PHYSICS

BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

ELECTROMAGNETIC WAVES

Sample Problem

1. When you look at the North Star (Polaris), you intercept ligllt from a star at a distance of 431 ly and emitting energy at a rate of 2.2×10^{3} times that of our Sun $(P_{\text{sun}} = 3.90 \times 10^{26}$ W. Neglecting any atmospheric absorption, find the ans values of the electric and magnetic fields when the starlight reaches you.

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2. Figure 32-15a, drawn in perspective, shows a system of three polarizing sheets in the palh of initially uL1polarized light. The polarizing direction of the first sheet is parallel to the y axis, that of the second sheet is al an angle of 60° counterclockwise from the y axis, and thaL of the third sheet is parallel to the x axis. What fraction of the initial intensity I_0 of the light emerges from the three-sheet system. and in which direction is that emerging light polarized?

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3. (a) In Fig. 32-19a, a beam of monochromatic light reflects and refracts at point A on the interface between material 1 with index of refraction n_1 = 1.33 and material 2 with index of refraction $n_2 =$ 1.77. The incident beam makes an angle of 50°) with the interface. What is the angle of reflection at poinl A ? What is the angle of refraction there?

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Checkpoint

1. The magnetic field B through the rectangle of Fig. 32-6 is shown at a different instant in part 1 of the figure here, B is directed in the xz plane, parallel to the z axis, and its magnitude is increasing. (a) Complete part 1 by drawing the induced electric fields, indicating both directions and relative magnitudes (as in Fig. 32-6). (b) For the same instant, complete part 2 of the figure by drawing the e lectric field of the electromagnetic wave. Also draw the induced magnetic fields, indicating both directions and relative magnitudes (as in Fig. 32-7).

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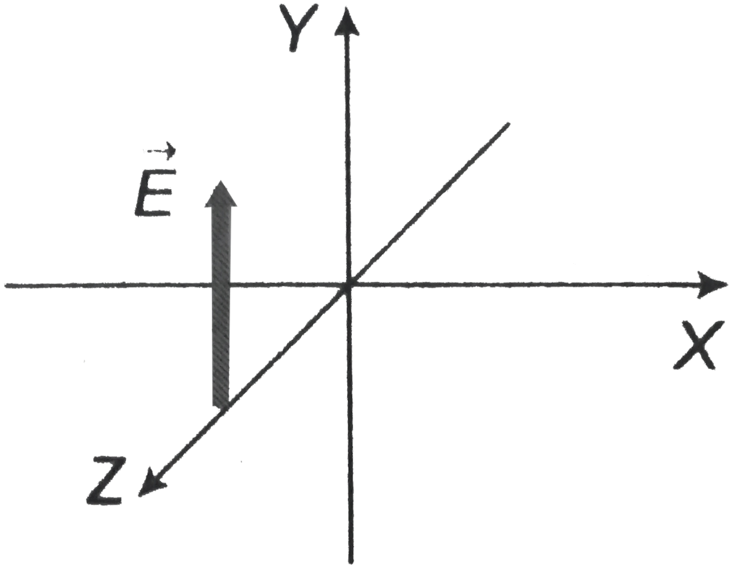
2. The figure here gives the electric field of an EM wave at a certain point and a certain. The wave is transporting energy in the negative z direction. What is the direction of the magnetic field of the wave at the point and instant?



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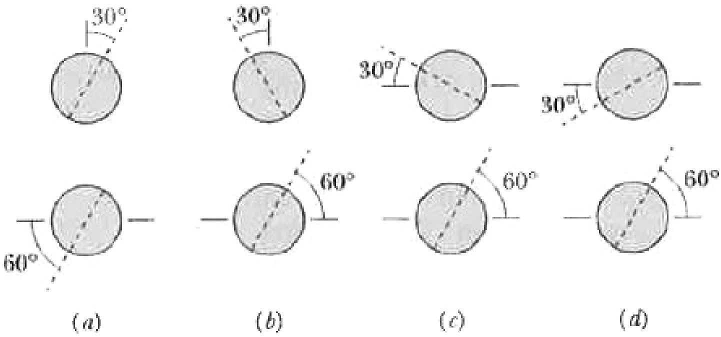
3. The figure shows four pairs of polarizing sheets, seen face-on. Each pair is mounted in the palh of initially unpolarized light. The polarizing direction of each sheet (indicated by the dashed line) is referenced to either a horizontal x axis or a vertical y axis. Rank the pairs according to the fraction of the initial intensity that they pass, greatest first.



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Problems

1. A beam of polarized light is sent into a system of two polarizing sheets . Relative to the polarization diretion of that incident light the polarizing direction of the sheets are at angles θ for the first sheet and 90° for the second sheet . (a) If 0.20 of the incident intensity is transmitted by the two sheets what is θ (b) What percentage of the incident intensity is transmitted if the first sheet angle is reduced to 0° ?

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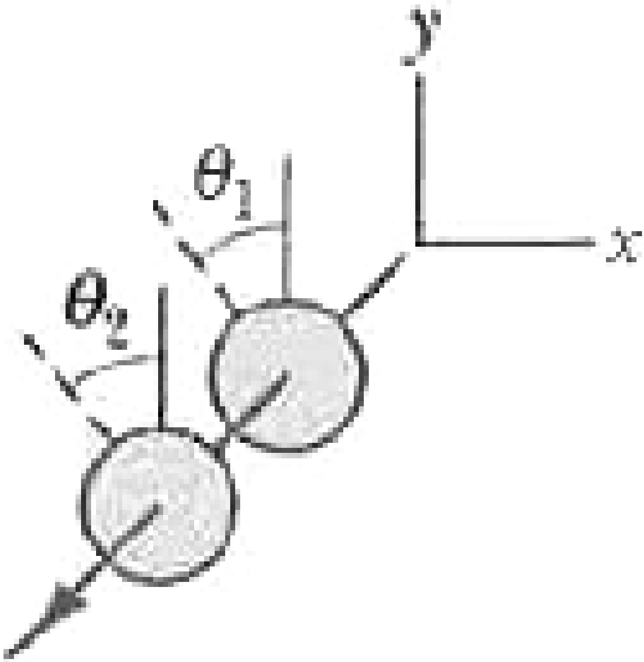
2. In Fig 32-24 a beam, of unpolarized light with intensity 43 W/m^2 is sent into a system of two polarizing sheets with polarizing directions at angles $\theta_1 = 70^\circ$ and $\theta_2 = 90^\circ$ to the y axis . What is the intensity of the light transmitted by the system ?



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3. In Fig 32-24 a beam of light with intensity 43 W/m^2 and polarization parallel to a y axis is sent into a system of two polarizing sheets with polarizing directions at angles of $\theta_1 = 70^\circ$ and $\theta_2 = 90^\circ$ to the y axis . (a) What is the intensity of the light transmitted by the two sheet system ? (b) What is the transmitted intensity if instead the initial polarization is parallel top the x axis ?

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4. We want to rotate the direction of polarization of a beam of polarized through 90° by sending the beam through one or more polarizing sheets . (a) What is the minimum number of sheets required ? (b) What is the minimum number of sheets required if the transmitted intensity is to be more than 65% of the original intensity ?

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5. In Fig 32-25 unpolarized light is sent into a system of three polarizing sheets. Which transmits 0.0500 of the initial light intensity . The polarizing directions of the first and third sheets are at angles $\theta_1 = 0^\circ$

and $\theta_3 = 90^\circ$. What are the (a) smaller and (b) larger possible values of angle $\theta_2 (< 90^\circ)$ for the polaring direction of sheets 2?

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6. At a beach the light is generally partially polarized due to reflections off sand and water. At a particular beach on a particular day near sundown the horizontal component of the electric field vector is 2.3 times the vertical component . A standing sunbather puts on polarizing sunglasses , the glasses eliminate the horizontal field component . (a) What fraction of the light intensity received before the glasses were put on now reaches the sunbather 's eyes ? (b) The sunbather still wearing the glasses lies on his side . What fraction of the light intensity received before the glasses were put on now reaches his eyes ?

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7. Light in vacuum is incident on the surface of a glass slab. In the vaccum the beam makes an angle of 32.0° with the normal to the surface while in the glass it makes an angle of 16.0° with the normal . What is the index of refraction of the glass ?

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8. An isotropic point source emits light at wavelength 500 nm at the rate of 200 W.A light detector is positioned 400 m from the source . What is the maximum rate `at which the magnetic component of the light changes with time at the detector's location ?

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9. The maximum electric field 27 m from an isotropic point source of light is 17 V/m. What are (a) the maximum value of the magnetic field and (b) the average intensity of the light there ? (c) What is the power of the source ?

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10. In a plane radio wave the maximum value of the electric field component is 5.00 V/m. Calculate (a) the maximum value of the magnetic field component and (b) the wave intensity .

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11. A plane electromagnetic wave with wavelength 5.0 m, travels in vacuum in the positive direction of an x axis . The electric field of amplitude 215 V/m oscillates parallel to the y axis. What are the (a) frequency (b) angular frequency and (c) angular wave number of the wave ? (d) What is the amplitude of the magnetic field component ? (e) Parallel to which axis does the magnetic field oscilate ? (f) What is the time -averaged rate of energy flow in watts per square meter associated with this wave ? The wave uniformly illuminates a surface of area 2.0 m^2 . If the surface totally absorbs the wave what are (g) the rate at which momentum is transferred to the surface and (h) the radiation pressure on the surface ?

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12. A black totally absorbing piece of carboard of area A=2.0 cm^2 intercepts light with an intensity of 10 W/m^2 from a camera strobe light . What radiation pressure is produced on the cardboard by the light ?

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13. What is the intensity of a traveling plane electromagnetic wave if B_m is 3.0×10^{-4} T ?

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14. From fig 32-2 approximate the (a) smaller and (b) larger wavelength at which the eye of a standard observer has half the eye's maximum sensitivity . What are the (c) wavelength (d) frequency and (e) period of the light at which the eye is the most sensitive ?

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15. Sunlight just outside Earth's atmosphere has an intensity of 1.40k W/m^2. Calculate (a) $E_m (b) B_m$, $(c) E_{\text{rms}}$ and (d) B_{rms} for sunlight there asuming it to be a plane wave .

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16. Assume (unrealistically) that a TV station acts as a point source broadcasting isotropically at 1.0 MW. What is the intensity of the transmitted signal reaching proxima Centauri the star nearest our solar system 4.3 ly away ? A light -year (ly) is the distance light travels in one year .

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17. A plane electromagnetic wave with has a maximum electric field magnitude of 3.20×10^{-4} V/m . Find the magnetic field amplitude .

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18. What inductance must be connected to a 25 p F capacitor in an oscillator capable of generating 410 nm (i.e visible) electromagnetic waves ? Comment on your answer.

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19. What is the radiation pressure 2.7 m away from a 315 W lightbulb ? Assume that the surface on which the pressure is exerted faces the bulb and is perfectly absorbing and that the bulb radiates uniformly in all directions .

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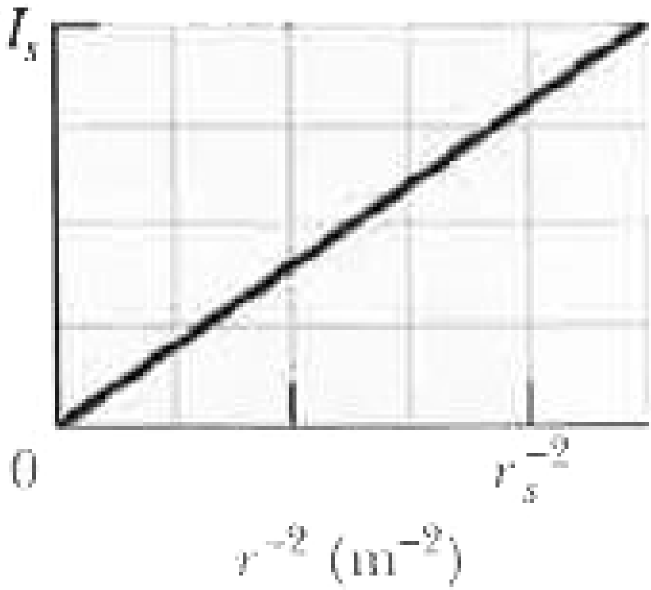
20. The intensity I of light from an isotropic point source is determined as a function of distance r from the source . Figure 32-29 gives intensity I versus the inverse square $r(-2)$ of that distance . The vertical axis scale is set by $I_s = 200W/m^2$ and the horizontal axis scale is set by

$r_s^{-2} = 8.0m^2$. What is the power of the source ?



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21. An airplane flying at a distance of 10 km from a radio transmitter receives a signal of intensity 28 $\mu W / m^2$. What is the amplitude of the (a) electric and (b) magnetic component of the signal at the airplane ? (c) If the transmitter radiates uniformly over a hemisphere what is the transmission power ?

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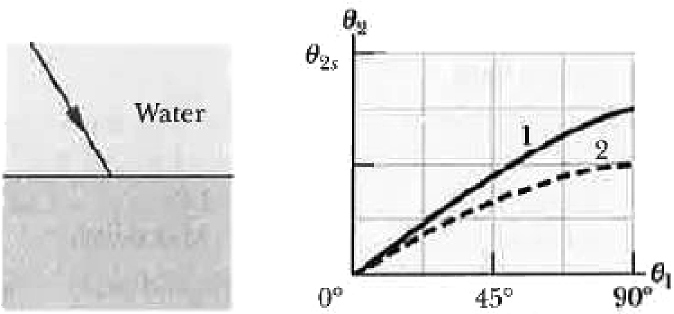
22. In Fig.32-30 a light ray in water is incident at angle θ_1 on a boundary with an underlying material into which some of the light refracts . There are two choices of underlying material. For each the angle of refreaction θ_2 versus the incident angle θ_1 is given in Fig. 32-30b . The vertical axis scale is set by $\theta_{2s} = 90^\circ$. Without calculation determine whether the index of refraction of (a) material 1 and (b) material 2 is greater or less than the index of water (n=1.33) . What is the index of refraction of (c) material 1 and (d) material 2?



(a) (b)

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23. A certain helium -neon laser emits red light in a narrow band of wavelengths centered at 632.8 nm and with a wavelength width (such as on the scale of Fig .32-1) of 5.00 pm. What is the corresponding frequency width for the emission ?

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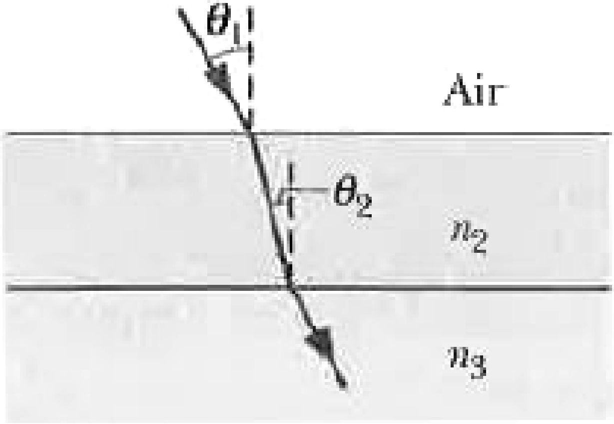
24. In Fig 32-31 a light ray in air is incident on a flat layer of material 2 that has an index of refraction $n_2 = 1.5$. Beneath material 2 is material 3 with an index of refraction n_3 . The ray is incident on the air -material 2 interface at the Brewster angle for that interface . The ray of light refracted into material 3 happens to be incident on the material 2 - material 3 interface at the Brewster angle for that interface . What is the value of n_3 ?



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25. A plane electromagnetic wave traveling in the positive direction of an x axis in vacuum has components $E_x = E_y = 0$ and $E_z = (4.0V/m)\cos\left[\left(\pi \times 10^{15} s^{-1}\right)(t - x/c)\right]$. (a) What is the amplitude of the magnetic field component ? (b) Parallel to Which axis does the magnetic field oscillate ? (c) When the electric field component field oscillate ? (c) When teh electric field component is in the the positive direction of the z axis at a certain point P what is the direction of the magnetic field component there ? (d) In what direction is the wave moving ?

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26. What is the wavelength of the electromagnetic wave emitted by the oscillator -antenna system of Fig -.32 -3 if $L = 0.253\mu$ H and C = 25.0 pF ?

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27. Unpolarized light of intensity 6.5 mW / m^2 is sent into a polarizing sheet as in Fig 32-11 . What are (a) the amplitude of the electric field component of the transmitted light and (b) the radiation pressure on the sheet due to its absorbing some of the light ?

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28. Some neodymium -glass lasers can provide 100 TW of power in 2.2 ns pulses at a wavelength of 0.26 mm. How much energy is contained in a single pulse ?

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29. (a) At what angle of incidence will the light reflected from water be completely polarized ? (b) Does this angle depend on the wavelength of the light ?

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Practice Questions Single Correct Choice Type

1. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.5 \times 10^{10} Hz$ and amplitued $480V/m$. The amplitude of oscillating magnetic field will be

A. $1.52 \times 10^{-8} Wb/m^2$

B. $1.52 \times 10^{-7} Wb/m^2$

C. $1.6 \times 10^{-6} Wb/m^2$

D. $1.6 \times 10^{-7} Wb/m^2$

Answer: C

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2. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2 \times 10^{10} Hz$ and amplitude $48V/m$. The wavelength of the wave will be-

A. 1.5m

B. 1.5×10^{-1} m

C. 1.5×10^{-2}m

D. 1.5×10^{-3} m

Answer: C

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3. The frequency of $e.m$ wave which is best suit to observe a particle of radius 3×10^{-4} is of order of:

A. 10^{15}

B. 10^{14}

C. 10^{13}

D. $10(12)$

Answer: B

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4. An electric field $\left(\overrightarrow{E}\right)$ and a magnetic field $\left(\overrightarrow{B}\right)$ exist in a region . The fields are not perpendicular to each other.

A. Will not pass through the region

B. Will pass through region

C. May pass through the region

D. Nothing is definite

Answer: C

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5. The sunlight strikes the upper atmosphere of the Earth with intensity 1.38 k W/m^2 . The peak value of electric field at that point will be (in kilovolt /meter)

A. 2.04

B. 4.08

C. 8.16

D. 1.02

Answer: D

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6. If ε_0 and μ_0 are respectively the electric permittivity and the magnetic permeability of free space and ε and μ the corresponding quantities in a medium, the refractive index of the medium is

A. $\sqrt{\frac{\varepsilon_0\mu_0}{\varepsilon\mu}}$

B. $\sqrt{\frac{\varepsilon\mu}{\varepsilon_0\mu_0}}$

C. $\sqrt{\frac{\varepsilon}{\varepsilon_0\mu_0}}$

D. $\sqrt{\frac{\varepsilon_0\mu_0}{\varepsilon}}$

Answer: B

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7. Which one of the following equations represents the modified from of Ampere's circuital law?

A. $\oint\vec{B}.\,d\vec{s}=0$

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

C. $\oint \vec{B} . d\vec{l} = \mu_0 I + \frac{1}{\varepsilon_0} \frac{dq}{dt}$

D. $\oint \vec{B} . d\vec{l} = \mu_0 I + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

Answer: D

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8. If the velocity of light in free space is 3×10^8 m/s , then value of wavelength of electromagnetic wave of frequency 2×10^6 Hz will be

A. 6×10^8 m

B. 15×10^4 m

C. 150 m

D. 1.5×10^{11} m

Answer: C

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9. An electromagnetic wave going through vacuum is described by $E = E_0 \sin(kx - \omega t)$. Which of the following is/are independent of the wavelength?

A. k

B. k/ω

C. ω^2

D. k / ω^2

Answer: D

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10. If E is an electric field and B is the magnetic induction then the energy flow per unit area per unit time in an electromagnetic field is given by

A. $E \times B$

B. E-B

C. $E^2 + B^2$

D. E/B

Answer: A

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11. Instantaneous displacement current of 1.0 A in the space between the paraller plates of $1\mu F$ capacitor can be established by changing potenial difference of:

A. 10^{-6} V/s

B. 10^6 V/s

C. 10^{-8} V/s

D. 10^8 V/s

Answer: B

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12. A beam of light of intensity 12 W/cm^2 in incident on a totally reflecting plane mirror of area 1.5 cm^2 . The force in Newton's acting on the mirror will be

A. 2.4×10^6

B. 1.2×10^{-9}

C. 3.6×10^{-8}

D. 5.6×10^{-5}

Answer: B

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13. A plane electromagnetic wave of wave intensity $6W/m^2$ strikes a small mirror of area $9cm^2$, held perpendicular to the approaching wave. The momentum transferred in kg-ms by the wave to the mirror each second will be:

A. 1.6×10^{-10}

B. 2.4×10^{-9}

C. 3.6×10^{-8}

D. 4.8×10^{-7}

Answer: A

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14. The average energy-density of electromagnetic wave given by $E = (50N/C)\sin(\omega t - kx)$ will be nearly:

A. $10^{-8} J/m^3$

B. $10^{-7} J/m^3$

C. $10^{-6} J/m^3$

D. $10^{-5} J/m^3$

Answer: A

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15. The magnetic field in the plane electromagnetic wave is given by

$B_z = 2 \times 10^{-7} \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ tesla.

The expression for electric field will be:

A. $E_z 30\sqrt{2} \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ V/m

B. $E_z = 60 \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ V/m

C. $E_y = 30\sqrt{2} \sin(0.5 \times 10^{11} x + 0.5 \times 10^3 t)$ V/m

D. $E_y = 60 \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ V/m

Answer: D

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16. Select the correct statement :

A. Ultraviolet light has a longer wavelength than infrared

B. Blue light has a higher frequency than x rays

C. Radio wave have higher frequency than gamma rays

D. Gamma rays have higher frequency than infrared waves

Answer: D

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17. The order of increasing wavelength for blue (b) green (g) red (r) and yellow (y) light is

A. r,y,g,b

B. r,g,y,b

C. g,y,b,r

D. b,g,y,r

Answer: D

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18. Of the following human eyes are most sensitive to

A. Red light

B. Violet light

C. Blue light

D. Green light

Answer: A

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19. If the wavelength of an electromagnetic wave is about the diameter of an apple what type of radiation is it ?

A. X ray

B. UV

C. Infrared

D. Microwave

Answer: D

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20. Which of the following types of electromagnetic radiation travels at the greatest speed in vacuum ?

A. Radio waves

B. Visible light

C. X rays

D. All of these at the same speed

Answer: D

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21. An electromagnetic wave is generated by

A. Any moving charge

B. Any accelerating charge

C. Only a charge with changing acceleration

D. Only a charge moving in a circle

Answer: B

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22. Which of these statements correctly describes the orientation of the electric field $\left(\vec{E}\right)$ the magnetic field $\left(\vec{B}\right)$ and velocity of propagation $\left(\vec{v}\right)$ of an electromagnetic wave?

A. $\left(\vec{E}\right)$ is perpendicular $\left(\vec{B}\right)$, $\left(\vec{v}\right)$ may have any orientation relative to $\left(\vec{E}\right)$

B. $\left(\overrightarrow{E}\right)$ is perpendicular to $\left(\overrightarrow{B}\right)$, $\left(\overrightarrow{v}\right)$ may have any orientation

perpendicular to (B), $\left(\overrightarrow{v}\right)$ may have any orientation

perpendicular to $\left(\overrightarrow{E}\right)$

C. $\left(\overrightarrow{E}\right)$ is perpendicular to $\left(\overrightarrow{B}\right)$, $\left(\overrightarrow{B}\right)$ is parallel to $\left(\overrightarrow{v}\right)$

D. Each of the three vectors is perpendicular to the other two

Answer: D

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23. An electromagnetic wave going through vacuum is described by

$E = E_0 \sin(kx - \omega t)$, $B = B_0 \sin(kx - \omega t)$.

Then

A. $E_0 k = B_0 \omega$

B. $E_0 B_0 \omega k$

C. $E_0 \omega = B_0 k$

D. None of these

Answer: A

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24. A free electrons is placed in the path of a plane electromagnetic wave. The electron will start moving

A. Along the electric field

B. Along the magnetic field

C. Along the direction of propagation of the wave

D. In a plane containing the magnetic field and the direction of propagation

Answer: A

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25. A beam of light travelling along x-axis is described by the electric field,

$E_y = (600 V m^{-1}) \sin \omega (t - x / c)$

Calculating the maximum electric and magnetic forces on a charge q=2e, moving along y-axis with a speed of $3 \times 10^7 m / s$, where $e = 1.6 \times 10^{-19} C$.

A. 19.2×10^{-17} N

B. $1.92 \times 10^{-17} N$

C. 0.192 N

D. None of these

Answer: B

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26. A plane electromagnetic wave travels in free space along x-axis. At a particular point in space, the electric field along y-axis is $9.3 V m^{-1}$. The magnetic induction (B) along z-axis is

A. 3.1×10^{-8} T

B. 3×10^{-5} T

C. 3×10^{-6} T

D. 9.3×10^{-6} T

Answer: A

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27. A plane e.m. wave travelling along the x-direction has a wavelength of 3mm. The variation in the electric field occurs in the y-direction with an amplitude $66Vm^{-1}$. The equation for the electric and magnetic fields as a function of x and t are respectively

A. $E_y = 33 \cos \pi \times 10^{11}\left(1 - \frac{x}{c}\right)$

$B_z = 1.1 \times 10^{-7} \cos \pi \times 10^{11}\left(t - \frac{x}{c}\right)$

B. $E_y = 11 \cos 2\pi \times 10^{11}\left(1 - \frac{x}{c}\right)$

$B_x = 11 \times 10^{-7} \cos 2\pi \times 10^{11}\left(t - \frac{x}{c}\right)$

C. $E_z = 33\cos\pi \times 10^{11}\left(1 - \frac{x}{c}\right)$

$B_x = 11 \times 10^{-7}\cos\pi \times 10^{11}\left(t - \frac{x}{c}\right)$

D. $E_y = 66\cos 2\pi \times 10^{11}\left(1 - \frac{x}{c}\right)$

$B_z = 2.2 \times 10^{-7}\cos 2\pi \times 10^{11}\left(t - \frac{x}{c}\right)$

Answer: D

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28. An electromagnetic wave is traveling in the positive x direction with its electric filed along the z axis and its magnetic field along the y axis . The fields are related by

A. $\frac{\partial E}{\partial x} = \frac{\mu_0\varepsilon_0\,\partial B}{\partial x}$

B. $\frac{\partial E}{\partial x} = \frac{\mu_0\varepsilon_0\,\partial B}{\partial t}$

C. $\frac{\partial B}{\partial x} = \frac{\mu_0\varepsilon_0\,\partial E}{\partial t}$

D. $\frac{\partial B}{\partial x} = \frac{\mu_0\varepsilon_0\,\partial E}{\partial t}$

Answer: D

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29. An electromagnetic wave of frequency $v = 3.0 MHz$ passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$. Then

A. Wavelength is doubled and frequency unchanged

B. Wavelength is doubled and frequency becomes half

C. Wavelength is halved and frequency remains unchanged

D. Wavelength and frequency both remains unchanged

Answer: C

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30. A plane electromagnetic wave $E_z = 100\cos(6 \times 10^8 t + 4x)$ V/m propagating in medium of dielectric constant is

A. 1.5

B. 2

C. 2.4

D. 4

Answer: D

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31. The dimensions of S = $(1/\mu_0)\overrightarrow{E} \times \overrightarrow{B}$ are

A. J/m^2

B. J/s

C. W/s

D. j/m^3

Answer: D

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32. The time -averaged energy in a sinusoidal electromagnetic wave is

A. Overwhelmingly electrical

B. Slightly more electrical than magnetic

C. Equally divided between the electric and magnetic fields

D. Overwhelmingly magnetic

Answer: C

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33. An electromagnetic wave is transposing energy in the negative y direction . At one point and one instant the magnetic field is in the positive x direction . The electric field at that point and instant is

A. Positive y direction

B. Negative y direction

C. Positive z direction

D. Negative z direction

Answer: D

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34. The light intensity 10 m from a point source is 1000 W/m^2 . The intensity 100 m from the same source is

A. $1000W/m^2$

B. $100W/m^2$

C. $10W/m^2$

D. $1W/m^2$

Answer: C

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35. The amplitude of electric field in a parallel light beam of intensity $4Wm^{-2}$ is

A. 35.5 N/C

B. 45.5 N/C

C. 49.5 N/C

D. 55.5 N/C

Answer: D

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36. Consider the following two statements regarding a linearly polarized, plane electromagnetic wave:

The electric field and the magnetic field have equal average values.

The electric energy and the magnetic energy have equal average values.

A. Both A and B are true

B. A is false but B is true

C. B is false but A is true

D. Both A and B are false

Answer: A

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37. The rms value of the electric field of the light from the sun is $720 N/C$

The total energy density of the electromagnetic wave is

A. $4.58 \times 10^{-6} J/m^3$

B. $6.37 \times 10^{-9} J/m^3$

C. $81.35 \times 10^{-12} J/m^3$

D. $3.3 \times 10^{-3} J/m^3$

Answer: A

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38. Evidence that electromagnetic waves carry momentum when

A. The tail of a comet points away from the Sun

B. Electron flow through a wire generates heat

C. A charged particle in a magnetic field moves in a circular orbit

D. Heat can be generated by rubbing two sticks together

Answer: D

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39. Light of uniform intensity shines perpendicularly on a totally absorbing surface fully illuminating the surface . If the area of the surface is decreased

A. The radiation pressure increases and the radiation force increases

B. The radiation pressure increases and the radiation force decreases

C. The radiation pressure stays the same and the radiation force increases

D. The radiation pressure stays the same and the radiation force decreases

Answer: D

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40. A linearly polarized transverse wave is propagating in z direction through a fixed -point P in space . At time t_0 the x component E_x and the y component E_y of the displacement at P are 3 and 4 units respectively . At a later time t_1 if E_x at P is 2 units the value of E_y will be

A. 5 units

B. 8/3 units

C. 3/8 units

D. 1/3 units

Answer: B

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41. A vertical automobile radio antenna is sensitive to electric fields that are polarized

A. Horizontally

B. In circles around the antenna

C. Vertically

D. Normal to the antenna in the forward direction

Answer: C

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42. Polarized light

A. Is a different form of light

B. Can show interference pattern

C. Travels in any medium with a velocity slightly more than that for unpolarized light

D. Has direction of vibration restricted in some way

Answer: D

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43. For linearly polarized light the plane of polarization is

A. Perpendicular to both the direction of polarization and the direction of propagation

B. Perpendicular to the direction of polarization and parallel to the direction of propagation

C. Parallel to the direction of polarization and perpendicualar to the direction of propagation

D. Parallel to both the direction of polarization and the direction of propagation

Answer: D

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44. An unpolarized beam of light has intensity I_0 . It is incident on to ideal polarizing sheets . The angle between the axes of polarization of these sheets is θ . Find θ if the emerging light has intensity $I_0/4)$

A. $\sin^{-1}(1/2)$

B. $\sin^{-1}(1/\sqrt{5})$

C. $\cos^{-1}(1/2)$

D. $\cos^{-1}(1/\sqrt{2})$

Answer: D

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45. Three polarizing sheets are placed in a stack with the polarizing directions of the first and third perpendicular to each other. What angle should the polarizing direction of the middle sheet make with the polarizing direction of the first sheet to obtain maximum transmitted intensity when unpolarized light is incident on the stack ?

A. 0

B. 30°

C. 45°

D. 60°

Answer: C

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46. A light bulb shines light along the x axis and through two parallel ideal polarizing filters one with a fixed polarizing axis and the other with an axis that rotates about the x axis and the yz plane . Looking toward the light bulb through the combined filtering system you see

A. A bulb almost disappearing twice per revolution and reaching a maximum intensity twice per revolution . The maximum brightness is not as bright as looking at an unfiltered bulb

B. As in (a) but once per revolution

C. As in (a) but with a maximum brightness as bright as an unfiltered bulb

D. As in (a) but with a bulb that disappears completely

Answer: A

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47. Two polaroids are kept crossed to each other. Now one of them is rotated through an angle of 45° . The percentage of incident light now transmitted through the system is

A. 0.15

B. 0.25

C. 0.5

D. 0.6

Answer: B

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48. A beam of light is linearly polarized . You wish to rotate its direction of polarization by 90° using one or more ideal polarizing sheets . To get maximum transmitted intensity , how many sheets should you use ?

A. 1

B. 2

C. 3

D. There is no way to rotate the direction of polarization 90° using polarizing sheets

Answer: D

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49. Electrimagnetic waves are transverse is nature is evident by

A. Polarization

B. Interference

C. Reflection

D. Diffraction

Answer: A

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50. Linear polarized light is incident at Brewster angle on the surface of a medium . If the incident beam is polarized parallel to the plane of incidence then the parallel component of light is

A. Completely refracted

B. Party refracted

C. Completely reflected

D. Completely absorbed

Answer: D

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51. When light is incident from air to glass at an angle 57°, the reflected beam is completely polarised. If the same beam is incident from water to glass, the angle of incidence at which reflected beam is completely polarised will be

A. $\theta = 57^\circ$

B. $\theta > 57^\circ$

C. $\theta < 57^\circ$

D. Cannot be determined

Answer: C

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52. Note the different types of electromagnetic radiation :

(1) X-rays

(2) radio waves

(3) gamma rays

(4) visible light

(5) infrared radiation

(6) ultraviolet radiation

Which list correctly ranks the electromagnetic waves in order of increasing frequency ?

A. 2,3,4,5,6,1

B. 2,5,4,6,1,3

C. 2,5,4,1,6,3

D. 3,1,6,4,5,2

Answer: B

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53. When a radio telescope observes a region of space between two stars it detects electromagnetic radiation that has a wavelength of 0.21 m . This radiation was emitted by hydrogen atoms in the gas and dust located in that region. What is the frequency of this radiation ?

A. 7.1×10^{10} Hz

B. 2.1×10^{14}Hz

C. 1.4×10^{9} Hz

D. 6.9×10^{11} Hz

Answer: C

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54. An FM radio station generates radio waves that have a frequency of 95.5 MHz. The frequency of the waves from a competing station have a frequency of 102.7 MHz. What is the difference in wavelength between the waves emitted from the two stations ?

A. 0.22 m

B. 0.84 m

C. 0.45 m

D. 2.4 m

Answer: A

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55. A radio wave sent from the surface of the Earth reflects from the surface of the moon and returns to the Earth . The elapsed time between the generation of the wave and the detection of the reflected wave is .6444 s. Determine the distance from the surface of the Earth to the surface of the Moon .

Note: The speed of light is 2.9979×10^8 m/s

A. 3.7688×10^8 m

B. 3.9638×10^8 m

C. 3.8445×10^8 m

D. 4.0551×10^8 m

Answer: B

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56. The average distance between the surface of the Earth and the surface of the Sun is 1.49×10^{11} m. How much time in minutes does it take for light leaving the surface of the Sun to reach the Earth ?

A. zero minutes

B. 8.3 min

C. 500 min

D. 74 min

Answer: B

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57. Which one of the following statements concening the energy carried by an electromagnetic wave is true ?

A. The energy is carred only by the electric field .

B. More energy is carried by the electric field than by the magnetic field.

C. The energy is carried equally by the electric and magnetic fields.

D. Moren energy is carried by the magnetic field than by the electric field.

Answer: C

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58. The amplitude of the electric field component of an electromagnetic wave is increased from E to 4 E. What is the corresponding change in the intensity of the wave ?

A. The intensity is unchanged by the increase in E .

B. The intensity increases by a factor of sixteen .

C. The intensity increases by a factor of four.

D. The intensity decreases by a factor of four.

Answer: B

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59. The peak value of the electric field component of an electromagnetic wave is E. At a particular instant the intensity of the wave is of 0.020 W/m^2 . If the electric field were increased to 5E what would be the intensity of the wave ?

A. $0.020W/m^2$

B. $0.25W/m^2$

C. $0.10W/m^2$

D. $0.50W/m^2$

Answer: D

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60. An electromagnetic wave has an electric field with peak value 250 N/C . What is the average intensity of the wave ?

A. $0.66W/m^2$

B. $83W/m^2$

C. $0.89W/m^2$

D. $120W/m^2$

Answer: B

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61. A laser uniformly illuminates an area with green light that has an average intensity of 550 W/m^2 . What is the rms value of the electric field of this light ?

A. 322 N/C

B. 455 N/C

C. 405 N/C

D. 643 N/C

Answer: B

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62. Electromagnetic waves are radiated uniformly in all directions from a source . The rms electric field of the waves is measured 35 km from the source to have an rms value of 0.42 N/C. Determine the average total power radiated by the source.

A. 4.1×10^5 W

B. 3.0×10^6 W

C. 8.3×10^5 W

D. 7.2×10^6 W

Answer: D

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Practice Questions More Than One Correct Choice Type

1. In a plane electromagnetic wave which of the following have zero average value ?

A. Magnetic field

B. Magnetic energy

C. Electric field

D. Electric energy

Answer: A::C

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2. Which of the following statements are correct with respect to the electromagnetic waves in an isotropic medium ?

A. Energy due to electric field is equal to that due to magnetic field .

B. Electric vector E and magnetic vector B are in phase .

C. For a given amplitude of E vector the intensity increases as the first power of frequency f .

D. For cylindrical wave fronts the amplitude of the wave varies in proportion to $1/r^2$ where r is the radius of the wave front.

Answer: A::B

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3. Which of the following pairs of space and time -varying E and B fields generate a plane electromagnetic wave traveling along z -direction ?

A. $E_x B_y$

B. E_y, B_x

C. E_x, B_z

D. E_z, B_x

Answer: A::B

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4. Which of the following are the properties of a plane polarized light ?

A. Electric field vectors lie in one plane

B. Magnetic field vectors lie in one plane

C. Both and vectors lie in the same plane

D. Vector is in the direction of propagation

Answer: A::B::D

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Practice Questions Linked Comprehension

1. Electromagnetic radiation is emitted by accelerating charges. The rate at which the e nergy is emitted from an accelerating charge that has charge q and acceleration a is given by dE/dt = $q^2 a^2 / 6\pi\varepsilon_0 c^3$, where c is the speed of light. A proton and an electron of kinetic energy 6 Me V is traveling in a particle accelerator in a circular orbit of radius 0.75 m. What fraction of its energy does a proton emit per second?

A. $1.1 \times 10^{-11} s^{-1}$

B. $2.1 \times 10^{-11} s^{-1}$

C. $3 \times 10^{-11} s^{-1}$

D. $1.4 \times 10^{-11} s^{-1}$

Answer: D

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2. Electromagnetic radiation is emitted by accelerating charges. The rate at which the e nergy is emitted from an accelerating charge that has charge q and acceleration a is given by dE/dt = $q^2a^2 / 6\pi\varepsilon_0 c^3$, where c is the speed of light. A proton and an electron of kinetic energy 6 Me V is traveling in a particle accelerator in a circular orbit of radius 0.75 m. What fraction of its energy does the proton emit per second?

A. $2.8 \times 10^{-8} s^{-1}$

B. $3.2 \times 10^{-8} s^{-1}$

C. $6 \times 10^{-11} s^{-1}$

D. None of these

Answer: A

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Practice Questions Matrix Match

1. Match the statements in Column I labeled as (a), (b), (c), and (d) with those in Column II labeled as (p), (q), (r), and (s).Any given statement in Column I can have correct matching with one or more statements in

Column II.

	Column I		Column II
(a)	$\oint \vec{E} . d\vec{s} = -\frac{d\phi_B}{dt}$	(p)	Maxwell's law of induction
(b)	$\oint \vec{B} . d\vec{s} = \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$	(q)	Ampere-Maxwell law
(c)	$\oint \vec{B} . d\vec{s} = \mu_0 I_{\text{enc}}$	(r)	Ampere's law
(d)	$\oint \vec{B} . d\vec{l} = u_0 \varepsilon_0 \frac{d\phi_E}{dt} + \mu_0 I_{\text{enc}}$	(s)	Faraday's law of indcution

A. $2.8 \times 10^{-8} s^{-1}$

B. $3.2 \times 10^{-8} s^{-1}$

C. $6 \times 10^{11} s^{-1}$

D. None of these

Answer: A::B::C::D

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2.

Column I

(a) All electromagnetic waves including visible light

(b) Electromagnetic waves whose frequency is in the range 500 kHz to 10

(c) The force exerted by an electromagnetic wave on unit area of surface

(d) The shortest wavelength radio waves

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3. In each question, there .is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Eac!h question bas 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

In the given table, Column I shows different laws in electromagnetic theory, Column II shows the related physica l quantities and Column III shows the equations related to the different laws.

Column I	Column II	Column II
(I) Gauss's law	(i)Magnetism	(J) $\oint \overrightarrow{B}.d\overrightarrow{s} = \mu_0\varepsilon_0\frac{d\phi_E}{dt} + \mu_0$
(II)Ampere's law	(ii)Current	(K) $\oint \overrightarrow{B}.d\overrightarrow{A} = 0$
(III)Gauss's law	(iii)Induction	(L) $\oint \overrightarrow{E}.d\overrightarrow{s} = \frac{d\phi_B}{dt}$
(IV)Faraday's	(iv)Electricity	(M) $\oint \overrightarrow{E}.d\overrightarrow{A} = \frac{q}{\varepsilon}$

In which law does the charge create diverging electric fields?

A. (I) (iv) (M)

B. (IV) (ii) (M)

C. (II) (i) (M)

D. (III) (iii) (M)

Answer: A

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4. In each question, there .is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Eac!h question bas 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

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Column I	Column II	Column II
(I) Gauss's law	(i) Magnetism	(J) $\oint \vec{B} \cdot d\vec{s} = \mu_0 \varepsilon_0 \frac{d\phi_E}{dt} + \mu_0$
(II) Ampere's law	(ii) Current	(K) $\oint \vec{B} \cdot d\vec{A} = 0$
(III) Gauss's law	(iii) Induction	(L) $\oint \vec{E} \cdot d\vec{s} = \frac{d\phi_B}{dt}$
(IV) Faraday's	(iv) Electricity	(M) $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon}$

Jn which law there are no magnetic monopoles invo lved?

A. (1) (ii) (J)

B. (III) (i) (K)

C. (II) (iii) (L)

D. (I) (i) (M)

Answer: B

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5. In each question, there .is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Eac!h question bas 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

In the given table, Column I shows different laws in electromagnetic theory, Column II shows the related physica l quantities and Column III shows the equations related to the different laws.

Column I	Column II	Column II
(I) Gauss's law	(i) Magnetism	(J) $\oint \overrightarrow{B} \,.\, d\overrightarrow{s} = \mu_0 \varepsilon_0 \frac{d\phi_E}{dt} + \mu_($
(II) Ampere's law	(ii) Current	(K) $\oint \overrightarrow{B} \,.\, d\overrightarrow{A} = 0$
(III) Gauss's law	(iii) Induction	(L) $\oint \overrightarrow{E} \,.\, d\overrightarrow{s} = \frac{d\phi_B}{dt}$
(IV) Faraday's	(iv) Electricity	(M) $\oint \overrightarrow{E} \,.\, d\overrightarrow{A} = \frac{q}{\varepsilon}$

In which law currents or changing electric fi elds(E's) make circulating magnetic fields (B's)?

A. (II) (ii) (J)

B. (I) (i) (L)

C. (IV) (i) (L)

D. (II) (iii) (M)

Answer: A

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6. There are various ways to produce the electromagnetic radiations. In the given table, Column I shows lhe process to form electromagnelic radiation. Column II shows the range of wavelength of the generated electromagnetic radiation and Column III shows the range of frequency of the generated electromagnetic radiation.

Column I	Column II
(I)Excitation and ejection of core atomic electrons	(i)Wavelength
(II)Excitation of molecular and atomic valence electrons	(ii)Wavelengtl
(III)Molecular vibration plasma oscillation	(iii)Wavelengt
(IV)Molecular electron excitation	(iv)Wavelengtl

(1) What are the characteristics of ultraviolet range of light?

A. (I) (iv) (M)

B. (IV) (ii) (L)

C. (II) (i) (K)

D. (II) (ii) (J)

Answer: D

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7. There are various ways to produce the electromagnetic radiations. In the given table, Column I shows lhe process to form electromagnelic radiation. Column II shows the range of wavelength of the generated electromagnetic radiation and Column III shows the range of frequency of the generated electromagnetic radiation.

Column I	Column II
(I)Excitation and ejection of core atomic electrons	(i)Wavelength
(II)Excitation of molecular and atomic valence electrons	(ii)Wavelengt
(III)Molecular vibration plasma oscillation	(iii)Wavelengt
(IV)Molecular electron excitation	(iv)Wavelengt

Wha t are the characte,istics of infrared range of light?

A. (I) (ii) (J)

B. (Ill) (iv) (L)

C. (II) (iii) (L)

D. (J) (i) (M)

Answer: B

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8. There are various ways to produce the electromagnetic radiations. In the given table, Column I shows lhe process to form electromagnelic radiation. Column II shows the range of wavelength of the generated electromagnetic radiation and Column III shows the range of frequency of the generated electromagnetic radiation.

Column I	Column II
(I)Excitation and ejection of core atomic electrons	(i)Wavelength
(II)Excitation of molecular and atomic valence electrons	(ii)Wavelengt
(III)Molecular vibration plasma oscillation	(iii)Wavelengt
(IV)Molecular electron excitation	(iv)Wavelengt

What are the characteristics of visible range of light?

A. (II) (ii) (J)

B. (TV) (i) (K)

C. (IV) (i) (L)

D. (II) (iii) (M)

Answer: B

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Practice Questions Integer Type

1. The velocity of electromagnetic waves in free space is 3×10^8 m/s. Whal is the frequency (in MHz) of the wavelength of vaJue 150 m?

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2. A parallel capacitor made of circular plates radius 10.0 cm has a capacitance of 200 pF. The capacitor is connected to a 200 a.c. supply with an angular frequency of $200\text{rad} \quad s^{-1}$.

(i) What is the r.m.s. value of conduction current

(ii) Is the conduction current equal to displacement current?

(iii) Find peak value of displacement current ?

(iv) Determine the amplitude of magnetic field at a point 2.0cm from the axis between the plates.

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3. A radiation of energy E falls normally on a perfctly refelecting surface . The momentum transferred to the surface is

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