distance between first order minima on both the side $W=\frac{2D\lambda}{d}$ $=\frac{2\times650\times10^{-9}}{0.6\times10^{-3}}\times60\times10^{-2}$ $=1.3\times10^{-3}m$	½ ½ ½ ½ ½ ½ 1 ½	5