SOLUTIONS: PHYSICS(042)			
Code: 55/5/3			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1	(A) 540 nm	**1**	**1**
2	(D) $\frac{X}{4}$	**1**	**1**
3	(B) $\frac{\sqrt{2}Q^2}{\pi\varepsilon_0 l}$	**1**	**1**
4	(B) becomes greater than C	**1**	**1**
5	(D) $\frac{4R}{3}$	**1**	**1**
6	(B) 5 cm	**1**	**1**
7	(C) 0.196 Am^2	**1**	**1**
8	(A) Infrared Rays	**1**	**1**
9	(B) $\left[M^0L^2T^{-2}\right]$	**1**	**1**
10	(A) X- rays	**1**	**1**
11	(C) $\frac{1}{4}$	**1**	**1**
12	(B) 0 and $4a^2$	**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	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is the not the correct explanation of the Assertion (A)	**1**	**1**
16	(D) Both Assertion (A) and reason (R) are false	**1**	**1**
	SECTION - B		
17	Finding effective resistance 2 $R_{BCD} = 2+4 = 6\Omega$ $R_{BD} = \frac{3\times 6}{6+3}$ $= 2\Omega$ $R_{BDE} = 2+8$ $= 10\Omega$	 ½ ½	

	$R_{BE} = \frac{40\times10}{40+10}$ $= 8\Omega$ $R_{AF} = 7+8+5$ $= 20\Omega$	½ ½	2
18	Finding magnetic field 2 Using Biot – Savart's law $\vec{B} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\vec{r}}{r^3}$ $= \frac{(10^{-7})[5(10^{-2})\hat{i}\times(3\hat{i}+4\hat{j})]}{5^3}$ $= 1.6\times10^{-10}\,\hat{k}\,T$	½ 1 ½	2
19	Defining distance of closest approach 1 Calculating distance of closest approach 1 It is the distance from nucleus at which α particles stops momentarily and then begins to retrace its path. **Alternatively** It is the distance from nucleus at which entire intial kinetic energy of the α particle gets converted into electrostatic potential energy. $r_0 = \frac{1}{4\pi\varepsilon_0}\frac{ze^2}{K.E}$ $= \frac{9\times10^9\times79\times(1.6\times10^{-19})^2}{3.95\times10^6\times1.6\times10^{-19}}$ $= 28.8\times10^{-15}\,m$	1 ½ ½	2
20	(a) Finding nature and position of the image 1 + 1 For refraction at convex surface $\frac{n_1}{-u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$ $\frac{n}{v} = \frac{[n-1-3]}{R}$ $v = \frac{nR}{n-4}$ For all values of n < 4, the value of v is negative and greater than R Therefore the nature of image is virtual and is formed in front of convex surface.	½ ½ 1	

	OR (b) Calculating intensity for the path difference $\lambda / 3$ 2 $\phi = \frac{2\pi}{\lambda} \times \Delta x$ $= \frac{2\pi}{\lambda} \times \frac{\lambda}{3}$ $= \frac{2\pi}{3}$ $I' = 4I \text{ Cos}^2 \phi/2 \qquad Given\, 4I = I_0$ $= I_0 \text{ Cos}^2 2\pi/6$ $= \frac{I_0}{4}$ Note: If a student attempt by using $I = I_1 + I_2 + 2\sqrt{I_1 I_2} Cos\phi$ **,**award full credit for correct answer.	 ½ ½ ½ ½ ½	 **2**
21	Finding the cut-off potential 2 $eV = h(\upsilon - \upsilon_0)$ $V = \frac{6.63 \times 10^{-34} \times (6.8 - 3.6) \times 10^{14}}{1.6 \times 10^{-19}}$ $= 1.33V$	 ½ **1** ½	 **2**
	SECTION - C		
22	(a) Explanation 1 (b) Calculation of ratio of total energy to initial energy 2 (a) When a conductor holds a large amount of charge its potential is also high. If electric field becomes high enough, the atoms or molecules of surrounding medium gets ionized. A breakdown occurs in medium and charge on conductor get neutralized or leaks away. (b) The common potential after the connection of two capacitors $Given\, V_1 = V, V_2 = 0$ $C_1 = C_2 = C$ $= \frac{CV}{2C}$ $= \frac{V}{2}$ $U_i = \frac{1}{2} CV^2$	 1 ½ ½	

	$U_f = \frac{1}{2}C'V'^2$ $= \frac{1}{2}\times 2C\times\left(\frac{V}{2}\right)^2$ $= \frac{1}{4}CV^2$ $\frac{U_f}{U_i} = \frac{1}{2}$	½ ½	3
23	(a) Explanation 1 (b) Finding distance from central maxima where Intensity is zero 2 (a) Wavelength of light is very small as compared to size of obstacles so diffraction of light is not seen easily. But sound waves have large wavelength, so they get diffracted easily by obstacles. (b) Position of first minima $x = \frac{\lambda D}{a}$ $= \frac{750\times10^{-9}\times1}{1.5\times10^{-3}}$ $= 0.5\ mm$	1 ½ 1 ½	3
24	(a) Calculating (i) Potential energy 1 (ii) Work done in turning the magnet by 180° 1 ½ (b) Identification of minimum potential energy alignment ½ (a) (i) $U = -MB\cos\theta$ $= -5\times0.4\times1$ $= -2\ J$ (ii) $W = MB(Cos\,\theta_2 - Cos\,\theta_1)$ $= -5\times0.4(-1-1)$ $= 4\ J$ (b) Potential energy is minimum in case (i)	½ ½ ½ ½ ½ ½	3
25	(a) Tracing path of the ray 2 ½ (b) Finding angle of deviation on ½ (a) $\sin i_c = \frac{1}{\sqrt{2}}$	½	

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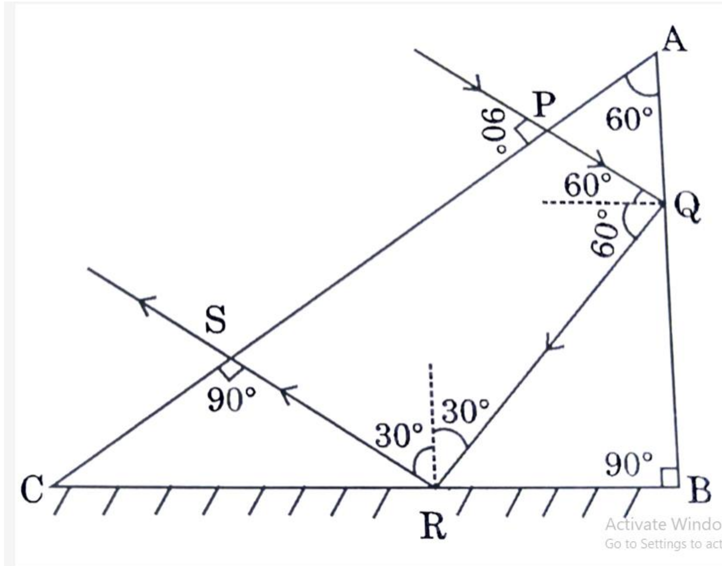
$i_c = 45^0$



(Deduct ½ mark for not showing arrow for the ray)

(b) The angle of deviation is 180^o from diagram

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½

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26

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(a)

Finding charge densities on A and B	3

For ball A

$q_1 = 2\sigma \times 4\pi R^2$

$= 8\pi R^2 \sigma$

For ball B

$q_2 = 3\sigma \times 4\pi (2R)^2$

$= 48\pi R^2 \sigma$

Total charge (Q) $= q_1 + q_2$

$= 56\pi R^2 \sigma$

When balls A and B are connected by a wire, their potentials will be equal
Let q be the charge on ball A and (Q – q) be the charge on the ball B after connecting wire.

$$\frac{Kq}{R} = \frac{K(Q - q)}{2R}$$

$2q = Q - q$

$$q = \frac{Q}{3}$$

$$= \frac{56\pi R^2 \sigma}{3}$$

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½

½

½

½

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$$Q - \frac{Q}{3} = \frac{112\pi R^2\sigma}{3}$$

$$\sigma_A = \frac{\frac{56\pi R^2\sigma}{3}}{4\pi R^2}$$ ½

$$= \frac{14}{3}\sigma$$

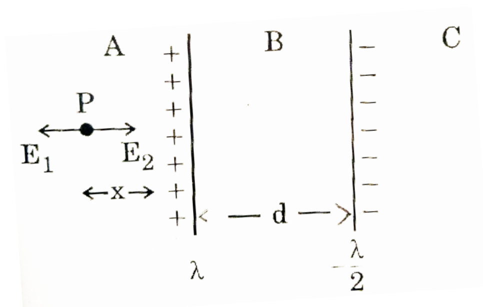
$$\sigma_B = \frac{\frac{112\pi R^2\sigma}{3}}{4\pi(2R)^2}$$ ½

$$= \frac{7}{3}\sigma$$

OR

(b)

Location of point at which net electric field is zero	2½
Identification of Region	½



½

Electric field due to wire 1 and wire 2 at point P

$$E_1 = \frac{\lambda}{2\pi\varepsilon_0 x}$$ ½

$$E_2 = \frac{\lambda/2}{2\pi\varepsilon_0(x+d)}$$ ½

At P, Net electric field is zero ½

$$E_1 = E_2$$

$$\frac{\lambda}{2\pi\varepsilon_0 x} = \frac{\lambda}{2\times 2\pi\varepsilon_0(x+d)}$$

$$x = -2d$$ ½

Negative sign indicates that point lies in the region C. ½

At a distance 2d from wire 1 electric field is zero.

3

(**Note** : Award full credit if a student finds the position by taking point in region C directly)

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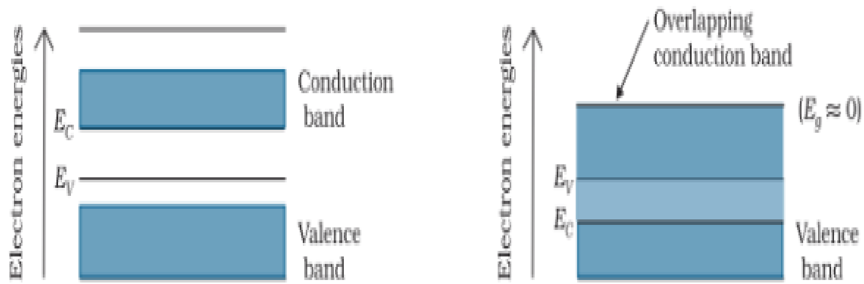
a) Drawing energy band diagrams	½ + ½ + ½
Formation of electron hole pair	½
b) Explanation	1

a)



CONDUCTORS</td><td>½</td><td></td></tr>
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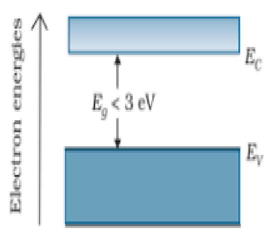
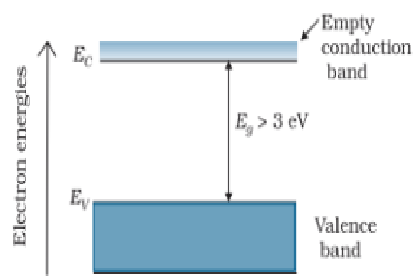


SEMICONDUCTORS



INSULATORS</td><td>½ + ½</td><td></td></tr>
<tr><td></td><td>At room temperature, thermal energy is sufficient for electrons to make them free from the bonds and create a vacancy called hole. Hence electron hole pair is formed.</td><td>½</td><td></td></tr>
<tr><td></td><td>(b) The valence electron in carbon and silicon lie in the second and third orbit respectively. So, the energy required to take out an electron will be less for silicon as compared to carbon. Hence number of free electrons for conduction in silicon are significant but negligibly small for carbon.</td><td>1</td><td>3</td></tr>
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Difference between half wave and full wave rectification	1
Working of full wave rectifier	2

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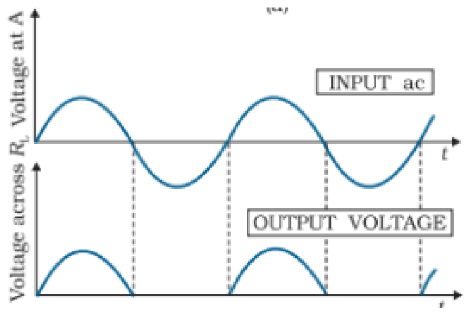
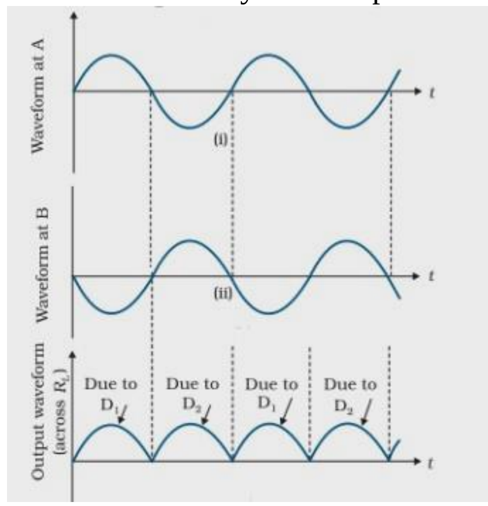
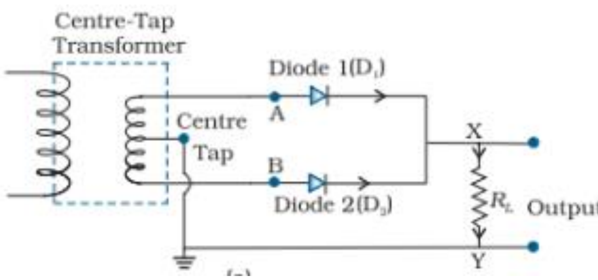
<tr><td></td><td>In half wave rectification there is output in one half of input cycle, whereas in full wave rectification, output is obtained for both half cycles of input (positive and negative)

Alternatively





Half wave Rectification Full wave Rectification

Working of full wave rectifier:


Suppose the input voltage to A with respect to the centre-tap at any instant is positive. At that instant, voltage at B being out of phase will be negative. So, diode D_1 gets forward biased and conducts (while D_2 being reverse biased is not conducting). Hence, during this positive half cycle we get an output current (and output voltage across the load resistor R_L). In the course of ac cycle when the voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. In this part of the cycle diode D_1 would not conduct but diode D_2 would, giving an output current and output voltage (across R_L) during the negative half cycle of the input ac.</td><td>1

1

1</td><td>3</td></tr>
<tr><td colspan="4">SECTION D</td></tr>
<tr><td>29</td><td>(i) (a) (A) (R_2 - $2R_1$)
(b) (B) 1.8 x 10^{-4} Nm
(ii) Award 1 mark for this question to all students .
(iii) (A) 0.25 Ω
(iv) (B) $\frac{NBA}{K}$</td><td>1

1
1
1</td><td>4</td></tr>
<tr><td>30</td><td>(i) (C) cut– off potential versus frequency of incident light
(ii) (a) (C) K_B > K_Y > K_R
(b) (A) Caesium
(iii) (D) Remains the same</td><td>1
1

1</td><td></td></tr>
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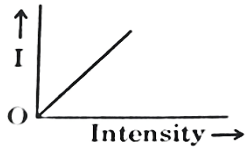
(iv) (C) **1** **4**

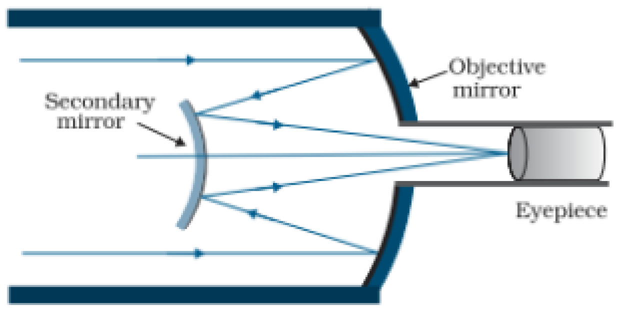


SECTION E

31

(a) Drawing ray diagram of reflecting telescope	1
Explanation of formation of image	1
Advantages	½ + ½
(b) Finding focal lengths of the two lenses	2

(i)



1

The parallel rays from a distant object are reflected by a large concave mirror. These rays are then reflected by a convex mirror placed just before the focus of concave mirror and are converged to a point outside the hole. The final image is viewed through eye piece. **1**

Advantages (any two)

1) No chromatic aberration.
2) Less spherical aberration
3) Less mechanical support required **½ + ½**
4) Brighter Image
5) High resolving power.
6) High magnifying power

(i) For image at infinity

$|f_0| + |f_e| = L$ **½**

According to question

$f_0 = 50 \times f_e$ **½**

$f_e + 50fe = 102$

$f_e = 2$ cm **½**

$f_0 = 100$ cm **½**

OR

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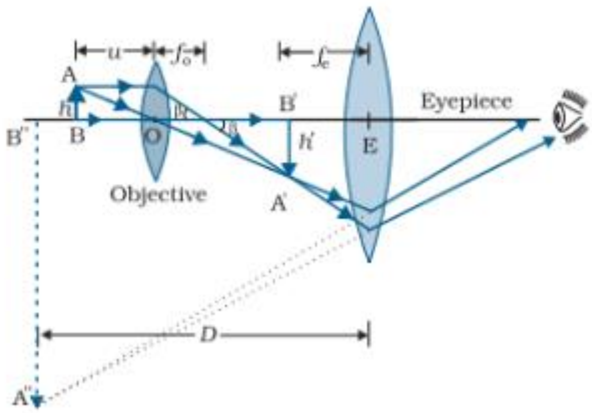
(b)

(i)	Two advantages of a compound microscope over simple microscope	½ + ½
	Drawing ray diagram and Explanation	1 + 1
(ii)	Obtaining power of combined lens	2

(i) Advantages (any two)
1) Larger magnification
2) Brighter image
Any other valid advantage



(deduct ½ mark for not showing arrow for ray diagram)

The lens nearest the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the eye piece, functions like a simple microscope and produces final image which is enlarged and virtual.

(ii) Power of plano concave lens $= P_1 = \dfrac{-(n_1-1)}{R}$

Power of convex lens $= P_2 = (n_2-1)\left(\dfrac{2}{R}\right)$

$P = P_1 + P_2$

$= \dfrac{(2n_2 - n_1 - 1)}{R}$
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<td>
½ + ½

1

1

½
½
½
½
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(a)

(i)	Finding current through batteries E_1, E_2 and E_3	3
(ii)	Finding effective resistance	2
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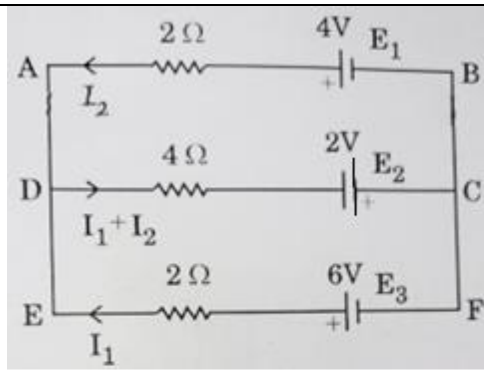
i)



½

In closed loop ABCD, using Kirchhoff's loop law

$4I_1 + 6I_2 = 6$ …………………………..(1) ½

Similarly In closed loop CDFE

$6I_1 + 4I_2 = 8$ …………………………..(2) ½

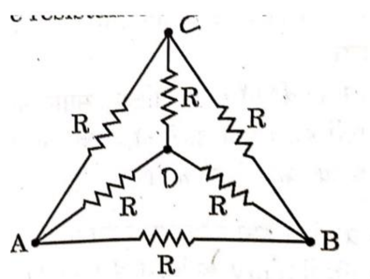
Solving eqn. (1) and (2)

$I_2 = \frac{1}{5}A$ ½

$I_1 = \frac{6}{5}A$ ½

$I_1 + I_2 = \frac{7}{5}A$ ½

ii)



Resistances R_{AC}, R_{CB} , R_{AD} , and R_{DB} form a balanced Wheatstone bridge

Hence current through R_{CD} is zero and will not contribute to equivalent resistance. ½

The equivalent resistance of bridge is R, is in parallel with R_{AB}

Series combinations of R_{AC} & R_{CB} and R_{AD} & R_{DB} is in parallel with R_{AB} ½

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R}$$

½

$$R_{eq} = \frac{R}{2}$$

Given R = 10Ω, Therefore R_{eq} = 5Ω ½

OR

(b)

(i)	Calculating	
	(I) ratio of electric fields at points A & B	1 ½
	(II) drift velocity of free electrons at point B	1 ½
(ii)	Finding net electric field at point $\vec{r}$	2

(i) (I) $\vec{j} = \sigma\vec{E}$ ½

$$\frac{j_A}{j_B} = \frac{E_A}{E_B}$$

$$= \frac{I/A_A}{I/A_B}$$ ½

$$= \frac{A_B}{A_A}$$ ½

$$= \frac{2}{1}$$ ½

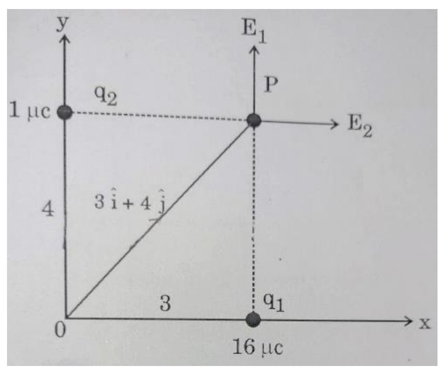
(II) $v_d = \frac{I}{neA}$ ½

$$= \frac{1}{8.5\times10^{28}\times1.6\times10^{-19}\times2\times10^{-7}}$$ ½

$$= 3.6\times10^{-4}\ m/s$$

(ii)

$$\vec{E} = \frac{Kq}{r^2}\hat{r}$$ ½



$$\vec{E}_1 = \frac{9\times10^9\times16\times10^{-6}}{(4)^2}\hat{j}$$ ½

$$= 9\times10^3\ \hat{j}$$

$$\vec{E}_2 = \frac{9\times10^9\times1\times10^{-6}}{(3)^2}\hat{i}$$ ½

$$= 10^3\ \hat{i}$$

$$\vec{E}_{net} = (\hat{i} + 9\hat{j})\,10^3\ N/C$$ ½

NOTE: Award full credit of this part if a student finds magnitude and direction separately.

Total: 5

33

(a)

i)	Defining self – inductance	1
	Deriving expression for energy	1
ii)	Drawing graphs showing the variation of	
	(I) Magnitude of emf induced with rate of change of current	1½
	(II) Energy stored with current	1½

Self Inductance is magnetic flux linked with a coil when the current through the coil is unity. **1**

Alternatively

Self Inductance is the induced emf induced in the coil when rate of change of current through the coil is unity.

To maintain growth of current, power has to be supplied from external source.

$$P = |e||I|$$ ½

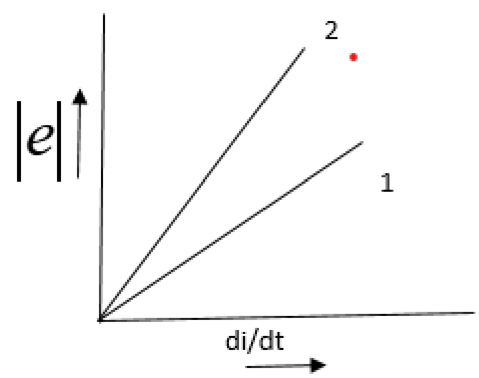
$$= \frac{dW}{dt} = LI\frac{dI}{dt}$$

$$dW = LIdI$$

$$W = \int LIdI$$

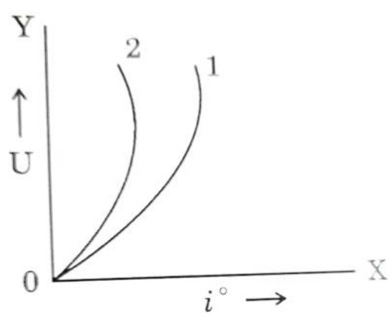
$$= \frac{1}{2}LI^2$$ ½

(I) $E = -L\frac{dI}{dt}$ ½



1

(II) $U = \frac{1}{2}LI^2$ Parabolic graph obtained. ½



1

(1 indicates 10mH) & (2 indicates 20mH)

OR

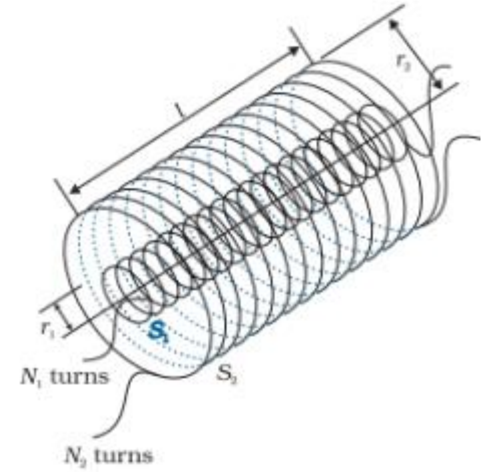
(a)

(i)	Defining mutual inductance	1
	Deducing expression for mutual inductance	2
(ii)	Finding flux linked with the inductor	2

(ii) Mutual inductance is defined as the induced emf in primary coil when the current in secondary coil changes at the unit rate. 1

Alternatively

Mutual inductance is defined as the magnetic flux linked with the primary coil when the current in secondary coil is unity.

		½	
	Consider two long co-axial solenoids each of length l. Radius of inner solenoid S_1 is r_1 and number of turns per unit length is n_1. The corresponding quantities for outer solenoid S_2 are r_2 and n_2 respectively. Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively. When a current I_2 is set up through S_2, it sets up magnetic flux through S_1.		
	$N_1\phi_1 = M_{12}I_2$	½	
	$= (n_1 l)\times(\pi r_1^2)\times(\mu_0 n_2 I_2)$		
	$= \mu_0 n_1 n_2 \pi r_1^2 l\, I_2$	½	
	$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l = M_{21}$	½	
	(ii)		
	$\lvert e\rvert = L\dfrac{dI}{dt}$	½	
	$L = \dfrac{e}{dI/dt}$		
	$= \dfrac{5\times10^{-3}}{2/40}$		
	$= 0.1\text{H}$	½	
	$\phi = LI$	½	
	$= 0.1\times\dfrac{2}{40}\times10$		
	$= 0.05\ Wb$	½	**5**