2019
PHYSICS
(Theory)
Full Marks: 70
Pass Marks: 21
Time: Three hours
Attempt all Questions.

The figures in the right margin indicate full marks for the questions.

Question Nos. 1 to 10, are "Very Short Answer" type questions carrying 1 mark each.

1. Use the expression $\vec{F} = q \left( \vec{v} \times \vec{B} \right)$ for the force experienced by a charge $q$ moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ to define the SI unit of magnetic field.

2. Where on the surface of the earth is the vertical component of earth's magnetic field zero?

3. The electric current flowing in a wire from P to Q is decreasing. Find out the direction of the induced current in the metallic loop kept above the wire as shown in the figure.
4. Find the reactance of a capacitor having a capacitance \( \frac{1}{\pi} \mu F \) at 50 Hz. 

5. The electric field vector of a plane electromagnetic wave oscillates sinusoidally at a frequency of 300 MHz. What is its wavelength? 

6. Find the de-Broglie wavelength of an electron accelerated through a potential difference of 100 V. 

7. Write the relation between average life and decay constant of a radioactive atom. 

8. Identify the logic gate and write its Boolean expression. 

9. Draw a neat labelled circuit diagram showing the use of an n-p-n transistor as a common emitter amplifier. 

10. What is sky wave propagation? Mention the frequency range used by this type of propagation. 

*Question Nos. 11 to 20 are ‘Short Answer Type-II’ questions carrying 2 marks each.*

11. Obtain the expression for the energy stored in a parallel plate capacitor of capacitance \( C \) charged to a potential \( V \). 

12. A point charge of 4.427 \( \mu C \) is at the centre of a cubic Gaussian surface 9.0 cm on the edge. Find the net electric flux through the surface. 

13. In the network shown, the equivalent resistance between A and B is \( \frac{4}{3} \Omega \). Find the value of \( r \). 

XXII Phy (T) 16/19 2
14. A horizontal overhead power line carries a current of 30 \( A \) in the east to west direction. What is the magnitude and direction of the magnetic field due to the current at a point 1.5\( m \) below the line. \( \left( \mu_0 = 4\pi \times 10^{-7} \text{T} \cdot \text{mA}^{-1} \right) \)

15. What is displacement current and write the modified Ampere's circuit law.

16. The refractive index of plastic is \( \sqrt{3} \). Calculate the angle of refraction for a ray of light incident at polarizing angle.

17. In a transistor, \( I_C = 0.98 \), \( I_B = 20 \mu A \). Find (i) \( \alpha \) and (ii) \( \beta \) of the transistor.

18. \[
\begin{array}{c}
\text{Unregulated Voltage} \\
\text{\textbackslash{}text{Regulated Voltage}}
\end{array}
\]

A zener diode of rating 100 \( mW \) is to be used as a voltage regulator. If the zener diode has the breakdown voltage of 5\( V \) and it has to regulate voltage which fluctuate between 3\( V \) and 7\( V \), what should be the value of \( R_s \) for safe operation.

19. Using block diagrams, name the segments of general communication system.

20. Write two points of advantages of FM broadcasting over AM broadcasting.

Question Nos. 21 to 27 are 'Short Answer Type-I' questions carrying 3 marks each.

21. Three charges of 1\( nC \), 2\( nC \) and 3\( nC \) are placed at the corners of an equilateral triangle of side \( \sqrt{3} \). Calculate electrostatic potential at a point equidistant from the three corners of the triangle.
22. Describe how a galvanometer can be converted into an ammeter.

23. Define self inductance and write its SI unit. Derive an expression for self inductance of a long solenoid of length \( l \), cross sectional area \( A \) having \( N \) number of turns.

24. A series LCR circuit with \( R = 1k \Omega, L = 1.0 \, mH, C = 0.001 \, \mu F \) is connected to a sinusoidal voltage of peak value \( 200\sqrt{2} \, V \). When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one cycle.

25. Write three points of difference between interference and diffraction.

26. Draw ray diagrams to show how a right angled prism can be used to deviate a ray of light through (i) 90° and (ii) 180°

27. 

In the fig. shown, two monochromatic radiations of intensities \( I_1 \) and \( I_2 \) (\( I_1 > I_2 \)) having the same frequency are in turn incident on a photo sensitive surface causing photo electric emission. Curve A and B show the variation of photo electric current with accelerating potential. Identify the curves representing radiation with intensity \( I_1 \) and \( I_2 \) giving reason. Also give reason why the two curves have the same stopping potential \( V_0 \).
Question Nos. 28 to 30 are ‘Long Answer Type’ questions carrying 5 marks each.

28. State Kirchhoff’s laws for an electric network. Using Kirchhoff’s laws obtain the balance condition in terms of resistances of four arms of a Wheatstone’s bridge.  

OR

Describe with the help of necessary circuit diagram how to determine the specific resistance of the material of a wire by using a metre bridge.  

29. Deduce Lens Makers formular for a double convex lens  

\[
\frac{1}{f} = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)
\]

where the symbols have their usual meanings.  

OR

Deduce the mirror formula  

\[
\frac{1}{v} + \frac{1}{u} = \frac{1}{f}
\]

(where the symbols have their usual meanings) for a concave mirror forming real image.  

30. Write the nuclear reaction of \( ^{235}_{92}U \) bombarded with a slow neutron. Calculate the energy released in KWh in the fission of 50 kg of \( ^{235}_{92}U \).  

OR

Using Bohr’s quantization condition for angular momentum of an electron revolving around the hydrogen nucleus, establish the expression of the radius of the stationary orbits of hydrogen atom.
Question Nos. 31 to 34 are ‘Multiple Choice Type’ questions carrying 1 mark each. Choose the correct answer out of the four alternatives and rewrite the correct answer.

31. If a charge \( q \) is placed at the centre of the line joining two equal charges \( Q \) such that the system is in equilibrium, then value of \( q \) is

A. \( \frac{Q}{2} \)

B. \( -\frac{Q}{2} \)

C. \( \frac{Q}{4} \)

D. \( -\frac{Q}{4} \)

32. A charged particle of mass \( m \) and charge \( q \) moves along a circular path of radius \( r \) that is perpendicular to a magnetic field \( B \). The time taken by the particle to complete one revolution is

A. \( \frac{2\pi mq}{B} \)

B. \( \frac{2\pi q^2 B}{m} \)

C. \( \frac{2\pi qB}{m} \)

D. \( \frac{2\pi m}{qB} \)
33. A laser operating at $3 \times 10^{14}$ Hz passes through an aperture of $10^{-2}m$. The angular spread in radians is

A. $10^{-2}$  
B. $10^{-4}$  
C. $10^{-6}$  
D. $10^{-8}$

34. Pure Silicon at 300 K has equal number of electrons and holes concentration of $1.5 \times 10^{16} \text{m}^{-3}$. Doping by indium increases the hole concentration ($n_h$) to $4.5 \times 10^{22} \text{m}^{-3}$. The number of electrons concentration ($n_e$) in doped Silicon is

A. $9 \times 10^{5}$  
B. $9 \times 10^{9}$  
C. $2.25 \times 10^{11}$  
D. $3 \times 10^{19}$