PHYSICS (042)
Code: 55/ 1 /3

Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior Secondary School Examination, 2026 (XIIth)
SUBJECT NAME : PHYSICS (Q.P. CODE : 042/55-1-3)

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General Instructions: -

1	The CBSE has decided to introduce On Screen Marking (OSM) for the evaluation of Class XII answer Book with the 2026 Examination.
2	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
3	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, evaluation done and several other aspects. Its leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in Newspaper/Website, etc. may invite action under various rules of the Board and IPC."**
4	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In Class-XII, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
5	The Marking scheme carries only suggested value points for the answers. These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
6	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after deliberation and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
7	Evaluators will mark (√) wherever answer is correct. For wrong answer CROSS 'X' be marked. Evaluators will not put right (✓) while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
8	If a question has parts, please award marks on the right-hand side for each part in the OSM Portal. Marks awarded for different parts of the question will be totaled up by the OSM System.
9	If a question does not have any parts, marks must be awarded in the left-hand margin in the OSM Portal. This may also be followed strictly.

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10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 0 to 70 (example 0 to 80/70/60/50/40/30 marks as given in Question Paper) has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past :- • Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) • Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0) Marks.
15	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
16	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.
17	**If a candidate attempts both alternatives/options in a question where only one option/ alternative is required to be attempted, the Evaluator shall award marks in both the options. The system will take the higher of two scores and disregard the other response.**
18	**In a question having two options/alternatives, if a candidate has attempted only one, then the evaluator shall mark "NA" (Not attempted) against the option that has not been attempted by the candidate.**

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Important Note

In questions provided with choice, main part of the question has been indicated with "OR" against the question number in OSM whereas in it's optional part "OR" is not indicated.

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MARKING SCHEME: PHYSICS (042)
Session: 2025–26
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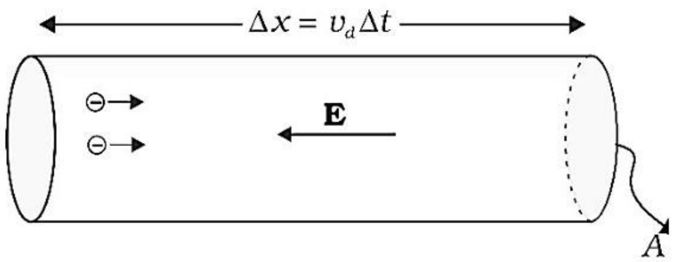
Q. No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks
	SECTION – A	HOME	
1.	(C) (i), (iii) and (iv) only		1
2.	(C) wavelength is halved and frequency remains unchanged.		1
3.	(C) Diffusion and drift currents are equal and opposite.		1
4.	(B) $\frac{r_2}{r_1}$		1
5.	(C) 135^0		1
6.	(A) $0.15\frac{V}{m}$		1
7.	(D) u>2R		1
8.	(D) - 2		1
9.	(B) Ultraviolet rays		1
10.	(A) $2\pi I$, along + X- axis		1
11.	(D) all these waves		1
12.	(D) 0.60		1
13.	(C) Assertion (A) is true, but reason (R) is false.		1
14.	(D) Both Assertion (A) and (R) Reason are false.		1
15.	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).		1
16.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).	HOME	1
	SECTION – B		
17.	• Writing the order of Magnitude of drift velocity ½ • Deducing the relation between current flowing through a conductor and drift velocity. $1\frac{1}{2}$		
	• Magnitude of drift velocity in conductor is of the order of a few mm/s	½	
			
	• For n number of free electrons per unit volume in a conductor of cross sectional area A, the total charge transported across the area in time Δt is $Q = -\ ne\ Av_d\Delta t$	½	

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	As electron moves in a direction opposite to that of electric field $I\,\Delta t = neA\,v_d\,\Delta t$ $I = neAv_d$	½ ½	HOME 2
18.	• Finding the ratio of maximum value of torque 2 Side of square $a = \frac{L}{4N}$ and radius of circular coil $r = \frac{L}{2\pi N}$ $\tau = NIBA$ $\frac{\tau_1}{\tau_2} = \frac{NIBA_1}{NIBA_2}$ $\frac{\tau_1}{\tau_2} = \frac{A_1}{A_2}$ $\frac{\tau_1}{\tau_2} = \frac{(L/4N)^2}{\pi\left(\frac{L}{2\pi N}\right)^2}$ $\frac{\tau_1}{\tau_2} = \frac{\pi}{4}$	½ ½ ½ ½	 2
19.	Finding least distance 2 (a) At the point of coincidence for dark fringes. $d\sin\theta = n\lambda_2 = (n+1)\lambda_1$ $n \times 600 = (n+1) \times 400$ $n = 2$ Position of dark fringe from the central maxima $y = \frac{(n+1)\lambda_1 D}{d}$ $y = \frac{3 \times 400 \times 10^{-9} \times 1.5}{1 \times 10^{-3}}$ $y = 1.8\text{mm}$ **Alternatively:** $y = \frac{n\lambda_2 D}{d}$ $y = \frac{2 \times 600 \times 10^{-9} \times 1.5}{1 \times 10^{-3}}$ $y = 1.8\,\text{mm}$ **OR** • Finding the least distance 2	½ ½ ½ ½	HOME
(b)	At the point of coincidence for bright fringes $\frac{n\lambda_2 D}{d} = \frac{(n+1)\lambda_1 D}{d}$	½	

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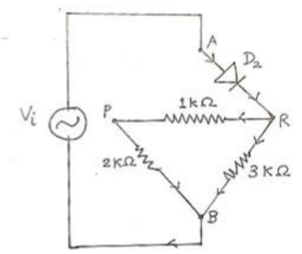
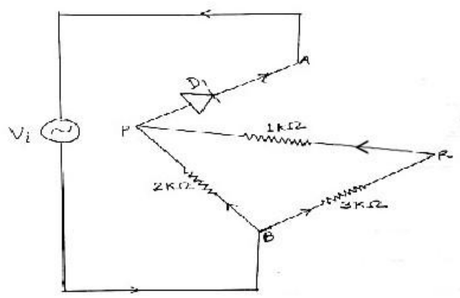
	$n \times 660 = (n+1) \times 440$ $n = 2$ Position of bright fringe from the central maxima $y = \frac{n\lambda_2 D}{d}$ $y = \frac{2 \times 660 \times 10^{-9} \times 1.5}{0.6 \times 10^{-3}}$ $y = 3.3\,mm$ **Alternatively:** $y = \frac{(n+1)\lambda_1 D}{d}$ $y = 3.3\ mm$	½ ½ ½	HOME 2
20.	Calculating the accelerating voltage 2 de-Broglie wavelength $\lambda = \frac{h}{\sqrt{2meV}}$ $V = \frac{h^2}{2me \times \lambda^2}$ $V = \frac{(6.6 \times 10^{-34})^2}{2 \times 9 \times 10^{-31} \times 1.6 \times 10^{-19} (0.011 \times 10^{-9})^2}$ $V = 12500\,Volts$	½ 1 ½	HOME 2
21.	Calculating the energy released 2 E_{bn} for (A=240) Nucleus = 7.6 MeV E_{bn} for two fragments (A=120) = 8.5 MeV Gain in $E_{bn} = 8.5 - 7.6$ $= 0.9\,MeV$ Total gain in binding energy $= 240 \times 0.9$ $= 216 MeV$ **Alternatively:** Binding energy for (A=240) nucleus is $= 240 \times 7.6$ MeV Binding energy for fragments is $= 2 \times 120 \times 8.5$ $= 240 \times 8.5$ MeV Energy released $= 240 \times 8.5 - 240 \times 7.6$ $= 240 \times (8.5 - 7.6)$ $= 240 \times 0.9$ $= 216$ MeV	½ ½ ½ ½	 2

	SECTION – C			HOME
22.	(a) Identifying the diode which conducts and justification. ½ (b) Redrawing the equivalent circuit. 1 (c) Calculating the output voltage drop across the three resistors. ½+½+½			
	(a) Diode D_2 is in forward bias and it conducts	½		
	(b) 	1		
	(c) Using ohm's law $V = IR$ Voltage drop across RP, PB and RB is $V_{RP} = 4V$, $V_{PB} = 8V$, $V_{RB} = 12V$	½+½+½		HOME
	Alternatively: If the student considers positive AC cycle reaching diode D_1 (a) Diode D_1 is in forward bias and it conducts.			
	(b) 			
	(c) Using Ohm's law $V = IR$ $V_{PB} = 12V, V_{PR} = 3V, V_{RB} = 9V$		3	
23.	Calculating the applied potential difference between the plates. 3			
	Since $a = \frac{qE}{m} = \frac{qV}{mL}$	½		
	$t = \frac{x}{u_x}$	½		

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$$y = \frac{1}{2}\left(\frac{qV}{mL}\right)\left(\frac{x}{u_x}\right)^2$$ ½

$$V = \frac{2ymLu_x^2}{ex^2}$$ ½

$$V = \frac{2\times1\times10^{-2}\times9.1\times10^{-31}\times2\times10^{-2}\left(3\times10^{7}\right)^2}{1.6\times10^{-19}\times(3\times10^{-2})^2}$$ ½

$$V = 2275\,\text{Volt}$$ ½

3

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24.

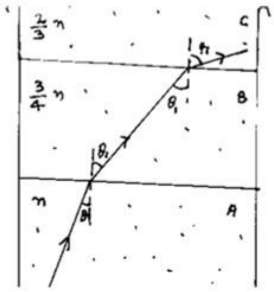
(a) Two Conditions for total internal reflection	½+½
(b) Proving that beam does not enter into region C at all for $\sin\theta \geq \frac{2}{3}$	2

(a) (i) Light must travel from denser medium to rarer medium. ½

(ii) Angle of incidence must be greater than Critical angle. ½

$i > i_c$

(b)



For refraction at AB interface

$$\frac{\sin\theta}{\sin\theta_1} = \frac{3n/4}{n}$$

$$\sin\theta = \frac{3}{4}\sin\theta_1 \qquad \text{------------------------ (1)}$$ ½

For refraction at BC interface

$$\frac{\sin\theta_1}{\sin r} = \frac{2n/3}{3n/4}$$

$$\sin\theta_1 = \frac{8}{9}\sin r \qquad \text{------------------------ (2)}$$ ½

From equations (1) and (2)

$$\frac{3}{2}\sin\theta = \sin r$$ ½

for $\sin\theta = \frac{2}{3}$

$\sin r = 1$ i.e $r = 90^0$

Ray grazes the surface

Hence for $\sin\theta \geq \frac{2}{3}$ does not enter the region C at all ½

3

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25.

(a) Deducing an expression for electric field at point due to the uniformly charged infinite plane thin sheet.	2
(b) Writing the net electric field due to two thin sheets.	
(i) Inside	½
(ii) Outside	½

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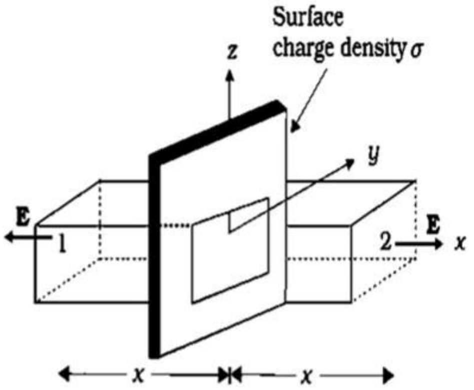
(a)



½

As seen from the figure, only the two faces 1 and 2 will contribute to the flux. Therefore, flux $\vec{E}.\Delta\vec{S}$ through both the surfaces are equal and add up. ½

Therefore, net flux through the Gaussian surface is 2 EA. The charge enclosed by the close surface is σ A.

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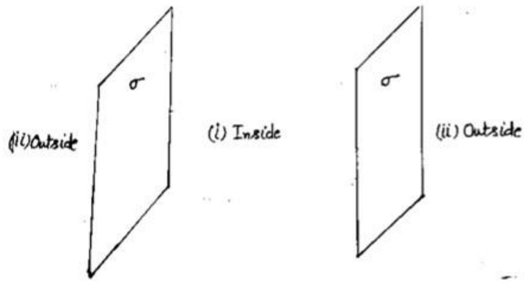
$$2EA = \frac{\sigma A}{\varepsilon_0}$$ ½

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$$ ½

(b)



(i) $E_{in} = 0$ ½

(ii) $E_{out} = \frac{\sigma}{\varepsilon_0}$ ½ 3

OR

(a) Obtaining the Condition for balanced Wheatstone bridge.	2
(b) Finding the net resistance of the given network.	1

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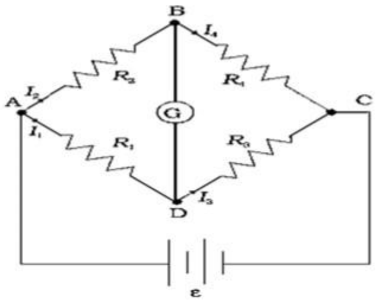
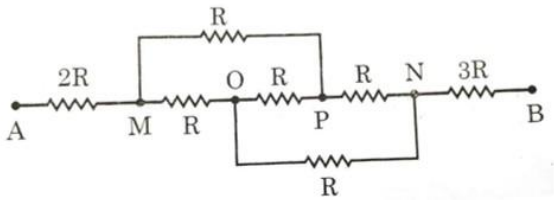
	(a)  By using Kirchhoff's rule to closed loops ADBA and CBDC. The first loop gives $-I_1R_1+0+I_2R_2=0$ ---------- (1) $\quad \because [V_B = V_D, \ I_g = 0]$ Second loop gives $I_4R_4+0-I_3R_3=0$ $\because I_g=0$, hence $I_1=I_3$ and $I_2=I_4$ $I_2R_4-I_1R_3=0$ ---------- (2) From equations (1) and (2) Hence $\frac{R_2}{R_1}=\frac{R_4}{R_3}$ (b)  Due to balanced Wheatstone bridge $R_{MN}=R$ Total resistance across AB $R_{AB}=R_{AM}+R_{MN}+R_{NB}$ $R_{AB}=2R+R+3R$ $R_{AB}=6R\ \Omega$	½ ½ ½ ½ ½ ½	3
26.	(a) Calculating the capacitance of the capacitor 1 (b) Calculating the electric field between the plates of the capacitor 1 (c) Calculating the energy stored in the capacitor 1 (a) For parallel plate capacitor $C_0=\frac{\varepsilon_0 A}{d}$ If the distance between the plate is doubled and dielectric slab of dielectric constant $K=1.8$ is introduced. The new capacitance $C=\frac{K\varepsilon_0 A}{2d}$	½	

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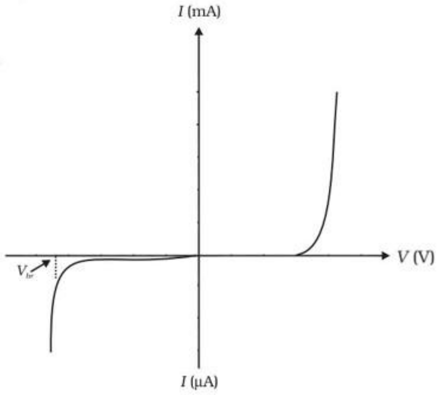
	$C = \frac{K}{2} C_o$ $C = \frac{1.8}{2} C_o$ $C = 0.9\ C_o$ New capacitance decreases (b) ∵ Battery is disconnected, charge on capacitor remains same. New potential on capacitor is $V' = \frac{Q}{C'}$ $V' = \frac{Q}{0.9C_o}$	½	HOME
	Electric field between the plates of capacitor $E' = \frac{V'}{d'}$ $E' = \frac{Q}{0.9C \times 2d}$ $E' = \frac{1}{1.8} \frac{Q}{Cd}$ $E' = \frac{E}{1.8}$ Electric field decreases (c) ∵ Energy stored in the capacitor $U = \frac{1}{2}\frac{Q^2}{C}$ $U' = \frac{1}{2}\frac{Q^2}{C'}$ $U' = \frac{1}{2}\frac{Q^2}{(0.9C_o)}$ $U' = \frac{U}{0.9}$ Energy stored increases	½ ½ ½ ½	HOME 3
27.	(a) Drawing V-I characteristics of silicon diode. 1 (b) Explanation of (i) Minority carrier injection in forward bias. 1 (ii) Break down voltage in reverse bias 1		

(a)



1

(b)

(i) Due to applied voltage, electrons from n-side cross the depletion region and reach p-side and holes from p-side cross the junction reach the n-side. This process under forward bias is called as minority charge injection. 1

(ii) The current under reverse bias is essentially voltage independent up to a critical reverse bias voltage known as breakdown voltage. 1

Alternatively:
The voltage in Reverse bias after which the value of reverse current starts increasing sharply is called breakdown voltage. 3

28.

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(a)	Reason for preference of image formed at infinity	½
(b)	Selecting the lenses for	
	(i) Telescope and	1
	(ii) Compound microscope	1
	reason	½

(a)

In the case of normal adjustment, the eye muscles remain relaxed while they are strained in the case when image is formed at near point while viewing the object, hence it is preferred. ½

(b)

- For Telescope

Lense L_2 is suitable as objective Lens ½

Lense L_3 is suitable as eyepiece ½

- For Compound microscope

Lense L_3 is suitable as objective lens ½

Lense L_1 is suitable as eyepiece ½

Reason

- For telescope, objective lens should have large aperture and large focal length
- For microscope, objective and eye lens should have moderate aperture but the objective should have large power. ½

3

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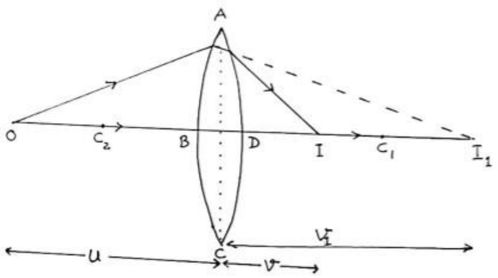
	SECTION - D		
29	(I) (B) radial magnetic field (II) (A) increasing number of turns of the coil (III) (D) 0.25 Nm OR (B) 3985 Ω (IV) (C) 0.01 Ω should be connected in parallel with it.	1 1 1 1	4
30	(I) (C) $h\nu_1$ and $h\nu_2$ (II) (A) greater for metal A because it has a smaller work function. (III) (D) the slope of the parallel lines will not change but more electrons will be emitted per second. (IV) (C) $\frac{2}{5}$ OR (A) me	1 1 1 1	4
	SECTION - E		
31	(a) Deriving the expression for lens maker's formula. 3 (b) Finding the distance of the final image from the object. 2  The first refracting surface forms the image of the object O at I_1 For refraction from first interface ABC $\frac{n_1}{OB}+\frac{n_2}{BI_1}=\frac{n_2-n_1}{BC_1}$ ------------- (1) Similarly for refraction from second interface ADC. The image I_1 acts as a virtual object for the second surface ADC $-\frac{n_2}{DI_1}+\frac{n_1}{DI}=\frac{n_2-n_1}{DC_2}$ -------------- (2) For thin lens $BI_1=DI_1$ By adding equations (1) and (2) $\frac{n_1}{OB}+\frac{n_1}{DI}=(n_2-n_1)\left[\frac{1}{BC_1}+\frac{1}{DC_2}\right]$ $-\frac{n_1}{u}+\frac{n_1}{v}=(n_2-n_1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$ $\frac{1}{v}-\frac{1}{u}=\left(\frac{n_2}{n_1}-1\right)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$ If object is kept at ∞, image will form at focus hence	 1 ½ ½ ½	HOME

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$$\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$ ½

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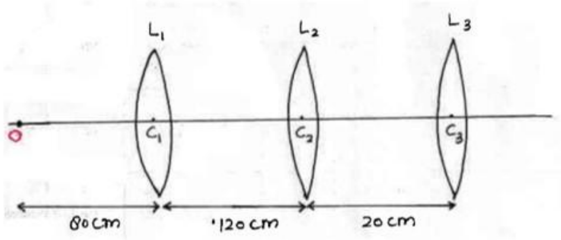
(b)



For lens L_1

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$ ½

$$\frac{1}{40}=\frac{1}{v_1}+\frac{1}{80}$$

$$\frac{1}{40}=\frac{1}{v_1}+\frac{1}{80}$$

$$\frac{1}{v_1}=\frac{1}{80}$$

$$v_1=80\,\text{cm}$$ ½

For lens L_2

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$$u_2=120-80$$

$$u_2=40\,\text{cm}$$

$$\frac{1}{40}=\frac{1}{v_2}+\frac{1}{40}$$

$$\frac{1}{v_2}=0$$

$$v_2=\infty$$ ½

For lens L_3

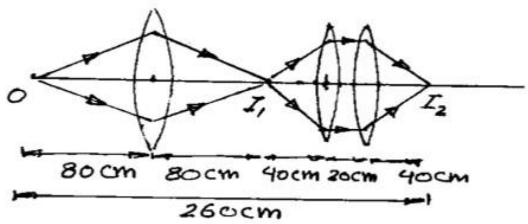
$$u_3=\infty$$

$$\frac{1}{40}=\frac{1}{v_3}+\frac{1}{\infty}$$

$$v_3=40\,\text{cm}$$

Distance between final image and object
= 80+120+20+40
=260 cm ½

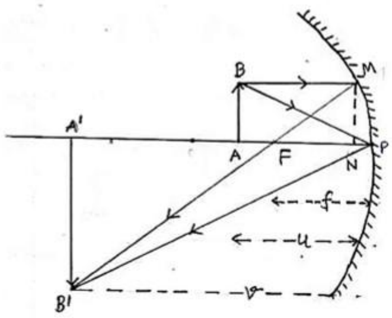
Alternatively:



OR

(a) •Drawing ray diagram	1
•Deriving of mirror formula	2
(b) Calculating the focal length of mirror	2

(a)



1

ΔBAP and $\Delta B'A'P$ are similar then

$$\frac{BA}{B'A'} = \frac{AP}{A'P} \quad \text{-----------------------(1)}$$ ½

$\because BA = MN$

ΔMNF and $\Delta B'A'F$ are similar then

$$\frac{MN}{B'A'} = \frac{NF}{A'F}$$

$$\frac{BA}{B'A'} = \frac{NF}{A'F} = \frac{PF}{A'F} \quad \text{(N is very close to P and BA = MN)} \quad \text{--------(2)}$$ ½

From equation (1) and (2)

$$\frac{AP}{A'P} = \frac{PF}{A'F}$$

$$\frac{-u}{-v} = \frac{-f}{-v+f}$$ ½

$$-uv + uf = -vf$$

$$\frac{-uv}{uvf} + \frac{uf}{uvf} = \frac{-vf}{uvf}$$

$$\frac{-1}{f} + \frac{1}{v} = \frac{1}{-u}$$

$$\boxed{\frac{1}{f} = \frac{1}{v} + \frac{1}{u}}$$ ½

Note: Award two marks if student derives mirror formula by using any other justified method

(b) $m = \frac{-v}{u}$ ½

$m = 2$

$\because v = -2u \Rightarrow v = -2(-10) = 20\,\text{cm}$ ½

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$ ½

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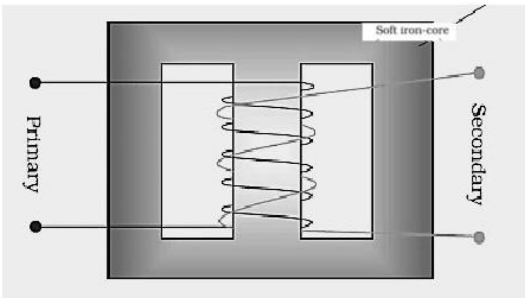
	$\frac{1}{20}-\frac{1}{10}=\frac{1}{f}$ $\frac{1-2}{20}=\frac{1}{f}$ $f=-20\text{ cm}$	½	HOME 5
32	(a) Stating Faraday's law 1 (b) Deriving of Expression for self-inductance. 2 (c) Finding the induced e.m.f 2 (a) The magnitude of the induced e.m.f in a circuit is equal to the time rate of change of magnetic flux through the circuit. **Alternatively:** $\varepsilon=-\frac{d\phi_B}{dt}$ (b) Magnetic field due to current carrying long solenoid of length *l* area of cross section A having n turns per unit length is $B=\mu_0 nI$ Total magnetic flux linked with the solenoid is $N\phi_B=(nl)(\mu_0 nI)(A)$ $=\mu_0 n^2 AlI$ Where *nl* is total number of turns. Thus ∴ Self inductance of the solenoid $L=\frac{N\phi_B}{I}$ $L=\mu_0 n^2 Al$ **Note:** Award full marks for any other correct alternative method (c) Induced e.m.f $\varepsilon=\frac{1}{2}Bl^2\omega$ $=\frac{1}{2}\times 4\times 10^{-3}\times\left(50\times 10^{-2}\right)^2\times(2\pi\times 1)$ $=3.14\text{ mV}$ **OR** (a) •Drawing labelled diagram of step-up transformer. 1 •Stating the principle ½ •Obtaining the ratio of voltages in terms of number of turns and current 2 (b) Finding: (i) Current in Primary coil 1/2 (ii) Output Voltage 1	1 ½ ½ ½ ½ ½ 1 ½	HOME

(a) Fig



1

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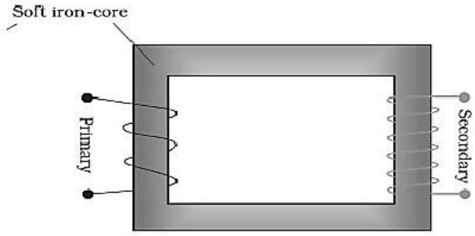
Alternatively:



Principle: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an e.m.f in it / mutual induction. ½

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Let ϕ be the flux in each turn in the core at time t due to current in the primary when a voltage v_p is applied to it. The induce e.m.f in the secondary coil is

$$\varepsilon_s = -N_s \frac{d\phi}{dt} \quad \text{------------------------------(1)}$$

½

Alternating flux ϕ also induces an e.m.f. called back e.m.f in the primary. This is

$$\varepsilon_p = -N_p \frac{d\phi}{dt} \quad \text{------------------------------(2)}$$

But

$\varepsilon_p = v_p$

If this were not so, the primary current would be infinite since the primary has zero resistance. If the secondary is an open circuit or the current taken from it is small then

$\varepsilon_s = v_s$

Now equations (1) and (2) can be written as.

$$\therefore \; v_s = -N_s \frac{d\phi}{dt} \quad \text{--- (3)}$$

$$v_p = -N_p \frac{d\phi}{dt} \quad \text{--- (4)}$$

½

From equations (3) and (4)

$$\frac{v_s}{v_p} = \frac{N_s}{N_p}$$

½

If the transformer is ideal the input power is equal to the power output

Since P = IV

$I_p V_p = I_s V_s$

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$$\frac{V_p}{V_s}=\frac{I_s}{I_p}$$ ½

(b)

(i)

$$P=V_pI_p$$

$$5000=200I_p$$ ½

$$I_p=25A$$

(ii)

$$\because \frac{N_p}{N_s}=\frac{V_p}{V_s}$$ ½

$$\frac{1}{5}=\frac{200}{V_s}$$ ½

$$V_s=1000V$$ 5

33.

(a)• Deriving an expression for the electric field $\vec{E}$ due to a dipole on the equatorial plane. 2½
•Writing the expression for electric field at a far off point. ½
(b) Calculating the force and torque. 2

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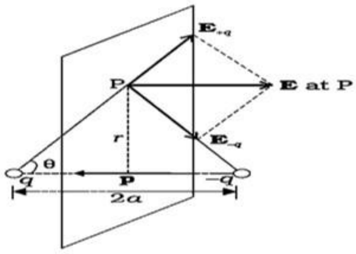

½

The magnitude of the electric fields due to the two charges + q and – q are given by ½

$$E_{+q}=\frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$$

$$E_{-q}=\frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$$

The components normal to the dipole axis cancel away. The components along the dipole axis add up. The Total electric field is opposite to $\vec{p}$.

$$\vec{E}=-\left(E_{+q}+E_{-q}\right)\cos\theta\left(\hat{p}\right)$$ 1

$$\vec{E}=-\frac{1}{4\pi\varepsilon_0}\frac{2qa}{\left(r^2+a^2\right)^{3/2}}\hat{p}$$ ½

At large distance r ≫a

$$\vec{E}=\frac{-2qa}{4\pi\varepsilon_0 r^3}\hat{p}$$ ½

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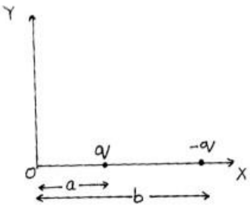
(b)



$\because \vec{F} = \vec{F}_{+q} + \vec{F}_{-q}$

Net force $= \left[+q.2\hat{i} - q.2\hat{i}\right]$ ½

$= 0$ N ½

Torque $\vec{\tau} = \vec{p} \times \vec{E}$

$\vec{\tau} = p\left(-\hat{i}\right) \times 2\hat{i}$ ½

$\tau = 0$ ½

Alternatively:

$\tau = pE\sin\theta$

Angle between $\vec{p}$ and $\vec{E}$ is π

OR

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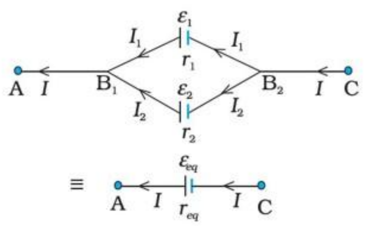
(a) Deriving the expression for	
• Equivalent e.m.f	2
• Equivalent internal resistance	1
(b) Finding the current through resistance 2R.	2

(a)



Let I_1 and I_2 are the currents leaving from the positive electrodes of the cells ε_1 and ε_2 respectively, Hence $I = I_1 + I_2$ ½

Potential difference across the terminals of cell ε_1 is

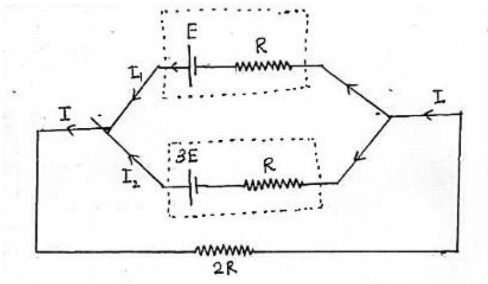
$V = \varepsilon_1 - I_1 r_1$

Potential difference across the terminals of cell ε_2 is

$V = \varepsilon_2 - I_2 r_2$

$I = I_1 + I_2$ ½

$I = \dfrac{\varepsilon_1 - V}{r_1} + \dfrac{\varepsilon_2 - V}{r_2}$

	$I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - v\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$		HOME
	$V = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$	½	
	$V = \varepsilon_{eq} - Ir_{eq}$		
	$\varepsilon_{eq} = \left(\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}\right)$	½	
	$r_{eq} = \left(\frac{r_1 r_2}{r_1 + r_2}\right)$	1	
	(b) · 		HOME
	Equivalent emf $E_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$		
	$E_{eq} = \frac{E \times R + 3E \times R}{R + R}$	½	
	$E_{eq} = \frac{4ER}{2R}$		
	$E_{eq} = 2E$	½	
	Equivalent resistance $r_{eq=} \frac{r_1 r_2}{r_2 + r_2}$		
	$r_{eq} = \frac{RR}{R + R}$	½	
	$r_{eq} = \frac{R}{2}$		
	$I = \frac{E_{eq}}{2R + \frac{R}{2}}$		
	$I = \frac{4E}{5R} A$	½	
			5

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