ELECTROMAGNETIC WAVES

FACT/DEFINITION TYPE QUESTIONS

1. The current in the electric circuit which arises due to flow of electrons in the connecting wires of the circuit in a defined closed path is called
(a) alternating current
(b) direct current
(c) conduction current
(d) displacement current

2. The conduction current is same as displacement current when source is
(a) ac only (b) dc only
(c) either ac or dc (d) neither dc nor ac

3. If a variable frequency ac source connected to a capacitor then with decrease in frequency, the displacement current will
(a) increase
(b) decrease
(c) remain constant
(d) first decrease then increase

4. Displacement current goes through the gap between the plates of a capacitor when the charge on the capacitor
(a) is changing with time (b) decreases
(c) does not change (d) decreases to zero

5 The displacement current was first postulated by
(a) Maxwell (b) Marconi
(c) Ampere (d) Hertz

6. Ampere's circuital law holds good for
(a) conduction current (b) displacement current
(c) both (a) and (b) (d) None of these

7. When radio waves passes through ionosphere, phase difference between space current and capacitive displacement current is
(a) 0 rad (b) $(3\pi/2)$ rad
(c) $(\pi/2)$ rad (d) π rad

8. Displacement current is
(a) continuous when electric field is changing in the circuit
(b) continuous when magnetic field is changing in the circuit
(c) continuous in both types of fields
(d) continuous through wires and resistance only

9. The displacement current is
(a) $\varepsilon_o \, d\phi_E / dt$ (b) $\frac{\varepsilon_o}{R} d\phi_E / dt$
(c) $\varepsilon_o \, E / R$ (d) $\varepsilon_o \, q \, C / R$

10. Maxwell's equation describe the fundamental law of
(a) electricity (b) magnetism
(c) mechanics (d) both (a) and (b)

11. If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic field vectors of an electromagnetic wave, then the direction of propagation of the electromagnetic wave, is along
(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{B} \times \vec{E}$ (d) $\vec{E} \times \vec{B}$

12. According to Maxwell's hypothesis, a changing electric field gives rise to
(a) an e.m.f
(b) electric displacement current
(c) magnetic field
(d) pressure gradient

13. Electromagnetic wave consists of periodically oscillating electric and magnetic vectors
(a) in mutually perpendicular planes but vibrating with a phase difference of π
(b) in mutually perpendicular planes but vibrating with a phase difference of $\frac{\pi}{2}$
(c) in randomly oriented planes but vibrating in phase
(d) in mutually perpendicular planes but vibrating in phase

14. An electromagnetic wave propagating along north has its electric field vector upwards. Its magnetic field vector point towards
(a) north (b) east
(c) west (d) downwards

15. The electromagnetic waves
(a) travel with the speed of sound
(b) travel with the same speed in all media
(c) travel in free space with the speed of light
(d) do not travel through a medium

16. Which of the following type of radiations are radiated by an oscillating electric charge?
(a) Electric (b) Magnetic
(c) Thermoelectric (d) Electromagnetic

17. If $\vec{E}$ and $\vec{B}$ are the electirc and magnetic field vectors of e.m. waves then the direction of propagation of e.m. wave is along the direction of
(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{E} \times \vec{B}$ (d) None of these

18. According to Maxwell's equation the velocity of light in any medium is expressed as
(a) $\frac{1}{\sqrt{\mu_0 \varepsilon_o}}$ (b) $\frac{1}{\sqrt{\mu \varepsilon}}$ (c) $\sqrt{\mu/\varepsilon}$ (d) $\sqrt{\frac{\mu_0}{\varepsilon}}$

19. The electromagnetic waves do not transport
(a) energy (b) charge
(c) momentum (d) information

20. The amplitudes of electric and magnetic fields related to each other are
(a) $E_0 = B_0$ (b) $E_0 = c B_0$
(c) $E_0 = \frac{B_0}{c}$ (d) $E_0 = \frac{c}{B_0}$

21. In an electromagnetic wave, the direction of the magnetic induction $\vec{B}$ is
(a) parallel to the electric field $\vec{E}$
(b) perpendicular to the electric field $\vec{E}$
(c) antiparallel to the Poynting vector $\vec{S}$
(d) random

22. The speed of electromagnetic wave is same for
(a) odd frequencies (b) even frequencies
(c) all frequencies (d) all intensities

23. A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum p and energy E, then
(a) $p = 0, E = 0$ (b) $p \neq 0, E \neq 0$
(c) $p \neq 0, E = 0$ (d) $p = 0, E \neq 0$

24. We consider the radiation emitted by the human body. Which one of the following statements is true?
(a) The radiation emitted is in the infrared region.
(b) The radiation is emitted only during the day.
(c) The radiation is emitted during the summers and absorbed during winters.
(d) The radiation is emitted lies in the ultraviolet region and hence is not visible.

25. The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is
(a) microwave, infrared, ultraviolet, gamma rays
(b) infrared, microwave, ultraviolet, gamma rays
(c) gama rays, ultraviolet, infrared, microwaves
(d) microwaves, gamma rays, infrared, ultraviolet

26. X-rays, gamma rays and microwaves travelling in vaccum have
(a) same wavelength but different velocities
(b) same frequency but different velocities
(c) same velocity but different wavelength
(d) same velocity and same frequency

27. Radio waves diffract around building, although light waves do not. The reason is that radio waves
(a) travel with speed larger than c
(b) have much larger wavelength than light
(c) are not electromagnetic waves
(d) None of these

28. Microwaves are detected by
(a) bolometer (b) point contact diodes
(c) thermopiles (d) the eye

29. Which of the following electromagnetic waves has the longest wavelength?
(a) uv-rays
(b) Visible light
(b) Radio waves
(d) Microwaves

30. Which of the following is of shortest wavelength?
(a) X-rays (b) γ-rays
(c) Microwaves (d) Radio waves

31. The range of wavelength of visible light is
(a) 10 Å to 100 Å (b) 4000 Å to 8000 Å
(c) 8000 Å to 10,000 Å (d) 10,000 Å to 15,000 Å

32. Which of the following is not electromagnetic waves?
(a) Cosmic rays (b) Gamma rays
(c) β-rays (d) X-rays

33. Which of the following electromagnetic radiations have the smallest wavelength?
(a) Ultraviolet waves (b) X-rays
(c) γ-rays (d) Microwaves

34. Which of the following rays has minimum frequency?
(a) U.V. ways (b) X-rays
(c) γ-rays (d) Infra-red rays

35. An accelerated electron would produce
(a) γ-rays (b) β-rays
(c) α-rays (d) e.m. waves

36. Which of the following is the infrared wavelength?
(a) 10^{-4} cm (b) 10^{-5} cm
(c) 10^{-6} cm (d) 10^{-7} cm

37. The wavelength of X-ray is of the order of
(a) 1 metre (b) 1 cm
(c) 1 micron (d) 1 angstrom

38. Radio waves of constant amplitude can be generated with
(a) rectifier (b) filter
(c) F.E.T. (d) oscillator

39. Radio waves do not penetrate in the band of
(a) ionosphere (b) mesosphere
(c) troposphere (d) stratosphere

40. What is the cause of "Green house effect"?
(a) Infrared rays (b) Ultraviolet rays
(c) X-rays (d) Radio waves

41. If v_s, v_x and v_m are the speed of soft gamma rays, X-rays and microwaves respectively in vacuum, then
(a) $v_s > v_x > v_m$ (b) $v_s < v_x < v_m$
(c) $v_s > v_x < v_m$ (d) $v_s = v_x = v_m$

42. The waves which are electromagnetic in nature are
(a) sound waves and light waves
(b) water waves and radio waves
(c) light waves and X-rays
(d) sound waves and water waves

43. In electromagnetic spectrum, the frequencies γ-rays, X-rays and ultraviolet rays are denoted by n_1, n_2 and n_3 respectively then
(a) $n_1 > n_2 > n_3$ (b) $n_1 < n_2 < n_3$
(c) $n_1 > n_2 < n_3$ (d) $n_1 < n_2 > n_3$

44. Ultraviolet spectrum can be studied by using a
(a) flint glass prism (b) direct vision prism
(c) nicol prism (d) quartz prism

45. The ozone layer in the atmosphere absorbs
(a) only the radiowaves
(b) only the visible light
(c) only the γ-rays
(d) X-rays and ultraviolet rays

46. Which one of the following has the maximum energy?
(a) Radio waves (b) Infrared rays
(c) Ultraviolet rays (d) Micro waves

47. Which one of the following has the shortest wavelength?
(a) Infrared rays (b) Ultraviolet rays
(c) Microwaves (d) Gamma rays

48. When electromagnetic waves enter the ionised layer of ionosphere, then the relative permittivity i.e. dielectric constant of the ionised layer
(a) does not change
(b) appears to increase
(c) appears to decrease
(d) sometimes appears to increase and sometimes to decrease

49. Ultraviolet rays coming from sun are absorbed by
(a) troposphere (b) ionosphere
(c) stratosphere (d) mesosphere

50. The EM waves when travel into different media gets
(a) refracted (b) transmitted
(c) reflected (d) emitted

51. The absorption of radio waves by the atmosphere depends upon
(a) their velocities
(b) their frequencies
(c) their distance from the transmitter
(d) None of these

52. The velocity of all radio waves in free space is 3×10^8 m/s. The frequency of a radio wave of wavelength 150m is
(a) 20 kHz (b) 2 kHz (c) 2 MHz (d) 1 MHz

53. The polarisation of electromagnetic wave is in
(a) the directions of electric and magnetic field
(b) the directions of electric field
(c) the direction of magnetic field
(d) can not be polarized

54. If the frequency of EM radiations is halved then the energy of EM radiation will become
(a) double (b) remains unchanged
(c) becomes half (d) becomes one fourth

55. Microwaves are electromagnetic waves with frequency in the range of
(a) Micro hertz (b) Giga hertz
(c) Mega hertz (d) Hertz

56. For television broadcasting the frequency employed is normally
(a) 30-300 MHz (b) 30-300 GHz
(c) 30-300 kHz (d) 30-300 Hz

57. Electromagnetic waves of frequency .... are reflected from ionosphere.
(a) 100 MHz (b) 2 MHz to 80 MHz
(c) upto 1.5 MHz (d) less than 1.5 MHz

58. When an electromagnetic wave enters an ionised layer of earth's atmosphere present in ionosphere
(a) the electron cloud will not oscillate in the electric field of the wave
(b) the electron cloud will oscillate in the electric field of wave in the phase of sinusoidal electromagnetic wave
(c) the electron cloud will oscillate in the electric field of wave in the opposite phase of sinusoidal electromagnetic wave
(d) the electron cloud will oscillate in the electric field of wave with a phase retardation of 90° for a sinusoidal electromagnetic wave.

59. An electron oscillating with a frequency of 3×10^6 Hz, would generate
(a) X-rays (b) ultraviolet rays
(c) radio waves (d) microwaves

60. The cellular mobile radio frequency band is
(a) 88 – 108 MHz (b) 54 – 72 MHz
(c) 540 – 1600 KHz (d) 840 – 935 MHz

61. Select the wrong statement. EM waves
(a) are transverse in nature.
(b) travel in free space at a speed of light.
(c) are produced by accelerating charges.
(d) travel in all media with same speed.

62. Ozone layer above earth's atmosphere will not
(a) prevent infrared radiations from sun reaching earth.
(b) prevent infra red radiations originated from earth from escaping earth's atmosphere.
(c) prevent ultraviolet rays from sun.
(d) reflect back radio waves.

63. Intensity of electromagnetic wave will be

(a) $I = c\mu_0 B_0^2 / 2$ (b) $I = c\varepsilon_0 B_0^2 / 2$

(c) $I = B_0^2 / c\mu_0$ (d) $I = E_0^2 / 2c\varepsilon_0$

64. The frequency of electromagnetic wave, which best suited to observe a particle of radii 3×10^{-4} cm is of the order of

(a) 10^{15} (b) 10^{14}

(c) 10^{13} (d) 10^{12}

65. If $\lambda = 10\,\text{Å}$ then it corresponds to

(a) infrared (b) microwaves

(c) ultraviolet (d) X-rays

66. 10 cm is a wavelength corresponding to the spectrum of

(a) infrared rays (b) ultra-violet rays

(c) microwaves (d) γ -rays

67. In an electromagnetic wave

(a) power is transmitted along the magnetic field

(b) power is transmitted along the electric field

(c) power is equally transferred along the electric and magnetic fields

(d) power is transmitted in a direction perpendicular to both the fields

68. The electric and the magnetic field associated with an E.M. wave, propagating along the +z-axis, can be represented by

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

(c) $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{i}\right]$ (d) $\left[\vec{E} = E_0\hat{j}, \vec{B} = B_0\hat{k}\right]$

69. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is

(a) the frequency of the microwaves has no relation with natural frequency of water molecules.

(b) microwaves are heat waves, so always produce heating.

(c) infra-red waves produce heating in a microwave oven.

(d) the frequency of the microwaves must match the resonant frequency of the water molecules.

70. Which of the following radiations has the least wavelength ?

(a) γ -rays (b) β -rays

(c) α -rays (d) X -rays

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

(a) Both magnetic and electric field

(b) Electric field only

(c) Magnetic energy

(d) Electric energy

72. The ratio of electric field vector E and magnetic field vector H i.e., $\left(\frac{E}{H}\right)$ has the dimensions of

(a) resistance

(b) inductance

(c) capacitance

(d) product of inductance and capacitance

73. The ozone layer absorbs radiation of wavelengths

(a) less than 3×10^{-7} m (b) more than 3×10^{-7} m

(c) less than 3×10^{-5} m (d) more than 3×10^{-5} m

74. The speed of electromagnetic wave in vacuum depends upon the source of radiation. It

(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 these

75. In which one of the following regions of the electromagnetic spectrum will the vibrational motion of molecules give rise to absorption ?

(a) Ultraviolet (b) Microwaves

(c) Infrared (d) Radio waves

76. The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along

(a) the same direction but differ in phase by 90°

(b) the same direction and are in phase

(c) mutually perpendicular directions and are in phase

(d) mutually perpendicular directions and differ in phase by 90°

77. Biological importance of ozone layer is

(a) it stops ultraviolet rays

(b) ozone layer reduce green house effect

(c) ozone layer reflects radio waves

(d) ozone layer controls O_2 / H_2 radio in atmosphere

78. It is possible to take pictures of those objects which are not fully visible to the eye using camera films sensitive to

(a) ultraviolet rays (b) infrared rays

(c) microwaves (d) radiowaves

79. The waves used in telecommunication are

(a) IR (b) UV

(c) Microwave (d) Cosmic rays

80. The electromagnetic radiation used in food processing sterilizing agent is

(a) microwaves (b) UV rays

(c) gamma rays (d) radio waves

STATEMENT TYPE QUESTIONS

81. Select the correct statement(s) from the following.

I. Displacement current comes into play in a region where electric field is changing with time.

II. Displacement current $I_D = \varepsilon_0 \frac{\partial\phi E}{\phi t}$

III. In case of a steady electric flux linked with a region the displacement current is minimum.

(a) I only (b) II only

(c) I and II only (d) I, II and III

82. An electromagnetic wave of intensity I falls on a surface kept in vacuum and exerts radiation pressure P on it. Which of the following statements are true?

I. Radiation pressure is I/c if the wave is totally absorbed.

II. Radiation pressure is I/c if the wave is totally reflected.

III. Radiation pressure is $2\ I/c$ if the wave is totally reflected.

(a) I and II (b) I and III

(c) III only (d) I, II and III

83. Which of the following is/are true for electromagnetic waves?

I. They transport energy.

II. They have momentum.

III. They travel at different speeds in air depending on their frequency.

(a) I and III (b) II only

(c) I, II and III (d) I and II

84. The amplitude of an electromagnetic wave in vacuum is doubled with no other changes made to the wave. As a result of this doubling of the amplitude, which of the following statements are incorrect?

I. The speed of wave propagation chages only

II. The frequency of the wave changes only

III. The wavelength of the wave changes only

(a) I and II (b) II and III

(c) I and III (d) I, II and III

85. Select the correct statement(s) from the following.

I. Wavelength of microwaves is greater than that of ultraviolet rays.

II. The wavelength of infrared rays is lesser than that of ultraviolet rays.

III. The wavelength of microwaves is lesser than that of infrared rays

IV. Gamma ray has shortest wavelength in the electromagnetic spectrum

(a) I and II (b) II and III

(c) III and IV (d) I and IV

MATCHING TYPE QUESTIONS

86. Match the columns I and II.

Column I	**Column II**
(A) Energy associated with an electromagnetic wave	1. $\frac{1}{\sqrt{\mu\varepsilon}}$
(B) Radiation pressure	2. $\frac{u}{c}$
(C) Speed of EM wave in a medium	3. $\frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$
(D) Displacement current	4. $I_D = \varepsilon_0 \frac{d\phi E}{dt}$

(a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)

(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)

(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

87. Various electromagnetic waves are given in column I and various frequency ranges in column II. Match the two columns.

Column I	**Column II**
(A) Radio waves	(1) 1×10^{16} to 3×10^{21} Hz
(B) γ–rays	(2) 1×10^{9} to 3×10^{11} HZ
(C) Microwaves	(3) 3×10^{18} to 5×10^{22} Hz
(D) X-rays	(4) 5×10^{5} to 10^{9} Hz.

(a) (A) → (2); (B) → (5); (C) → (3); (D) → (4)

(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)

(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

88. Match the Column I and Column II.

Column I Electromagnetic wave	**Column II** Use
(A) ultraviolet rays	(1) In satellite for army purpose
(B) Infrared rays	(2) Aircraft navigation in' RADAR
(C) Microwave	(3) Television and cellular phones
(D) Radio wave	(4) Checking mineral sample

(a) (A) → (4); (B) → (1); (C) → (2); (D) → (3)

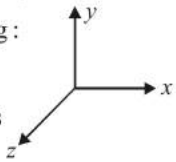
(b) (A) → (2); (B) → (2); (C) → (4); (D) → (3)

(c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

(d) (A) → (2); (B) → (1); (C) → (4); (D) → (3)

DIAGRAM TYPE QUESTIONS

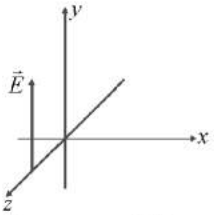
89. Light wave is travelling along y-direction. If the corresponding $\vec{E}$ vector at any time is along the x-axis, the direction of $\vec{B}$ vector at that time is along :



(a) y-axis (b) x-axis

(c) $+z$-axis (d) $-z$-axis

90. The figure here gives the electric field of an electromagnetic wave at a certain point and a certain instant. The wave is transporting energy in the negative z-direction. The direction of the magnetic field of the wave at that point and instant is



(a) + ve x-direction (b) –ve x-direction

(c) +ve z-direction (d) –ve y-direction

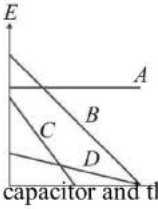
91. The figure shows graphs of the electric field magnitude E versus time t for four uniform electric fields, all contained within identical circular regions. Which of them is according to the magnitudes of the magnetic field?

(a) A

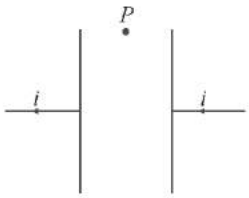
(b) B

(c) C

(d) D



92. Figure shows a parallel plate capacitor and the current in the connecting wires that is discharging the capacitor.



(a) The displacement current is leftward.

(b) The displacement current is rightward

(c) The electric field $\vec{E}$ is rightward

(d) The magnetic field at point P is out the page.

ASSERTION- REASON TYPE QUESTIO

Directions : Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

93. **Assertion :** Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor does not change.
Reason : The displacement current arises in the region in which the electric field is constant with time.

94. **Assertion :** When variable frequency a.c. source is connected to a capacitor, displacement current increases with increase in frequency.
Reason : As frequency increases conduction current also increases.

95. **Assertion :** The displacement current in a parallel-plate capacitor of capacitance C can be written as $i_d = C\left(\frac{dV}{dt}\right)$, where V is the potential difference between the plates.
Reason : The displacement current in free space is given by $i_d = \epsilon_0 \frac{d\phi_e}{dt}$.

96. **Assertion :** Electromagnetic wave are transverse in nature.
Reason : The electric and magnetic fields in electromagnetic waves are perpendicular to each other and the direction of propagation.

97. **Assertion :** Electromagnetic waves interact with matter and set up oscillations.
Reason : Interaction is independent of the wavelength of the electromagnetic wave.

98. **Assertion :** Electromagnetic waves carry energy and momentum.
Reason : Electromagnetic waves can be polarised.

99. **Assertion :** Electromagnetic waves exert radiation pressure.
Reason : Electromagnetic waves carry energy.

100. **Assertion :** The electromagnetic wave is transverse in nature.
Reason : Electromanetic wave propagates parallel to the direction of electric and magnetic fields.

101. **Assertion :** The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.
Reason : Velocity of electromagnetic waves in free space is constant.

102. **Assertion :** The basic difference between various types of electromagnetic waves lies in their wavelength or frequencies.
Reason : Electromagnetic waves travel through vacuum with the same speed.

103. **Assertion :** Microwaves are better carrier of signals than optical waves.
Reason : Microwaves move faster than optical waves.

104. **Assertion :** Infrared radiation plays an important role in maintaining the average temperature of earth.
Reason : Infrared radiations are sometimes referred to as heat waves.

CRITICAL THINKING TYPE QUESTIONS

105. The charge on a parallel plate capacitor varies as $q = q_0 \cos 2\pi\upsilon t$. The plates are very large and close together (area = A, separation = d). The displacement current through the capacitor is

(a) $q_0\, 2\pi\upsilon \sin\pi\upsilon t$ (b) $-q_0\, 2\pi\upsilon \sin 2\pi\upsilon t$

(c) $q_0\, 2\pi \sin\pi\upsilon t$ (d) $q_0\, \pi\upsilon \sin 2\pi\upsilon t$

106. When an electromagnetic waves enter the ionised layer of ionosphere, the motion of electron cloud produces a space current and the electric field has its own capacitative displacement current, then

(a) the space current is in phase of displacement current

(b) the space current lags behind the displacement current by a phase 180°.

(c) the space current lags behind the displacement current by a phase 90°.

(d) the space current leads the displacement current by a phase 90°.

107. In order to establish an instantaneous displacemet current of 1 mA in the space between the plates of 2μF parallel plate capacitor, the potential difference need to apply is

(a) $100\ Vs^{-1}$ (b) $200\ Vs^{-1}$
(c) $300\ Vs^{-1}$ (d) $500\ Vs^{-1}$

108. The electric field of an electromagnetic wave travelling through vaccum is given by the equation $E = E_0 \sin(kx - \omega t)$. The quantity that is independent of wavelength is

(a) $k\omega$ (b) $\frac{k}{\omega}$
(c) $k^2\omega$ (d) ω

109. An electromagnetic wave of frequency $\upsilon = 3$ MHz passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4$. Then

(a) wavelength and frequency both become half.
(b) wavelength is doubled and frequency remains unchanged.
(c) wavelength and frequncy both remain unchanged.
(d) wavelength is halved and frequency remains unchanged.

110. The electric field associated with an e.m. wave in vacuum is given by $\vec{E} = \hat{i}\ 40 \cos(kz - 6 \times 10^8 t)$, where E, z and t are in volt/m, meter and seconds respectively. The value of wave vector k is

(a) $2\ m^{-1}$ (b) $0.5\ m^{-1}$
(c) $6\ m^{-1}$ (d) $3\ m^{-1}$

111. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is

(a) 3 V/m (b) 6 V/m (c) 9 V/m (d) 12 V/m

112. If a source is transmitting electromagnetic wave of frequency 8.2×10^6 Hz, then wavelength of the electromagnetic waves transmitted from the source will be

(a) 36.6 m (b) 40.5 m
(c) 42.3 m (d) 50.9 m

113. In a plane electromagnetic wave propagating in space has an electric field of amplitude 9×10^3 V/m, then the amplitude of the magnetic field is

(a) 2.7×10^{12} T (b) 9.0×10^{-3} T
(c) 3.0×10^{-4} T (d) 3.0×10^{-5} T

114. In an electromagnetic wave, the electric and magnetic fields are $100\ V\ m^{-1}$ and $0.265\ A\ m^{-1}$. The maximum energy flow is

(a) $26.5\ W/m^2$ (b) $36.5\ W/m^2$
(c) $46.7\ W/m^2$ (d) $765\ W/m^2$

115. The transmitting antenna of a radiostation is mounted vertically. At a point 10 km due north of the transmitter the peak electric field is $10^{-3}\ Vm^{-1}$. The magnitude of the radiated magnetic field is .

(a) 3.33×10^{-10} T (b) 3.33×10^{-12} T
(c) 10^{-3} T (d) 3×10^5 T

116. 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

117. A new system of unit is evolved in which the values of μ_0 and ϵ_0 are 2 and 8 respectively. Then the speed of light in this system will be

(a) 0.25 (b) 0.5
(c) 0.75 (d) 1

118. The rms value of the electric field of the light coming from the Sun is 720 N/C. The average 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) $3.3 \times 10^{-3}\ J/m^3$

119. The transmitting antenna of a radiostation is mounted vertically. At a point 10 km due north of the transmitter the peak electric field is $10^{-3}\ Vm^{-1}$. The magnitude of the radiated magnetic field is

(a) 3.33×10^{-10} T (b) 3.33×10^{-12} T
(c) 10^{-3} T (d) 3×10^5 T

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (c) **2.** (c)

3. (b) Current through capacitor,

$$I = \frac{E}{X_C} = \frac{E}{\frac{1}{\omega C}} = \omega CE = 2\pi\upsilon\, CE \text{ or } I \propto \upsilon.$$

$\therefore$ decrease in frequency υ of ac source decreases the conduction current. As displacement current is equal to conduction current, decrease in υ decreases displacement current in circuit.

4. (a) Displacement current arises when electric field in a region is changing with time. It will be so if the charge on a capacitor is changing with time.

5. (a)

6. (c) In the steady state $\oint B.dl = \mu_o(I)$, where I is conduction current.

[In non steady state $\oint B.d\ell = (I + I_d)$, where I_d is displacement current.]

7. (a)

8. (a) Displacement current is set up in a region where the electric field is changing with time.

9. (a) $I_D = \varepsilon_o \, d\phi_E / dt$.

10. (d) Maxwell's equations describe the fundamental laws of electricity and magnetism.

11. (d)

12. (c) According to Maxwell, a changing electric field is a source of magnetic field.

13. (d) Electromagnetic wave consists of periodically oscillating electric and magnetic vectors in mutually perpendicular planes but vibrating in phase.

14. (b)

15. (c) The electromagnetic waves of all wavelengths travel with the same speed in space which is equal to velocity of light.

16. (d)

17. (c) The direction of propagation of electromagnetic wave is perpendicular to the variation of electric field $\vec{E}$ as well as to the magnetic field $\vec{B}$

18. (b) Velocity of light in a medium,

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_o \mu_r \varepsilon_r}} = \frac{1}{\sqrt{\mu\varepsilon}}$$

19. (b) **20.** (b) **21.** (b)

22. (d) The speed of electromagnetic wave in a region is same for all intensities but different for different frequencies.

23. (b) An electromagnetic wave has both energy and momentum.

24. (a) Every body at all time, at all temperature emit radiation (except at $T = 0$), which fall in the infrared region.

25. (a)

26. (c) In vacuum X-rays, gamma rays and microwaves travel with same velocity, i.e., with the velocity of light c ($=3 \times 10^8$ m s^{-1}) but have different wavelengths.

27. (b) The wavelength of radiowaves being much larger than light, has a size comparable to those of buildings, hense diffract from them.

28. (b) **29.** (b) **30.** (b)

31. (b) The range of visible radiations is 4000Å to 8000 Å

32. (a) Cosmic rays are coming from outer space, having high energy charged particles, like a-particle, proton etc. b-rays are stream of high energy electrons, coming from the nucleus of radioactive atoms.

33. (c) **34.** (c) **35.** (d)

36. (a) The wavelength of infrared region is 8×10^{-5} cm to 3×10^{-3} cm. So maximum wavelength of infrared region $= 8 \times 10^{-5}$ cm $\approx 10^{-4}$ cm.

37. (d) **38.** (d)

39. (a) Radiowaves are reflected by ionosphere.

40. (a) **41.** (d)

42. (c) Light waves and X-rays are electromagnetic waves.

43. (a) From electromagnetic spectrum, frequencies of γ-rays is greater than frequency of X-rays. Frequency of X-rays is greater than frequency of ultraviolet rays.

44. (d) **45.** (d) **46.** (c) **47.** (d)

48. (c) **49.** (b) **50.** (c) **51.** (a)

52. (c) Here : Velocity of electromagnetic waves in free space and wavelength

$v = 3 \times 10^8$ m/s and $\lambda = 150\, m$

The frequency of radio waves is given by

$$= \frac{v}{\lambda} = \frac{3 \times 10^8}{150} = 2 \times 10^6\, Hz = 2 \text{ MHz}.$$

53. (b) **54.** (c) **55.** (b) **56.** (a) **57.** (b)

58. (d) **59.** (c) **60.** (d) **61.** (d)

62. (d) Ozone layer will absorb ultraviolet rays; reflect the infrared radiation and does not reflect back radiowaves.

63. (b) **64.** (a) **65.** (d) **66.** (c) **67.** (d)

68. (a) E.M. wave always propagates in a direction perpendicular to both electric and magnetic fields. So, electric and magnetic fields should be along + X and + Y- directions respectively. Therefore, option (a) is the correct option.

69. (d) Required condition : Frequency of microwaves = Resonant frequency of water molecules.

71. (a) $\xrightarrow{\lambda \text{ decreasing}}$

RMIVUXGC

R → Radio waves M → Micro waves

I → Infra red rays V → Visible rays

U → Ultraviolet rays X → x rays

G → γ rays C → Cosmic rays

⇒ γ rays has least wavelength

71. (a) Both magnetic and electric fields have zero average value in a plane e.m. wave.

72. (a) **73. (a)**

74. (c) Speed of EM waves in vacuum $= \frac{1}{\sqrt{\mu_0 \in_0}} =$ constant

75. (b) Molecular spectra due to vibrational motion lie in the microwave region of EM-spectrum. Due to Kirchhoff's law in spectroscopy the same will be absorbed.

76. (c) $\vec{E}$ and $\vec{B}$ are mutually perpendicular to each other and are in phase i.e., they become a zero and minimum at the same place and at the same time.

77. (a) **78. (b)** **79. (c)** **80. (b)**

STATEMENT TYPE QUESTIONS

81. (c)

82. (b) Momentum per unit time per unit area

$$= \frac{\text{intensity}}{\text{speed of wave}} = \frac{I}{c}$$

Change in momentum per unit time per unit area $= \Delta I/c$ = radiation pressure (P), *i.e.* $P = \Delta I/c$.

Momentum of incident wave per unit time per unit area $= I/c$

When wave is fully absorbed by the surface, the momentum of the reflected wave per unit time per unit area = 0

Radiation pressure (P) = change in momentum per unit time per unit area $= \frac{\Delta I}{c} = \frac{I}{c} - 0 = \frac{I}{c}$

When wave is totally reflected, then mommentum of the reflected wave per unit time per unit area $= -I/c$.

Radiation pressure $(P) = \frac{I}{c} - \left(-\frac{I}{c}\right) = \frac{2I}{c}$

Here, P lies between $\frac{I}{c}$ and $\frac{2I}{c}$.

83. (c)

84. (d) : Velocity of electromagnetic wave

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \ m\ s^{-1}$$

It is independent of amplitude, frequency and wavelength of electromagnetic wave.

85. (d) : $\lambda_{micro} > \lambda_{infrared} > \lambda_{ultraviolet} > \lambda_{gamma}$

MATCHING TYPE QUESTIONS

86. (a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)

87. (c) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

The frequency ranges of various waves are as under : Radiowaves ; 5×10^5 to 10^9 Hz; γ-rays ; 3×10^{18} to 5×10^{22} Hz Microwaves; 1×10^9 to 3×10^{11} Hz; X-rays ; 1×10^{16} to 3×10^{21} Hz.

88. (a) (A) → (4); (B) → (1); (C) → (2); (D) → (3)

DIAGRAM TYPE QUESTIONS

89. (c) Light wave is an electromagnetic wave in which $\vec{E}$ and $\vec{B}$ are at right angles to each other as well as at right angles to the direction of wave propagation.

90. (a) Direction of energy progration of EM-waves is given by

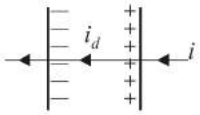
$\vec{D} = K(\vec{E} \times \vec{B})$ or $-\hat{k} = K(E\,\hat{j} \times \vec{B})$

Clearly direction of magnetic field is along positive x-axis.

91. (c) $\oint \vec{B}.d\vec{\ell}\sqrt{b^2 - 4ac} = \mu_0 \in_0 \frac{d\phi}{dt}$

or $B \times 2\pi r = \mu_0 \in_0 A\left(\frac{dE}{dt}\right) \ \therefore \ B \propto \left(\frac{dE}{dt}\right)$

92. (a) According to conservation of charge, the displacement current must be leftward.



ASSERTION- REASON TYPE QUESTIO

93. (d) Displacement current arises when electric field in a region is changing with time, which is given by

$$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$$

It will be so if the charge on a capacitor is not constant but changing with time.

94. (a) **95. (a)**

96. (a) Transverse waves are those waves in which the particles of the medium oscillate perpendicular to the direction of wave propagation.

97. (c) Electrormagnetic waves interact with matter via their electric and magnetic field which in oscillation of charges present in all matter. The detailed interaction and so the mechanism of absorption, scattering, etc. depend of the wavelength of the electromagnetic wave, and the nature of the atoms and molecules in the medium.

98. (b) Consider a plane perpendicular to the direction of propagation of the electromagnetic wave. If electric charges are present in this plane, they will be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charge thus acquired energy and momentum from the wave. This illustrate the fact that an electromanetic wave like other waves carries energy and momentum.

99. (a) Electromagnetic waves have linear momentum as well as energy. This concludes that they can exert radiation pressure by falling beam of electromagnetic radiation on an object.

100. (c) This electromagnetic wave contains sinusoidally time varying electric and magnetic field which act perperndicular to each other as well as at right angle to the direction of propagation of waves, so electromagnetic waves are transverse in nature. Electromagnetic wave propagate in the perpendicular direction to both fields.

101. (b) $v = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{c}{\sqrt{\mu_r \varepsilon_r}}$

102. (a) The basic difference between various types of electromagnetic waves lies in their wavelengths or frequencies since all of them travel through vacuum with the same speed. Consequently, the waves differ considerably in their mode of interaction with matter.

103. (d) The optical waves used in optical fibre communication are better carrier of signals than microwaves. The speed of microwave and optical wave is the same in vacuum.

104. (b) Infrared radiation help to maintain the earth warmth through the greenhouse effect. Incoming visible light which passes relatively easily through the atmosphere is absorbed by the earth's surface and re-radiated as infrared radiation. The radiation is trapped by greenhouse gases such as carbon dioxide and water vapour and they heat up and heat their surrondings.

CRITICAL THINKING TYPE QUESTIONS

105. (b) Displacement current, I_D = conduction current, I_C

$\therefore \quad \frac{dq}{dt} = \frac{d}{dt}\ [q_0 \cos 2\pi\upsilon t] = -\ q_0\ 2\pi\upsilon\ \sin 2\pi\upsilon t$

106. (b)

107. (d) $I_d = 1\ mA = 10^{-3}$ A

$C = 2\mu F = 2 \times 10^{-6}$ F

$$I_D = I_C = \frac{d}{dt}\ (CV) = C\ \frac{dV}{dt}$$

Therefore, $\frac{dV}{dt} = \frac{I_D}{C} = \frac{10^{-3}}{2\times10^{-6}} = 500\ \text{Vs}^{-1}$

Therefore, applying a varying potential difference of 500 V s^{-1} would produce a displacement current of desired value.

108. (b) Here, $k = \frac{2\pi}{\lambda}$, $\omega = 2\pi\upsilon$

$\therefore \quad \frac{k}{\omega} = \frac{2\pi/\lambda}{2\pi\upsilon} = \frac{1}{\pi\upsilon} = \frac{1}{c} \qquad (\because\ c = \upsilon\ \lambda)$

where c is the speed of electromagnetic wave in vacuum. It is a constant whose value is $3 \times 10^6\ m\ s^{-1}$

109. (d) The frequency of electromagnetic wave remains unchanged but the wavelength of electromagnetic wave changes when it passes from one medium to another.

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$\therefore \quad c \propto \frac{1}{\sqrt{\varepsilon_0}}$ and $v \propto \frac{1}{\sqrt{\varepsilon}}$

$\therefore \quad \frac{c}{v} = \sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$

$\frac{c}{v} = \frac{\upsilon\lambda}{\upsilon\lambda'} = \frac{\lambda}{\lambda'} = 2$ or $\lambda' = \frac{\lambda}{2}$

110. (a) On comparing the given equation to

$\vec{E} = a_0\hat{i}\ \cos(\omega t - kz)$

$\omega = 6 \times 10^{8z}$,

$k = \frac{2\pi}{r} = \frac{\omega}{c}$

$k = \frac{\omega}{c} = \frac{6\times10^8}{3\times10^8} = 2\,\text{m}^{-1}$

111. (b) From question,

$B_0 = 20\ \text{nT} = 20 \times 10^{-9}\text{T}$

$\vec{E}_0 = \vec{B}_0 \times \vec{C}$

$|\vec{E}_0| = |\vec{B}_0|\ .\ |\vec{C}| = 20\times10^{-9} \times 3\times10^8 = 6\ \text{V/m}.$

($\because$ velocity of light in vacuum $C = 3 \times 10^8\ \text{ms}^{-1}$)

112. (a) Here, $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{8.2\times10^6} = 36.6\,\text{m}.$

113. (d) $B_0 = \frac{E_0}{c} = \frac{9\times10^3}{3\times10^8} = 3\times10^{-5}\,\text{T}.$

114. (a) Here, amplitude of electric field, $E_0 = 100$ V/m; amplitude of magnetic field, $H_0 = 0.265$ A/m. We know that the maximum rate of energy flow,

$S = E_0 \times H_0 = 100 \times 0.265 = 26.5\ \text{W/m}^2.$

115. (b) $B_0 = \frac{E_0}{c}$

E_0 - Electric field, c - speed of light, B_0 - Magnetic Field.

$B_0 = \frac{10^{-3}}{3\times10^8} = 3.33\times10^{-12}\ \text{T}$

116. (a) Velocity of light

$C = \frac{E}{B} \Rightarrow B = \frac{E}{C} = \frac{9.3}{3\times10^8} = 3.1\times10^{-8}\,\text{T}$

117. (a) The speed of light $C = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = \frac{1}{\sqrt{2\times8}} = \frac{1}{4} = 0.25$

118. (a) $E_{rms} = 720$

The average total energy density

$= \frac{1}{2}\epsilon_0\ E_0^2 = \frac{1}{2}\epsilon_0\ [\sqrt{2}E_{rms}]^2 = \epsilon_0\ E_{rms}^2$

$= 8.85\times10^{-12} \times (720)^2$

$= 4.58\times10^{-6}\ \text{J/m}^3$

119. (b) $B_0 = \frac{E_0}{c}$

E_0 - Electric field, c - speed of light, B_0 - Magnetic Field.

$B_0 = \frac{10^{-3}}{3\times10^8} = 3.33\times10^{-12}\ \text{T}$