General Instructions :

(i) All questions are compulsory.

(ii) There are 30 questions in total. Question Nos. 1 to 8 are very short answer type questions and carry one mark each.

(iii) Question Nos. 9 to 18 carry two marks each. Question Nos. 19 to 27 carry three marks each and question nos. 28 to 30 carry five marks each.

(iv) One of the questions carrying three marks weightage is value based question.

(v) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each weightage. You have to attempt only one of the choices in such questions.

(vi) Use of calculators is not permitted. However, you may use log tables if necessary.

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

\[ c = 3 \times 10^8 \text{ m/s} \]
\[ h = 6.63 \times 10^{-34} \text{ Js} \]
\[ e = 1.6 \times 10^{-19} \text{ C} \]
\[ \mu_0 = 4\pi \times 10^{-7} \text{ T mA}^{-1} \]
\[ \frac{1}{4\pi \varepsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2} \]
\[ m_e = 9.1 \times 10^{-31} \text{ kg} \]
Define the term ‘Mobility’ of charge carriers in a conductor. Write its S.I. unit.

\[ C(t) = 2 \sin (8\pi t) \text{ volt.} \]

The carrier wave is given by

\[ C(t) = 2 \sin (8\pi t) \text{ volt.} \]

The modulating signal is a square wave as shown. Find modulation index.

Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why?

Show variation of resistivity of copper as a function of temperature in a graph.
6. A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens?

7. Write the expression, in a vector form, for the Lorentz magnetic force \( \mathbf{F} \) due to a charge moving with velocity \( \mathbf{V} \) in a magnetic field \( \mathbf{B} \). What is the direction of the magnetic force?

8. The figure given below shows the block diagram of a generalized communication system. Identify the element labelled ‘X’ and write its function.

9. Out of the two magnetic materials, ‘A’ has relative permeability slightly greater than unity while ‘B’ has less than unity. Identify the nature of the materials ‘A’ and ‘B’. Will their susceptibilities be positive or negative?
10. Given a uniform electric field \( \mathbf{E} = 5 \times 10^3 \text{ N/C} \) through a square of 10 cm on a side whose plane is parallel to the y-z plane. What would be the flux through the same square if the plane makes a 30° angle with the x-axis?

11. For a single slit of width “\(a\)”, the first minimum of the interference pattern of a monochromatic light of wavelength \(\lambda\) occurs at an angle of \(\frac{\lambda}{a}\). At the same angle of \(\frac{\lambda}{a}\), we get a maximum for two narrow slits separated by a distance “\(a\)”. Explain.
13. विद्युत नियम लिखिए। संचार में व्याख्या कीजिए कि ये नियम किस प्रकार न्यायसंगत हैं।

State Kirchhoff’s rules. Explain briefly how these rules are justified.

14. दर्शाएं अनुसार किसी परिपथ में एस देन्स के साथ श्रेणीक्रम में संयोजित ‘C’, परिवर्ती प्रतिरोधक ‘R’ तथा कोई बल्ब ‘B’ संयोजित है। बल्ब जल्दी चमकने के साथ जलता है। (i) प्रतिरोधक R को समान रखकर, संयोजित को परिवर्तन के बीच कोई परलोक पट्टिका रख दी जाए, (ii) धारता को समान रखकर प्रतिरोधक R में वृद्धि कर दी जाए, तो बल्ब की चमक क्या परिवर्तन होगा?

A capacitor ‘C’, a variable resistor ‘R’ and a bulb ‘B’ are connected in series to the ac mains in circuit as shown. The bulb glows with some brightness. How will the glow of the bulb change if (i) a dielectric slab is introduced between the plates of the capacitor, keeping resistance R to be the same; (ii) the resistance R is increased keeping the same capacitance?

15. साइक्लोट्रॉन का मूल तत्त्व लिखिए। संचार में उल्लेख कीजिए कि इस मशीन का उपयोग आवश्यक कारणों को उच्च ऊर्जा के लिए व्याप्त करने में किस प्रकार किया जाता है?

State the underlying principle of a cyclotron. Write briefly how this machine is used to accelerate charged particles to high energies.

16. 4 cm लम्बाई के किसी बैरियल दिप्लॉड को, जब किसी एकसामान दिप्लॉड क्षेत्र में इस प्रकार रखा जाता है कि दिप्लॉड का अस्थि शेर से 60° का कोण बना, तब वह दिप्लॉड 4√3 Nm के बल आपूर्ण का अनुसरण करता है। यदि इस पर आवेश ± 8 nC है, तो इस दिप्लॉड को विद्युत ऊर्जा परिवर्तन कीजिए।

An electric dipole of length 4 cm, when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of 4√3 Nm. Calculate the potential energy of the dipole, if it has charge ±8 nC.
17. A proton and a deuteron are accelerated through the same accelerating potential. Which one of the two has
(a) greater value of de-Broglie wavelength associated with it, and
(b) less momentum?
Give reasons to justify your answer.

18. (i) Monochromatic light of frequency $6.0 \times 10^{14}$ Hz is produced by a laser. The power emitted is $2.0 \times 10^{-3}$ W. Estimate the number of photons emitted per second on an average by the source.

(ii) Draw a plot showing the variation of photoelectric current versus the intensity of incident radiation on a given photosensitive surface.

19. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited?
Calculate the wavelengths of the first member of Lyman and first member of Balmer series.
20. When Sunita, a class XII student, came to know that her parents are planning to rent out the top floor of their house to a mobile company she protested. She tried hard to convince her parents that this move would be a health hazard.

Ultimately her parents agreed:

(1) In what way can the setting up of a transmission tower by a mobile company in a residential colony prove to be injurious to health?

(2) By objecting to this move of her parents, what value did Sunita display?

(3) Estimate the range of e.m. waves which can be transmitted by an antenna of height 20 m. (Given radius of the earth = 6400 km)

21. A potentiometer wire of length 1 m has a resistance of 10 Ω. It is connected to a 6 V battery in series with a resistance of 5 Ω. Determine the emf of the primary cell which gives a balance point at 40 cm.

22. (a) Draw a labelled ray diagram showing the formation of a final image by a compound microscope at least distance of distinct vision.

(b) The total magnification produced by a compound microscope is 20. The magnification produced by the eye piece is 5. The microscope is focussed on a certain object. The distance between the objective and eye piece is observed to be 14 cm. If least distance of distinct vision is 20 cm, calculate the focal length of the objective and the eye piece.
23. (a) A mobile phone lies along the principal axis of a concave mirror. Show, with the help of a suitable diagram, the formation of its image. Explain why magnification is not uniform.

(b) Suppose the lower half of the concave mirror’s reflecting surface is covered with an opaque material. What effect this will have on the image of the object? Explain.

24. (a) Obtain the expression for the energy stored per unit volume in a charged parallel plate capacitor.
(b) The electric field inside a parallel plate capacitor is E. Find the amount of work
done in moving a charge q over a closed rectangular loop a b c d.

OR

(a) Derive the expression for the capacitance of a parallel plate capacitor having
plate area A and plate separation d.

(b) Two charged spherical conductors of radii R_1 and R_2 when connected by a
conducting wire acquire charges q_1 and q_2 respectively. Find the ratio of their
surface charge densities in terms of their radii.

25. (a) समानलयन सी बनाने में व्यक्त करी एन्डरियर का परिपेक्ष निम्न लिखित है।

(b) समान लम्बाई के दो लम्ब समान विद्युतरोधी सोलनाइड S_1 तथा S_2 चित्र में दर्शाए अनुसार एक-दूसरे
के ऊपर लिप्त हैं। कोई व्यमी धारा “I” भीतरी सोलनाइड S_1 से इसके दूसरे सिरे B तक प्रवाहित
होती है, जो बाहरी सोलनाइड S_2 से संयोजित है तथा जिससे समान धारा “I” विकसित दिशा में प्रवाहित
होकर सिरे A से बाहर आती है। यदि इनमें प्रति इकाई लम्बाई लपेटों की संख्या n_1 तथा n_2 है, तो (i)
अक्ष पर भीतरी तथा (ii) संयुक्त निकाय के बाहर किसी विन्दु पर कुल चुम्बकीय क्षेत्र का परिमाण और
dिशा ज्ञात कीजिए।
(a) State Ampere’s circuital law, expressing it in the integral form.

(b) Two long coaxial insulated solenoids, S₁ and S₂ of equal lengths are wound one over the other as shown in the figure. A steady current “I” flows through the inner solenoid S₁ to the other end B, which is connected to the outer solenoid S₂ through which the same current “I” flows in the opposite direction so as to come out at end A. If n₁ and n₂ are the number of turns per unit length, find the magnitude and direction of the net magnetic field at a point (i) inside on the axis and (ii) outside the combined system.

26. निम्नलिखित के उत्तर दीजिए:

(a) उन वैद्युत धमाकीय तरंगों का नाम लिखिए जो रेडियो प्रणालियों में मापदंड संचालन में उपयोग के लिए उपयुक्त हैं। इन तरंगों का आवश्यक परामर्श लिखिए।

(b) यदि पृथ्वी पर बादामण्डल न होता, तो इसका औसत पृथ्वीय ताप आज के ताप की तुलना में अधिक होता अथवा कम? व्याख्या कीजिए।

(c) कोई वैद्युत धमाकीय तरंग लिस्ट गुण्ड पर आपत्ति करती है, उस पर दाब आरोपित करती है। इसकी पूर्व तौल पीवीएस कीजिए।

Answer the following:

(a) Name the em waves which are suitable for radar systems used in aircraft navigation. Write the range of frequency of these waves.

(b) If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.

(c) An em wave exerts pressure on the surface on which it is incident. Justify.
27. (a) Radioactivity occurs in decay of the nucleus for which expression, \( N = N_0 e^{-\lambda t} \) be written.

(b) (i) In the decay of \(^{22}\text{Na}\) by the beta \((\beta^-)\) decay, the expression for the nuclear reaction is given by \( ^{22}\text{Na} \to ^{22}\text{Mg} + e^- + \bar{\nu} \). The nuclear reaction for the decay of \(^{22}\text{Na}\) is \(^{22}\text{Na} \to ^{22}\text{Mg} + e^- + \bar{\nu} \).

(ii) In the decay of \(^{22}\text{Na}\), the nucleus formed is \(^{22}\text{Mg}\), which is an isotope.

(a) Deduce the expression, \( N = N_0 e^{-\lambda t} \), for the law of radioactive decay.

(b) (i) Write symbolically the process expressing the \(\beta^-\) decay of \(^{22}\text{Na}\). Also write the basic nuclear process underlying this decay.

(ii) Is the nucleus formed in the decay of the nucleus \(^{22}\text{Na}\), an isotope or isobar?

28. (a) (i) The expression for the total mass of the object can be written as \( \sum m = \sum m_i \).

(ii) The expression for the total angular momentum of the system can be written as \( \sum J = \sum J_i \).

(b) The expression for the total energy of the system can be written as \( \sum E = \sum E_i \).

29. (a) (i) ‘Two independent monochromatic sources of light cannot produce a sustained interference pattern’. Give reason.

(ii) Light waves each of amplitude “a” and frequency “w”, emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by \( y_1 = a \cos wt \) and \( y_2 = a \cos(wt + \phi) \) where \( \phi \) is the phase difference between the two, obtain the expression for the resultant intensity at the point.
(b) In Young’s double slit experiment, using monochromatic light of wavelength \( \lambda \), the intensity of light at a point on the screen where path difference is \( \lambda \), is \( K \) units. Find out the intensity of light at a point where path difference is \( \lambda/3 \).

OR

(a) How does one demonstrate, using a suitable diagram, that unpolarised light when passed through a Polaroid gets polarised?

(b) A beam of unpolarised light is incident on a glass-air interface. Show, using a suitable ray diagram, that light reflected from the interface is totally polarised, when \( \mu = \tan \theta_B \), where \( \mu \) is the refractive index of glass with respect to air and \( \theta_B \) is the Brewster’s angle.

29. (a) किसी ऐसे सरल प्रयोग (अथवा कियाकलाप) का वर्णन कीजिए जो यह दर्शाता है कि किसी कुण्डली में प्रेरित विद्युत बहुक बल (emf) की धुना स्वैच्छिक इस प्रकार होती है कि वह ऐसी धारा उत्पन्न करने का प्रयास करती है जो उसे उत्पन्न करने वाले चुम्बकीय फ्लॅक्स में परिवर्तन का विरोध करें

(b) किसी प्रेरक जिसका रोटेशन काँटा \( L \) है, से प्रवाहित धारा में निरन्तर वृद्धि हो रही है। निम्नलिखित विचारणों को दर्शाने के लिए ग्राफ खोजिए:

(i) चुम्बकीय फ्लॅक्स और धारा के बीच
(ii) प्रेरित emf और \( \frac{dl}{dt} \) के बीच
(iii) सतही चुम्बकीय रिश्तन ऊर्जा और धारा के बीच

(a) मूल अवधारों का वर्णन करते हुए किसी ac जनवर का वृत्ताकार आरोह खोजिए। इसके कार्यकारी धिराश्लाना का संयोग में उल्टेंद कौटीए। किसी चुम्बकीय क्षेत्र में गूणजन करने वाले किसी लूप (फास) द्वारा जनित

(i) चुम्बकीय फ्लॅक्स, तथा
(ii) प्रत्यायत emf और समय के बीच विचारण को दर्शाने के लिए ग्राफ खोजिए।

(b) ac मैंस के साथ प्रतिदिन नलिका के उपयोग में चाक कुण्डली की आवश्यकता क्यों होती है?
(a) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce a current which opposes the change of magnetic flux that produces it.

(b) The current flowing through an inductor of self inductance \( L \) is continuously increasing. Plot a graph showing the variation of

(i) Magnetic flux versus the current
(ii) Induced emf versus \( \frac{dl}{dt} \)
(iii) Magnetic potential energy stored versus the current.

OR

(a) Draw a schematic sketch of an ac generator describing its basic elements. State briefly its working principle. Show a plot of variation of

(i) Magnetic flux and
(ii) Alternating emf versus time generated by a loop of wire rotating in a magnetic field.

(b) Why is choke coil needed in the use of fluorescent tubes with ac mains?

30. (a) एक प-एन संधि के माध्यम से व्याप्ति प्रक्रिया का समाप्ति में उत्पन्न कीजिए और इसकी भी स्वतंत्र रूप से व्याप्ति कीजिए कि हारणी क्षेत्र का निर्माण किस प्रकार होता है

(b) आवर्तक परिपथ आरेखों को सहायता से यह दर्शाएं कि किसी p-n संधि के लिए

(i) आवर्तक वातावरण
(ii) परिपथिक वातावरण में V-I अभिलाभिक किस प्रकार प्राप्त किया जाता है।

द्वितीयकारण में इन अभिलाभियों का उपयोग किस प्रकार किया जाता है?

(a) किसी ट्रांजिस्टर के तीन खंडों के बीच उनके साझा और मादन-स्तर के आधार पर विनियम कीजिए।

(b) किसी ट्रांजिस्टर को किस प्रकार बायपास करके सक्षम अवस्था में लाया जाता है?

(c) आवर्तक परिपथ आरेख की सहायता से व्याप्ति कीजिए कि CE विनियम में कोई n-p-n ट्रांजिस्टर, किस प्रकार किसी लघु ज्या वक्रीय निवेशी वोल्टेज का प्रवर्तन करता है। ac धारा लिख के लिए सूत्र लिखिए।
(a) State briefly the processes involved in the formation of p-n junction explaining clearly how the depletion region is formed.

(b) Using the necessary circuit diagrams, show how the V-I characteristics of a p-n junction are obtained in

(i) Forward biasing

(ii) Reverse biasing

How are these characteristics made use of in rectification?

OR

(a) Differentiate between three segments of a transistor on the basis of their size and level of doping.

(b) How is a transistor biased to be in active state?

(c) With the help of necessary circuit diagram, describe briefly how n-p-n transistor in CE configuration amplifies a small sinusoidal input voltage. Write the expression for the ac current gain.