ELECTROMAGNETIC WAVES PROPERTIES

2011

1. The electric and the magnetic field, associated with an electromagnetic wave, propagating along the z=axis. Can be represented by

a) $\left[E = E_0\,\hat{k}, B = B_0\,\hat{i}\right]$ b) $\left[E = E_0\,\hat{j}, B = B_0\,\hat{j}\right]$

c) $\left[E = E_0\,\hat{j}, B = B_0\,\hat{K}\right]$ d) $\left[E = E_0\,\hat{j}, B = B_0\,\hat{J}\right]$

2. The electromagnetic wave having the shortest wavelength is

a) X-rays b) γ-rays c) infrared rays d) microwaves

3. The part of the spectrum of the electromagnetic radiation used to cook food is

a) ultraviolet rays b) cosmic rays c) X-rays d) microwaves

4. A part of the spectrum of the electromagnetic radiation used to cook food is

a) Ultraviolet rays b) cosmic rays c) elliptical d) planar

5. For a medium with permittivity ε and permeability μ, the velocity of light is given by

a) $\sqrt{\mu / g}$ b) $\sqrt{\mu\varepsilon}$ c) $1/\sqrt{\mu\varepsilon}$ d) $\sqrt{\varepsilon / \mu}$

2010

6. An electromagnetic wave going through vacuum is described by $E = E_0\ \sin(kx - \omega t)$, $B = B_0\ \sin(kc - \omega t)$. Which of the following equations is true?

a) $E_0 k = B_0 \omega$ b) $E_0\,\omega = B_0 k$ c) $E_0\,B_0 = \omega k$ d) none of these

7. A source emits electromagnetic waves of wavelength 3m. One beam reaches the observer directly and other after reflection from a water surface, travelling 1.5m extra distance and with intensity reduced to (1/4) as compared to intensity due to direct beam alone. The resultant intensity will be

a) (1/4) fold b) (3/4) fold c) (5/4) fold d) (9/4) fold

8. The essential distinction between X-rays and γ rays is that

a) γ-rays have smaller wavelength than X-rays

b) γ-rays emanate from nucleus while x-rays emanate from outer part of the atom

c) γ-rays have greater ionizing power than X-rays

d) γ-rays are more penetrating than x-rays

9. The spped of electromagnetic wave in vacuum depends upon the source of radiation

a) increases as we move from γ-rays to radio waves

b) decreases as we move from γ-rays to radio waves

c) is same for all of them d) None of the above

10. In free space electron is placed in the path of a plane electromagnetic wave, it will start moving along

a) centre of earth b) equator of earth c) magnetic field d) electric field

11. The average magnetic energy density of an electromagnetic wave length λ travelling in free space is given by

a) $\frac{B^2}{2\lambda}$ b) $\frac{B^2}{2\mu_0}$ c) $\frac{2B^2}{\mu_0\lambda}$ d) $\frac{B}{\mu_0\lambda}$

12. The magnetic field in a plane electromagnetic wave is given by

$B_y = 2\times10^{-7}\sin\left(0.5\times10^3 x + 1.5\times10^{11}t\right)$

This electromagnetic wave is

a) a visible light b) an infrared wave c) a microwave d) a radio wave

13. Which of the following shows green house effect?

a) Ultraviolet rays b) Infrared rays c) X-rays d) None of these

14. A plane electromagnetic wave propagating in the X-direction has wavelength of 6.0 mm. The electric field is in the Y-direction and its maximum magnitude of $33 Vm^{-1}$. The equation for the electric field as function of x and t is

a) $11\sin\pi\left(t - x/c\right)$ b) $33\sin\pi\times10^{11}\left(t - x/c\right)$

c) $33\sin\pi\left(t - x/c\right)$ d) $11\sin\pi\times10^{11}\left(t - x/c\right)$

15. Which of the following statement is false for the properties of electromagnetic waves?

a) Both electric and magnetic field vectors attain the maxima and minima at the same place and same time

b) The energy is electromagnetic wave is divided equally between electric and magnetic vectors.

c) Both electric and magnetic field vectors are parallel to each other and perpendicular to the direction of propagation of wave.

d) These waves do not require any material medium for propagation

16. Which one of the following is the property of monochromatic, plane electromagnetic waves in free space?

a) Electric and magnetic fields have a phase difference of $\pi/2$

b) The energy contribution of both electric and magnetic fields are equal

c) The direction of propagation is in the direction of Bx E

d) The pressure exerted by the wave is the product of its speed and energy density

e) The speed of the wave is B/e

17. Which of the following waves has the maxi wavelength?

a) X-rays b) IR rays c) UV rays d) Radiowaves

18. The sun delivers $10^4 W/m^2$ of electromagnetic flux the earth's surface. The total power that is incident roof of dimensions $(10\times10)m^2$ will be

a) $10^4 W$ b) $10^5 W$ c) $10^6 W$ d) $10^7 W$

19. Velocity of electromagnetic waves in vacuum is given by

a) $\sqrt{\mu_0\varepsilon_0}$ b) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ c) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ d) $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$

20. Which is the correct expression of velocity of light?

a) $\frac{1}{\sqrt{\varepsilon_0\mu_0}}$ b) $\frac{E_0}{B_0}$ c) $\frac{c}{\mu}$ d) All of these

21. Which force in nature exists every where?

a) Nuclear force b) Electromagnetic force c) Weak force d) Gravitation

2009

22. The average electric field of electromagnetic waves in certain region of free space is $9\times10^{-4} NC^{-1}$. Then the average magnetic field in the same region is of the order of

a) $27\times10^{-4}T$ b) $3\times10^{-12}T$

c) $\left(\frac{1}{3}\right)\times10^{-4}T$ d) $3\times10^{12}T$ e) $\left(\frac{1}{3}\right)\times10^{12}T$

23. If $\varepsilon_0 and\ \mu_0$ are respectively, the electric permittivity and the magnetic permeability of free space, ε and μ the corresponding quantities in a medium, the refractive index of the medium is

a) $\sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$ b) $\frac{\mu\varepsilon}{\mu_0\varepsilon_0}$ c) $\sqrt{\frac{\mu_0\varepsilon_0}{\mu\varepsilon}}$ d) $\sqrt{\frac{\mu\mu}{\varepsilon\varepsilon_0}}$

24. Which of the following has/have zero average value in a plane electromagnetic wave?

a) Both magnetic and electric fields b) Electric field only

c) Magnetic field only d) Magnetic energy

e) Electric energy

25. An electromagnetic wave has

a) electric vector only b) magnetic vector only

c) electric and magnetic vectors perpendicular to each other

d) neither the electric vector nor the magnetic vector

26. In fog, neither photographs vector nor the magnetic vector radiations are more clear than those obtained during visible light because

a) scattering of I-R light is more than visible light

b) scattering of I-R light is more than visible light

c) the intensity of I-R light from the object is less

d) scattering of I-R light is less than visible light

27. The velocity of an electromagnetic wave in vacuum can be changed by changing

a) frequency b) amplitude c) wavelength 4) none of these

2008

28. The velocity of electromagnetic radiation in a medium of permittivity ε_0 and permeability μ_0 is given by

a) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ b) $\sqrt{\mu_0\varepsilon_0}$ c) $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$ d) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$

29. Assertion (A): Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor does not change.

Reason (R): The displacement current arises in the region in which the electric field and hence the electric flux does not change with time

a) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'

b) Both 'A' and 'R' are true and 'R' is not correct explanation of 'A'

c) 'A' is true but 'R' is false d) 'A' is false but 'R' is true

30. In an electromagnetic wave, the electric and magnetising fields are $100 Vm^{-1}$ and $0.255\, Am^{-1}$. The maximum energy flow is

a) $26.5 Wm^{-2}$ b) $36.5 Wm^{-2}$ c) $46.7 Wm^{-2}$ d) $765\, Wm^{-2}$

31. In an oscillating L-C circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic fields is

a) Q/2 b) $Q/\sqrt{3}$ c) $Q/\sqrt{2}$ d) Q

2007

32. The electric and magnetic fields of an electromagnetic wave are

a) in phase and parallel to each other

b) in opposite phase and perpendicular to each other

c) in opposite phase and parallel to each other

d) in phase and perpendicular to each other

33. Electromagnetic waves are produced by

a) accelerated charged particle b) decelerated charged particle

c) charge in uniform motion d) None of the above

34. A beam of light travelling along x-axis is described by the electric field $E_y\left(600Vm^{-1}\right)\sin\omega\left(t-x/c\right)$. Then maximum magnetic force on a charge q=2e, moving along y-axis with a speed of $3.0\times10^{7}\ ms^{-1}$ is $\left(e=1.6\times10^{-19}C\right)$

a) $19.2\times10^{-17}\ N$ b) $1.92\times10^{-17}\ N$ c) $0.192\ N$ d) none of the above

35. The sound waves after being converted into electrical waves are not transmitted as such because

a) they are heavily absorbed by the atmosphere

b) they travelled with the speed of sound

c) the height of antenna has to be increased several time

d) the frequency is not constant

36. All components of the electromagnetic spectrum in vacuum have the same

a) Energy b) velocity c) wavelength d) frequency

2006

37. The electric field E and magnetic field B in electromagnetic wave are

a) parallel to each other b) inclined at an angle of 45^0

c) perpendicular to each other 4) opposite to each other

38. The magnetic field amplitude of an electromagnetic wave is 2×10^{-7} T. It electric field amplitude if the wave is travelling in free space is

a) $6Vm^{-1}$ b) $60Vm^{-1}$ c) $10/6Vm^{-1}$ d) None of these

39. A perfectly reflecting mirror has an area of $1 cm^2$. Light energy is allowed to fall on it for 1 h at the rate of $10 W\, cm^{-2}$. The force that acts on the mirror is

a) 3.35×10^{-8} b) $6.7\times10^{-8} N$ c) $1.34\times10^{-7} N$ d) $2.4\times10^{-4} N$

40. A parallel plate capacitor is charged to $60 \mu C$. Due to a radioactive source, the plate loses charge at the rate of $1.8\times10^{-8} Cs^{-1}$. The magnitude of displacement current is

a) $1.8\times10^{-8} Cs^{-1}$ b) $3.6\times10^{-8} Cs^{-1}$ c) $4.1\times10^{-11} Cs^{-1}$ d) $5.7\times10^{-12} Cs^{-1}$

PROPERTIES

KEY

1) d	2) b	3) a	4) a	5) b	6) a	7) d	8) b	9) c	10) d
11) b	12) c	13) b	14) b	15) c	16) b	17) d	18) c	19) d	20) d
21) b	22) b	23) a	24) a	25) c	26) d	27) d	28) c	29) d	30) a
31) c	32) d	33) a	34) b	35) a	36) b	37) c	38) b	39) b	40) a

SOLUTIONS

6. $\frac{E_0}{B_0} = c$

$k = \frac{2\pi}{\lambda} and\ \omega = 2\pi v$

$E_0 k = B_0 \omega$

7. Resultant amplitude $= \sqrt{I} + \sqrt{I/4} = \frac{3}{2}\sqrt{I}$

Resultant intensity $= \left(\frac{3}{2}\sqrt{I}\right)^2 = \frac{9}{4} I = \frac{9}{4} fold$

11. $U = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$

$\therefore \frac{B^2}{2\mu_0}$

12. $B_y = 2\times10^{-7} \sin\left(0.5\times10^3 x = 15\times10^{11} t\right)$

Comparing with, $B_y = B_0 \sin(kx + \omega t)$

$k = 0.5\times10^3$

$\Rightarrow \lambda = \frac{2\pi}{0.5\times10^{3}}0.011256$

The wavelength range of microwaves is $10^{-3}\,to\,0.3$. The wavelength of this wave lies between $10^{-3}\,to\,0.3$, Hence the equation represents a microwaves.

14. $\omega = 2\pi v = \frac{2\pi c}{\lambda} = \frac{2\pi\times3\times10^{8}}{6\times10^{-3}}$

$E_y = E_0 \sin\omega\left(t - \frac{x}{c}\right) = 33\sin\pi\times10^{11}\left(t - x/c\right)$

18. Total power = solar constant x area $= 10^{4}\times(10\times10) = 10^{6}W$

30. $S = E_0 \times H_0$

$E_0 = 100Vm^{-1}, H_0 = 0.265Am^{-1}$

$\therefore\ S = 100\times0.26 = 26.5Wm^{-2}$

31. $U_{E\max} = \frac{Q^2}{2C}$

$U_{R\max} = \frac{Li_0^2}{2}$

Where I_0 is the current at this time

For the given instant $U_E = U_B$

$\frac{q^2}{2C} = \frac{Li^2}{2}$

From energy conservation

$U_E + U_B = U_{E\max} = U_{B\max}$

$\Rightarrow 2\frac{q^2}{2C} = \frac{Q^2}{2C} \Rightarrow q = \frac{Q}{\sqrt{2}}$

34. $B_0 = \frac{E_0}{c}$

$E_0 = 600Vm^{-1}, c = 3\times10^{8}ms^{-1}$

$\therefore\ B_0 = \frac{600}{3\times10^{8}} = 2\times10^{-6}T$

$F_m = qvB_0 = 2evB_0 = 2\times1.6\times10^{-19}\times3\times10^{7}\times2\times10^{-6} = 1.92\times10^{-17}N$

38. $E = E_0 in(kx - \omega t)$ and $B = B_0 \sin(kx - \omega t)$

$c = \frac{E_0}{B_0}$ or $E_0 = B_0 c$

$B_0 = 2\times10^{-7} T, c = 3\times10^8\ ms^{-1}$

$\therefore E_0 = 2\times10^{-7}\times3\times10^8 = 60 Tm^{-1} = 60 Vm^{-1}$

39. $p = \frac{h}{\lambda} = \frac{h}{(c/v)} = \frac{hv}{c} = \frac{E}{c}$

On reflection, change in momentum per second = force

$= 2p = \frac{2E}{c} = \frac{2\times10}{3\times10^8} = 6.7\times10^{-8} N$

40. $I_d = \frac{dq}{dt} = 1.8\times10^{-8} Cs^{-1}$

ELECTROMAGNETIC SPECTRUM

2011

1. Refractive index of the material of a prism is 1.5. If $\delta_m = A$ what will be a value of angle of the given prism? (where δ_m =minimum deviation and A=angle of prism)

a) 82.8^0 b) 41.4^0 c) 48.6^0 d) 90^0

2. The rate of loss of heat of a body is directly proportion to the difference of temperature of the body and surroundings. This statement is known as

a) Stefan's law b) Newton's law of cooling

c) Wien's law d) Kirchhoff's law

2010

3. The maximum kinetic energy of photoelectrons

a) various linearly with the frequency of the incident radiation

b) various linearly with the wavelength of incident light

c) proportional to the frequency of the incident radiation

d) Proportional to the square of the frequency of incident radiation

2008

4. Which of the following undergoes largest diffraction?

a) Infrared light b) Radio waves c) γ-rays d) Ultraviolet light

2007

5. An electromagnetic radiation has energy of 13.2 keV. Then the radiation belongs to the region of

a) Visible light b) Ultravilet c) infrared

d) X-ray e) microwave

2006

6. The correct option, if speed of gamma rays, X-rays and microwaves are $v_g, v_x \text{ and } v_m$ respectively will be

a) $v_g > v_x > v_m$ b) $v_g < v_x < v_m$ c) $v_g > v_x < v_m$ d) $v_g = v_x = v_m$

7. We find that the temperature of air decreases as one goes up from the earth's surface because

a) the atmospheric pressure drops with height

b) the earth which radiates in the infrared region is the main heat source and temperature drops a we go away from it.

c) the density of air drops with height and the air therefore cannot hold stronger as we go up

d) winds are stronger as we go up

8. The wavelength of a radio wave of frequency of 1 MHz is

a) 400 m b) 300m c) 350 m d) 200m

2005

9. In the electromagnetic spectrum, the visible spectrum lies between

a) Radio wave and microwaves b) infrared and ultraviolet rays

c) Microwaves and infrared spectrum d) X-ray and gamma ray spectrum

2004

10. Which radiations are used in treatment of muscles ache?

a) Infrared b) Ultraviolet c) Microwave d) X-rays

11. The waves which cannot travel in vacuum are

a) X-rays b) radio waves c) infrasonic waves d) ultraviolet rays

12. A fire screen produces sensation of cooling as

a) it allows both infrared and visible light but cuts off ultraviolet

b) it allows infrared and cuts off shorter wavelengths

c) it cuts off both visible light and infrared

d) it allows only visible light and cuts off infrared

ELECTROMAGNETIC SPECTRUM

KEY

1)a 2)b 3)a 4)b 5)d 6)d 7)b 8)b 9)b 10)a 11)c 12)d

SOLUTIONS

1. $\mu = 1.5$ and $\delta_m = A$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

$$1.5 = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin A}{\sin\frac{A}{2}}$$

A= 82.8^0

5. $E = \frac{hc}{\lambda}$

Or $\lambda = \frac{hc}{E} = \frac{6.6\times10^{-34}\times3\times10^8}{13.2\times10^3\times1.6\times10^{-19}} = 0.9375\times10^{-10}\,m$

(Wavelength range of X-rays is from $10^{-11}\,m\,to\,10^{-8}\,m$ to 100A)

8. $\lambda = \frac{c}{v} = \frac{3\times10^8}{1\times10^6} = 3\times10^2 = 300m$