PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Relativistic electromagnetism - CSIR NET Physics PYQs

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

9 questions . Answer key included

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Q1. [June 2015] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2015 June	5 M

The Dirac Hamiltonian $H = c\vec{\alpha}\cdot\vec{p} + \beta mc^2$ for a free electron corresponds to the classical relation $E^2 = p^2c^2 + m^2c^4$. The classical energy-momentum relation of a particle of charge q in a electromagnetic potential

$(\phi, \vec{A})$ is $(E - q\phi)^2 = c^2\left(\vec{p} - \frac{q}{c}\vec{A}\right)^2 + m^2c^4$.

Therefore, the Dirac Hamiltonian for an electron in an electromagnetic field is

1. $c\vec{\alpha}\cdot\vec{p} + \frac{e}{c}\vec{A}\cdot\vec{A} + \beta mc^2 - e\phi$
2. $c\vec{\alpha}\cdot\left(\vec{p} + \frac{e}{c}\vec{A}\right) + \beta mc^2 + e\phi$
3. $c\left(\vec{\alpha}\cdot\vec{p} + e\phi + \frac{e}{c}|\vec{A}|\right) + \beta mc^2$
4. $c\vec{\alpha}\cdot\left(\vec{p} + {}^{e}\vec{A}\right) + \beta mc^2 - e\phi$

Q2. [June 2016] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2016 June	5M

The values of the electric and magnetic fields in a particular reference frame (in Gaussian units) are $\boldsymbol{E} = 3\hat{x} + 4\hat{y}$ and $\boldsymbol{B} = 3\hat{z}$, respectively. An inertial observer moving with respect to this frame measures the magnitude of the electric field to be $|\boldsymbol{E}'| = 4$. The magnitude of the magnetic field $|\boldsymbol{B}'|$ measured by him is

1. 5

2. 9

3. 0

4. 1

Q3. [Dec 2017] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2017 Dec	5M

In the rest frame S_1 of a point particle with electric charge q_1 another point particle with electric charge q_2 moves with a speed v parallel to the x-axis at a perpendicular distance l. The magnitude of the electromagnetic force felt by q_1 due to q_2 when the distance between them is minimum, is

[In the following $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$]

1. $\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\gamma l^2}$
2. $\frac{1}{4\pi\varepsilon_0}\frac{\gamma q_1 q_2}{l^2}$
3. $\frac{1}{4\pi\varepsilon_0}\frac{\gamma q_1 q_2}{l^2}\left(1+\frac{v^2}{c^2}\right)$
4. $\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\gamma l^2}\left(1+\frac{v^2}{c^2}\right)$

Q4. [Dec 2018] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2018 Dec	5M

In an inertial frame uniform electric and magnetic field $\vec{E}$ and $\vec{B}$ are perpendicular to each other and satisfy $|\vec{E}|^2 - |\vec{B}|^2 = 29$ (in suitable units). In another inertial frame, which moves at a constant velocity with respect to the first frame, the magnetic field is $2\sqrt{5}\hat{k}$. In the second frame, an electric field consistent with the previous observations is

1. $\frac{7}{\sqrt{2}}(\hat{i} + \hat{j})$
2. $7(\hat{i} + \hat{k})$
3. $\frac{7}{\sqrt{2}}(\hat{i} + \hat{k})$
4. $7(\hat{i} + \hat{j})$

Q5. [June 2019] . 5.0 marks
Electromagnetism > Relativistic electromagnetism

CSIR NET	2019 June	5M

A inertial observer A at rest measures the electric and magnetic field $E = (\alpha, 0,0)$ and $B = (\alpha, 0,2\alpha)$ in a region, where a is a constant. Another inertial observer B, moving with a constant velocity with respect to A, measures the fields as $E' = \left(E_x', \alpha, 0\right)$ and $B' = \left(\alpha, B_y', \alpha\right)$. Then in units $c = 1, E_x'$ and B_y' are given, respectively, by

1. -2α and α
2. 2α and $-\alpha$
3. α and -2α
4. $-\alpha$ and 2α

Q6. [June 2020] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2020 June	5M

The electric field due to a uniformly charged infinite line along the z - axis, as observed in the rest frame S of the line charge, is $\vec{E}(\vec{r}) = \frac{\lambda}{2\pi\epsilon_0}\frac{x\hat{i}+y\hat{j}}{(x^2+y^2)}$. In a frame M moving with a constant speed v with respect to S along the z - direction, the electric field $\vec{E}'$ is (in the following $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$)

1. $E'_x = E_x$ and $E'_y = E_y$
2. $E'_x = \beta\gamma E_x$ and $E'_y = \beta\gamma E_y$
3. $E'_x = E_x/\gamma$ and $E'_y = E_y/\gamma$
4. $E'_x = \gamma E_x$ and $E'_y = \gamma E_y$

Q7. [June 2022] . 3.5 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2022 June	3.5M

The electric and magnetic fields in an inertial frame are $\vec{E} = 3a\hat{i} - 4\hat{j}$ and $\vec{B} = \frac{5a}{c}\hat{k}$, where a is a constant. A massive charged particle is released from rest. The necessary and sufficient condition that there is an inertial frame, where the trajectory of the particle is a uniform-pitched helix, is

1. $1 < a < \sqrt{2}$
2. $-1 < a < 1$
3. $a^2 > 1$
4. $a^2 > 2$

Q8. [June 2023] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2023 June	5M

The charge density and current of an infinitely long perfectly conducting wire of radius a, which lies along the z-axis, as measured by a static observer are zero and a constant I, respectively. The charge density measured by an observer, who moves at a speed $v = \beta c$ parallel to the wire along the direction of the current, is

1. $-\frac{I\beta}{\pi a^2 c\sqrt{1-\beta^2}}$
2. $-\frac{I\beta\sqrt{1-\beta^2}}{\pi a^2 c}$
3. $\frac{I\beta}{\pi a^2 c\sqrt{1-\beta^2}}$
4. $\frac{I\beta\sqrt{1-\beta^2}}{\pi a^2 c}$

Q9. [June 2025] . 3.5 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2025 June	3.5M	EMT

In a particular inertial frame, electric field $\vec{E}$ and magnetic field $\vec{B}$ are

$$\vec{E} = E_0\hat{x}, \vec{B} = \frac{E_0}{2c}\hat{x}$$

Which of the following statements is true?

1. There exists an inertial frame where $\vec{E} = 0, \vec{B} \neq 0$
2. There exists no inertial frame where either $\vec{E} = 0$ or $\vec{B} = 0$
3. There exists an inertial frame where $\vec{B} = 0, \vec{E} \neq 0$
4. There exists an inertial frame where both $\vec{E} = 0$ and $\vec{B} = 0$

Answer Key

9 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Electromagnetism	Relativistic electromagnetism	**4**
Q2	Electromagnetism	Relativistic electromagnetism	**3**
Q3	Electromagnetism	Relativistic electromagnetism	**2**
Q4	Electromagnetism	Relativistic electromagnetism	**1**
Q5	Electromagnetism	Relativistic electromagnetism	**3**
Q6	Electromagnetism	Relativistic electromagnetism	**4**
Q7	Electromagnetism	Relativistic electromagnetism	**3**
Q8	Electromagnetism	Relativistic electromagnetism	**1**
Q9	Electromagnetism	Relativistic electromagnetism	**2**

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