Electrodynamics and Rel JEST

https://snboseplc.com/electrodynamics-and-relativity-JEST/

JEST Questions

Q.No:1 JEST-2012

An observer in an inertial frame finds that at a point P the electric field vanishes but the magnetic field does not. This implies that in any other inertial frame the electric field $\vec{E}$ and the magnetic field $\vec{B}$ satisfy
(a) $|\vec{E}|^2 = |\vec{B}|^2$
(b) $\vec{E} \cdot \vec{B} = 0$
(c) $\vec{E} \times \vec{B} = 0$
(d) $\vec{E} = 0$

Q.No:2 JEST-2012

A circular conducting ring of radius R rotates with constant angular velocity ω about its diameter placed along the x-axis. A uniform magnetic field B is applied along the y-axis. If at time $t = 0$ the ring is entirely in the xy-plane, the emf induced in the ring at time $t > 0$ is
(a) $B\omega^2\pi R^2 t$
(b) $B\omega\pi R^2 \tan(\omega t)$
(c) $B\omega\pi R^2 \sin(\omega t)$
(d) $B\omega\pi R^2 \cos(\omega t)$

Q.No:3 JEST-2012

A small magnet is dropped down a long vertical copper tube in a uniform gravitational field. After a long time, the magnet
(a) attains a constant velocity
(b) moves with a constant acceleration
(c) moves with a constant deceleration
(d) executes simple harmonic motion

Q.No:4 JEST-2012

A time-dependent magnetic field $\vec{B}(t)$ is produced in a circular region of space, infinitely long and of radius R. The magnetic field is given as $\vec{B} = B_0 t\hat{z}$ for $0 \le r < R$, where B_0 is a positive constant. The electric field for $r > R$ is
(a) $\dfrac{B_0 R^2}{r}\hat{r}$
(b) $\dfrac{B_0 R^2}{2r}\hat{\theta}$
(c) $-\dfrac{B_0 R^2}{r}\hat{r}$
(d) $-\dfrac{B_0 R^2}{2r}\hat{\theta}$

Q.No:5 JEST-2013

At 'equilibrium' there can not be any free charge inside a metal. However, if you forcibly put charge in the interior then it takes some finite time to 'disappear', i.e. move to the surface. If the conductivity, σ, of a metal is $10^6(\Omega m)^{-1}$ and the dielectric constant $\epsilon_0 = 8.85 \times 10^{-12}$Farad$/m$, this time will be approximately:
(a) 10^{-5}sec
(b) 10^{-11}sec
(c) 10^{-9}sec
(d) 10^{-17}sec

Q.No:6 JEST-2013

An electromagnetic wave of frequency ω travels in the x-direction through vacuum. It is polarized in the y-direction and the amplitude of the electric field is E_0. With $k = \omega/c$ where c is the speed of light in vacuum, the electric and the magnetic fields are then conventionally given by
(a) $\vec{E} = E_0 \cos(ky - \omega t)\hat{x}$ and $\vec{B} = \dfrac{E_0}{c}\cos(ky - \omega t)\hat{z}$
(b) $\vec{E} = E_0 \cos(kx - \omega t)\hat{y}$ and $\vec{B} = \dfrac{E_0}{c}\cos(kx - \omega t)\hat{z}$
(c) $\vec{E} = E_0 \cos(kx - \omega t)\hat{z}$ and $\vec{B} = \dfrac{E_0}{c}\cos(kx - \omega t)\hat{y}$
(d) $\vec{E} = E_0 \cos(kx - \omega t)\hat{x}$ and $\vec{B} = \dfrac{E_0}{c}\cos(ky - \omega t)\hat{y}$

Q.No:7 JEST-2013

The electric and magnetic fields caused by an accelerated charged particle are found to scale as $E \propto r^{-n}$ and $B \propto r^{-m}$ at large distances. What are the values of n and m?
(a) $n = 1, m = 2$
(b) $n = 2, m = 1$
(c) $n = 1, m = 1$
(d) $n = 2, m = 2$

Q.No:8 JEST-2014

An electron is executing simple harmonic motion along the y-axis in right handed coordinate system. Which of the following statements is true for emitted radiation?
(a) The radiation will be most intense in xz plane
(b) The radiation will be most intense in xy plane
(c) The radiation will violate causality
(d) The electron's rest mass energy will reduce due to radiation loss

S. N. Bose Physics Learning Centre

Q.No:9 JEST-2015

The skin depth of a metal is dependent on the conductivity (σ) of the metal and the angular frequency (ω) of the incident field. For a metal of high conductivity, which of the following relations is correct? (Assume that $\sigma \gg \epsilon\omega$, where ϵ is the electrical permittivity of the medium.)

(a) $d \propto \sqrt{\frac{\sigma}{\omega}}$
(b) $d \propto \sqrt{\frac{1}{\sigma\omega}}$
(c) $d \propto \sqrt{\sigma\omega}$
(d) $d \propto \sqrt{\frac{\omega}{\sigma}}$

Q.No:10 JEST-2015

The approximate force exerted on a perfectly reflecting mirror by an incident laser beam of power 10 mW at normal incidence is
(a) $10^{-13}N$
(b) $10^{-11}N$
(c) $10^{-9}N$
(d) $10^{-15}N$

Q.No:11 JEST-2015

Which of the following expressions represents an electric field due to a time varying magnetic field?
(a) $K(x\hat{x} + y\hat{y} + z\hat{z})$
(b) $K(x\hat{x} + y\hat{y} - z\hat{z})$
(c) $K(x\hat{x} - y\hat{y})$
(d) $K(y\hat{y} - x\hat{x} + 2z\hat{z})$

Q.No:12 JEST-2016

The maximum relativistic kinetic energy of β particles from a radioactive nucleus is equal to the rest mass energy of the particle. A magnetic field is applied perpendicular to the beam of β particles, which bends it to a circle of radius R. The field is given by:
(A) $3m_0c/eR$
(B) $\sqrt{2}m_0c/eR$
(C) $\sqrt{3}m_0c/eR$
(D) $\sqrt{3}m_0c/2eR$

Q.No:13 JEST-2016

How much force does light from a $1.8W$ laser exert when it is totally absorbed by an object?
(A) $6.0 \times 10^{-9}N$
(B) $0.6 \times 10^{-9}N$
(C) $6.0 \times 10^{-8}N$
(D) $4.8 \times 10^{-9}N$

Q.No:14 JEST-2016

Self inductance per unit length of a long solenoid of radius R with n turns per unit length is:
(A) $\mu_0\pi R^2n^2$
(B) $2\mu_0\pi R^2n$
(C) $2\mu_0\pi R^2n^2$
(D) $\mu_0\pi R^2n$

Q.No:15 JEST-2017

Consider magnetic vector potential $\vec{A}$ and scalar potential Φ which define the magnetic field $\vec{B}$ and electric field $\vec{E}$. If one adds $-\vec{\nabla}\lambda$ to $\vec{A}$ for a well-defined λ, then what should be added to Φ so that $\vec{E}$ remains unchanged up to an arbitrary function of time, $f(t)$?
(A) $\frac{\partial\lambda}{\partial t}$
(B) $-\frac{\partial\lambda}{\partial t}$
(C) $\frac{1}{2}\frac{\partial\lambda}{\partial t}$
(D) $-\frac{1}{2}\frac{\partial\lambda}{\partial t}$

Q.No:16 JEST-2017

A plane electromagnetic wave propagating in air with $\vec{E} = (8\hat{i} + 6\hat{j} + 5\hat{k})e^{i(\omega t+3x-4y)}$ is incident on a perfectly conducting slab positioned at $x = 0$. $\vec{E}$ field of the reflected wave is
(A) $(-8\hat{i} - 6\hat{j} - 5\hat{k})e^{i(\omega t+3x+4y)}$
(B) $(-8\hat{i} + 6\hat{j} - 5\hat{k})e^{i(\omega t+3x+4y)}$
(C) $(-8\hat{i} + 6\hat{j} - 5\hat{k})e^{i(\omega t-3x-4y)}$
(D) $(-8\hat{i} - 6\hat{j} - 5\hat{k})e^{i(\omega t-3x-4y)}$

Q.No:17 JEST-2018

An electromagnetic wave of wavelength λ is incident normally on a dielectric slab of thickness t. If K is the dielectric constant of the slab, the change in phase of the emergent wave compared with the case of propagation in the absence of the dielectric slab is
(A) $\sqrt{K} - 1$
(B) 2π
(C) $\frac{2\pi t}{\lambda}$
(D) $\frac{2\pi t}{\lambda}(\sqrt{K} - 1)$

Q.No:18 JEST-2018

Two conductors are embedded in a material of conductivity 10^{-4}ohm-m and dielectric constant $\epsilon = 80\epsilon_0$. The resistance between the two conductors is 10^6ohm. What

S. N. Bose Physics Learning Centre

is the capacitance (in pF) between the two conductors? Ignore the decimal part of the answer.

Q.No:19 JEST-2018

Two parallel rails of a railroad track are insulated from each other and from the ground. The distance between the rails is 1 meter. A voltmeter is electrically connected between the rails. Assume the vertical component of the earth's magnetic field to be 0.2 gauss. What is the voltage developed between the rails when a train travels at a speed of 180 km/h along the track? Give the answer in milli-volts.

Q.No:20 JEST-2018

The elastic wave on a stretched rectangular membrane of size $L \times 2L$ in the x-y plane is described by the function

$$A \sin \frac{\pi x}{L} \sin \frac{\pi y}{L} \cos(\omega t + \phi),$$

where A and ϕ are constants. The speed of the elastic waves is v. The angular frequency ω is

(A) $\frac{\sqrt{5}\pi v}{L}$
(B) $\frac{\sqrt{2}\pi v}{L}$
(C) $\frac{\sqrt{5}\pi v}{2L}$
(D) $\frac{\sqrt{17}\pi v}{2L}$

Q.No:21 JEST-2019

A very long solenoid (axis along z direction) of n turns per unit length carries a current which increases linearly with time, $i = Kt$. What is the magnetic field inside the solenoid at a given time t?

(A) $\mathbf{B} = \mu_0 nKt\hat{\mathbf{z}}$
(B) $\mathbf{B} = \mu_0 nK\hat{\mathbf{z}}$
(C) $\mathbf{B} = \mu_0 nKt(\hat{\mathbf{x}} + \hat{\mathbf{y}})$
(D) $\mathbf{B} = \mu_0 cnKt\hat{\mathbf{z}}$

Q.No:22 JEST-2019

The magnetic field (Gaussian units) in an empty space is described by

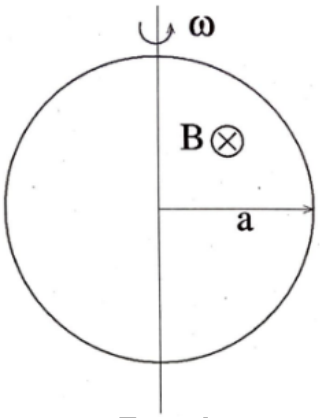
$$\mathbf{B} = B_0 \exp(ax) \sin(ky - \omega t)\hat{\mathbf{z}}.$$

What is the y-component of the electric field?

(A) $-\frac{ac}{\omega} B_0 \sin(ky - \omega t)$
(B) $-\frac{ac}{\omega} B_0 \exp(ax) \cos(ky - \omega t)$
(C) $-B_0 \sin(ky - \omega t)$
(D) 0

Q.No:23 JEST-2019

A circular metal loop of radius $a = 1m$ spins with a constant angular velocity $\omega = 20\pi$ rad/s in a magnetic field $B = 3$ Tesla, as shown in the figure. The resistance of the loop is 10 Ohms. Let P be the power dissipated in one complete cycle. What is the value of $\frac{P}{\pi^3}$ in Watts?



Q.No:24 JEST-2020

Two rails of a railroad track are insulated from each other and from the ground, and are connected by a millivoltmeter. What is the reading of the millivoltmeter when a train travels at the speed of 90 km/hr down the track? Assume that the vertical component of the earth's magnetic field is 0.2 gauss and that the tracks are separated by two meters. Use 1 gauss = 10^{-4} Tesla = 10^{-4} V $\cdot$ sec/m^2.

(A) 10
(B) 1
(C) 0.2
(D) 180

Q.No:25 JEST-2020

An electromagnetic field is given by

$$\vec{E}(\vec{r}, t) = -\frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \theta(vt - r)\hat{r}, \quad \vec{B}(\vec{r}, t) = 0$$

where

$$\theta(x) = \begin{cases} 1 & \text{for } x > 0 \\ 0 & \text{for } x \leq 0 \end{cases}$$

The corresponding charge density ρ and current density $\vec{J}$ are given by

(A) $\rho = -q\delta^3(\vec{r})\theta(vt - r) + \frac{q}{4\pi r^2}\theta(vt - r); \vec{J} = 0$
(B) $\rho = -q\delta^3(\vec{r})\theta(vt - r); \vec{J} = 0$
(C) $\rho = \frac{q}{4\pi r^2}\theta(vt - r); \vec{J} = \frac{qv}{4\pi r^2}\delta(vt - r)\hat{r}$
(D) $\rho = -q\delta^3(\vec{r})\theta(vt - r) + \frac{q}{4\pi r^2}\delta(vt - r); \vec{J} = \frac{qv}{4\pi r^2}\delta(vt - r)\hat{r}$

S. N. Bose Physics Learning Centre

Q.No:26 JEST-2020

A laser has output power of 150 mW with beam diameter of 2 mm at a wavelength 630 nm. What is the value of the electric field in units of V/m? Use Coulomb's constant, $1/(4\pi\epsilon_0) = 9 \times 10^9$ N m^{2}C^{-2}.

Q.No:27 JEST-2021

Consider a sphere of radius R containing a charge with volume density $\rho(r) = 4\pi\epsilon_0\alpha/r$. The charge is zero outside the sphere. The electromagnetic potentials (ϕ and $\vec{\mathbf{A}}$) inside the sphere may be written in many ways. Which of the following values of ϕ and $\vec{\mathbf{A}}$ inside the sphere describe the situation correctly?

(A) $\phi = 0, \vec{\mathbf{A}} = -2\pi\alpha t\hat{\mathbf{r}}$
(B) $\phi = 2\pi\alpha r, \vec{\mathbf{A}} = 0$
(C) $\phi = 0, \vec{\mathbf{A}} = -\pi\alpha t\hat{\mathbf{r}}$
(D) $\phi = \pi\alpha r, \vec{\mathbf{A}} = 0$

Q.No:28 JEST-2022

A circularly polarized laser of power P is incident on a particle of mass m. The particle, which was initially at rest, completely absorbs the incident radiation. The kinetic energy of the particle as a function of time t is given by

(a) $\dfrac{2Pt\left(\dfrac{Pt}{mc^2}+1\right)}{}$

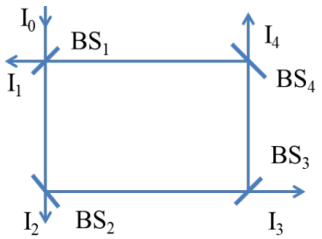
(b) $\dfrac{2Pt\left(\dfrac{Pt}{mc^2}-1\right)}{}$

(c) $\dfrac{P^2t^2}{2mc^2}$

(d) $\dfrac{Pt}{2}$

Q.No:29 JEST-2023

A beam of light of intensity $I_0 = 120$ W/m^2 is incident on the optical system shown in the figure. BS_1, BS_2, BS_3, and BS_4 are ideal, 50/50 beamsplitters (reflects 50% and transmits 50% of incident light intensity). I_1, I_2, I_3, and I_4 are the total intensities measured by detectors. What will be the intensity I_3?



(a) 32 W/m^2
(b) 20 W/m^2
(c) 16 W/m^2
(d) 12 W/m^2

Q.No:30 JEST-2024

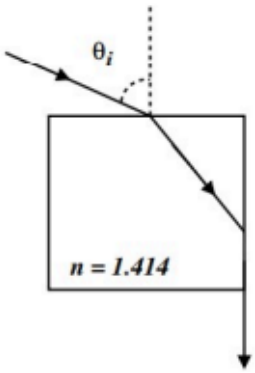
A semi-infinite, thin wire extending from $-\infty$ to zero along the z-axis carries a constant current I in the positive z-direction. The wire is charge-neutral except at $z = 0$, where the inflowing charge is accumulated. What is the absolute value of the line integral

$$\frac{4}{\mu_0 I}\oint \vec{B}\cdot d\vec{l}$$

along the circle $x^2 + y^2 = 1$? $\vec{B}$ is the magnetic field and μ_0 is the permeability in free space. Assume that the accumulated charge at $z = 0$ is a point charge.

Q.No:31 JEST-2025

A ray of light is incident on a glass cube of refractive index 1.414 as shown in the figure. Find the angle of incidence θ_i, such that the ray grazes down the side of the glass cube.



(a) $\pi/4$
(b) $\pi/3$
(c) 0
(d) $\pi/2$

Q.No:32 JEST-2025

For a plane electromagnetic wave propagating with wave vector $\vec{k}$ in a homogeneous and isotropic medium, which of the following holds?

(a) $\vec{E}\times\vec{B} = \vec{0}$
(b) $\vec{k}\cdot(\vec{E}\times\vec{B}) = 0$
(c) None of the others.
(d) $\vec{E}\cdot\vec{B} = 0$

S. N. Bose Physics Learning Centre

Q.No:33 JEST-2026

An electromagnetic wave of angular frequency ω is propagating in a dispersive medium with refractive index $n = n(\omega)$. If the speed of light in vacuum is c, the group velocity of the electromagnetic wave in the dispersive medium is

(a) $\dfrac{c}{n + \omega \dfrac{dn}{d\omega}}$

(b) $\dfrac{cn}{1 + \dfrac{\omega}{n}\dfrac{dn}{d\omega}}$

(c) $\dfrac{c\omega \dfrac{dn}{d\omega}}{1 + \dfrac{\omega}{n}\dfrac{dn}{d\omega}}$

(d) $\dfrac{c}{1 + \dfrac{n}{\omega}\dfrac{d\omega}{dn}}$

Q.No:34 JEST-2026

In the electrodynamics set-up, a gauge transformation takes the vector potential $\vec{A}$ to $\vec{A} + \vec{\nabla} f$, where

$$f = \alpha x^2 t^2$$

with a positive constant α. Which of the following statements is correct about the electric field ($\vec{E}$) and scalar potential ϕ at $(t, x, y, z) = (-1, 1, 0, 0)$?

(a) $\vec{E}$ remains same and ϕ decreases.

(b) Both $\vec{E}$ and ϕ increase.

(c) Both $\vec{E}$ and ϕ remain same.

(d) $\vec{E}$ remains same and ϕ increases.

Q.No:35 JEST-2026

An infinite material has electron moving freely in the background of fixed positive charges. Initially the average charge density of electrons (ρ^-) and that of the positive charges (ρ^+) satisfy

$$\rho^+ = -\rho^- = \rho_0.$$

What is the average net charge density of the material if an electric field $\vec{E}$ is turned on resulting in a steady velocity u of the electrons throughout the material? c is the speed of light.

(a) 0

(b) $\rho_0 \left(1 - \dfrac{1}{(1 - u^2/c^2)^{3/2}}\right)$

(c) $\rho_0 \left(\dfrac{1}{\sqrt{1 - u^2/c^2}} - 1\right)$

(d) $\rho_0 \left(1 - \dfrac{1}{\sqrt{1 - u^2/c^2}}\right)$

Q.No:36 JEST-2026

Two concentric conducting spheres of radii 4 m and 5 m respectively, enclose a medium of conductivity σ (in units of $\mathrm{m}^{-1}\Omega^{-1}$) between their surfaces. The potential difference between the surfaces of the spheres is maintained at V (in volts). In this setup, there will be a current I (in amperes) between the spheres. What is the characteristic length scale $\left(\dfrac{I}{4\pi\sigma V}\right)$ of the system in metres?

S. N. Bose Physics Learning Centre

Question No.	Entrance with year	
1	2012	(b)
2	2012	(c)
3	2012	(a)
4	2012	(d)
5	2013	(d)
6	2013	(b)
7	2013	(c)
8	2014	(a)
9	2015	(b)
10	2015	(b)
11	2015	(d)
12	2016	(C)
13	2016	(A)
14	2016	(A)
15	2017	(A)
16	2017	(C)
17	2018	(D)
18	2018	30 (pF)
19	2018	1 (mV)
20	2018	(B)
21	2019	(A)
22	2019	(B)
23	2019	(Numerical)
24	2020	(B)
25	2020	(D)
26	2020	6000 (V/m)
27	2021	(A)
28	2022	(a)
29	2023	(c)
30	2024	2
31	2025	(d)
32	2025	(d)
33	2026	(a)
34	2026	(d)
35	2026	(d)
36	2026	20 (metres)

S. N. Bose Physics Learning Centre