# Electromagnetic Waves JEE Main PYQ - 2

**Total Time:** 25 Minute **Total Marks:** 40

## Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

### Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

# Electromagnetic Waves

**1.** During the propagation of electromagnetic waves in a medium, **[2014]** **(+4, -1)**

**a.** electric energy density is double of the magnetic energy density

**b.** electric energy density is half of the magnetic energy density

**c.** electric energy density is equal to the magnetic energy density

**d.** Both electric and magnetic energy densities are zero

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**2.** For plane electromagnetic waves propagating in the $z$ direction, which one of the following combination gives the correct possible direction for $\vec{E}$ and $\vec{B}$ field respectively ? **(+4, -1)**

**[Online April 11, 2015]**

**a.** $\left(\hat{i}+2\hat{j}\right)$ and $\left(2\hat{i}-\hat{j}\right)$

**b.** $\left(-\hat{2}i-3\hat{j}\right)$ and $\left(3\hat{i}-2\hat{j}\right)$

**c.** $\left(2\hat{i}+3\hat{j}\right)$ and $\left(\hat{i}-2\hat{j}\right)$

**d.** $\left(3\hat{i}+4\hat{j}\right)$ and $\left(4\hat{i}-3\hat{j}\right)$

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**3.** Match List -1 (Electromagnetic wave type) with List - II (Its association/application) and select the correct option from the choices given below the lists : **(+4, -1)**

**[2014]**

**a.** (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)

**b.** (a)-(i), (b)-(ii), (c)-(iv), (d)-(iii)

**c.** (a)-(iii), (b)-(ii), (c)-(i), (d)-(iv)

**d.** (a)-(i), (b)-(ii), (c)-(iii), (d)-(iv)

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**4.** Select the correct statement from the following **[Online April 9, 2013]** **(+4, -1)**

**a.** Electromagnetic waves cannot travel in vacuum

**b.** Electromagnetic waves are longitudinal waves

**c.** Electromagnetic waves are produced by charges moving with uniform velocity

**d.** Electromagnetic waves carry both energy and momentum as they propagate through space

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**5.** The magnetic field of a plane electromagnetic wave is given by $\vec{B} = B_0\hat{i}[cos(kz - \omega t)] + B_1\hat{j}cps(kz + \omega t)$. where $B_0 = 3\text{\textdiamond}10^{-5}T$ and $B_1 = 2\text{\textdiamond}10^{-6}$ T. The rms value of the force experienced by a stationary charge Q = 10 C at z = 0 is closest to : **(+4, -1)**

**[9 April 2019 I]**

**a.** $0.9\,N$

**b.** $0.1\,N$

**c.** $3 \times 10^{-}2\,N$

**d.** $0.6\,N$

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**6.** The self induced emf of a coil is $25$ volts. When the current in it is changed at uniform rate from $10\,A$ to $25\,A$ in $1s$, the change in the energy of the inductance is : **(+4, -1)**

**[Online May 26, 2012]**

**a.** 437.5 J

**b.** 637.5 J

**c.** 740 J

**d.** 540 J

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**7.** A wave in a string has amplitude of 2 cm. The wave travels in the +ve direction of x axis with a speed of 128 $^{-1}$ and it is noted that 5 complete waves fit in 4 m length of the string. The equation describing the wave is: **(+4, -1)**

**a.** (A) = (0.02) sin(7.85 + 1005 )

**b.** (B) = (0.02)msin(15.7 − 2010 )

**c.** (C) = (0.02)msin(15.7 + 2010 )

**d.** (D) = (0.02) sin(7.85 − 1005 )

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**8.** In an electromagnetic wave, the magnitude of electric and magnetic fields are 100 V/m and 0.265 A/m. The maximum energy flow is **(+4, -1)**

**[2012]**

**a.** (A) 26.5 $W/m^2$

**b.** (B) 36.5 $W/m^2$

**c.** (C) 46.7 $W/m^2$

**d.** (D) 765 $W/m^2$

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**9.** Choose the correct options based on the column shown below. **(+4, -1)**

| | | | |
|---|---|---|---|
| 1. | TV signal | (P) | 12 GHz |
| 2. | Satellite | (Q) | 30 MHz |
| 3. | AM | (R) | 88 MHz |
| 4. | FM | (S) | 1 MHz |

**a.** 1 - P, 2 - Q, 3 - R, 4 - S

**b.** 1 - Q, 2 - P, 3 - S, 4 - R

**c.** 1 - S, 2 - Q, 3 - R, 4 - P

**d.** 1 - P, 2 - Q, 3 - S, 4 - R

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**10.** In an electromagnetic wave electric field and magnetic field is given by **(+4, -1)**

$E = E_0 \sin(kx - \omega t + \phi)$

$B = B_0 \sin(kx - \omega t + \phi)$

**[Online April 9, 2014]**

Find correct relation.

**a.** $\frac{\omega}{k} = \frac{E_0}{B_0}$

**b.** $\frac{E_0}{B_0} = \frac{\omega}{k}$

**c.** $\frac{\omega}{k} = B_0$

**d.** $\frac{\omega}{k} = E_0 B_0$

# Answers

1. **Answer: c**

## Explanation:

Energy is equally divided between the electric and magnetic fields. The Electric energy density is equivalent to the magnetic energy density.

Here, $u_E = ½ \epsilon_0 E^2$

$u_B = B^2/2\mu 0$

Also, $E = cB$ and $c = 1/\sqrt{\mu_0 \epsilon_0}$

Therefore, we get $u_E = ½ \epsilon_0 E^2 = ½ \epsilon_0 (cB)^2$

$= ½ \epsilon_0 \frac{1}{\mu_o \epsilon_o} B^2$

$u_E = u_B$

So, the correct answer is C) During the propagation of electromagnetic waves in a medium, electric energy density is equal to the magnetic energy density.

## Concepts:

### 1. Electromagnetic waves:

The waves that are produced when an electric field comes into contact with a magnetic field are known as Electromagnetic Waves or EM waves. The constitution of an oscillating magnetic field and electric fields gives rise to electromagnetic waves.

## Types of Electromagnetic Waves:

Electromagnetic waves can be grouped according to the direction of disturbance in them and according to the range of their frequency. Recall that a wave transfers energy from one point to another point in space. That means there are two things going on: the disturbance that defines a wave, and the propagation of wave. In this context the waves are grouped into the following two categories:

- **Longitudinal waves:** A wave is called a longitudinal wave when the disturbances in the wave are parallel to the direction of propagation of the wave. For example, sound waves are longitudinal waves because the change of pressure occurs parallel to the direction of wave propagation.
- **Transverse waves:** A wave is called a transverse wave when the disturbances in the wave are perpendicular (at right angles) to the direction of propagation of the wave.

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2. **Answer: b**

### Explanation:

$\vec{E}$ and $\vec{B}$ are mutually perpendicular
$\vec{E} \times \vec{B} = \vec{C} = C\hat{k}$
$\Rightarrow (-2\hat{i} - 3\hat{j}) \cdot (3\hat{i} - 2\hat{j}) = -6 + 6 = 0$
$\Rightarrow (-2\hat{i} - 3\hat{j}) \times (3\hat{i} - 2\hat{j}) = (6 + 9)\hat{k} = 15\hat{k}$

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3. **Answer: d**

**Explanation:**

(a) Infrared rays are used to treat muscular strain (b) Radiowaves are used for broadcasting (c) X-rays are used to detect fracture of bones (d) Ultraviolet rays are absorbed by ozone

**Concepts:**

1. **Electromagnetic waves:**

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4. **Answer: d**

### Explanation:

Electromagnetic waves do not required any medium to propagate. They can travel in vacuum. They are transverse in nature like light. They carry both energy and momentum. A changing electric field produces a changing magnetic field and vice-versa. Which gives rise to a transverse wave known as electromagnetic wave

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5. **Answer: d**

### Explanation:

Maximum Electric field E = (B) (c) $\vec{E_0} = (3 \times 10^{-5})c(-\hat{j})$ $\vec{E_1} = (3 \times 10^{-6})c(-\hat{i})$ Maximum force $\vec{F_{net}} = q\vec{E} = qc(-3 \times 10^{-5}\hat{j} - 2 \times 10^{-6}\hat{i})$ $\vec{F_{0max}} = 10^{-4} \times 3 \times 10^8\sqrt{(3 \times 10^{-5})^2 + (2 \times 10^{-6})^2} = 0.9N$ $F_{rms} = \frac{F_0}{\sqrt{2}} = 0.6N \quad (approx)$ Option (4)

### Concepts:

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6. **Answer: a**

### Explanation:

$L\frac{di}{dt} = 25$ $L \times \frac{15}{1} = 25$ $L = \frac{5}{3}H$ $\Delta E = \frac{1}{2} \times \frac{5}{3} \times (25^2 - 10^2) = \frac{5}{6} \times 525 = 437.5\,J$

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7. **Answer: d**

### Explanation:

Explanation:
It is given that the amplitude of the wave in a string is, i.e., A = 2 cmAnd also, the wave is travelling in the positive x-direction.And the velocity = 128 $^{-1}$ According to the question 5 complete waves fit in a 4m length of the string, which means that:5 = 4 ----(1)From (1) equation, = $\frac{4}{5}$And the propagation constant, = $\frac{2}{}$ = $2\frac{5}{4}$ = 7.85Also, the phase velocity of the wave is given by: = – = 128 $^{-1}$ = × = 128 × 7.85 = 1004.8 ≈ 1005 / The equation of wave can be represented as: = sin( – )By putting the given values in the above equation we get: = 2sin(7.85 – 1005 )
= (0.02)sin(7.85 – 1005 ) (amplitude in meter = 0.02 )
= (0.02)msin(7.85 – 1005 )Hence the correct option is (D).

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8. **Answer: a**

### Explanation:

Explanation:
Given:Electrical field E = 100 V/mMagnetic field B = 0.265 A/mThe energy flow is given by the Poynting vector = × = sin = [ = 90 , as and are perpendicular to each other] = 100 / × 0.265 / = 26.5 / $^2$ Hence, the correct option is (A).

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9. **Answer: b**

### Explanation:

The correct answer is (B): 1 - Q, 2 - P, 3 - S, 4 - R
TV Signal - (Q) 30 MHz
Satellite - (P) 12 GHz
AM - (S) 1 MHz
FM - (R) 88 MHz

### Concepts:

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10. **Answer: a**

**Explanation:**

$E_0 = B_0C$

Speed of light $C = \frac{\omega}{k}$

$\frac{E_0}{B_0} = \frac{\omega}{k}$

So, the correct option is (A) : $\frac{\omega}{k} = \frac{E_0}{B_0}$

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