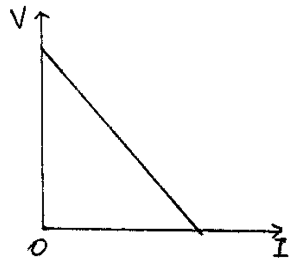
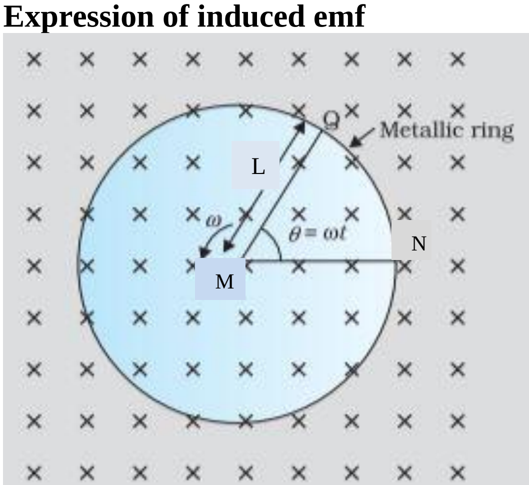
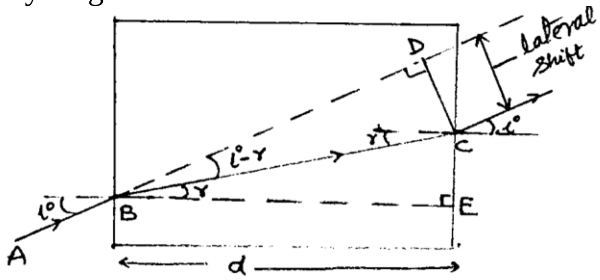
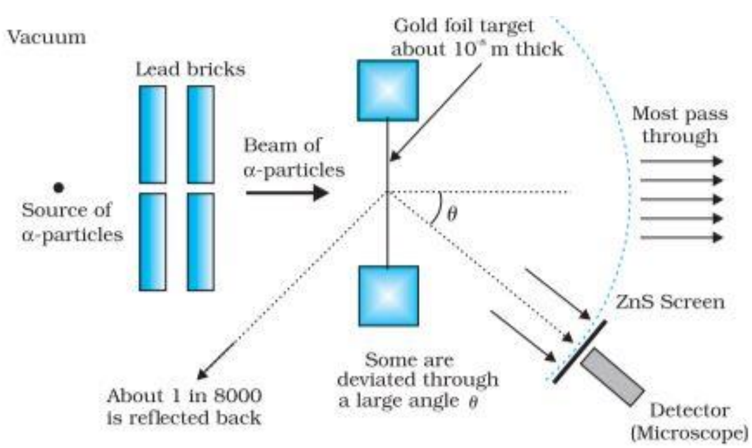
	SOLUTIONS: PHYSICS(042)		
	Code: 55/6/2		
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	(A) $\frac{P}{4}$	1	1
2.	(C) g	1	1
3.	(B) $(-0.16\hat{j}+0.12\hat{k})N$	1	1
4.	(A) 10 V	1	1
5.	(B) $\frac{1}{2}$	1	1
6.	(C) $2I_0$	1	1
7.	(C) $\left[\frac{n^2-1}{n}\right]R$	1	1
8.	(C) small resistance in parallel	1	1
9.	(D) $F_{pp}=F_{pn}=F_{nn}$	1	1
10.	(D) 0.55 nm	1	1
11.	(D) does not move at all	1	1
12.	(B) 1.326×10^{-27}	1	1
13.	(C) Assertion (A) is true, But Reason (R) is false.	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.	(D) Both Assertion (A) and Reason (R) are false.	1	1
	SECTION B		
17.	Plotting the graph — 1 Explaining how to find emf and internal resistance of cell — ½ + ½ Graph showing the variation of terminal voltage V of the cell as a function of current I.		

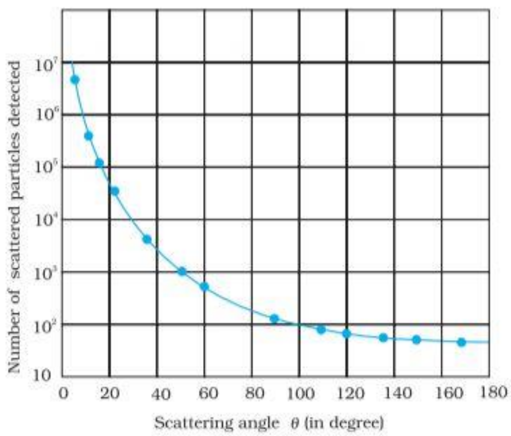
	 $V = E - Ir$ E = intercept on y-axis (i.e. V-axis) r = $\lvert \text{slope of graph} \rvert$	1 ½ ½	 2
18.	Explanation for higher electron concentration in n-type semiconductor in comparison to hole concentration 2 In a doped semiconductor the total number of conduction electrons is due to the electrons contributed by donors and those generated intrinsically, while the total number of holes is only due to the holes from the intrinsic sources.	2	2
19.	Finding force exerted by laser beam 2 No. of photons ejected per second = $\frac{P}{E}$ $= \frac{P}{\left(\frac{hc}{\lambda}\right)}$ Momentum of photon, $p = \frac{h}{\lambda}$ Force exerted by laser beam $F = 2 \times \frac{P}{\left(\frac{hc}{\lambda}\right)} \times \frac{h}{\lambda}$ $= \frac{2P}{c}$ $= \frac{2 \times 5 \times 10^{-3}}{3 \times 10^{8}}$ $F = 3.33 \times 10^{-11}$ N	½ ½ ½ ½	 2
20.	Finding angle of incidence 1 Finding angle of refraction on face AB 1		

	In a prism we know $A+\delta=i+e \quad and\ A=r_1+r_2$ At minimum deviation $i=e\ \ and\ \ r_1=r_2=r$ $A+D_m=2i$ $i=\frac{A+D_m}{2}$ $A=2r$ $r=A/2$	½ ½ ½ ½	2
21.	(a) Finding the intensity for path difference of (i) $\frac{\lambda}{3}$ 1 (ii) $\frac{\lambda}{2}$ 1 (i) $\Delta\phi=\frac{2\pi}{\lambda}.\Delta x$ $\Delta\phi=\frac{2\pi}{\lambda}.\frac{\lambda}{3}=\frac{2\pi}{3}$ $I=4I_0\cos^2\frac{\phi}{2}$ $I=4I_0\cos^2\frac{\pi}{3}$ $I=I_0$ (ii) $\Delta\phi=\frac{2\pi}{\lambda}.\frac{\lambda}{2}=\pi$ $I=4I_0\cos^2\frac{\pi}{2}$ $I=0$ OR (b) Finding- The position of the image 1½ The nature of the image ½ $\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R}$	½ ½ ½ ½ ½	

	$\frac{1.5}{v} - \frac{1}{(-12)} = \frac{1.5-1}{30}$ v = -22.5 cm Image is virtual and erect.	½ ½ ½	2
	SECTION - C		
22.	(a) Defining drift velocity 1 (b) Derivation of formula for current density in terms of relaxation time 2 (a) Drift velocity is the average velocity with which the free electrons move under external electric field in a conductor. (b) Current density $j = \frac{I}{A}$ $\because I = neAv_d$ $\therefore j = nev_d$ $But\ v_d = \frac{eE\tau}{m}$ $\therefore j = \frac{ne^2\tau E}{m} = \frac{ne^2\tau}{m}\left(\frac{V}{l}\right)$	1 ½ ½ ½ ½	3
23.	(a) Stating Lenz's law 1 Obtaining expression for induced emf 2 **Lenz's law** The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it. **Expression of induced emf** 	1	

	The magnitude of the emf generated across the length dr of the rod as it moves at right angles to the magnetic field is given by $d\varepsilon = B\text{v}\,dr$ $\varepsilon = \int d\varepsilon$ $= \int_0^L B\text{v}\,dr$ $\varepsilon = \int_0^L B\omega r\,dr$ $\varepsilon = \frac{1}{2}BL^2\omega$ **Alternatively:** Area of the sector (QMN) = $\frac{1}{2}L^2\theta$ Induced emf is $\varepsilon = B\times\frac{d}{dt}\left(\frac{1}{2}L^2\theta\right)$ $\varepsilon = \frac{1}{2}BL^2\frac{d\theta}{dt}$ $\varepsilon = \frac{1}{2}BL^2\omega$ OR (b) Definition of self inductance 1 Deriving expression for self inductance for a long solenoid 2 Self inductance of a coil is the ratio of the flux linkage to the current flowing in the coil. **Alternatively:** Self inductance of a coil is defined as the flux linked with the coil when unit current flows through it. **Alternatively**: Self inductance of a coil may be defined as the magnitude of emf induced in the coil when current changes at the rate of 1 A/s in the coil. **Expression for self inductance of a long solenoid:** The magnetic field due to current flowing in the solenoid, B = $\mu_0 nI$ Total flux linked with the given solenoid $N\phi_B = (nl)(\mu_0 nI)\,\text{A}$ $N\phi_B = \mu_0 n^2\,\text{A}\,lI$ Self inductance	½ ½ ½ ½ ½ ½ ½ ½ 1 ½ ½	

	$L=\frac{N\phi_B}{I}$ $L=\mu_0 n^2 A l$	½ ½	3
24.	Obtaining expression for lateral shift 2½ Condition for shift to be minimum ½ Ray diagram  $\sin(i-r)=\frac{CD}{BC}$ --------(1) $\cos r=\frac{BE}{BC}=\frac{d}{BC}$ Putting in equation (1) $CD=\frac{d\sin(i-r)}{\cos r}$ Shift will be minimum for minimum angle of incidence.	1 ½ ½ ½ ½	3
25.	Describing briefly Geiger- Marsden scattering experiment 1 Graph showing the variation of number of scattered particles 1 Lead from the graph to discovery of nucleus 1  	1	

	 A small fraction of number of incident α -particles rebound back. It indicates that the number of α -particles undergoing head on collision is very small. From this we conclude that the positive charge is concentrated in a very small volume called nucleus.	1 1	 3
26.	Finding Q value of given reaction 2½ Writing nature of reaction ½ Mass defect Δm = mass of the reactants – mass of the products $\Delta m = 2\times12 - 19.992439 - 4.002603$ $\Delta m = 0.004958u$ $Q = \Delta m \times 931$ $= 0.004958 \times 931$ $= 4.62\,\text{MeV}$ The reaction is exothermic.	½ ½ ½ ½ ½ ½	 3
27.	Finding- (i) The torque acting on the loop 1 (ii) The magnitude and direction of net force 2 (i) $\tau = mB\sin\theta$ As $\vec{m}$ and $\vec{B}$ are in same direction, $\theta = 0^0$ $\tau = 0$ (ii) $F = \dfrac{\mu_0 I_1 I_2 l}{2\pi r}$ $F_{net} = \dfrac{\mu_0 I_1 I_2 l}{2\pi}\left(\dfrac{1}{r_1} - \dfrac{1}{r_2}\right)$	½ ½ ½	

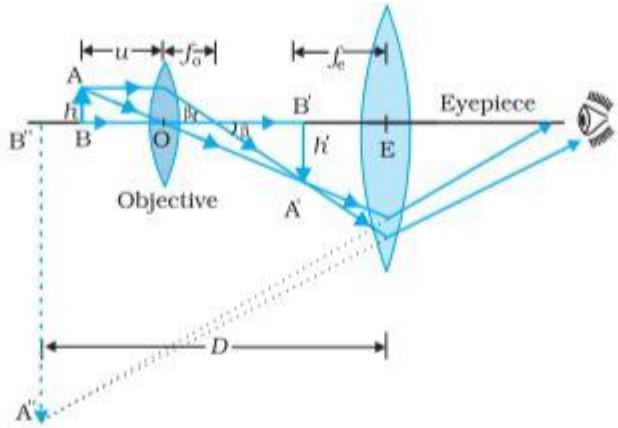
	$=\dfrac{4\pi\times10^{-7}\times2\times1\times5\times10^{-2}}{2\pi\times10^{-2}}\left(1-\dfrac{1}{2}\right)$ $F_{net}=1\times10^{-6}$ N Net force on the loop is towards the long straight wire.	½ ½ ½	3
28.	Naming the electromagnetic waves 1½ Writing wavelength range 1½ The electromagnetic waves used are (i) Microwaves (ii) Ultraviolet / Infrared (iii) X-Rays Wavelength range of electromagnetic waves used (i) 0.1 m to 1 mm (ii) 400 nm to 1 nm / 1mm to 700 nm (iii) 1 nm to 10^{-3} nm	½ ½ ½ ½ ½ ½	3
	SECTION- D		
29.	(i) (B) Antimony (ii) (C) 0.05 eV (iii) (B) A layer of positive charge on n side and a layer of negative charge on p side appear (iv) (a) (B) The applied voltage mostly drops across the depletion region OR (b) (C) 100 Hz	1 1 1 1	4
30.	(i) (A) $\left(\dfrac{C}{4}\right)$ (ii) (B) $\dfrac{\sigma}{\sigma-\sigma_p}$ (iii) (C) $\dfrac{1}{2}\varepsilon_0E^2V$ (iv) (a) (D) 6 OR (b) (B) $\dfrac{2K}{K+1}$	1 1 1 1	4

SECTION - E

31. (a)

(i) Drawing ray diagram of compound microscope	1½
Obtaining an expression for total magnification	1½
(ii) Calculating distance between the objective and the eye-piece	2

(i)



1½

Note: Deduct ½ mark for not showing arrows with the rays.

Magnification produced by objective

$m_0 = \frac{h'}{h} = \frac{L}{f_o}$ ½

Magnification produced by eye-piece

$m_e = 1 + \frac{D}{f_e}$

If the final image is formed at infinity

$m_e = \frac{D}{f_e}$ ½

Total magnification

$m = m_0 \times m_e$

$= \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$ ½

(ii) $\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_0}$ ½

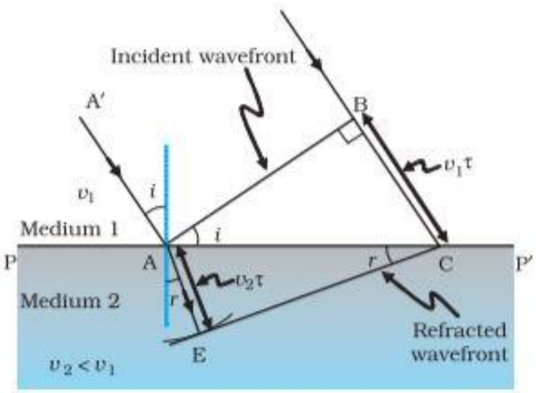
$\frac{1}{v_o} - \frac{1}{(-1.5)} = \frac{1}{1.25}$

$v_o = 7.5\,\text{cm}$ ½

$L = |v_o| + |f_e|$ as final image is formed at infinity ($v_e = \infty, u_e = f_e$) ½

L = 7.5 + 5

L= 12.5 cm ½

	OR		
	(b)		
	(i) Explaining the refraction of a plane wavefront 1 Verification of Snell's law 2 (ii) Deducing that a convex mirror always produces a virtual image of an object 2		
	(i)		
		1	
	$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$	½	
	$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$	½	
	$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$		
	$\frac{\sin i}{\sin r} = \frac{c/n_1}{c/n_2}$	½	
	$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ or $n_1 \sin i = n_2 \sin r$	½	
	(ii) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$	½	
	$u < 0$, $f > 0$		
	$\frac{1}{v} + \frac{1}{(-u)} = \frac{1}{f}$	½	
	$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$	½	
	$\frac{1}{v}$ is positive		
	$\therefore$ v is positive $\Rightarrow$ virtual image	½	5

32.

(i) Finding the amount of work done	2
(ii) Finding	
(I) The electric field at their common centre	1
(II) The potential at their common centre	2

(a)

(i) $V = -\int \vec{E} \cdot \vec{dr}$

$= -\int 40\,x\,dx$

$= -20\,x^2$ ½

Potential at A (0, 3m), $V_A = 0$

Potential at B (5m, 0), V_B = -500 V ½

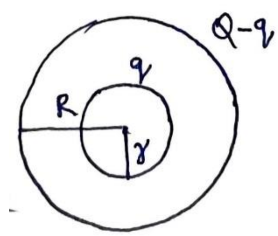
Work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0)

$W = q(V_B - V_A)$ ½

$= 1(-500 - 0)$

$W = -500\,J$ ½

(ii) (I) Electric field at the common centre will be zero as the charge enclosed by the inner sphere is zero. 1



Alternatively: $q_{en} = 0$ ½

$\phi_E = 0$

$\oint \vec{E}.\vec{ds} = 0$

$E = 0$ ½

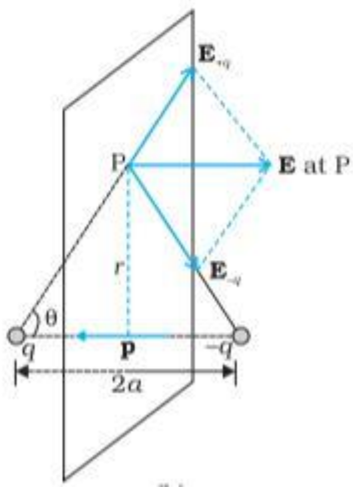
(II) ∵ Surface charge densities are equal

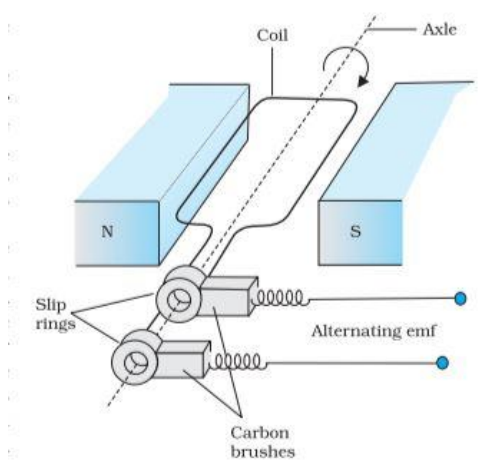
$\frac{q}{4\pi r^2} = \frac{Q-q}{4\pi R^2}$ ½

$q = \frac{Qr^2}{R^2 + r^2}$ ½

Potential at common centre

$V = \frac{kq}{r} + \frac{k(Q-q)}{R}$ ½

	$V=\frac{k}{r}\frac{Qr^2}{(R^2+r^2)}+\frac{k}{R}\left[Q-\frac{Qr^2}{(R^2+r^2)}\right]$		
	$V=\frac{kQ(R+r)}{R^2+r^2}$	½	
	OR		
	(b)		
	(i) Obtaining expression for electric field due to a dipole on its equatorial plane — 2 Finding electric field: (I) At centre of the dipole — ½ (II) At a point r >> a — ½ (ii) Calculating net electric flux through cube — 2		
	(i)		
		½	
	The magnitudes of the electric field due to two charges +q and -q are		
	$E_{+q}=\frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$		
	$E_{-q}=\frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$	½	
	The total electric field		
	$\vec{E}=-\left(E_{+q}+E_{-q}\right)\cos\theta\,\hat{p}$		
	$\vec{E}=-\frac{\vec{p}}{4\pi\varepsilon_0\left(r^2+a^2\right)^{3/2}}$	½	
	Direction of electric field is opposite to dipole moment ($\vec{p}$)	½	
	(I) At centre of dipole, r = 0		
	$\vec{E}=-\frac{-\vec{p}}{4\pi\varepsilon_0 a^3}$	½	

	(II) At a point r>>a $\vec{E} = -\frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$ (ii) $\vec{E} = (10x+5)\hat{i}$ N/C $\phi_L = \int \vec{E}.\vec{ds}$ $= -E_L(L^2)$ $= -5L^2$ $\phi_R = E_R(L^2)$ $= (10L+5)L^2$ $\phi_{net} = \phi_L + \phi_R$ $= -5L^2 + (10L+5)L^2$ $= 10L^3$ Nm^2/C	½ ½ ½ ½ ½	5
33.	**(a)** (i) Writing principle of ac generator — 1 Labelled diagram of ac generator — 1 Working of ac generator — 1 (ii) Finding rms voltages across three circuit elements — 1½ Explanation of the algebraic sum of rms voltages across three circuit elements is more than the rms voltage source — ½ **(i) Principle:** It works on the principle of electromagnetic induction.  **Working:** The coil is mechanically rotated in the uniform magnetic field. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil. (i) $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$	1 1 1	

$$= \sqrt{(400)^2 + \left(100\pi \times \frac{5}{\pi} - \frac{1}{100\pi \times \frac{50}{\pi} \times 10^{-6}}\right)^2}$$

$$= 500\,\Omega$$

$$I_{rms} = \frac{V_{rms}}{Z}$$

$$I_{rms} = \frac{140}{\sqrt{2} \times 500} = \frac{0.28}{\sqrt{2}}\ \text{A}$$

$$(V_{rms})_R = I_{rms}\ R$$

$$= \frac{0.28}{\sqrt{2}} \times 400$$

$$= \frac{112}{\sqrt{2}} = 56\sqrt{2}\ \text{V}$$ ½

$$(V_{rms})_L = I_{rms}\ \omega \text{L}$$

$$= \frac{0.28}{\sqrt{2}} \times 500$$

$$= \frac{140}{\sqrt{2}} = 70\sqrt{2}\ \text{V}$$ ½

$$(V_{rms})_C = I_{rms}\ \frac{1}{\omega C}$$

$$= \frac{0.28}{\sqrt{2}} \times 200$$

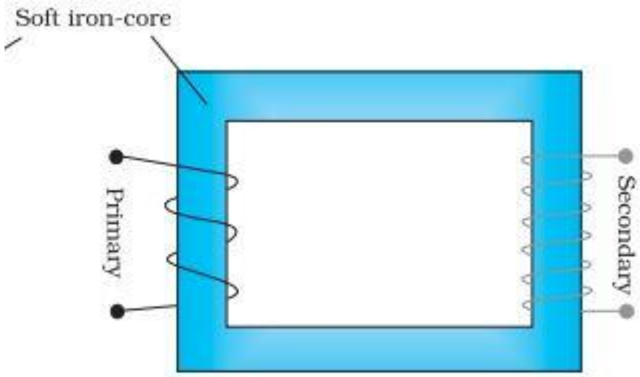
$$= \frac{56}{\sqrt{2}} = 28\sqrt{2}\ \text{V}$$ ½

The algebraic sum of voltages is more than the rms voltage of source because voltages across R, L and C are not in phase. ½

OR

(b)

(i)	Writing principle of transformer	1
	Labelled diagram of step-up transformer	1
	Working of step-up transformer	1
(ii)	Finding-	
	• rms value of input current	1
	• expression for instantaneous output voltage	½
	• expression for instantaneous output current	½

	(i) **Principle**: It works on the principle of mutual induction.  **Working:** When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. Since the no. of turns are more in secondary windings an emf induced is proportional to the no. of turns. Therefore more emf is developed across the secondary windings. (ii) $P_i = V_p I_p$ $200 = \frac{20}{\sqrt{2}} I_p$ $I_p = 10\sqrt{2}\text{A}$ $\frac{V_o}{V_i} = \frac{250}{50}$ $5 = \frac{V_o}{V_i}$ $V_o = 100\sin(100\pi)\text{t V}$ $\text{P}_o = (V_o)_{rms}(I_o)_{rms}$ $200 = \frac{100}{\sqrt{2}}(I_o)_{rms}$ $(I_o)_{rms} = 2\sqrt{2}\text{A}$ $\therefore I_o = (2\sqrt{2})\sqrt{2}\sin(100\pi)\text{t}$ $I_o = 4\sin(100\pi)\text{t A}$	1 1 1 ½ ½ ½ ½	5