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## PHYSICS

## BOOKS - CP SINGH PHYSICS

## (HINGLISH)

## ELECTROMAGNETIC WAVES

Example

1. The maximum magnetic field in a plane electromagnetic wave is $4 \mu T$. The wave is
going in the $x$-direction and magnetic field is
in $y$-direction. Find the maximum electric field in the wave and its direction.

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2. (a) Find the energy stored in a 90 cm length of a laser beam operating at $5 m W$.
(b) Find the amplitude of the electric field in a parallel beam of light of intensity $8.85 W . m^{2}$.

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3. The electric field in an electromahetic wave is given by $E=100 \sin \omega(t-x / c)$. Find the energy contained in a cylinder of crross section $20 \mathrm{~cm}^{2}$ and length 1 m along the $x$-axis.

Also find intensity of wave.

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4. Calculate the electric and magnetic fields produced by the radiation coming form a $30 \pi W$ bulb at a distance of 3 m . Assume that
the efficiency of the bulb is $10 \%$ and it is a point source.

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5. A light beam travelling in the $x$-direction is described by the eectirc field
$E_{y}=(300 V / m) \sin \omega(t-x / c)$. An electron
is constrained to move along the $y$-direction
with a speed of $2.0 \times 10^{7} \mathrm{~m} / \mathrm{sec}$. Find the maximum electric force and the maximum magnetic force on the electron.

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6. Light with an energy flux of $40 \mathrm{~W} / \mathrm{cm}^{2}$ falls on a non-reflecting surface at normal incidence. If the surface has an area of $20 \mathrm{~cm}^{2}$,
find the average force exerted on the surface during a 30 min time span.

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7. A plane electromagnetic wave propagating in the $x$-direction has a wavelength of 5.0 mm .

The electric field is in the $y$-direction and its maximum magnitude is $30 V\left(m^{-1}\right)$. Write suitable equations for the electric and magnetic fields as a function of $x$ and $t$.

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8. The magnetic field in a plane electromagnetic wave is given by
$B_{y}=2 \times 10^{7} T \sin \left(0.5 \times 10^{3} x+1.5 \times 10^{11} t\right) T$
(a) What is the wavelength and frequency of
the wave?
(b) Write an expression for the eletric field.

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9. A parallel plate capacitor with plate area $A$ and separation between the plates $d$, is charged by a constant current $i$. Consider a plane surface of area $A / 4$ parallel to the plates and drawn symmetrically between the plates. Find the displacement current through this area.

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10. A parallel plate capacitor with circular plates of radius $1 m$ has a capacitor of $1 n F$. At
$t=0$, it is connected for charging in series
with a resistor $R=1 M \Omega$ across a $2 V$ battery.

Calculate the magnetic field at a point $P$,
halfway between the cnetre and the periphery
of the plates, after $t=10^{-3} \mathrm{sec}$.


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Exercises

1. Which of the following is correct regarding electromagnetic wave?
A. In electromagnetic wave, electirc and
magnetic field vector oscillate
perpendicular to direction of progation
B. If wave is propagating in $x$-direction

$$
\begin{aligned}
& E=E_{0} \sin \omega\left(t-\frac{x}{c}\right) \\
& B=B_{0} \sin \omega\left(t-\frac{x}{c}\right) \\
& E_{0}=c B_{0}, c=\frac{1}{\sqrt{\mu_{0} \varepsilon_{0}}}
\end{aligned}
$$

C. Intensity of the wave $I=1 / 2 \varepsilon_{0} E_{0}^{2} c$

## D. All options are correct

# 2. Electromagnetic waves are produced by 

A. a static charge
B. a moving charge
C. an accelerating charge
D. chargeless particle

## Answer: C

3. Speed of electromagnetic waves is the same
A. for all wavelength
B. in all media
C. for all intensities
D. for all frequencies

## Answer: C

4. An em wave going through vacuum is described by $E=E_{0} \sin (k x-\omega t)$

$$
B=B_{0} \sin (k x-\omega t)
$$

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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5. A plane electromagnetic wave is incident on
a material surface. The wave delivers
momentum p and energy E .

$$
\begin{aligned}
& \text { A. } p=0, E \neq 0 \\
& \text { B. } p \neq 0, E=0 \\
& \text { C. } p \neq 0, E \neq 0 \\
& \text { D. } p=0, E=0
\end{aligned}
$$

Answer: C

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6. An electromagnetic wave going through
vacuum is described by
$E=E_{0} \sin (k x-\omega t)$. Which of the following is/are independent of the wavelength?
A. $k$
B. $\omega$
C. $k / \omega$
D. $k \omega$

Answer: C
7. Which of the following have zero average value un a plane electromagnetic wave?
(i)electric field (ii)magnetic field
(iii) electric energy (iv) magnetic enegry
A. $(i),(i i)$
B. $(i i),(i i i)$
C. $(i),(i i i)$
D. $(i),(i v)$

## Answer: A

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8. 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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9. The energy contained in a small volume through which an electromagnetic wave is passing oscillates with
A. zero frequency
B. the frequency of the wave
C. half the frequency of the wave
D. double the frequency of the wave

## Answer: D

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10. An electric field $(\vec{E})$ and a magnetic field $(\vec{B})$ exist in a region. The fields are not
perpendicular to each other.
A. This is not possible
B. No electromagnetic wave is passing
through the region
C. An electromagnetic wave may be passing
through the region
D. An electromagnetic wave is certinaly
passing thorugh the region

Answer: C
11. Choose the correct option
A. The radiation in increasing order of
frequency areradio waves, micro waves,
infrared, visible, ultraviolet, $x$-rays,
gamma rays, cosmic rays
B. The wavelength of colours in increasing
order violet, indigo, blue, green, yellow, orange and red
C. The speed of light is maximum in

## vacuum

D. All options are correct

## Answer: D

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12. The electric and the magnetic field, associated with an e.m. wave propagating along the + zaxis, can be represented by
A. $\left(\vec{E}=E_{0} \hat{j}, \vec{B}=B_{0} \hat{k}\right)$
B. $\left(\vec{E}=E_{0} \hat{j}, \vec{B}=B_{0} \hat{j}\right)$
c. $\left(\vec{E}=E_{0} \hat{k}, \vec{B}=B_{0} \hat{i}\right)$
D. $\left(\vec{E}=E_{0} \hat{j}, \vec{B}=B_{0} \hat{i}\right)$

Answer: D

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13. An electromagnetic wave travel along $z^{-}$ axis. Which of the following pair of space and
time varying fields would generate such a wave?
A. $E_{x}, B_{y}$
B. $E_{y}, B_{x}$
C. $E_{z}, B_{x}$
D. $E_{y}, B_{z}$

Answer: A
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14. The frequencies of $X$-rays, $\gamma$-rays and ultraviolet rays are respectively $a, b$ and $c$ .Then
A. altb, bgt c
B. agtb, bgt c
C. agtb, blt c
D. altb, blt c

Answer: A

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15. The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along
A. the same direction but differ in ohase by
$90^{\circ}$
B. the same direction and are in phase
C. mutually perpendicualr directions and
are in phase
D. mutually perpendicular directions and
differ in phase by $90^{\circ}$

Answer: C

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16. An electromagnetic wave in vacuum has the electric and magnetic field $\vec{E}$ and $\vec{B}$, which are always perpendicular to each other. The direction of polarization is given by $\vec{X}$ and that of wave propagation by $\vec{K}$. Then
A. $\vec{X}|\mid \vec{B}$ and $\hat{k}| \mid \vec{B} \times \vec{E}$
B. $\vec{X}|\mid \vec{E}$ and $\hat{k}| \mid \vec{E} \times \vec{B}$

# c. $\vec{X}|\mid \vec{B}$ and $\hat{k}| \mid \vec{E} \times \vec{B}$ <br> D. $\vec{X}|\mid \vec{E}$ and $\hat{k}| \mid \vec{B} \times \vec{E}$ 

Answer: B

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17. The electric field associted with an electromagnetic wave in vacuum is given by
$\vec{E}=\hat{i} 40 \cos \left(k z=6 \times 10^{8} t\right)$, when $E, z$ and $t$
are in volt/m metre and second respectively
find the wave vector.
A. $2 m^{-1}$
B. $0.5 m^{-1}$
C. $6 m^{-1}$
D. $3 m^{-1}$

Answer: A

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18. The magnetic field amplitude of an electromagnetic wave is $2 \times 10^{-7} T$. Its'
electirc field amplitude if the wave is traveling in free space is
A. $6 \mathrm{Vm}^{-1}$
B. $60 \mathrm{Vm}^{-1}$
C. $10 / 6 \mathrm{Vm}^{-1}$
D. none of these

Answer: B

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19. The rms value of the electric field of the
light from the sun is $720 \mathrm{~N} / \mathrm{C}$ The total energy density of the electromagnetic wave is

$$
\begin{aligned}
& \text { A. } 6.37 \times 10^{-9} \mathrm{~J} / \mathrm{m}^{3} \\
& \text { B. } 81.35 \times 10^{-12} \mathrm{~J} / \mathrm{m}^{3} \\
& \text { C. } 3.3 \times 10^{-3} \mathrm{~J} / \mathrm{m}^{3} \\
& \text { D. } 4.58 \times 10^{-6} \mathrm{~J} / \mathrm{m}^{3}
\end{aligned}
$$

Answer: D

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20. If the total electromagnetic energy falling
on a surface is $U$ then the total momentum delivered (for complate absorption) is
A. $U / c$
B. $c U$
C. $U / c^{2}$
D. $c^{2} U$

Answer: A

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## 21. Find the energy stored in a 60 cm length of

a laser beam operating at 4 mW .

$$
\begin{aligned}
& \text { A. } 8 \times 10^{-12} J \\
& \text { B. } 0.8 \times 10^{-12} J \\
& \text { C. } 0.008 \times 10^{-12} J \\
& \text { D. } 80 \times 10^{-12} J
\end{aligned}
$$

Answer: A

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