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Maharashtra State Board 11th Physics Solutions Chapter 13 Electromagnetic Waves and Communication System

1. Choose the correct option.

Question 1.
The EM wave emitted by the Sun and responsible for heating the Earth's atmosphere due to green house effect is
(A) Infra-red radiation
(B) X ray
(C) Microwave
(D) Visible light
Answer:
(A) Infra-red radiation

Question 2.
Earth's atmosphere is richest in
(A) UV
(B) IR
(C) X-ray
(D) Microwaves
Answer:
(B) IR

Question 3.
How does the frequency of a beam of ultraviolet light change when it travels from air into glass?
(A) depends on the values of p and e
(B) increases
(C) decreases
(D) remains same
Answer:
(D) remains same

Question 4.
The direction of EM wave is given by
(A) $\vec{E} \times \vec{B}$
(B) $\vec{E} . \vec{B}$
(C) along $\vec{E}$
(D) along $\vec{B}$
Answer:
(A) $\vec{E} \times \vec{B}$

Question 5.
The maximum distance upto which TV transmission from a TV tower of height h can be received is proportional to
(A) $h^{1/2}$
(B) h
(C) $h^{3/2}$
(D) h^2
Answer:
(A) $h^{1/2}$

Question 6.
The waves used by artificial satellites for communication purposes are
(A) Microwave
(B) AM radio waves
(C) FM radio waves
(D) X-rays
Answer:
(A) Microwave

Question 7.
If a TV telecast is to cover a radius of 640 km, what should be the height of transmitting antenna?
(A) 32000 m
(B) 53000 m
(C) 42000 m
(D) 55000 m
Answer:
(A) 32000 m

2. Answer briefly.

Question 1.
State two characteristics of an EM wave.
Answer:
i. The electric and magnetic fields, $\vec{E}$ and $\vec{B}$ are always perpendicular to each other and also to the direction of propagation of the EM wave. Thus, the EM waves are transverse waves.

ii. The cross product ($\vec{E}$ × $\vec{B}$) gives the direction in which the EM wave travels. ($\vec{E}$ × $\vec{B}$) also gives the energy carried by EM wave.

Question 2.
Why are microwaves used in radar?
Answer:
Microwaves are used in radar systems for identifying the location of distant objects like ships, aeroplanes etc.

Question 3.
What are EM waves?
Answer:
Waves that are caused by the acceleration of charged particles and consist of electric and magnetic fields vibrating sinusoidally at right angles to each other and to the direction of propagation are called EM waves or EM radiation.

Question 4.
How are EM waves produced?
Answer:

1. According to quantum theory, an electron, while orbiting around the nucleus in a stable orbit does not emit EM radiation even though it undergoes acceleration.
2. It will emit an EM radiation only when it falls from an orbit of higher energy to one of lower energy.
3. EM waves (such as X-rays) are produced when fast moving electrons hit a target of high atomic number (such as molybdenum, copper, etc.).
4. An electric charge at rest has an electric field in the region around it but has no magnetic field.
5. When the charge moves, it produces both electric and magnetic fields.
6. If the charge moves with a constant velocity, the magnetic field will not change with time and hence, it cannot produce an EM wave.
7. But if the charge is accelerated, both the magnetic and electric fields change with space and time and an EM wave is produced.
8. Thus, an oscillating charge emits an EM wave which has the same frequency as that of the oscillation of the charge.

Question 5.
Can we produce a pure electric or magnetic wave in space? Why?
Answer:
No.
In vacuum, an electric field cannot directly induce another electric field so a “pure” electric field wave cannot exist and same can be said for a “pure” magnetic wave.

Question 6.
Does an ordinary electric lamp emit EM waves?
Answer:
Yes, ordinary electric lamp emits EM waves.

Question 7.
Why light waves travel in vacuum whereas sound wave cannot?
Answer:
Light waves are electromagnetic waves which can travel in vacuum whereas sound waves travel due to the vibration of particles of medium. Without any particles present (like in a vacuum) no vibrations can be produced. Hence, the sound wave cannot travel through the vacuum.

Question 8.
What are ultraviolet rays? Give two uses.
Answer:
Production:

1. Ultraviolet rays can be produced by the mercury vapour lamp, electric spark and carbon arc lamp.
2. They can also be obtained by striking electrical discharge in hydrogen and xenon gas tubes.
3. The Sun is the most important natural source of ultraviolet rays, most of which are absorbed by the ozone layer in the Earth’s atmosphere.

Uses:

1. Ultraviolet rays destroy germs and bacteria and hence they are used for sterilizing surgical instruments and for purification of water.
2. Used in burglar alarms and security systems.
3. Used to distinguish real and fake gems.

Question 9.
What are radio waves? Give its two uses.
Answer:

1. Radio waves are produced by accelerated motion of charges in a conducting wire. The frequency of waves produced by the circuit depends upon the magnitudes of the inductance and the capacitance.
2. Thus, by choosing suitable values of the inductance and the capacitance, radio waves of desired frequency can be produced.

Uses:

1. Radio waves are used for wireless communication purpose.
2. They are used for radio broadcasting and transmission of TV signals.
3. Cellular phones use radio waves to transmit voice communication in the ultra high frequency (UHF) band.

Question 10.
Name the most harmful radiation entering the Earth's atmosphere from the outer space.
Answer:
Ultraviolet radiation.

Question 11.
Give reasons for the following:
i. Long distance radio broadcast uses short wave bands.
ii. Satellites are used for long distance TV transmission.
Answer:
i. Long distance radio broadcast uses short wave bands because electromagnetic waves only in the frequency range of short wave bands only are reflected by the ionosphere.

ii. a. It is necessary to use satellites for long distance TV transmissions because television signals are of high frequencies and high energies. Thus, these signals are not reflected by the ionosphere.
b. Hence, satellites are helpful in long distance TV transmission.

Question 12.
Name the three basic units of any communication system.
Answer:
Three basic (essential) elements of every communication system are transmitter, communication channel and receiver.

Question 13.
What is a carrier wave?
Answer:
The high frequency waves on which the signals to be transmitted are superimposed are called carrier waves.

Question 14.
Why high frequency carrier waves are used for transmission of audio signals?
Answer:
An audio signal has low frequency (<20 kHz) and low frequency signals cannot be transmitted over large distances. Because of this, a high frequency carrier waves are used for transmission.

Question 15.
What is modulation?
Answer:
The signals in communication system (e.g. music, speech etc.) are low frequency signals and cannot be transmitted over large distances. In order to transmit the signal to large distances, it is superimposed on a high frequency wave (called carrier wave). This process is called modulation.

Question 16.
What is meant by amplitude modulation?
Answer:
When the amplitude of carrier wave is varied in accordance with the modulating signal, the process is called amplitude modulation.

Question 17.
What is meant by noise?
Answer:

1. A random unwanted signal is called noise.
2. The source generating the noise may be located inside or outside the system.
3. Efforts should be made to minimize the noise level in a communication system.

Question 18.
What is meant by bandwidth?
Answer:
The bandwidth of an electronic circuit is the range of frequencies over which it operates efficiently.

Question 19.
What is demodulation?

Answer:
The process of regaining signal from a modulated wave is called demodulation. This is the reverse process of modulation.

Question 20.
What type of modulation is required for television broadcast?
Answer:
Amplitude modulation is required for television broadcast.

Question 21.
How does the effective power radiated by an antenna vary with wavelength?
Answer:

1. To transmit a signal, an antenna or an aerial is needed.
2. Power radiated from a linear antenna of length l is, $P \propto (l\lambda)^2$
   where, λ is the wavelength of the signal.

Question 22.
Why should broadcasting programs use different frequencies?
Answer:
If broadcasting programs run on same frequency, then the information carried by these waves will get mixed up with each other. Hence, different broadcasting programs should run on different frequencies.

Question 23.
Explain the necessity of a carrier wave in communication.
Answer:

1. Without a carrier wave, the input signals could be carried by very low frequency electromagnetic waves but it will need quite a bit of amplification in order to transmit those very low frequencies.
2. The input signals themselves do not have much power and need a fairly large antenna in order to transmit the information.
3. Hence, it is necessary to impose the input signal on carrier wave as it requires less power in order to transmit the information.

Question 24.
Why does amplitude modulation give noisy reception?
Answer:
i. In amplitude modulation, carrier is varied in accordance with the message signal.

ii. The higher the amplitude, the greater is magnitude of the signal. So even if due to any reason, the magnitude of the signal changes, it will lead to variation in the amplitude of the signal. So its easy for noise to disturb the amplitude modulated signal.

Question 25.
Explain why is modulation needed.
Answer:
Modulation helps in avoiding mixing up of signals from different transmitters as different carrier wave frequencies can be allotted to different transmitters. Without the use of these waves, the audio signals, if transmitted directly by different transmitters, would get mixed up.

3. Solve the numerical problem.

Question 1.
Calculate the frequency in MHz of a radio wave of wavelength 250 m. Remember that the speed of all EM waves in vacuum is 3.0×10^8 m/s.
Answer:
Given: $\lambda = 250$ m, $c = 3 \times 10^8$ m/s
To find: Frequency (v)
Formula: $c = v^8$
Calculation: From formula,
$v = c\lambda = 3 \times 10^8 250 = 1.2 \times 10^6$ Hz
$= 1.2$ MHz

Question 2.
Calculate the wavelength in nm of an X-ray wave of frequency 2.0×10^{18} Hz.
Solution:
Given: $c = 3 \times 10^8$, $v = 2 \times 10^{18}$ Hz
To find: Wavelength (λ)
Formula: $c = v\lambda$
Calculation. From formula,
$\lambda = cv = 3 \times 10^8 2 \times 10^{18} = 1.5 \times 10^{-10}$
$= 0.15$ nm

Question 3.
The speed of light is 3×10^8 m/s. Calculate the frequency of red light of wavelength of 6.5×10^{-7} m.
Answer:
Given: $c = 3 \times 10^8$ m/s, $\lambda = 6.5 \times 10^{-7}$ m
To find: Frequency (v)
Formula: $c = v\lambda$

Calculation: From formula,
$v = c\lambda = 3\times10^{8}6.5\times10^{-7} = 4.6 \times 10^{14}$ Hz

Question 4.
Calculate the wavelength of a microwave of frequency 8.0 GHz.
Answer:
Given: $v = 8$ GHz $= 8 \times 10^{9}$ Hz,
$c = 3 \times 10^{8}$ m/s
To find: Wavelength (λ)
Formula: $c = v\lambda$
Calculation: From formula,
$\lambda = c\lambda = 3\times10^{8}8\times10^{9} = 3.75 \times 10^{-2}$
$= 3.75$ cm

Question 5.
In a EM wave the electric field oscillates sinusoidally at a frequency of 2×10^{10} What is the wavelength of the wave?
Answer:
Given: $v = 2 \times 10^{10}$ Hz, $c = 3 \times 10^{8}$ m
To find: Wavelength (λ)
Formula: $c = v\lambda$
Calculation: From formula,
$\lambda = c\lambda = 3\times10^{8}2\times10^{10} = 1.5 \times 10^{-2}$

Question 6.
The amplitude of the magnetic field part of a harmonic EM wave in vacuum is B0 = 5 X 10-7 T. What is the amplitude of the electric field part of the wave?
Answer:
Given: $B_0 = 5 \times 10^{-7}$ T, $c = 3 \times 10^{8}$
To find: Amplitude of electric field (E_0)
Formula: $c = E_oB_o$
Calculation /From formula,
$E_0 = c \times B_0$
$= 3 \times 10^{8} \times 5 \times 10^{-7}$
$= 150$ V/m

Question 7.
A TV tower has a height of 200 m. How much population is covered by TV transmission if the average population density around the tower is $1000/km^2$? (Radius of the Earth $= 6.4 \times 10^{6}$ m)
Answer:
Given: $h = 200$ m,
Population density (n)
$= 1000/km^2 = 1000 \times 10^{-6}/m^2 = 10^{-3}/m^2$
$R = 6.4 \times 10^{6}$ m
To find: Population covered
Formulae: i. $A = \pi d^2 = \pi(\sqrt{2Rh})^2 = 2\pi Rh$
ii. Population covered = nA
Calculation /From formula (i),
$A = 2\pi Rh$
$= 2 \times 3.142 \times 6.4 \times 10^{6} \times 200$
$\approx 8 \times 10^{9}$ m²
From formula (ii),
Population covered = nA
$= 10^{-3} \times 8 \times 10^{9}$
$= 8 \times 10^{6}$

Question 8.
Height of a TV tower is 600 m at a given place. Calculate its coverage range if the radius of the Earth is 6400 km. What should be the height to get the double coverage area?
Answer:
Given: $h = 600$ m, $R = 6.4 \times 10^{6}$ m
To find: Range (d)
Height to get the double coverage (h')
Formula: $d = \sqrt{2hR}$
Calculation: From formula,
$d = \sqrt{2\times600\times6.4\times10^{6}} = 87.6 \times 10^{3} = 87.6$ km
Now, for A' = 2A
$\pi(d')^2 = 2(\pi d^2)$
$\therefore (d')^2 = 2d^2$
From formula,

h′ = $(d')_2 2R$

= $2d_2 2R$

= 2 × h ..... ($\because$ h = $d_2 2R$)

= 2 × 600

=1200 m

Question 9.
A transmitting antenna at the top of a tower has a height 32 m and that of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in line of sight mode? Given radius of Earth is 6.4 × 10_6 m.
Answer:
Given: h_t = 32 m, h_r = 50 m, R = 6.4 × 10_6 m
To find: Maximum distance or range (d)

Formula: d = $\sqrt{2Rh}$

Calculation: From formula,

$d_t = \sqrt{2Rh_t} = \sqrt{2 \times 6.4 \times 10_6 \times 32}$

= 20.238 × 10^3 m
= 20.238 km

$d_r = \sqrt{2Rh_t}$

$= \sqrt{2 \times 6.4 \times 10_6 \times 50}$

= 25.298 × 10^3 m
= 25.298 km
Now, d = d_t + d_r
= 20.238 + 25.298
= 45.536 km

11th Physics Digest Chapter 13 Electromagnetic Waves and Communication System Intext Questions and Answers

Can you recall? (Textbookpage no. 229)

Question 1.
i. What is a wave?
Answer:
Wave is an oscillatory disturbance which travels through a medium without change in its form.

ii. What is the difference between longitudinal and transverse waves?
Answer:
a. Transverse wave: A wave in which particles of the medium vibrate in a direction perpendicular to the direction of propagation of wave is called transverse wave.
b. Longitudinal wave: A wave in which particles of the medium vibrate in a direction parallel to the direction of propagation of wave is called longitudinal wave.

iii. What are electric and magnetic fields and what are their sources?
Answer:
a. Electric field is the force experienced by a test charge in presence of the given charge at the given distance from it.
b. A magnetic field is produced around a magnet or around a current carrying conductor.

iv. By which mechanism heat is lost by hot bodies?
Answer:
Hot bodies lose the heat in the form of radiation.

Question 2.
What are Lenz's law, Ampere's law and Faraday's law?
Answer:
Lenz's law:
Whereas, Lenz's law states that, the direction of the induced emf is such that the change is opposed.

Ampere's law:
Ampere's law describes the relation between the induced magnetic field associated with a loop and the current flowing through the loop.

Faraday's law:
Faraday's law states that, time varying magnetic field induces an electromotive force (emf) and an electric field.

Internet my friend. (Tpxtboakpage no. 240)

https//www.iiap.res.in/centers/iao
[Students are expected to visit the above mentioned website and collect more information about different EM wave propagations used by astronomical observatories.]