SET – 1

Series : BVM/1

कोड नं.
Code No. **55/1/1**

रोल नं.
Roll No.

परीक्षार्थी कोड को उत्तर–पुस्तिका के मुख–पृष्ठ पर अवश्य लिखें ।
Candidates must write the Code on the title page of the answer-book.

- कृपया जाँच कर लें कि इस प्रश्न–पत्र में मुद्रित पृष्ठ **15** हैं ।
- प्रश्न–पत्र में दाहिने हाथ की ओर दिए गए कोड नम्बर को छात्र उत्तर–पुस्तिका के मुख–पृष्ठ पर लिखें ।
- कृपया जाँच कर लें कि इस प्रश्न–पत्र में **27** प्रश्न हैं ।
- **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, प्रश्न का क्रमांक अवश्य लिखें ।**
- इस प्रश्न–पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न–पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक छात्र केवल प्रश्न–पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर–पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।

- Please check that this question paper contains **15** printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains **27** questions.
- **Please write down the Serial Number of the question before attempting it.**
- 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

भौतिक विज्ञान (सैद्धान्तिक)

PHYSICS (Theory)

निर्धारित समय : 3 घंटे *अधिकतम अंक : 70*
Time allowed : 3 hours *Maximum Marks : 70*

सामान्य निर्देश :

(i) ***सभी** प्रश्न अनिवार्य हैं । इस प्रश्न–पत्र में कुल 27 प्रश्न हैं ।*

(ii) *इस प्रश्न–पत्र के **चार** भाग हैं : **खण्ड–अ, खण्ड–ब, खण्ड–स** और **खण्ड–द** ।*

(iii) ***खण्ड–अ** में 5 प्रश्न हैं, प्रत्येक का **1** अंक है । **खण्ड–ब** में 7 प्रश्न हैं, प्रत्येक के **2** अंक हैं । **खण्ड–स** में 12 प्रश्न हैं, प्रत्येक के 3 अंक हैं । **खण्ड–द** में 3 प्रश्न हैं, प्रत्येक के 5 अंक हैं ।*

(iv) *प्रश्न–पत्र में समग्र पर कोई विकल्प नहीं है । तथापि **एक** अंक वाले **दो** प्रश्नों में, **दो** अंकों वाले **दो** प्रश्नों में, **तीन** अंकों वाले **चार** प्रश्नों में और **पाँच** अंकों वाले **तीनों** प्रश्नों में आन्तरिक चयन प्रदान किया गया है । ऐसे प्रश्नों में आपको दिए गए चयन में से केवल **एक** प्रश्न ही करना है ।*

(v) *जहाँ आवश्यक हो, आप निम्नलिखित भौतिक नियतांकों के मानों का उपयोग कर सकते हैं :*

$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}
इलेक्ट्रॉन का द्रव्यमान (m_e) = 9.1×10^{-31} kg
न्यूट्रॉन का द्रव्यमान = 1.675×10^{-27} kg
प्रोटॉन का द्रव्यमान = 1.673×10^{-27} kg
आवोगाद्रो संख्या = 6.023×10^{23} प्रति ग्राम मोल
बॉल्ट्ज़मान नियतांक = 1.38×10^{-23} JK^{-1}

General Instructions :

(i) ***All** questions are compulsory. There are **27** questions in all.*

(ii) *This question paper has **four** sections : Section **A**, Section **B**, Section **C** and Section **D**.*

(iii) *Section **A** contains **five** questions of **one** mark each, Section **B** contains **seven** questions of **two** marks each, Section **C** contains **twelve** questions of **three** marks each, and Section **D** contains **three** questions of **five** marks each.*

(iv) *There is no overall choice. However, an internal choice(s) has been provided in **two** questions of **one** mark, **two** questions of **two** marks, **four** questions of **three** marks and **three** questions of **five** marks weightage. You have to attempt only **one** of the choices in such questions.*

(v) *You may use the following values of physical constants wherever necessary :*

$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}
Mass of electron (m_e) = 9.1×10^{-31} kg
Mass of neutron = 1.675×10^{-27} kg
Mass of proton = 1.673×10^{-27} kg
Avogadro's number = 6.023×10^{23} per gram mole
Boltzmann constant = 1.38×10^{-23} JK^{-1}

खण्ड – अ

SECTION – A

1. किसी अनावेशित चालक प्लेट के निकट स्थित किसी बिन्दु आवेश – Q के विद्युत क्षेत्र के पैटर्न को दर्शाइए । **1**

Draw the pattern of electric field lines, when a point charge – Q is kept near an uncharged conducting plate.

2. यदि किसी चालक की लम्बाई और उसके ताप को नियत रखते हुए उसके सिरों पर अनुप्रयुक्त विभवान्तर को दो गुना कर दिया जाए, तो इलेक्ट्रॉनों की गतिशीलता किस प्रकार परिवर्तित होगी ? **1**

How does the mobility of electrons in a conductor change, if the potential difference applied across the conductor is doubled, keeping the length and temperature of the conductor constant ?

3. प्रकाश विद्युत उत्सर्जन के संदर्भ में "देहली आवृत्ति" की परिभाषा लिखिए । **1**

अथवा

विद्युतचुम्बकीय विकिरण के फोटॉन चित्रण में पद "तीव्रता" की परिभाषा लिखिए ।

Define the term "threshold frequency", in the context of photoelectric emission.

OR

Define the term "Intensity" in photon picture of electromagnetic radiation.

4. ध्रुवण कोण 30° के किसी सघन माध्यम में प्रकाश की चाल क्या है ? **1**

What is the speed of light in a denser medium of polarising angle 30° ?

5. संचरण की व्योम तरंग विधा में, प्रेषक सिग्नल के आवृत्ति परिसर को 30 MHz से कम पर प्रतिबंधित क्यों किया जाता है ? **1**

अथवा

भू–तरंग संचरण में प्रसारण क्षेत्र परिसर किन कारकों पर निर्भर करता है ?

In sky wave mode of propagation, why is the frequency range of transmitting signals restricted to less than 30 MHz ?

OR

On what factors does the range of coverage in ground wave propagation depend ?

खण्ड – ब

SECTION – B

6. दो बल्बों के अनुमतांक (P_1, V) और (P_2, V) हैं। यदि इन बल्बों के (i) श्रेणी संयोजन, (ii) पार्श्व संयोजन को किसी आपूर्ति V के सिरों से संयोजित किया गया है, तो P_1 और P_2 के पदों में इन दोनों संयोजनों में होने वाले शक्ति क्षय ज्ञात कीजिए। **2**

Two bulbs are rated (P_1, V) and (P_2, V). If they are connected (i) in series and (ii) in parallel across a supply V, find the power dissipated in the two combinations in terms of P_1 and P_2.

7. 1.5 अपवर्तनांक के उस समावतल लेंस की वक्रता त्रिज्या ज्ञात कीजिए जिसकी क्षमता 1.4 अपवर्तनांक के माध्यम में रखे जाने पर –5D है। **2**

अथवा

काँच के एक समबाहु प्रिज़्म का वायु में अपवर्तनांक 1.6 है। $4\sqrt{2}/5$ अपवर्तनांक के किसी माध्यम में रखे जाने पर इस प्रिज़्म का न्यूनतम विचलन परिकलित कीजिए।

Calculate the radius of curvature of an equi-concave lens of refractive index 1.5, when it is kept in a medium of refractive index 1.4, to have a power of –5D ?

OR

An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of minimum deviation of the prism, when kept in a medium of refractive index $4\sqrt{2}/5$.

8. समान गतिज ऊर्जा के किसी एल्फा कण और किसी प्रोटॉन को इनकी गति की दिशा के अभिलम्बवत कार्यरत किसी चुम्बकीय क्षेत्र $\vec{B}$ में बारी–बारी से गुजरने दिया जाता है। इनके द्वारा चले गए वृत्तीय पथों की त्रिज्याओं का अनुपात परिकलित कीजिए। **2**

An α-particle and a proton of the same kinetic energy are in turn allowed to pass through a magnetic field $\vec{B}$, acting normal to the direction of motion of the particles. Calculate the ratio of radii of the circular paths described by them.

9. बोर का कोणीय संवेग का क्वांटमी प्रतिबंध लिखिए । ब्रेकेट श्रेणी की लघुतम तरंगदैर्ध्य परिकलित कीजिए और उल्लेख कीजिए कि यह विद्युत चुम्बकीय स्पेक्ट्रम के किस भाग से संबंधित है । **2**

अथवा

हाइड्रोजन परमाणु की प्रथम उत्तेजित अवस्था में इलेक्ट्रॉन का कक्षीय आवर्तकाल परिकलित कीजिए ।

State Bohr's quantization condition of angular momentum. Calculate the shortest wavelength of the Bracket series and state to which part of the electromagnetic spectrum does it belong.

OR

Calculate the orbital period of the electron in the first excited state of hydrogen atom.

10. किसी TV टॉवर से प्रेषित सिग्नल को किसी निश्चित दूरी से अधिक दूरी पर प्राप्त क्यों नहीं किया जा सकता है ? प्रेषक ऐंटीना और अभिग्राही एन्टेना के बीच के इष्टतम पृथकन के लिए व्यंजक लिखिए । **2**

Why a signal transmitted from a TV tower cannot be received beyond a certain distance ? Write the expression for the optimum separation between the receiving and the transmitting antenna.

11. विद्युतचुम्बकीय विकिरण का तरंग सिद्धान्त प्रकाश विद्युत प्रभाव की व्याख्या क्यों नहीं कर सका ? इस समस्या का समाधान फोटॉन चित्रण द्वारा किस प्रकार हुआ ? **2**

Why is wave theory of electromagnetic radiation not able to explain photo electric effect ? How does photon picture resolve this problem ?

12. द्रव्यमान m के किसी आवेशित कण से संबद्ध दे ब्राग्ली तरंगदैर्ध्य (λ) और $1/\sqrt{V}$ के बीच विचरण को दर्शाने के लिए ग्राफ खींचिए, यहाँ V वह विभवान्तर है जिससे कण को त्वरित किया गया है । यह ग्राफ हमें कण के आवेश के परिमाण के विषय में किस प्रकार सूचित करता है ? **2**

Plot a graph showing variation of de Broglie wavelength (λ) associated with a charged particle of mass m, versus $1/\sqrt{V}$, where V is the potential difference through which the particle is accelerated. How does this graph give us the information regarding the magnitude of the charge of the particle ?

खण्ड – स

SECTION – C

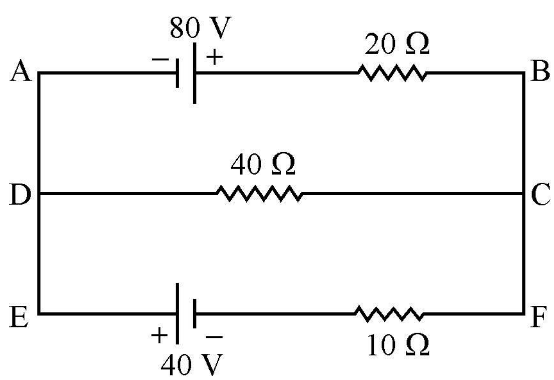
13. (a) किसी एकसमान चुम्बकीय क्षेत्र के तदनुरूपी z-अक्ष में समविभव पृष्ठ खींचिए।

(b) किसी वैद्युत-द्विध्रुव की अक्षीय रेखा के अनुदिश किसी बिन्दु पर विद्युत विभव के लिए व्यंजक व्युत्पन्न कीजिए। **3**

(a) Draw the equipotential surfaces corresponding to a uniform electric field in the z-direction.

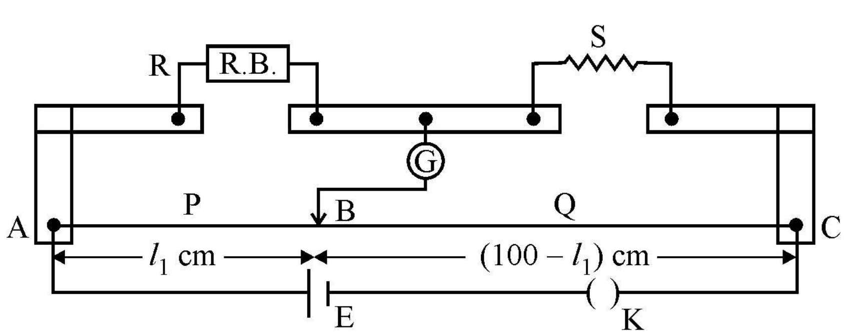
(b) Derive an expression for the electric potential at any point along the axial line of an electric dipole.

14. किरचौफ के नियमों का उपयोग करके नीचे दिए गए परिपथ में 40 Ω और 20 Ω के प्रतिरोधकों से प्रवाहित धारा परिकलित कीजिए : **3**

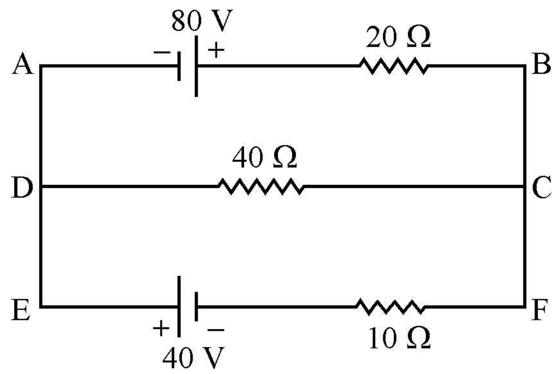


अथवा

किसी मीटर सेतु में अन्त्य त्रुटि क्या होती है ? इसे किस प्रकार पराभूत किया जाता है ? किसी मीटर सेतु की दो भुजाओं में क्रमशः R = 5 Ω और S प्रतिरोध हैं। जब प्रतिरोध S को समान प्रतिरोध द्वारा शंट (पार्श्व पथ) कर दिया जाता है, तो नया संतुलन बिन्दु 1.5 l_1, पर पाया जाता है, यहाँ l_1 आरम्भिक संतुलन लम्बाई है। S का मान परिकलित कीजिए।



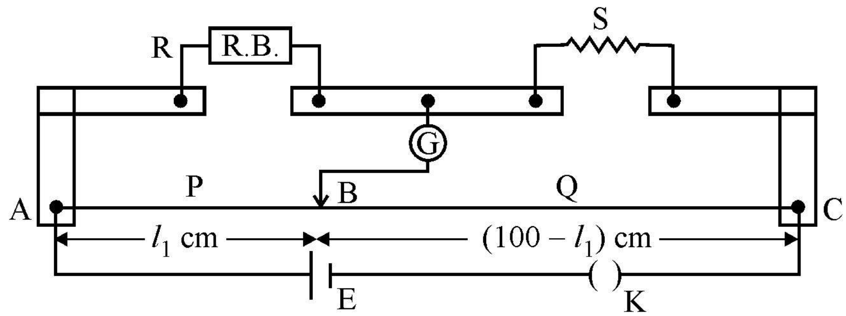
Using Kirchhoff's rules, calculate the current through the 40 Ω and 20 Ω resistors in the following circuit :



OR

What is end error in a metre bridge ? How is it overcome ? The resistances in the two arms of the metre bridge are R = 5 Ω and S respectively.

When the resistance S is shunted with an equal resistance, the new balance length found to be 1.5 l_1, where l_1 is the initial balancing length. Calculate the value of S.



15. (a) रेडार और नेत्र शल्यता में उपयोग होने वाली विद्युतचुम्बकीय तरंगों के उत्पन्न करने और संसूचन के एक स्रोत का उल्लेख कीजिए । उनकी आवृति परास लिखिए ।

(b) सिद्ध कीजिए की दोलायमान विद्युत क्षेत्र का औसत ऊर्जा घनत्व और दोलायमान चुम्बकीय क्षेत्र के औसत ऊर्जा घनत्व के समान है । **3**

(a) Identify the part of the electromagnetic spectrum used in (i) radar and (ii) eye surgery. Write their frequency range.

(b) Prove that the average energy density of the oscillating electric field is equal to that of the oscillating magnetic field.

16. पद 'तरंगाग्र' की परिभाषा लिखिए। हाइगेन्स तरंग सिद्धान्त के नियम का उपयोग करके परावर्तन के नियम का सत्यापन कीजिए। **3**

अथवा

किसी माध्यम के 'अपवर्तनांक' की परिभाषा लिखिए। उस स्थिति में अपवर्तनांक के स्नेल के नियम को सत्यापित कीजिए जब कोई समतल तरंगाग्र सघन माध्यम से विरल माध्यम में संचरण कर रहा है।

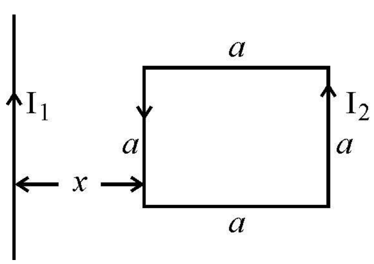
Define the term wavefront. Using Huygen's wave theory, verify the law of reflection.

OR

Define the term, "refractive index" of a medium. Verify Snell's law of refraction when a plane wavefront is propagating from a denser to a rarer medium.

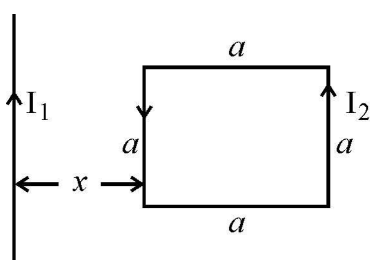
17. (a) अन्योन्य प्रेरकत्व की परिभाषा और इसका SI मात्रक लिखिए।

(b) आरेख में दर्शाए अनुसार किसी अनन्त लम्बाई के सीधे चालक, जिससे स्थायी धारा I_1 प्रवाहित हो रही है, से दूरी x पर भुजा a का कोई वर्ग-पाश (लूप) रखा है, जिसमें धारा I_2 प्रवाहित हो रही है। इस वर्ग पाश पर लगने वाले परिणामी बल के लिए व्यंजक व्युत्पन्न कीजिए। **3**



(a) Define mutual inductance and write its S.I. unit.

(b) A square loop of side 'a' carrying a current I_2 is kept at distance x from an infinitely long straight wire carrying a current I_1 as shown in the figure. Obtain the expression for the resultant force acting on the loop.



18. (a) किसी चुम्बकीय क्षेत्र में स्थित किसी धारावाही पाश पर कार्य करने वाले बल आघूर्ण के लिए व्यंजक व्युत्पन्न कीजिए।

(b) किसी धारावाही कुण्डली को किसी अरीय चुम्बकीय क्षेत्र में रखने पर अरीय चुम्बकीय क्षेत्र के महत्त्व की व्याख्या कीजिए। **3**

(a) Derive the expression for the torque acting on a current carrying loop placed in a magnetic field.

(b) Explain the significance of a radial magnetic field when a current carrying coil is kept in it.

19. निकट बिन्दु समायोजन स्थिति में किसी खगोलीय दूरबीन (दूरदर्शक) का नामांकित आरेख खींचिए।

किसी वेधशाला में रखे बृहत अपवर्ती दूरदर्शक के अभिदृश्यक की फोकस दूरी 15 m और नेत्रिका की फोकस दूरी 1.0 cm है। यदि इस दूरदर्शक का उपयोग चन्द्रमा को देखने के लिए किया जाता है, तो अभिदृश्यक द्वारा बने चन्द्रमा के प्रतिबिम्ब का व्यास ज्ञात कीजिए। चन्द्रमा का व्यास 3.48×10^6 m और चन्द्रमा की कक्षा की त्रिज्या 3.8×10^8 m है। **3**

Draw a labelled ray diagram of an astronomical telescope in the near point adjustment position.

A giant refracting telescope at an observatory has an objective lens of focal length 15 m and an eyepiece of focal length 1.0 cm. If this telescope is used to view the Moon, find the diameter of the image of the Moon formed by the objective lens. The diameter of the Moon is 3.48×10^6 m, and the radius of lunar orbit is 3.8×10^8 m.

20. (a) चुम्बकत्व के लिए गाउस का नियम लिखिए। इसके महत्त्व की व्याख्या कीजिए।

(b) किसी छड़ चुम्बक की चुम्बकीय क्षेत्र रेखाओं के चार महत्त्वपूर्ण गुण लिखिए। **3**

अथवा

प्रत्येक का एक-एक उदाहरण देते हुए अनुचुम्बकीय, प्रतिचुम्बकीय और लोह चुम्बकीय पदार्थों के बीच तीन विभेदनकारी बिन्दु लिखिए।

(a) State Gauss's law for magnetism. Explain its significance.

(b) Write the four important properties of the magnetic field lines due to a bar magnet.

OR

Write three points of differences between para-, dia- and ferro- magnetic materials, giving one example for each.

21. किसी रेडियोएक्टिव नमूने के 'क्षयांक' की परिभाषा लिखिए । किसी दिए गए रेडियोएक्टिव नाभिक के विघटन की दर आरम्भ होने के 20 घण्टे और 30 घण्टे के पश्चात क्रमशः 10000 विघटन प्रति सेकण्ड और 5,000 विघटन प्रति सेकण्ड है । $t = 0$ पर नाभिकों की आरम्भिक संख्या तथा अर्धायु परिकलित कीजिए । **3**

Define the term 'decay constant' of a radioactive sample. The rate of disintegration of a given radioactive nucleus is 10000 disintegrations/s and 5,000 disintegrations/s after 20 hr. and 30 hr. respectively from start. Calculate the half life and initial number of nuclei at $t = 0$.

22. (a) तीन फोटोडायोड D_1, D_2 और D_3 ऐसे अर्धचालकों के बने हैं जिनके बैण्ड–अन्तराल क्रमशः 2.5 eV, 2 eV और 3 eV हैं । इनमें से कौन सा फोटोडायोड 600 nm तरंगदैर्ध्य के प्रकाश का संसूचन नहीं कर सकेगा ?

(b) व्याख्या कीजिए कि फोटोडायोडों का प्रचालन पश्चदिशिक बायस में करना क्यों आवश्यक है । **3**

(a) Three photo diodes D_1, D_2 and D_3 are made of semiconductors having band gaps of 2.5 eV, 2 eV and 3 eV respectively. Which of them will not be able to detect light of wavelength 600 nm ?

(b) Why photodiodes are required to operate in reverse bias ? Explain.

23. (a) n-p-n ट्रांजिस्टर के तीन खण्डों के कार्यों का संक्षेप में वर्णन कीजिए ।

(b) C-E विन्यास में n-p-n ट्रांजिस्टर के निर्गत अभिलाक्षणिक का अध्ययन करने के लिए परिपथ व्यवस्था खींचिए । व्याख्या कीजिए कि निर्गत अभिलाक्षणिक किस प्रकार प्राप्त किया जाता है । **3**

अथवा

पूर्ण तरंग दिष्टकारी का परिपथ आरेख खींचकर इसकी कार्यविधि की व्याख्या कीजिए । इसके निवेशी और निर्गत तरंगरूपों को भी आलेखित कीजिए ।

(a) Describe briefly the functions of the three segments of n-p-n transistor.

(b) Draw the circuit arrangement for studying the output characteristics of n-p-n transistor in CE configuration. Explain how the output characteristics is obtained.

OR

Draw the circuit diagram of a full wave rectifier and explain its working. Also, give the input and output waveforms.

24. (a) यदि किसी आयाम माडुलित तरंग के अधिकतम और निम्नतम आयामों को A और B द्वारा निरूपित किया गया है, तो A, B के पदों में माडुलन सूचकांक के लिए व्यंजक लिखिए ।

(b) 2 MHz आवृत्ति और 15 V शिखर वोल्टता की किसी वाहक तरंग का माडुलन करने के लिए 20 kHz आवृत्ति और 10 V शिखर वोल्टता के किसी संदेश सिग्नल का उपयोग किया गया है । माडुलन सूचकांक परिकलित कीजिए । सामान्यतः माडुलन – सूचकांक एक से कम क्यों रखा जाता है ? **3**

(a) If A and B represent the maximum and minimum amplitudes of an amplitude modulated wave, write the expression for the modulation index in terms of A & B.

(b) A message signal of frequency 20 kHz and peak voltage 10 V is used to modulate a carrier of frequency 2 MHz and peak voltage of 15 V. Calculate the modulation index. Why the modulation index is generally kept less than one ?

खण्ड – द

SECTION – D

25. (a) परिवर्ती आवृत्ति के किसी ac स्रोत के सिरों से संयोजित किसी श्रेणी LCR परिपथ की प्रतिबाधा के लिए व्यंजक लिखिए तथा ac स्रोत की आवृत्ति के साथ प्रतिबाधा के विचरण को दर्शाने के लिए ग्राफ खींचिए ।

(b) LCR परिपथ में अनुनाद की स्थिति में प्रेरक और संधारित्र के सिरों पर वोल्टताओं के बीच कितना कलान्तर होता है ?

(c) किसी प्रेरक को 200 V dc वोल्टता से संयोजित करने पर 1A धारा प्रवाहित होती है । जब इसी प्रेरक को 50 Hz आवृत्ति के 200 V के ac स्रोत से संयोजित किया जाता है, तो केवल 0.5A धारा ही प्रवाहित होती है । व्याख्या कीजिए कि दूसरे प्रकरण में धारा कम क्यों है । प्रेरक का स्वप्रेरकत्व भी परिकलित कीजिए । **5**

अथवा

(a) किसी ऐसी युक्ति का आरेख खींचिए जिसका उपयोग उच्च ac वोल्टता को निम्न ac वोल्टता में परिवर्तित करने के लिए किया जाता है और उसका कार्यकारी सिद्धांत लिखिए । इस युक्ति में होने वाले ऊर्जा–क्षय के चार स्रोत लिखिए ।

(b) कोई छोटा शहर जिसकी विद्युत शक्ति की माँग 220 V पर 1200 kW है, 440 V पर शक्ति उत्पन्न करने वाले विद्युत संयंत्र से 20 km दूर है । शक्ति संचरण के लिए उपयोग की जाने वाली दो तारों की लाइन का प्रतिरोध 0.5 Ω प्रति किलोमीटर है । यह शहर विद्युत लाइन से 4000-220 अपचायी ट्रांसफॉर्मर से होकर उपबिजलीघर पर विद्युत शक्ति प्राप्त करता है । ऊष्मा के रूप में लाइन शक्ति–क्षय का आकलन कीजिए ।

(a) In a series LCR circuit connected across an ac source of variable frequency, obtain the expression for its impedance and draw a plot showing its variation with frequency of the ac source.

(b) What is the phase difference between the voltages across inductor and the capacitor at resonance in the LCR circuit ?

(c) When an inductor is connected to a 200 V dc voltage, a current of 1A flows through it. When the same inductor is connected to a 200 V, 50 Hz ac source, only 0.5 A current flows. Explain, why ? Also, calculate the self inductance of the inductor.

OR

(a) Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device.

(b) A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

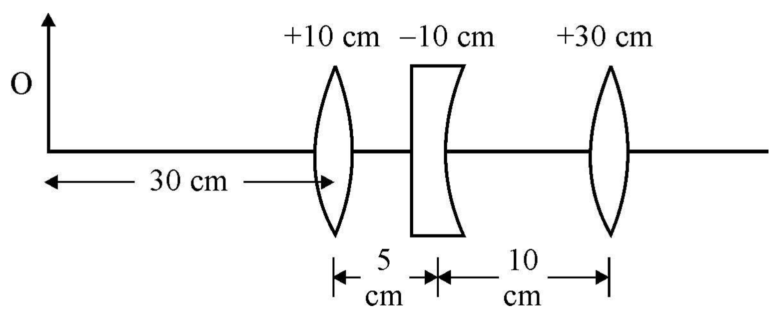
26. (a) व्यतिकरण और विवर्तन परिघटनाओं के बीच विभेदन करने वाले किन्हीं दो विशिष्ट लक्षणों का वर्णन कीजिए । यंग के द्विझिरी प्रयोग में व्यतिकरण पैटर्न की तीव्रता के लिए व्यंजक व्युत्पन्न कीजिए ।

(b) एकल झिरी प्रयोग के कारण विवर्तन में झिरी का द्वारक 3 mm है । यदि इस झिरी पर 620 nm तरंगदैर्ध्य का कोई एकवर्णी प्रकाश अभिलम्बवत् आपतन करता है, तो पर्दे पर एक ओर प्रथम कोटि निम्निष्ट और तृतीय कोटि उच्चिष्ठ के बीच पृथकन परिकलित कीजिए । पर्दे और झिरी के बीच की दूरी 1.5 m है । **5**

अथवा

(a) किन परिस्थितियों में पूर्ण आन्तरिक परावर्तन की परिघटना का प्रेक्षण किया जाता है ? माध्यम के अपवर्तनांक और आपतन के क्रांतिक कोण के बीच संबंध प्राप्त कीजिए ।

(b) आरेख में दर्शाए अनुसार +10 cm; –10 cm और +30 cm फोकस दूरी के तीन लेंस समाक्ष व्यवस्थित किए गए हैं । इस संयोजन द्वारा बने अंतिम प्रतिबिम्ब की स्थिति ज्ञात कीजिए ।



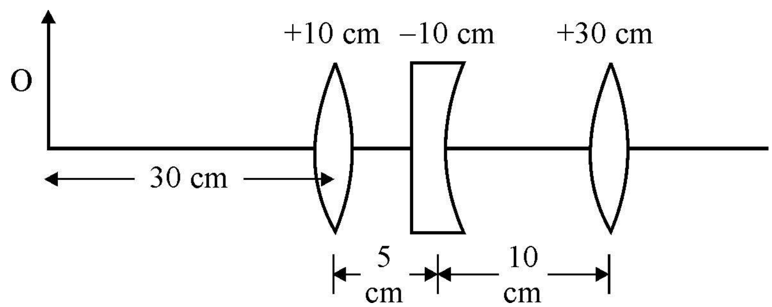
(a) Describe any two characteristic features which distinguish between interference and diffraction phenomena. Derive the expression for the intensity at a point of the interference pattern in Young's double slit experiment.

(b) In the diffraction due to a single slit experiment, the aperture of the slit is 3 mm. If monochromatic light of wavelength 620 nm is incident normally on the slit, calculate the separation between the first order minima and the 3rd order maxima on one side of the screen. The distance between the slit and the screen is 1.5 m.

OR

(a) Under what conditions is the phenomenon of total internal reflection of light observed ? Obtain the relation between the critical angle of incidence and the refractive index of the medium.

(b) Three lenses of focal lengths +10 cm, –10 cm and +30 cm are arranged coaxially as in the figure given below. Find the position of the final image formed by the combination.



27. (a) एक बैटरी से जुड़े किसी समान्तर पट्टिका संधारित्र की पट्टिकाओं के बीच आवेश स्थानान्तरित करने की प्रक्रिया का संक्षेप में वर्णन कीजिए । किसी संधारित्र में संचित ऊर्जा के लिए व्यंजक व्युत्पन्न कीजिए ।

(b) किसी समान्तर पट्टिका संधारित्र को विभवान्तर V तक आवेशित किया गया है । इसे स्रोत से वियोजित करके समान धारिता के किसी अन्य अनावेशित संधारित्र के साथ संयोजित किया गया । इस संयोजन में संचित ऊर्जा और आरम्भ में एकल संधारित्र में संचित ऊर्जा का अनुपात परिकलित कीजिए । **5**

अथवा

(a) किसी वैद्युत द्विध्रुव की विषुवत रेखा के किसी बिन्दु पर विद्युत क्षेत्र के लिए व्यंजक व्युत्पन्न कीजिए ।

(b) दो सर्वसम बिन्दु, प्रत्येक q, आवेश वायु में एक दूसरे से 2m दूरी पर रखे हैं । अज्ञात परिमाण और चिह्न का कोई तीसरा आवेश 'Q' इन आवेशों को मिलाने वाली रेखा पर इस प्रकार रखा है कि निकाय संतुलन में रहता है । आवेश Q की स्थिति और चिह्न ज्ञात कीजिए ।

(a) Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor.

(b) A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

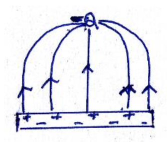
OR

(a) Derive an expression for the electric field at any point on the equatorial line of an electric dipole.

(b) Two identical point charges, q each, are kept 2m apart in air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q.

MARKING SCHEME – PHYSICS

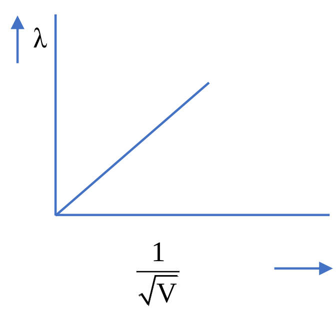
55/1/1

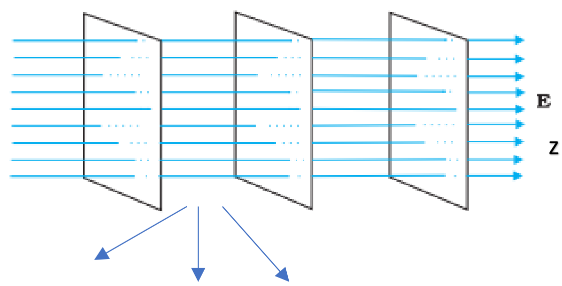
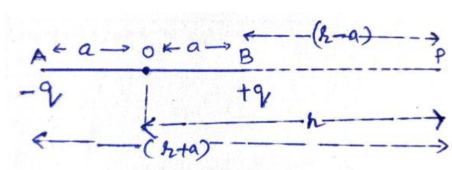
Q. No.	Value Points/ Expected answers	Marks	Total Marks
1	 [Note: i) Deduct ½ mark, if arrows are not shown. ii) do not deduct any mark, if charges on the plates are not shown]	1	1
2	No Change	1	1
3	Threshold frequency equals the minimum frequency of incident radiation (light) that can cause photoemission from a given photosensitive surface. (Alternatively) The frequency below which the incident radiations cannot cause the photoemission from photosensitive surface. OR Intensity of radiation is proportional to (/ equal to) the number of energy quanta (photons) per unit area per unit time.	1	1
4	$_d\mu_r = \tan 30^0 = \frac{1}{\sqrt{3}}$ (where $_d\mu_r$ is the retractive index of rarer medium w.r.t denser medium) $\therefore \mu_d = \sqrt{3}$ $v = \frac{c}{\mu} = \frac{3 \times 10^8}{\sqrt{3}} = \sqrt{3} \times 10^8$ m/s [Note- Also accept if a student solves it as follows) $\mu = \tan i_p$ $\mu = \tan 30^0 = \frac{1}{\sqrt{3}}$ $\therefore v = \frac{3 \times 10^8}{\frac{1}{\sqrt{3}}} = 3\sqrt{3} \times 10^8$ m/s (Note: Award this one mark if a student just writes the formula but does not solve it.)	½ ½ ½ ½	1
5	The waves beyond 30 MHz frequency penetrate through the Ionosphere/ are not reflected back. OR Transmitted Power and Frequency	1 ½ + ½	1
	SECTION - B		
6	Calculation of Power dissipation in two combinations 1 +1 $R_1 = \frac{V^2}{P_1}$, $R_2 = \frac{V^2}{P_2}$, $P_s = \frac{V^2}{Rs} = \frac{P_1 P_2}{P_1+P_2}$ $\frac{1}{Ps} = \frac{1}{P_1} + \frac{1}{P_2}$ $\frac{1}{Rp} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{P_1+P_2}{V^2}$	½ ½ ½	

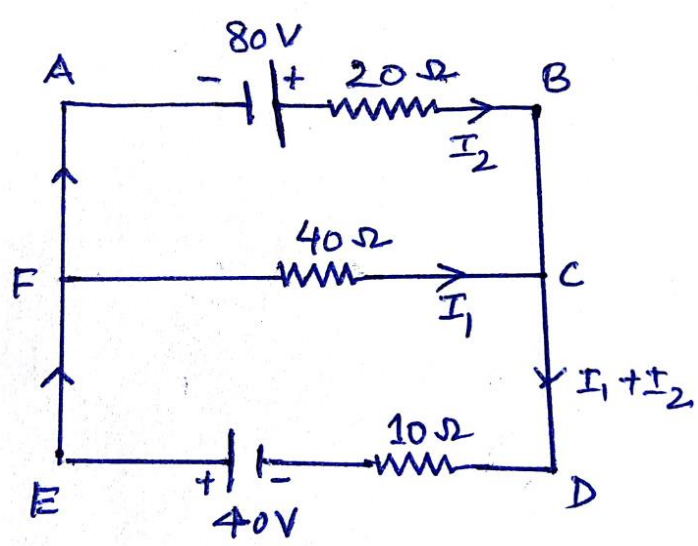
	$\therefore P_p = \frac{V^2}{R_P} = P_1 + P_2$	½	2
7	Calculation of focal length ½ Lens maker's formula ½ Calculation of radius of curvature 1 $f = \frac{1}{P} = \frac{1}{-5}$ m $= -\frac{100}{5}$ cm $= -20$ cm $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R1} - \frac{1}{R2}\right)$ $\mu_2 = 1.5$, $\mu_1 = 1.4$, $R_1 = -R$ $R_2 = R$ $\frac{1}{-20} = \left(\frac{1.5}{1.4} - 1\right)\left(-\frac{1}{R} - \frac{1}{R}\right)$ $\frac{1}{-20} = \left(\frac{0.1}{1.4}\right)\left(-\frac{2}{R}\right)$ $R = \frac{20}{7}$ cm (= 2.86 cm) OR Formula ½ Substitution and calculation 1½ $\mu = \frac{\sin\frac{(A + D_m)}{2}}{\sin A/2}$ $\mu = \frac{\mu_2}{\mu_1} = \frac{1.6}{\frac{4}{5}\sqrt{2}} = \frac{8}{4\sqrt{2}} = \sqrt{2}$ $\sqrt{2} = \frac{\sin(\frac{60 + D_m}{2})}{Sin\ 60/2} = \frac{sin\frac{(60 + D_m)}{2}}{Sin\ 30}$ $\therefore \sin(\frac{60 + D_m}{2}) = \sqrt{2} \cdot \frac{1}{2} = \frac{1}{\sqrt{2}} = \text{Sin } 45^0$ $\therefore \frac{60 + D_m}{2} = 45^o$ $\therefore D_m = 30^0$	½ ½ ½ ½ ½ ½ ½ ½	2 2
8	Formula ½ Calculation of ratio of radii 1½	½	

	radius r = $\frac{mv}{q\,B} = \frac{\sqrt{2mk}}{qB}$ $K_\alpha = K_{proton}$ $M_\alpha = 4\,m_p$ $q_\alpha = 2q_p$ $\frac{r_\alpha}{r_p} = \frac{\frac{\sqrt{2m_\alpha K}}{q_\alpha B}}{\frac{\sqrt{2m_p K}}{q_p B}}$ $= \sqrt{\frac{m_\alpha}{m_p}} \times \sqrt{\frac{q_p}{q_\alpha}}$ $= \sqrt{4} \times ½ = 1$	½ ½ ½	2
9	Statement of Bohr's quantization condition ½ Calculation of shortest wavelength 1 Identification of part of electromagnetic spectrum ½ Electron revolves around the nucleus only in those orbits for which the angular momentum is some integral of h/2π. (where h is planck's constant) (Also give full credit it a student write mathematically mvr = $\frac{nh}{2\pi}$) $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ For Brackett Series, Shortest wavelength is for the transition of electrons from $n_i = \infty$ to $n_f = 4$ $\frac{1}{\lambda} = R\left(\frac{1}{4^2}\right) = \frac{R}{16}$ $\lambda = \frac{16}{R}\,\text{m}$ = 1458.5 nm on substitution of value of R [Note: Don't deduct any mark for this part, when a student does not substitute the value of R, to calculate the numerical value of λ] Infrared region OR Statement of the Formula for r_n ½ Statement of the formula for v_n ½ Obtaining formula for T_n ½ Getting expression for T_2 (n = 2) ½ $Radius\ r_n = \frac{h^2\epsilon_0}{\pi m e^2} n^2$	½ ½ ½ ½ ½	

	$velocity\ \ v_n = \frac{2\pi e^2}{4\pi\varepsilon_0 h}\frac{1}{n}$ $Time\ period\ \ T_n = \frac{2\pi r_n}{v_n} = \frac{4\varepsilon_0^2 h^3 n^3}{me^4}$ For first excited state of hydrogen atom n=2 $T_2 = \frac{32\varepsilon_0^2\, h^3}{me^4}$ On calculation we get $T_2\ \approx 1.22\ X\ 10^{-15}\ s.$ (However, do not deduct the last ½ mark if a student does not calculate the numerical value of T_2) Alternatively $r_n = (\,0.53\, n^2\,)A^0\ = 0.53\ X\ 10^{-10}\ n^2$ $v_n = (\frac{c}{137\ n})$ $T_n = \frac{2\pi(0.53)}{\left(\frac{c}{137\ n}\right)}\ X\ 10^{-10}\ n^2$ = $\frac{2\pi(0.53)}{c}\ X\ 10^{-10}\ n^3$ x 137 s = $\frac{2 \times 3.14 \times 0.53 \times 10^{-10} \times 8 \times 137}{3\ x\ 10^8}$ s = 1215.97 x 10^{-18} = (1.22 x 10^{-15}) s Alternatively If the student writes directly T_n α n^3 T_2 = 8 times of orbital period of the electron in the ground state (award one mark only)	½ ½ ½ ½ ½ ½ ½	2 2
10.	Reason 1 Expression 1 Because of line of sight nature of propagation, direct waves get blocked at some point by the curvature of earth. [Alternatively : The transmitting antenna of height h, the distance to the horizon equals d= $\sqrt{2hR}$ (R = Radius of earth, which is upto a certain distance from the TV tower] The optimum separation between the receiving and transmitting antenna. d = $\sqrt{2h_T R} + \sqrt{2h_R R}$ [Where h_T = height of Transmitting antenna (h_R = Height of Receiving antenna)]	1 1	2

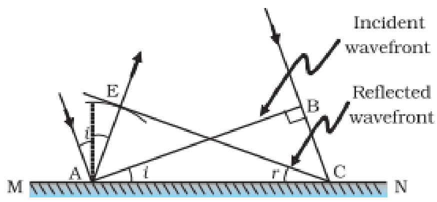
11.	Reason for inability of e.m. theory 1 Resolution through photon picture 1 The explanation based on e.m theory does not agree with the experimental observations (instantaneous nature , max K.E of emitted photoelectron is independent of intensity, existence of threshold frequency) on the photoelectric effect. **[Note: Do not deduct any mark if the student does not mention the relevant experimental observation or mentions any one or any two of these observation.]** The photon picture resolves this problem by saying that light, in interaction with matter behaves as if it is made of quanta or packets of energy, each of energy h ν . This picture enables us to get a correct explanation of all the observed experimental features of photoelectric effect. [NOTE: Award the first mark if the student just writes "As per E.M. theory the free electrons at the surface of the metal absorb the radiant energy continuously, this leads us to conclusions which do not match with the experimental observations"] Also award the second mark if the student just writes "The photon picture give us the Einstein photoelectric equation K_{max} (= eV_o) = h ν - ϕ_0 which provides a correct explanation of the observed features of the photoelectric effect.	1 1	2
12.	Plot of the graph showing the variation of λ Vs $\frac{1}{\sqrt{V}}$ 1 Information regarding magnitude of charge 1  $\because \lambda = \frac{h}{\sqrt{2mqV}}$	1 ½	

	$\dfrac{\lambda}{\left(\dfrac{1}{\sqrt{v}}\right)} = \dfrac{h}{\sqrt{2mq}}$ = slope $q = \dfrac{h^2}{2m\,(slope)^2}$	½	2
13.	<u>SECTION C</u> (a) Drawing of equipotential surfaces 1 (b) Derivation of the expression of electric potential 2  **Equipotential Surfaces** [Note : Award ½ mark if the student just writes: The equipotential surfaces are the equidistant planes perpendicular to the Z -axis and does not draw them or " The equipotential surfaces are equidistant planes parallel to the X-Y Plane".] [NOTE: In this part the Hindi version requires the student to draw equipotential surfaces for a uniform magnetic field.] **"Award this 1 mark if the student just writes that these cannot be drawn."** (b)  Potential at point P $V_p = V_{-q} + V_{+q}$	1 ½	

	$= \frac{1}{4\pi \in_0}\frac{-q}{(r+a)} + \frac{1}{4\pi \in_0}\frac{q}{(r-a)}$ $= \frac{q}{4\pi \in_0}\left[\frac{1}{(r-a)} - \frac{1}{(r+a)}\right]$ $= \frac{q}{4\pi \in_0}\left[\frac{r+a-r+a}{(r-a)(r+a)}\right]$ $= \frac{q}{4\pi \in_0} \times \frac{2a}{(r^2-a^2)} = \frac{qX2a}{4\pi\varepsilon_\circ(r^2-a^2}$ $= \frac{1}{4\pi \in_0}\frac{p}{(r^2-a^2)}$ (where P is the dipole moment)	½ ½ ½	3
14.	Writing two loop equations 1 + 1 Calculation of currents through 40Ω and 20 Ω resistors 1  In loop ABCFA $+80 - 20\,I_2 + 40\,I_1 = 0$ $4 = I_2 - 2\,I_1$ In loop FCDEA $-40\,I_1 - 10(I_1 + I_2) + 40 = 0$	1	

	$-50\ I_1 - 10\ I_2 + 40 = 0$ $5\ I_1 + I_2 = 4$ Solving these two equations $I_1 = 0A$ & $I_2 = 4A$	1 ½ ½	3
	OR End error, overcoming ½ Formula for meter bridge ½ Calculation of value of S 2 The end error, in a meter bridge, is the error arising due to (i)Ends of the wire not coinciding with the 0 cm / 100 cm marks on the meter scale. (ii)Presence of contact resistance at the joints of the meter bridge wire with the metallic strips . It can be reduced/overcome by finding balance length with two interchanged positions of R and S and taking the average value of 'S' from two readings. (Note: Award this ½ make even if student just writes only the point (i) or point (ii) given above.) For a meter bridge $\frac{R}{S} = \frac{l}{100 - l}$ For the two given conditions $\frac{5}{S} = \frac{l_1}{100 - l_1}$ $\frac{5}{S/2} = \frac{1.5 l_1}{100 - 1.5 l_1}$ Dividing the two $2 = \frac{1.5 l_1}{(100 - 1.5 l_1)} \times \frac{(100 - l_1)}{l_1}$ $200 - 3\ l_1 = 150 - 1.5\ l_1$	½ ½ ½ ½	

	$l_1 = \frac{100}{3}$ cm Putting the value of l_1 in any one of the two given conditions. S = 10Ω	½ ½	3
15.	(a) Identification ½ + ½ Frequency Range ½ + ½ (b) Proof 1 Microwaves: Frequency range ($\sim$ 10^{10} to 10^{12} hz) Ultraviolet rays: Frequency range ($\sim$ 10^{15} to 10^{17} hz) Note: Award $(\frac{1}{2}+\frac{1}{2})$ marks for frequency ranges even if the student just writes the correct order of magnitude for them) (b) Average energy density of the electric field = ½ $\in_0 E^2$ = ½ $\in_0 (cB)^2$ $= \frac{1}{2} \in_0 \frac{1}{\mu_0 \in_0} B^2$ $= \frac{1}{2} \frac{B^2}{\mu_0}$ = Average energy density of the magnetic field. [Note: Award 1 mark for this part if the student just writes the expressions for the average energy density of the electric and magnetic fields.]	½+½ ½+½ ½ ½	3
16.	Definition of the wavefront 1 Verification of the law of Reflection 2 The wave front is defined as a surface of constant phase Alternatively: The wave front is a locus of points which oscillate in phase Consider a plane wave AB incident at an angle 'I' on a reflecting surface MN	1	

		1	
	let t = time taken by the wave front to advance from B to C. ∴ BC = vt		
	Let CE represent the tangent plane drawn from the point C to the sphere of radius 'vt' having A as its center.		
	then AE= BC= vt	½	
	it follows that		
	Δ EAC $\cong$ ΔBAC		
	Hence $\angle i = \angle r$	½	
	∴ Angle of incidence = angle of reflection		
	OR		3
	Definition of the refractive index — 1 Verification of laws of refraction — 2		
	The refractive index of medium 2, w.r.t medium 1 equals the ratio of the sine of angle of incidence (in medium 1) to the sine of angle of refraction (in medium 2)		
	Alternatively: Refractive index of radium 2 w.r.t medium 1 $n_{21} = \frac{\sin i}{\sin r}$		
	Alternatively : Refractive index of medium 2 w.r.t medium 1	1	
	$n_{21} = \frac{\text{Velcoity of light in medium 1}}{\text{Velocity of light in medium 2}}$		

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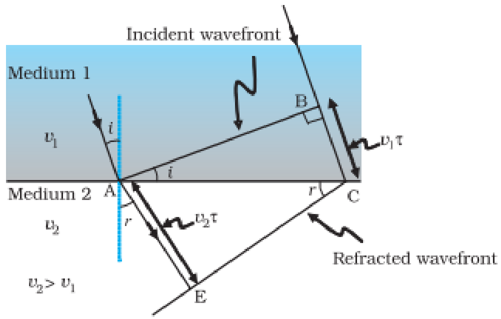

The figure drawn here shows the refracted wave front corresponding to the given incident wave front.

It is seen that

$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$

$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$

$\therefore \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu_{21}$

This is Snell's law of refraction.
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(a) Definition of mutual inductance and S.I unit 1+½
(b) Obtaining the expression for resultant force on the loop 1½

(a) Mutual inductance equals the magnetic flux associated with a coil when unit current flows in its neighbouring coil.

Alternatively: Mutual inductance equals the induced emf in a coil when the rate of change of current in its neighbouring coil is one ampere/ second.
S.I unit : henry (H) or weber/ampere (or any other correct SI unit)

(b) Force per unit length between two parallel straight conductors

$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$
Force on the part of the loop which is parallel to infinte straight wire and at a distance x from it.
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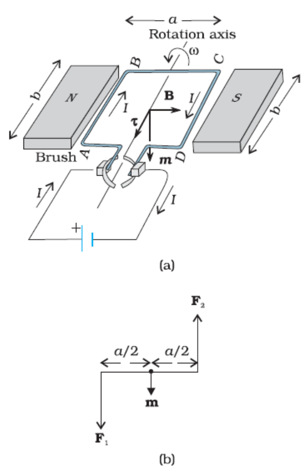
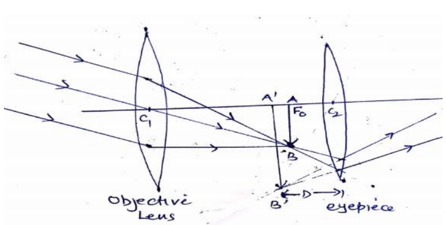
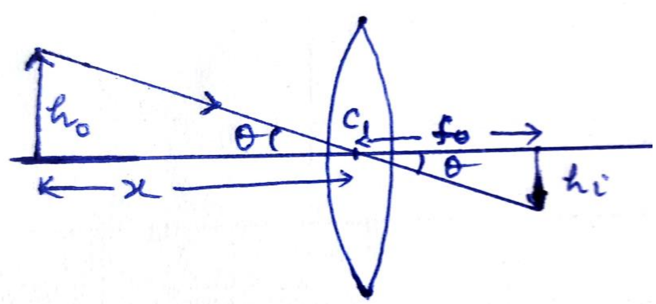
	$F_1 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{x}$ (away from the infinte straight wire) Force on the part of the loop which is at a distance (x + a) from it $F_2 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{(x + a)}$ (towards the infinte straight wire) Net force $F = F_1 - F_2$ $F = \frac{\mu_0 I_1 I_2\ a}{2\pi}\left[\frac{1}{x} - \frac{1}{x+a}\right]$ $F = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a^2}{x\,(x + a)}$ (away from the infinte straight wire)	½ ½ ½	3
18.	(a) Derivation of the expression for torque 2 (b) Significance of radial magnetic field 1 (a) Consider the simple case when a rectangular loop is placed in a uniform magnetic field B that is in the plane of the loop  Force on arm AB = F_1 = IbB (directed into the plane of the loop) Force on arm CD = F_2= IbB (directed out of the plane of the loop) Therefore the magnitude of the torque on the loop due to these pair of forces $\tau = F_1\frac{a}{2} + F_2\frac{a}{2}$	½ ½ ½	

	= I (ab) B = IAB = mB (A = ab = area of the loop) <u>Alternatively</u> Also accept if the student does calculations for the general case and obtains the result Torque = IAB sin ϕ Alternatively Also accept if the student says that the euivalent magnetic moment $\vec{m}$ (m),associated with a current carrying loop is $\vec{m} = IA\,\hat{n}$ (A = Area of loop) The torque, on a magnetic dipole, in a magnetic field, is given by $\vec{\tau} = \vec{m} \times \vec{B}$ $\therefore \quad \tau = IA(\hat{n} \times \vec{B})$ Hence Magnitude of torque is = IAB sin ϕ (b) When a current carrying coil is kept in a radial magnetic field the corresponding moving coil galvanometer would have a linear scale Alternatively " In a radial magnetic field two sides of the rectangular coil remain parallel to the magnetic field lines while its other two sides remain perpendicular to the magnetic field lines. This holds for all positions of the coil."	½ ½ 1	3
19.	Labelled ray diagram of an astronomical telescope 1 ½ Calculation of the diameter of the image of the moon. 1½  	1½	

	[Note: (i) Deduct ½ mark If arrows are not shown. (ii) Award one mark of this part if a student draws the ray diagram for normal Adjustment / relaxed eye.]		
	Angular magnification of the telescope = $\frac{f_o}{f_e} = \frac{15}{0.01} = 1500$	½	
	For objective lens, $\tan\alpha = \frac{3.48X\,10^6}{3.8X10^8}$		3
	For eyepiece $\tan\beta = \frac{h_i}{f_e} = \frac{h_i}{10^{-2}}$	½	
	∴ Magnifying power $= \frac{\beta}{\alpha} = \frac{\frac{h_i}{10^{-2}}}{\frac{3.48\,X10^6}{3.8\,X\,10^8}}$ $= \frac{h_i X 3.8 X 10^8}{3.48 X 10^6 X 10^{-2}}$ =1500		
	h_i = 13.73 cm	½	
	Also accept angular magnification of the telescope $= \frac{f_o}{f_e}\left(1 + \frac{f_e}{d}\right) = \frac{15}{0.01}\left(1 + \frac{0.01}{0.25}\right) = 1560$ So, h_i = 14.29 cm		
	Alternatively  	½	
	From figure: $\frac{h_o}{x} = \frac{h_i}{f_o}$ [Where h_o and h_i are the diameter of the moon and diameter of the image of the moon respectively.]	½	
	$h_i = \frac{h_o f_o}{x}$	½	
	$= \frac{3.48 \times 10^6}{3.8 \times 10^8} \times 15$ = 13.73cm	½	3

20.

(a)statement of Gauss's law in magnetism	½
Its significance	½
(b)Four Important properties	½ x4

(a) Gauss's law for magnetism states that "The total flux of the magnetic field, through any closed surface, is always zero. — ½

Alternatively

$$= \oint_S \vec{B}.\vec{d}s = 0$$

This law implies that magnetic monopoles do not exist" / magnetic field lines form closed loops — ½

[Note: Award this I mark if the student just attempts it]

(b) Four properties of magnetic field lines — ½

(i) Magnetic field lines always form continuous closed loops.

(ii) The tangent to the magnetic field line at a given point represents the direction of the net magnetic field at that point. — ½

(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field. — ½

(iv) Magnetic field lines do not intersect. — ½

OR

Three points of difference	3 x ½
One example of each	1½

	Diamagnetic	Paramagnetic	Ferromagnetic	
1	$-1 \le \chi < 0$	$0 < \chi < \varepsilon$	$\chi >> 1$	½
2	$0 \le \mu_r < 1$	$1 \le \mu_r < 1+\varepsilon$	$\mu_r >> 1$	½
3	$\mu < \mu_0$	$\mu > \mu_0$	$\mu >> \mu_0$	½

Where ε is any positive constant.

[Note: Give full credit of this part if student write any other three correct difference]

Examples (Any one example of each type)

Diamagnetic materials: Bi,Cu, Pb,Si, water, NaCl, Nitrogen (at STP) — ½

Paramagnetic materials: Al,Na,Ca, Oxygen(at STP), Copper chloride — ½

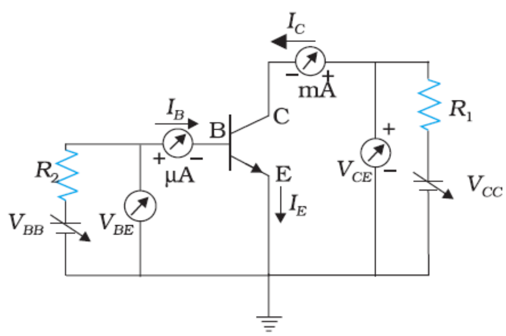
Ferromagnetic materials: Fe,Ni,Co,AlniCo — ½ — 3

21.

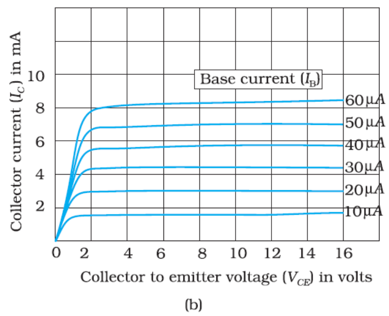
Definition of decay constant	1
Calculation of half life	1
Calculation of initial number of nuclei at t=0	1

	The decay constant (λ) of a radioactive nucleus equals the ratio of the instantaneous rate of decay $\left(\frac{\Delta N}{\Delta t}\right)$ to the corresponding instantaneous number of radioactive nuclei. Alternatively: The decay constant (λ) of a radioactive nucleus is the constant of proportionality in the relation between its rate of decay and number of its nuclei at any given instant. Alternatively: $\frac{\Delta N}{\Delta t} \propto N$ $\frac{\Delta N}{\Delta t} = \lambda N$ The constant (λ) is known as the decay constant Alternatively: The decay constant equals the reciprocal of the mean life of a given radioactive nucleus . $\lambda = \frac{1}{\tau}$ where τ= mean life Alternatively: The decay constant equal the ratio of $\ln_e 2$ to the half life of the given radioactive element. $\lambda = \frac{\ln_e 2}{T_{1/2}}$ Where $T_{1/2}$ = Half life Alternatively: The decay constant of a radioactive element, is the reciprocal of the time in which the number of its nuclei reduces to 1/e of its original number. **(Note: Do not deduct any mark of this definition, if a student does not write the formula in support of the definition)** We have $R = \lambda N$	1 ½	3

	R (20 hrs) = 10000 = λ N_{20} R (30 hrs) = 5000 = λ N_{30} $\therefore \quad \frac{N_{20}}{N_{30}} = 2$ This means that the number of nuclei, of the given radioactive nucleus, gets halved in a time of (30 - 20) hours = 10 hours $\therefore$ Half life = 10 hours This means that in 20 hours (= 2 half lives), the original number of nuclei must have gone down by a factor of 4. Hence Rate of decay at t = 0 $\lambda N_0 = 4\lambda N_{20}$ =4X10000 = 40,000 disintegration per second (Note : Award full marks of the last part of this question even if student does not calculate initial number of nuclei and calculates correctly rate of disintegration at t=0) i.e R_0 = 40,000 disintegration per second $N_0 = \frac{40000}{\lambda} = \frac{40000}{\ln_e 2} \times 10 \times 60 \times 60$ $N_0 = \frac{144 \times 10^7}{0.693} = 2.08 \times 10^9 \ nuclei$	½ ½ ½	3
22.	(a) Calculation of energy of a photon of light — 1½ (b) Identification of photodiode — 1½ Why photodiode are operated in reverse bias — 1 We have $E = h\nu = \frac{hc}{\lambda}$ $= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{600 \times 10^{-9}}$ J	½ ½	

	$= \dfrac{19.89 \times 10^{-26}}{6\times10^{-7} \times 1.6\times10^{-19}}$ eV $= \dfrac{19.89}{9.6}$ eV = 2.08eV The band gap energy of diode D_2 (= 2eV) is less than the energy of the photon. Hence diode D_2 will not be able to detect light of wavelength 600 nm. [Note: Some student may take the energy of the photon as 2eV and say that all the three diodes will be able is detect this right , Award them the ½ mark for the last part of identification] (b) A photodiode when operated in reverse bias, can measure the fractional change in minority carrier dominated reverse bias current with greater ease Alternatively: It is easier is observe the change in current with change in light intensity , if a reverse bias is applied	½ ½ 1	3
23.	(a) Functions of the three segments $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}$ (b) Circuit diagram for studying the output characteristics 1 obtaining output characteristics ½ (i) Emitter : supplies the large number of majority carriers for current flow through the transistor (ii) Base: Allows most of the majority charge carriers to go over to the collector Alternatively , It is the very thin lightly doped central segment of the transistor. Collector : collects a major portion of the majority charge carriers supplied by the emitter. (b)  The output characteristics are obtained by observing the variation of I_c when V_{CE} is varied keeping I_B constant .	½ ½ ½ 1 ½	

Note:Award the last ½ mark even if the student just draws the graph for output characteristics



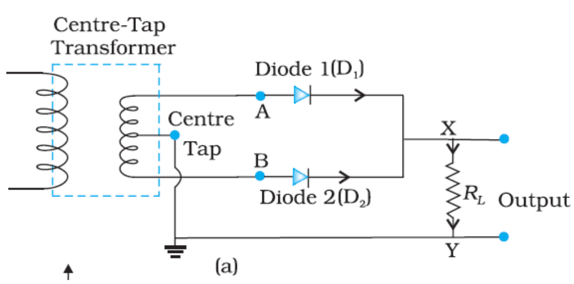
(b)

[Note: Do not deduct marks of this part, for not writing values on the axis]

OR

Circuit diagram of full wave rectifier	½
working	½
Input and output wave forms	½ + ½

The circuit diagram of a full wave rectifier is shown below.



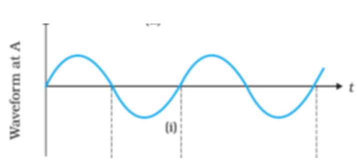
(a)

1

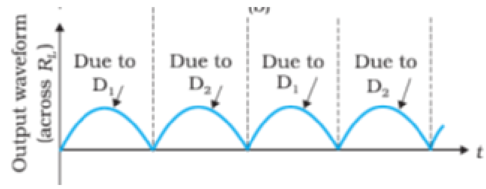
Because of the center tap in the secondary of the transformer, diodes 1 and 2 get forward biased in successive halves of the input ac cycle. However the current through the load flows in the same direction in both the halves of he input ac cycle. We therefore, get a unidirectional (rectified) current through the load for the full cycle of the input ac.

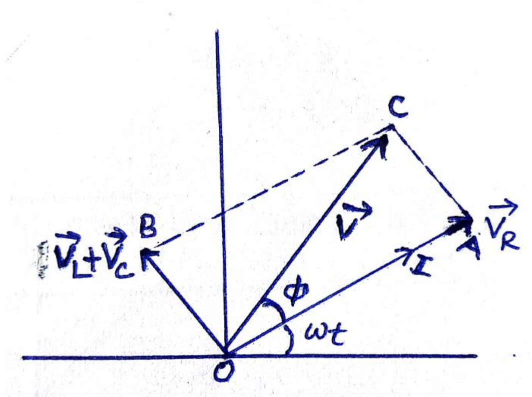
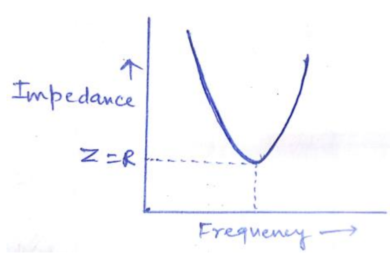
1

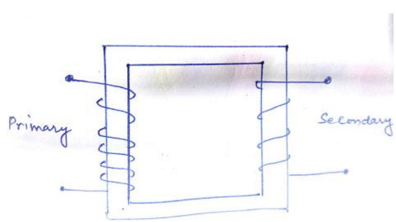
The input and output wave forms are as shown below.



½

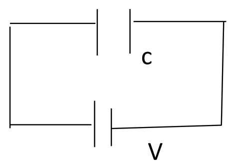
		½	3
24.	(a)Obtaining the expression for modulation index in terms of A and B 1 ½ (b) calculation of μ 1 Reason ½ We are given that $A = A_c + A_m$ and $B = A_c - A_m$ $A_c = (A + B)/2$ $A_m = (A - B)/2$ $\therefore \quad \mu = \frac{A_m}{A_c}$ $= \frac{A-B}{A+B}$ (b) We have $\mu = \frac{A_m}{A_c}$ $= \frac{10}{15} = 2/3$ μ is kept less than one to avoid distortion	½ ½ ½ ½ ½ ½	3
25.	SECTION D (a) Derivation of the expression for impedance 2 plot of impedance with frequency ½ b) Phase difference between voltage across inductor and capacitor ½ (c) Reason and calculation of self induction $\frac{1}{2}+1\frac{1}{2}$		

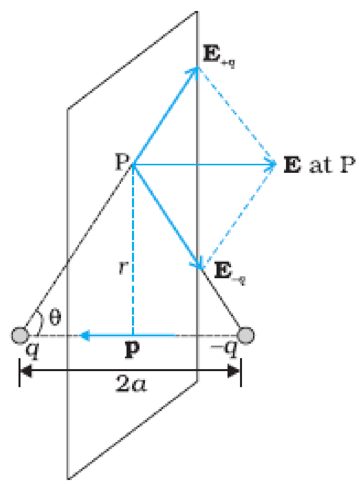
	 $\lvert\vec{V}\rvert = V_m$ $\lvert V_R\rvert = V_{Rm}$ $\lvert V_L\rvert = V_{Lm}$ From the figure, the pythagorean theorem gives $V_m^2 = V_{Rm}^2 + (V_{Lm} - V_{cm})^2$ $V_{Rm} = i_m R$, $V_{Lm} = i_m X_L$, $V_{cm} = i_m Xc$, $V_m = i_m Z$ $= (i_m Z)^2 = (I_m R)^2 + (i_m X_L - i_m X_c,)$ $z^2 = R^2 + ((X_L - X_c)^2$ $\therefore z = \sqrt{R^2 + (X_L - X_c)^2}$ [note: award these two marks, If a student does it correctly for the other case i.e $(V_c > V_L)$]  (b) Phase difference between voltage across inductor and the capacitor at resonance is 180° (c) Inductor will offer an additional impedance to ac due to its self inductance.	1 ½ ½ ½ ½ ½	

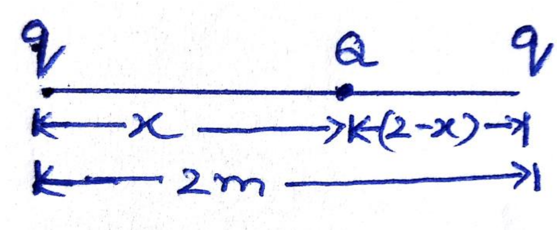
	$R=\frac{V_{rm}}{I_{rms}}=\frac{200}{1}=200\ \Omega$		
	Impedance of the inductor $Z=\frac{V_{rms}}{I_{rms}}=\frac{200}{0.5}=400\ \Omega$	½	
	Since $Z=\sqrt{R^2+(X_L)^2}$ $\therefore (400)^2-(200)^2=(X_L)^2$		
	$X_L=\sqrt{600X200}=346.4\ \Omega$	½	
	Inductance (L) $=\frac{X_L}{w}=\frac{364.4}{2X3.14X\ 50}=1.1\text{H}$	½	
	OR		
	(a) Diagram of the device — 1 working Principle — ½ Four sources of energy loss — $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}+\frac{1}{2}$ (b) Estimation of Line power loss — 1½		
	(a)  	1	
	Working Principle : When the alternating voltage is applied to the primary , the resulting current produces an alternating magnetic flux in secondary and induces an emf in it./It works on the mutual induction.	½	
	Four sources of energy loss (i) Flux leakage between primary and secondary windings (ii) Resistance of the windings (iii)Production of eddy currents in the iron core. (iv)Magnetization of the core.	½ ½ ½ ½	
	(b) Total resistance of the line = length X resistance per unit length $= 40$ km x $0.5\ \Omega/km$ $= 20\ \Omega$	½	

	Current flowing in the line I = $^{P}/_{V}$ I= $\frac{1200 X 10^3}{4000}$ = 300A ∴ *Line power loss in the form of heat* P=I^2 R =$((300)^2$ x 20 = 1800 kW	½ ½	5
26.	(a) ~~Two characteristic~~Two characteristic features of distinction ___2 ~~Dervation~~Derivation of the expression for the intensity $1\frac{1}{2}$ (b) Calculation of separation between the first order (a) (Any two of the following) (i) Interference pattern has number of equally spaced bright and dark bands while diffraction pattern has central bright maximum which is twice as wide as the other maxima. (ii) Interference is obtained by the superposing two waves originating from two narrow slits. The diffraction pattern is the superposition of the continuous family of waves originating from each point on a single slit. (iii) In interference pattern, the intensity of all bright fringes is same, while in diffraction pattern intensity of bright fringes go on decreasing with the increasing order of the maxima (iv)In interference pattern , the first maximum falls at an angle of $\frac{\lambda}{a}$. where a is the separation between two narrow slits, while in diffraction pattern, at the same angle first minimum occurs. (where 'a' is the width of single slit.) Displacement produced by source s_1 Y_1 = a cos wt Displacement produced by the other source 's_2' Y_2= a cos (wt + Ø) Resultant displacement Y = Y_1 + Y_2 = a [cos wt + cos (wt + Ø) = 2a cos ($^{Ø}/_{2}$) cos (wt + $^{Ø}/_{2}$) Amplitude of resultant wave A= 2a cos ($^{Ø}/_{2}$) Intensity I α A^2 I= KA^2= K 4 $a^2 cos^2$ ($\frac{Ø}{2}$)	½ + ½ ½ + ½ ½ ½ ½	

	(a) Distance of First order minima from centre of the central maxima = $x_{D1}=\frac{\lambda D}{a}$ Distance of third order maxima from centre of the central maxima $X_{B3}=\frac{7D\lambda}{2a}$ ∴ Distance between first order minima and third order maxima= $x_{B3} - x_{d1}$ $= \frac{7D\lambda}{2a} - \frac{\lambda D}{a}$ $= \frac{5D\lambda}{2a}$ $= \frac{5\ X\ 620\ X\ 10^{-9}\ X\ 1.5}{2X3X10^{-3}}$ $=775\ X\ 10^{-6}$m $=7.75\ X\ 10^{-4}$m	½ ½ ½	
	OR (a) Two conditions of total internal reflection — 1 +1 (b) Obtaining the relation — 1 (c) Calculating of the position of the final image — 2		
	(a) (i) Light travels from denser to rarer medium. (ii) Angle of incidence is more than the critical angle For the Grazing incidence μ sin i_c = 1 sin 90° $\mu = \frac{1}{sin i_c}$ (b) For convex lens of focal Length 10 cm $\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$ $\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-30}$ => v_1 = 15 cm Object distance for concave lens u_2= 15-5 =10 cm $\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$ $\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{10}$ $v_2 = \infty$	1 1 ½ ½ ½ ½ ½	

	For third lens $\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$ $\frac{1}{3_\circ} = \frac{1}{v_3} - \frac{1}{\infty} \Rightarrow v_3 = 30\ cm$	½	5
27.	a) Description of the process of transferring the charge. $\frac{1}{2}$ Derivation of the expression of the energy stored $2\frac{1}{2}$ b) Calculation of the ratio of energy stored 2		
	(a) 		
	The electrons are transferred to the positive terminal of the battery from the metallic plate connected to the positive terminal, leaving behind positive charge on it. Similarly, the electrons move on to the second plate from negative terminal, hence it gets negatively charged. Process continuous till the potential difference between two plates equals the potential of the battery. [Note: award this $\frac{1}{2}$ mark, If the student writes, there will be no transfer of charge between the plates]	½	
	Let 'dw' be the work done by the battery in increasing the charge on the capacitor from q to (q+ dq).		
	$dW = V\ dq$	½	
	Where $V = \frac{q}{c}$	½	
	$\therefore dW = \frac{q}{c} dq$	½	
	Total work done in changing up the capacitor		
	$W = \int dw = \int_0^Q \frac{q}{c} dq$	½	
	$\therefore W = \frac{Q^2}{2C}$	½	
	Hence energy stored = $W = \frac{Q^2}{2C}$ $(= \frac{1}{2} CV^2 = \frac{1}{2} QV)$		
	(b) Charge stored on the capacitor q=CV When it is connected to the uncharged capacitor of same capacitance, sharing of charge takes place between the two capacitor till the potential of both the capacitor becomes $\frac{V}{2}$	½	

	Energy stored on the combination $(u_2) = \frac{1}{2}\text{C}\left(\frac{\text{V}}{2}\right)^2 + \frac{1}{2}\text{C}\left(\frac{\text{V}}{2}\right)^2 = \frac{CV^2}{4}$	½	
	Energy stored on single capacitor before connecting	½	
	$U_1 = \frac{1}{2}CV^2$		
	Ratio of energy stored in the combination to that in the single capacitor		
	$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2}$ = 1:2	½	
	OR		
	(a) Derivation for the expression of the electric field on the equatorial line — 3 (b) Finding the position and nature of Q — 1 + 1		
	(a)  	1	
	The magnitude of the electric fields due to the two charges +q and -q are		
	$E_{+q} = \frac{1}{4\pi \in_0} \frac{q}{\left(r^2+a^2\right)}$	½	
	$E_{-q} = \frac{1}{4\pi \in_0} \frac{q}{\left(r^2+a^2\right)}$	½	
	The components normal to the dipole axis cancel away and the components along the dipole axis add up		5
	Hence total Electric field = - $(E_{+q} + E_{-q})\cos\theta \ \hat{p}$	½	

	$E = -\frac{2qa}{4\pi\varepsilon_0 \left(r^2 + a^2\right)^{3/2}} \hat{p}$	½	
	(b)  	½	
	System is in equilibrium therefore net force on each charge of system will be zero. For the total force on 'Q' to be zero $\frac{1}{4\pi \in_0} \frac{qQ}{x^2} = \frac{1}{4\pi \in_0} \frac{qQ}{\left(2-x\right)^2}$	½	
	x = 2 – x 2x = 2 x = 1 m	½	
	(Give full credit of this part, if a students writes directly 1m by observing the given condition) For the equilibrium of charge "q" the nature of charge Q must be opposite to the nature of charge q.	½	5