SAMPLE PAPER-04
PHYSICS (Theory)
(Questions)
Class – XII

Time allowed: 3 hours Maximum Marks: 70

General Instructions:

a) All the questions are compulsory.
b) There are **26** questions in total.
c) Questions **1** to **5** are very short answer type questions and carry **one** mark each.
d) Questions **6**to **10** carry **two** marks each.
e) Questions **11** to **22** carry **three** marks each.
f) Questions **23** to **26** carry **five** marks each.
g) 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 in five marks each. You have to attempt only one of the choices in such questions.
h) Use of calculators is **not** permitted. However, you may use log tables if necessary.
i) You may use the following values of physical constants wherever necessary:

$c = 3x10^{8} m/s$

$h = 6.63x10^{-34} Js$

$e = 1.6x10^{-19} C$

$\mu_o = 4\pi x10^{-7} TmA^{-1}$

$\frac{1}{4\pi\varepsilon_0} = 9x10^{9} Nm^2C^{-2}$

$m_e = 9.1x10^{-31} kg$

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1. What is the basic use of capacitor?
2. The current i flows in a wire of circular cross section with the free electrons travelling with a drift velocity v. What is the drift velocity of electrons when a current of 2i flows in another wire of twice the radius and of the same material?
3. A radioactive material has a half life of 1 minute. If one of the nuclie decays now, when will the next one decay?
4. What is the value of conductivity of a semiconductor at absolute zero?
5. The surfaces of sunglasses are curved, yet their power may be zero. Why?
6. Define the term electric dipole moment. Is it a scalar or a vector quantity?
7. In what ways electric and magnetic fields are different?
8. Velocity of light in glass is 2×10^8 m/s and that in air 3×10^8 m/s. By how much would an ink dot appear to be raised, when covered by a glass plate 6.0 cm thick?
9. In a photoelectric effect experiment, for radiation with frequency ν_0, with $h\nu_0 = 8$ eV, electrons are emitted with energy 2 eV. What is the energy of the electrons emitted for incoming radiation of frequency $1.25\nu_0$?
10. Why is an FM signal less susceptible to noise than an AM signal?
11. (a) What is meant by energy density of a parallel plate capacitor? Derive its expression also.

(b) What is the area of the plates of a 2 Farad parallel plate air capacitor, given that the separation between the plates is 0.5 cm?

12. (a) For the given carbon resistor, let the first strip be yellow, second strip be red, third strip be orange and forth be gold. What is its resistance? (b) What are thermistors?

13. State Ampere's circuital law. Also find the expression for the magnetic field due to the infinite long straight wire carrying current by using this law.

14. (a) What do you mean by hypermetropia? What are its possible cause and how it is corrected? (b) A hypermetropic person whose near point is at 100 cm wants to read a book at 25 cm. Find the nature and power of the lens needed.

15. Light falls from glass (n = 1.5) to air. Find the angle of incidence from which the angle of deviation is 90^0?

16.

a) Represent the AM process graphically.

b) Write its two advantages

17. Why is the mass of a nucleus always less than the sum of the masses of its constituents, neutrons and protons?

18. Define coefficient of mutual inductance of two cells. A secondary coil of n_2 turns is wound on a long solenoid of area of cross section A having a primary coil of n_1 turns per unit length. What is the mutual inductance of the two cells?

19.

a. What is transmission medium?

b. Explain the term short wave band and medium wave band.

c. What is a transducer?

20. Three point charges of +2μc and -3μc are kept at the vertices A,B and C respectively of an equilateral triangle of side 20cm. what should be the sign and magnitude of the charge to be placed at the mid-point M of side BC. So that charges at remains in equilibrium.

21.

a. What do you understand by the term 'magnetic length' and 'geometric length' of the magnet?

b. How are the two related to each other?

c. Define angle of a dip at a given place.

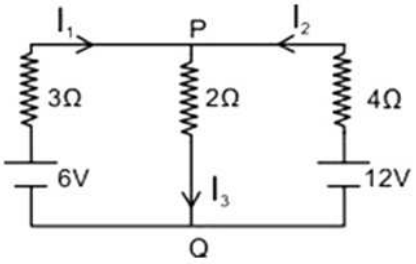
22. The oscillating magnetic field in a plane electromagnetic wave is given by $B_\gamma = 8\text{x}10^{-6}\sin(20\text{x}10^{11}t + 300\pi x)T$. Calculate the wavelength of electromagnetic wave. Write down the expression for oscillating electric field.

23. Ram had gone out of station, on a vacation for one week. After coming back, he tried to start his car but failed. He realizedthat he needs to charge the battery of his car. He went to the workshop to hire a battery charger. Ram connected the black lead of the battery charger to the positive terminal of the car battery and the red lead to the negative terminal of the car battery. The car battery was not charged. Ram thought over it and decided to reverse the leads. Now he was successful in charging the car battery.

a. What according to you are the values displayed by Ram?

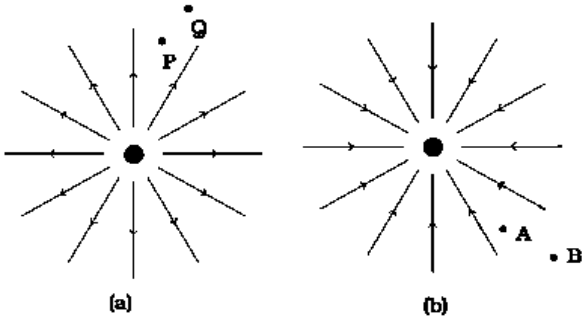
b. How should a battery charger be connected to a car battery?

24. Calculate the value of current I_1, I_2 and I_3 in the circuit given below usingKirchhoff's law.



Or

The diagram given below shows the field lines of a positive and negative point charge respectively.



a) Give the signs of the potential difference $V_P - V_Q$; $V_B - V_A$.

b) Give the sign of the potential energy difference of a small negative charge between the points Q and P; A and B.

c) Give the sign of the work done by the field in moving a small positive charge from Q to P.

d) Give the sign of the work done by the external agency in moving a small negative charge from B to A.

e) Does the kinetic energy of a small negative charge increase or decrease in going from B to A?

25. An object is placed at (i) 10 cm; (ii) 5 cm in front of a concave mirror of radius of curvature 15 cm. Find the position, nature, and magnification of the image in each case.

Or

Answer the following:

a. A virtual image, we always say cannot be caught on a screen. Yet, when we see a virtual image we are obviously, bringing it on the screen of our eye. Is there a contradiction?

b. Why must both objective and eye piece of a compound microscope have short focal lens?

c. When viewing through a compound microscope, our eye should be positioned not on the eye piece but a short distance away from it for best viewing. Why?

26. You have learnt in the text how Huygens's principle leads to the laws of reflection and refraction. Use the same principle to deduce directly that a point object placed in front of a plane mirror produces a virtual image whose distance from the mirror is equal to the object distance from the mirror.

Or

Answer the following:

(a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?

(b) In what way is diffraction from each slit related to the interference pattern in a double-slit experiment?

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why?

(d) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily?

(e) Ray optics is based on the assumption that light travels in a straight line. Diffraction effects disprove this assumption. Yet the ray optics assumption is so commonly used in understanding location and several other properties of images in optical instruments. Justify?

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Solutions

1. To store the charge and electricity.

2. $v_d = \frac{i}{nAe} = v$

   $v_d^{`} = \frac{2i}{n(4A)e} = \frac{1}{2}\frac{i}{nAe} = \frac{v}{2}$

3. The next nucleus can decay any time.

4. Zero

5. The both the surfaces of sun glasses are curved. Also, $R_1 = R_2$

   As $P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

   P = 0.

6. The electric dipole moment is defined as the product of either cahrge and the distance between the two charges.

   $\vec{p} = q \times 2\vec{a}$, where 2a is the seperation between the two charges
   It is a vector quantity.

7. (i) Electric field is due to charges at rest as well as in motion, whereas magnetic field is due to a magnet or current flowing through a conductor.

   (ii) The strength of electric field at a point decreases with the dielectric medium but the strength of magnetic field increases when a prmeable medium is inserted there.
   (iii) The electric lines of force representing the electric field do not form a closed path, whereas the magnetic lines of force form a close path.

8. $v = 2 \times 10^8$ m/s, $c = 3 \times 10^8$ m/s

   $\mu = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^8} = 1.5$

   Real depth, x = 6.0 cm, Apparent depth, y = ?

   $\mu = \frac{x}{y}$

   $y = \frac{x}{\mu} = \frac{6}{1.5} = 4$ cm

Rise in the position of the dot = x – y = 6 – 4 = 2 cm

9. 9: $E = h\nu - \phi_0$

$2\ eV = 8\ eV - \phi_0$

Or, $\phi_0 = 8 - 2 = 6\ eV$

Now, $E` = h\nu` - \phi_0 = h \times 1.25\nu_0 - \phi_0 = 1.25 \times 8 - 6 = 4\ eV$.

10. In FM transmission, message is in the form of frequency variation of carrier waves. During the process of modulation, noise gets amplitude modulated, changing the amplitude of carrier waves. Obviously, the message signal, in the form of frequency variations, is not affected. That is why FM signal is less susceptible to noise than an AM signal.

11. (a) It is defined as the total energy stored per unit volume of the capacitor.

Expression:

$$u = \frac{\text{total energy(U)}}{\text{volume(V)}} = \frac{\frac{1}{2}CV^2}{Ad} = \frac{1}{2}\left(\frac{\epsilon_0 A}{d}\right)\left(\frac{E^2 d^2}{Ad}\right)$$

$$u = \frac{1}{2}\epsilon_0 E^2$$

(b) C = 2 Farad, d = 0.5 cm = 5×10^{-3} m, $\epsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$, A = ?

$$C = \frac{\epsilon_0 A}{d}$$

$$A = \frac{Cd}{\epsilon_0} = \frac{2 \times 5 \times 10^{-3}}{8.85 \times 10^{-12}} = 1.13 \times 10^9\ m^2.$$

12. (a) As we know that the numbers for yellow, red and orange are 4, 2 and 3. Gold represents tolerance of ± 5%.

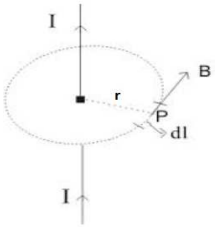
Thus, the value of resistance is $42 \times 10^3\ \Omega$ ± 5%.

(b) A thermistor is a heat sensitive device whose resistivity changes very rapidly with change of temperature.

13. It states that the line integral of magnetic field induction $\vec{B}$ around a closed path in vacuum is equal to μ_0 times the total current I threading the closed path.

Expression for the magnetic field:

Consider an infinite long straight wire lying in the plane of paper. Let I be the current flowing through it from X to Y. A magnetic field is produced which is has the same magnitude at all the points that are at the same distance from the wire, i.e., the magnetic field has cylindrical symmetry around the wire.



Let P be a point at a perpendicular distance r from the straight wire and $\vec{B}$ be the magnetic field at point P. Now consider an ampereian loop as a circle of radius r, perpendicular to the plane of paper with centre on the wire such that point P lies on the loop. The magnitude of the magnetic field is same at all points on this loop. The magnetic field is tangential to the circumference of the circular loop. The line integral $\vec{B}$ round the closed loop is:

$$\oint \vec{B}.d\vec{l} = \oint B\,dl\,Cos0° = B\oint dl = B\,2\pi r$$

Now by using the Ampere's circuital law

$$\oint \vec{B}.d\vec{l} = \mu_0 I$$

$$B\,2\pi r = \mu_0 I$$

or $$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0}{4\pi}\frac{2I}{r}$$,

14. (a) It is the defect of human eye by virtue of which the eye can see clearly the far off objects but the nearby objects cannot be seen clearly. In case of hypermetropia, the near point shifts away from the eye.

The main causes of this defect is:
(i) contraction in the size of the eye ball (ii) increase in the focal length of eye lens.
To correct this defect, the person has to use the spectacles with convex lens of suitable focal length.
(b) u = - 25 cm, v = - 100 cm, f = ?
By using lens equation,

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

$$\frac{1}{f} = \frac{1}{25} - \frac{1}{100} = \frac{3}{100}$$

f = 100/3 = 33.3 cm
P = 100/f = 100/(100/3) = 3 D.

15. Since

$$\sin i_e = \frac{1}{n} = \frac{1}{1.5} = 0.6667$$

$$i_e = 41.8^0$$

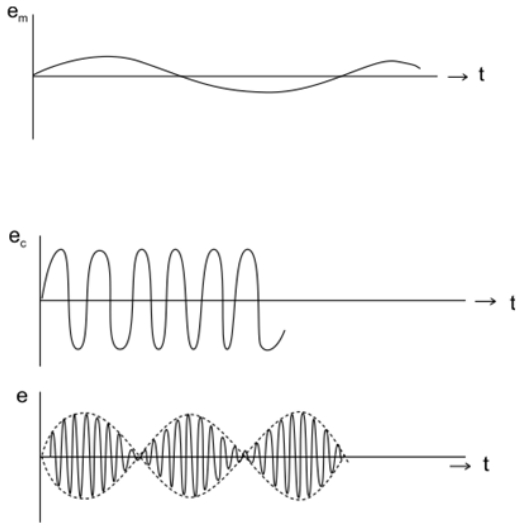
Deviation = $90^0 - i_c = 90^0 - 41.8^0 = 48.2^0$

This is the maximum attainable deviation in refraction.

In reflection deviation = $180^0 - 2i$

Therefore $i = 45^0$

16.



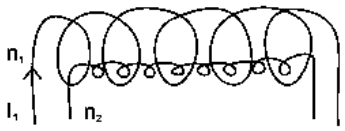
Advantages:

(i) For speech transmission

(ii) Short range distance communication.

17. During the formation of a nucleus, the protons and neutrons come closer to a distance of 10^{-14} m. The energy required for the purpose is spent by the nucleons at the expense of their masses. So mass of the nucleus formed is less than the sum of the masses of the individual nucleons.

18. Mutual inductance is numerically equal to the induced emf produced in coil when the rate of change of current is unity in the neighbouring coil.



Derivation:

Let n_1 = number of turns per unit length in first and

n_2 = number of turns unit length in secondary coil

$\varphi_{21} = M_{21} I_1$

$= N_2BA$

$= N_2 (\mu_0 n_1 I_1) A$

$M_{21}I_1 = \mu_0 N_1N_2I_1 A/L$

$M_{21} = \mu_0 n_1 n_2 AL$

Similarly $M_{12} = n_1 n_2 AL$

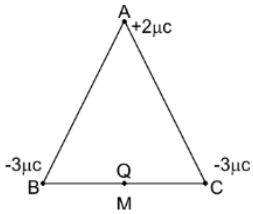
19.

a. The link, which transfers information from the information source to the destination, is called transmission medium.

b. The radio waves in the frequency range 500 kHz to 1500 kHz is called medium wave band while those in the frequency range from a few MHz to 30 MHz is called short wave band.

c. A device which converts energy in one form to another is called a transducer.

20. For equilibrium of charges A, the nature of charge at M must be



$\vec{F}_{AB} + \vec{F}_{AC} + \vec{F}_{AM} = 0$

$\Rightarrow \vec{F}_{AB} + \vec{F}_{AC} = -\vec{F}_{AM}$

$$\left|\vec{F}_{AB} + \vec{F}_{AC}\right| = \sqrt{F^1 + F^2 + 2FF\cos 60} = F\sqrt{3}$$

$$= \frac{9 \text{ x } 10^9 \text{ x } 3 \text{ x } 10^{-6} \text{ x } 2 \text{ x } 10^{-6}}{400 \text{ x } 10^{-4}} N$$

$$= \frac{9 \text{ x } 10^9 \text{ x } 3 \text{ x } 10^{-6} \text{ x } 2 \text{ x } 10^{-6}}{400 \text{ x } 10^{-4}} \sqrt{3}$$

$$\frac{^3 9 \text{ x } 10^9 \text{ x } Q \text{ x } 2 \text{ x } 10^{-6}}{300 \text{ x } 10^{-4}}$$

$$\Rightarrow \frac{\sqrt{3}}{4} \text{ x } 10^{-6} Q$$

$$Q = 0.43 \mu C$$

21.

a. The actual length of a magnet is called the geometric length of the magnet. The distance between the poles of a magnet is called the magnetic length of the magnet.

b. The geometric length of the magnet is nearly 8/7 times the magnetic length of the magnet.

c. It is the angle made by the direction of earth's total magnetic field with the horizontal direction.

22. $B = B_0 \sin(\omega t + bx)$

$B_Y = 8 \times 10^{-5} \sin(2 \times 10^{11} t + 300\pi x)$

$\Omega = 2 \times 10^{11}$ rad/s , $K = 300\pi = 2\pi/\lambda$

$= 2\pi / 300 = 1/.150m = 0.006$

Then, $E_Z = E_0 \sin(\omega t + kx)$

Where $E_0 = CB_0 = 3 \times 108 \times 8 \times 10^{-5} = 2400 N/C$

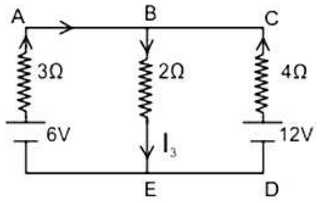
$E_Z = 2400 \sin(2 \times 10^{11} t + 300\pi x)$

23.

a. Ram is a very active and smart person. He has a scientific temperament. He is not easily discouraged. He applies his mind to solve a problem.

b. The positive and negative of the battery charger should be connected to the positive and negative respectively of the battery to be charged.

24. The circuit is written as follows:



In loop ABEFA

$2I_3 + 3I_1 = 6$

$2I_1 + 2I_2 + 3I_1 = 6$

$5I_1 + 2I_2 = 6$ --(i)

In loop BEDCB

$2I_1 + 6I_2 = 12$

$I_1 + 3I_2 = 6$ --(ii)

$13I_2 = 24$

$\therefore I_2 = \frac{24}{13} A$

Using eqn 2,

$I_1 + 3 \text{ x } \frac{24}{13} I_2 = 6$

$I_1 = 6 - \frac{72}{13} = \frac{6}{13} A$

$I_1 = \frac{6}{13} A, I_2 = \frac{24}{13} A, I_3 = \frac{30}{13} A$

Or

a) Potentials at both the points P and Q are positive. P is nearer to the source charge than Q. we know that the electrostatic potential at a point is inversely proportional to the distance of the point from the charge.

Therefore, $V_P > V_Q$

Potentials at both the points A and B are negative. Point B is farther from the charge than the point A. So, potential at B is less negative than at A.

Therefore, $V_B > V_A$

b) $(P.E)_Q - (P.E)_P > 0$; $(P.E)_A - (P.E)_B > 0$.

c) When a small positive charge is moved from Q to P, the electric force and displacement are oppositely directed. So, the work done by the field is negative.

d) When the negative charge is at B, it will experience a force of repulsion away from the source charge. The external agency shall have to apply a force towards the charge. Since both the force and displacement will be in the same direction therefore, the work done will be positive.

e) In going from B to A, the negative charge has to perform work against force of repulsion. So, the K.E decreases.

25. The focal length f = - 15/2 cm =- 7.5 cm

i. The object distance u = -10 cm. Then,

$\frac{1}{v} + \frac{1}{-10} = \frac{1}{-7.5}$

$v = \frac{10 \text{ x } 7.5}{-2.5} = -30\text{cm}$

The image is 30 cm from the mirror on the same side as the object.

$\text{Magnification} = -\frac{v}{u} = -3$

The image is magnified, real and inverted.

ii. The object distance u = - 5 cm. Then,

$$\frac{1}{v}+\frac{1}{-5}=\frac{1}{-7.5}$$

$$v = \frac{5 \text{ x } 7.5}{(7.5 - 5)} = 15 \text{ cm}$$

The image is formed at 15 cm behind the mirror. It is a virtual image.

$$\text{Magnification} = -\frac{v}{u} = 3$$

The image is magnified, virtual and erect.

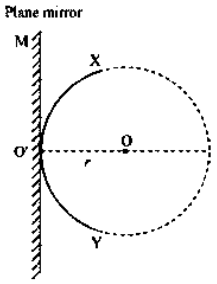
Or

a) The virtual image produced by a spherical mirror or a lens act as a virtual object for the eye lens which produce a real image on the retina. Hence there is no such contradiction.

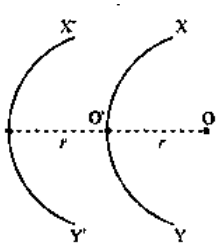
b) A lens of short focal length is not easy to manufacture. Further, a lens of shorter focal length would be quite thick at centre and such a lens disperses the white light and a multi-coloured image is formed. This defect in a lens is called chromatic aberration.

c) The eye-piece produces the image of the object lens itself. This image is called eye ring. An important point about it is all the rays from an object and refracted from the object lens pass through it. The eye would receive all the rays from object if it is placed in a position of the eye ring provided area of pupil of the eye is greater than or at least equal to the area of the eye ring.

26. Let an object at O be placed in front of a plane mirror MO at a distance r



A circle is drawn from the centre (O) such that it just touches the plane mirror at point O', according to Huygens' principle XY is the wave front of incident light. If the mirror is absent, then a similar wave front X'Y' as (XY) would from behind O' at distance r



X'Y' can be considered as a virtual reflected ray for the plane mirror. Hence point object placed in from of the plane mirror produces a virtual image whose distance from the mirror is equal to the object distance(r).

Or

(a) In a single slit diffraction experiment, if the width of the slit is made double the original width, then the size of the central diffraction band reduces to half and the intensity of the central diffraction band increases up to four times.

(b) The interference pattern in a double – slit experiment is modulated by diffraction from each slit. The pattern is the result of the interference of the diffracted wave from each slit.

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. This is because light waves are diffracted from the edge of the circular obstacle. Which interferes constructively at the centre of the shadow? This constructive interference produces a bright spot.

(d) Bending of waves by obstacle by a large angle is possible when the size of the obstacle is comparable to the wavelength of the waves.

On the other hand, the wave length of the light is too small in comparison to the size of the obstacle. Thus the diffraction angle will be very small. Hence the students are unable to see each other. On the other hand, the size of the wall is comparable to the wavelength of the sound waves. Thus the bending of the waves takes place at a large angle. Hence the students are able to hear each other.

(e) The justification is that in ordinary optical instruments the size of the aperture involved is much larger than the wavelength of the light used.