PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

EM Waves - CSIR NET Physics PYQs

Electromagnetism . All PYQs (2015-2025) with answer key

21 questions . Answer key included

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Q1. [June 2015] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2015 June	3.5 M

A plane electromagnetic wave is travelling along the positive z-direction. The maximum electric field along the x direction is $10\ \mathrm{V/m}$. The approximate maximum values of the power per unit area and the magnetic induction B, respectively, are

1. 3.3×10^{-7} watts $/\mathrm{m}^2$ and 10 tesla
2. 3.3×10^{-7} watts $/\mathrm{m}^2$ and 3.3×10^{-8} tesla
3. 0.265 watts $/\mathrm{m}^2$ and 10 tesla
4. 0.265 watts $/\mathrm{m}^2$ and 3.3×10^{-8} tesla

Q2. [June 2015] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2015 June	5 M

The electric and magnetic fields in the charge free region $z > 0$ are given by

$$\vec{E}(\vec{r},t) = E_0 e^{-k_1 z}\cos(k_2 x - \omega t)\hat{j}$$

$$\vec{E}(\vec{r},t) = \frac{E_0}{\omega} e^{-k_1 z}\left[k_1 \sin(k_2 x - \omega t)\hat{i} + k_2 \cos(k_2 x - \omega t)\hat{k}\right]$$

where ω, k_1 and k_2 are positive constants. The average energy flow in the x-direction is

1. $\frac{E_0^2 k_2}{2\mu_0 \omega} e^{-2k_1 z}$
2. $\frac{E_0^2 k_2}{\mu_0 \omega} e^{-2k_1 z}$
3. $\frac{E_0^2 k_1}{2\mu_0 \omega} e^{-2k_1 z}$
4. $\frac{1}{2} c\epsilon_0 E_0^2 e^{-2k_1 z}$

Q3. [June 2016] . 3.5 marks
Electromagnetism > EM Waves

CSIR NET	2016 June	3.5M

The x - and z-components of a static magnetic field in a region are $B_x = B_0(x^2 - y^2)$ and $B_z = 0$, respectively. Which of the following solutions for its y component is consistent with the Maxwell equations?

1. $B_y = B_0 xy$
2. $B_y = -2B_0 xy$
3. $B_y = -B_0(x^2 - y^2)$
4. $B_y = B_0\left(\frac{1}{3}x^3 - xy^2\right)$

Q4. [Dec 2017] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2017 Dec	3.5M

An electromagnetic wave is travelling in free space (of permittivity ε_0) with electric field

$$\vec{E} = \hat{k} E_0 \cos q(x - ct)$$

The average power (per unit area) crossing planes parallel to $4x + 3y = 0$ will be

1. $\frac{4}{5} \varepsilon_0 c E_0^2$
2. $\varepsilon_0 c E_0^2$
3. $\frac{1}{2} \varepsilon_0 c E_0^2$
4. $\frac{16}{25} \varepsilon_0 c E_0^2$

Q5. [Dec 2017] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2017 Dec	3.5M

A plane electromagnetic wave from within a dielectric medium (with $\varepsilon = 4\varepsilon_0$ and $\mu = \mu_0$) is incident on its boundary with air, at $z = 0$. The magnetic field in the medium is

$$\vec{H} = \hat{j} H_0 \cos(\omega t - kx - k\sqrt{3}z),$$

where ω and k are positive constants.

The angles of reflection and refraction are, respectively,

1. 45^0 and 60^0
2. 30^0 and 90^0
3. 30^0 and 60^0
4. 60^0 and 90^0

Q6. [June 2017] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2017 June	3.5M

An electromagnetic wave (of wavelength λ_0 in free space) travels through an absorbing medium with dielectric permittivity given by $\varepsilon = \varepsilon_R + i\varepsilon_I$ where $\frac{\varepsilon_I}{\varepsilon_R} = \sqrt{3}$. If the skin depth is $\frac{\lambda_0}{4\pi}$, the ratio of the amplitude of electric field E to that of the magnetic field B, in the medium (in ohms) is

1. 120π
2. 377
3. $30\sqrt{2}\pi$
4. 30π

Q7. [Dec 2018] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2018 Dec	3.5M

An electromagnetic wave propagates in a nonmagnetic medium with relative permittivity $\varepsilon = 4$. The magnetic field for this wave is

$$\vec{H}(x,y) = \hat{k}H_0\cos(\omega t - \alpha x - \alpha\sqrt{3}y)$$

where H_0 is a constant. The corresponding electric field $\vec{E}(x,y)$ is

1. $\frac{1}{4}\mu_0 H_0 c\left(-\sqrt{3}\hat{i} + \hat{j}\right)\cos\left(\omega t - \alpha x - \alpha\sqrt{3}y\right)$
2. $\frac{1}{4}\mu_0 H_0 c\left(\sqrt{3}\hat{i} + \hat{j}\right)\cos\left(\omega t - \alpha x - \alpha\sqrt{3}y\right)$
3. $\frac{1}{4}\mu_0 H_0 c\left(\sqrt{3}\hat{i} - \hat{j}\right)\cos\left(\omega t - \alpha x - \alpha\sqrt{3}y\right)$
4. $\frac{1}{4}\mu_0 H_0 c(-\sqrt{3}\hat{i} - \hat{j})\cos(\omega t - \alpha x - \alpha\sqrt{3}y)$

Q8. [June 2018] . 3.5 marks
Electromagnetism > EM Waves

CSIR NET	2018 June	3.5M

In The electric field of a plane wave in a conducting medium is given by

$$\vec{E}(z,t) = \hat{i}E_0 e^{-z/3a}\cos\left(\frac{z}{\sqrt{3}a} - \omega t\right),$$

where ω is the angular frequency and $a > 0$ is a constant. The phase difference between the magnetic field $\vec{B}$ and the electric field $\vec{E}$ is

1. 30^0 and $\vec{B}$ lags behind $\vec{B}$
2. 30^0 and $\vec{B}$ lags behind $\vec{E}$
3. 60^0 and $\vec{E}$ lags behind $\vec{B}$
4. 60^0 and $\vec{B}$ lags behind $\vec{E}$

Q9. [Dec 2019] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2019 Dec	3.5M

The electric field of an electromagnetic wave is $\vec{E} = \hat{i}\sqrt{2}\sin(kz - \omega t)Vm^{-1}$. The average flow of energy per unit area per unit time, due to this wave, is

1. $27 \times 10^{4}\ \mathrm{W/m^2}$
2. $27 \times 10^{-4}\ \mathrm{W/m^2}$
3. $27 \times 10^{-2}\ \mathrm{W/m^2}$
4. $27 \times 10^{2}\ \mathrm{W/m^2}$

Q10. [Dec 2019] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2019 Dec	5M

An alternating current $I(t) = I_0\cos(\omega t)$ flows through a circular wire loop of radius R, lying in the xy-plane, and cantered at the origin. The electric field $\vec{E}(\vec{r}, t)$ and the magnetic field $\vec{B}(\vec{r}, t)$ are measured at a point $\vec{r}$ such that $r \gg \frac{c}{\omega} \gg R$, where $\vec{r} = |\vec{r}|$. Which one of the following statements is correct?

1. The time-averaged $|\vec{E}(\vec{r}, t)| \propto \frac{1}{r^2}$
2. The time-averaged $|\vec{E}(\vec{r}, t)| \propto \omega^2$
3. The time-averaged $|\vec{B}(\vec{r}, t)|$ as a function of the polar angle θ has a minimum at

$$\theta = \frac{\pi}{2}$$

4. $\vec{B}(\vec{r}, t)$ is along the azimuthal direction

Q11. [June 2020] . 3.5 marks
Electromagnetism > EM Waves

CSIR NET	2020 June	3.5M

Let $\vec{E}(x, y, z, t) = \vec{E}_0 \cos(2x + 3y - \omega t)$, where ω is a constant, be the electric field of an electromagnetic wave travelling in vacuum. Which of the following vectors is a valid choice for $\vec{E}_0$?

1. $\hat{i} - \frac{3}{2}\hat{j}$
2. $\hat{i} + \frac{3}{2}\hat{j}$
3. $\hat{i} + \frac{2}{3}\hat{j}$
4. $\hat{i} - \frac{2}{3}\hat{j}$

Q12. [June 2020] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2020 June	5M

A spacecraft of mass $m = 1000\,\text{kg}$ has a fully reflecting sail that is oriented perpendicular to the direction of the sun. The sun radiates $10^{26}\,\text{W}$ and has a mass $M = 10^{30}\,\text{kg}$. Ignoring the effect of the planets, for the gravitational pull of the sun to balance the radiation pressure on the sail, the area of the sail will be

1. $10^2\,\text{m}^2$
2. $10^4\,\text{m}^2$
3. $10^8\,\text{m}^2$
4. $10^6\,\text{m}^2$

Q13. [June 2022] . 3.5 marks
Electromagnetism > EM Waves

CSIR NET	2022 June	3.5M

An electromagnetic wave is incident from vacuum normally on a planer surface of a nonmagnetic medium. If the amplitude of the electric field of the incident wave is E_0 and that of the transmitted wave is $2E_0/3$, then neglecting any loss, the refractive index of the medium is

1. 1.5
2. 2.0
3. 2.4
4. 2.7

Q14. [June 2023] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2023 June	3.5M

A long cylindrical wire of radius R and conductivity σ, lying along the z-axis, carries a uniform axial current density I. The Poynting vector on the surface of the wire is (in the following $\hat{\rho}$ and $\hat{\varphi}$ denote the unit vectors along the radial and azimuthal directions respectively)

1. $\frac{I^2R}{2\sigma}\hat{\rho}$
2. $-\frac{I^2R}{2\sigma}\hat{\rho}$
3. $-\frac{I^2\pi R}{4\sigma}\hat{\varphi}$
4. $\frac{I^2\pi R}{4\sigma}\hat{\varphi}$

Q15. [June 2023] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2023 June	5M

he electric and magnetic fields at a point due to two independent sources are $\mathbf{E}_1 = \mathrm{E}(\alpha\hat{\imath} + \beta\hat{\jmath}), \mathbf{B}_1 = \mathrm{B}\hat{k}$ and $\mathbf{E}_2 = \mathrm{E}\hat{\imath}, \mathbf{B}_2 = -2\mathrm{B}\hat{k}$, where $\alpha, \beta, \mathrm{E}$ and B are constants. If the Poynting vector is along $\hat{\imath} + \hat{\jmath}$, then

1. $\alpha + \beta + 1 = 0$
2. $\alpha + \beta - 1 = 0$
3. $\alpha + \beta + 2 = 0$
4. $\alpha + \beta - 2 = 0$

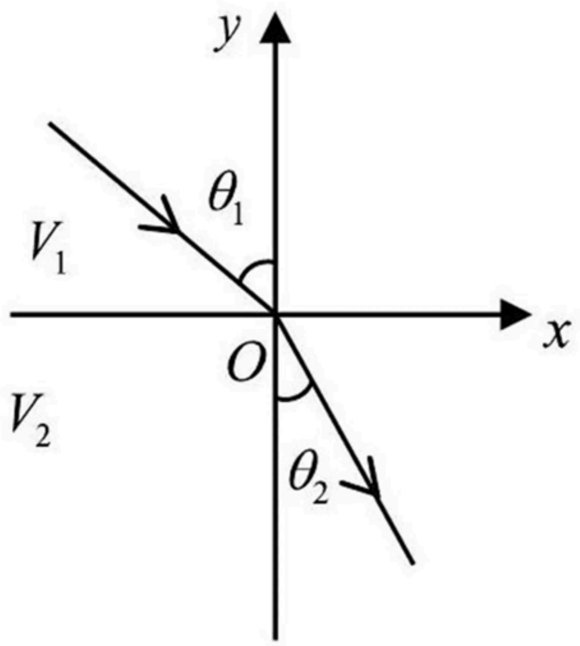
Q16. [June 2024] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2024 June	3.5M

The region $y > 0$ has a constant electrostatic potential V_1 and $y < 0$ has a constant electrostatic potential $V_2 \neq V_1$. A charged particle with momentum $\overrightarrow{p_1}$ is incident at an angle θ_1 on the interface of the two regions (see figure below). If the particle has momentum $\overrightarrow{p_2}$ in the region $y < 0$, then the angle θ_2 is given by

1. $\cos^{-1}\left(\frac{p_2}{p_1}\cos\theta_1\right)$
2. $\cos^{-1}\left(\frac{p_1}{p_2}\cos\theta_1\right)$
3. $\sin^{-1}\left(\frac{p_2}{p_1}\sin\theta_1\right)$
4. $\sin^{-1}\left(\frac{p_1}{p_2}\sin\theta_1\right)$



Q17. [June 2024] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2024 June	3.5M

The electric field of an electromagnetic wave in free space is given by

$$\vec{E} = E_0 \sin(\omega t - k_z z)\hat{j}$$

The magnetic field $\vec{B}$ vanishes for $t = \frac{k_z z}{\omega}$. The Poynting vector of the system is

1. $\frac{k_z}{2\mu_0\omega} E_0^2 \sin^2(\omega t - k_z z)\hat{k}$
2. $\frac{4k_z}{\mu_0\omega} E_0^2 \sin^2(\omega t - k_z z)\hat{k}$
3. $\frac{2k_z}{\mu_0\omega} E_0^2 \sin^2(\omega t - k_z z)\hat{k}$
4. $\frac{k_z}{\mu_0\omega} E_0^2 \sin^2(\omega t - k_z z)\hat{k}$

Q18. [June 2024] . 5.0 marks
Electromagnetism > EM Waves

CSIR NET	2024 June	5M

In a non-magnetic material with no free charges and no free currents, the permittivity ∈ is a function of position. If $\vec{E}$ represents the electric field and $\mu_0, \in_0$ are free space permeability and permittivity respectively, which one of the following expressions is correct?

1. $\nabla^2 E - \mu_0 \frac{\partial^2(\in E)}{\partial t^2} - \frac{1}{\epsilon_0}\nabla(E \cdot \nabla \in) = 0$

2. $\nabla^2 E - \mu_0 \frac{\partial^2(\in E)}{\partial t^2} + \frac{1}{\epsilon_0}\nabla(E \cdot \nabla \in) = 0$

3. $\nabla^2 \vec{E} - \mu_0 \frac{\partial^2(\in \vec{E})}{\partial t^2} + \vec{\nabla}\left(\frac{1}{\epsilon}\vec{E} \cdot \vec{\nabla} \in\right) = 0$

4. $\nabla^2 E - \mu_0 \frac{\partial^2(\in E)}{\partial t^2} - \nabla\left(\frac{1}{\epsilon} E \cdot \nabla \in\right) = 0$

Q19. [June 2024] . 5.0 marks
Electromagnetism > EM Waves

CSIR NET	2024 June	5M

A radio station antenna on the earth's surface radiates 50 kW power isotropically. Assume the electromagnetic waves to be sinusoidal and the ground to be a perfect absorber. Neglecting any transmission loss and effects of earth's curvature, the peak value of the magnetic field (in Tesla) detected at a distance of 100 km is closest to

1. 1.5×10^{-11}
2. 5.5×10^{-11}
3. 8.5×10^{-11}
4. 3.5×10^{-11}

Q20. [Dec 2025] . 5.0 marks
Electromagnetism > EM Waves

CSIR NET	2025 Dec	5M	EMT

A monochromatic plane wave is incident normally from a dielectric medium A onto another dielectric medium B. The indices of refraction satisfy $n_A < n_B$. One-fourth of the incident energy is reflected back into medium A. Let $\vec{E}$ be the resultant electric field due to the superposition of the incident wave and the reflected wave. Then, the ratio of the two time-averages $\langle \vec{E}^2 \rangle_{\text{min}} / \langle \vec{E}^2 \rangle_{\text{max}}$ is

1. $\frac{1}{8}$
2. $\frac{1}{9}$
3. $\frac{4}{9}$
4. $\frac{1}{4}$

Q21. [June 2025] . 3.5 marks
Electromagnetism > EM Waves

CSIR NET	2025 June	3.5M	EMT

A plane electromagnetic wave $\overrightarrow{E_I}\cos(k_z z + \omega t)$ is incident normally on a perfectly reflecting mirror in vacuum. If the permittivity of free space is ε_0, the force exerted on an area A of the mirror would be

1. $A\varepsilon_0\left|\overrightarrow{E_I}\right|^2 \hat{z}$
2. $-\frac{A\varepsilon_0}{2}\left|\overrightarrow{E_I}\right|^2 \hat{z}$
3. $\frac{A\varepsilon_0}{2}\left|\overrightarrow{E_l}\right|^2 \hat{Z}$
4. $-A\varepsilon_0\left|\overrightarrow{E_I}\right|^2 \hat{z}$

Answer Key

21 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Electromagnetism	EM Waves	**4**
Q2	Electromagnetism	EM Waves	**1**
Q3	Electromagnetism	EM Waves	**2**
Q4	Electromagnetism	EM Waves	**None**
Q5	Electromagnetism	EM Waves	**2**
Q6	Electromagnetism	EM Waves	**4**
Q7	Electromagnetism	EM Waves	**1**
Q8	Electromagnetism	EM Waves	**None**
Q9	Electromagnetism	EM Waves	**2**
Q10	Electromagnetism	EM Waves	**2**
Q11	Electromagnetism	EM Waves	**4**
Q12	Electromagnetism	EM Waves	**4**
Q13	Electromagnetism	EM Waves	**2**
Q14	Electromagnetism	EM Waves	**2**
Q15	Electromagnetism	EM Waves	**1**
Q16	Electromagnetism	EM Waves	**4**
Q17	Electromagnetism	EM Waves	**4**
Q18	Electromagnetism	EM Waves	**3**
Q19	Electromagnetism	EM Waves	**2**
Q20	Electromagnetism	EM Waves	**2**
Q21	Electromagnetism	EM Waves	**4**

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