REM Exam 2024

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1 Question 1 (/5)

From the fact that $\mu^{eff} = ...$ Proof that the Poynting vector is given by $\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$

Tip: Start with the xx theorem and use product rule A.xx.

2 Question 2 (/5)

You are given a sketch of a capacitor with a charge distribution ρ and both planes have a current surface density given by $\pm\mathbf{K}$.

a) Calculate the electric field between the plates

b) Calculate the magnetic field between the plates

c) If you add a resistive strip between the plates calculate the power dissipated by the resistor and check that this is equal to the magnitude of the flux of the Poynting vector.

3 Question 3 (/5)

a) Proof that both sets A, V and A',V' give rise to the same $\mathbf{E}$ and $\mathbf{B}$: $A' = A + \nabla\lambda$ $V' = V - \frac{\partial\lambda}{\partial t}$

b) The potentials A and V of a stationary electrid charge in the origin were given in a strange way ($V = 0$ and $A \neq 0$) and he asked to find the λ which would bring the potentials A and V to a more familiar form (where $V \neq 0$ and $A = 0$).

4 Question 4 (/5)

You have a superconducter below critical temperature in a uniform magnetic field $\mathbf{B} = B\hat{\mathbf{z}}$ and a perfect conductor in a uniform electric field $\mathbf{E} = E\hat{\mathbf{z}}$.

a) Draw the E/B field lines (NOT the H,D,M or P field lines).

b) Calculate the induced charge current distribution on the superconductor and calculate the induced charge density on the perfect conductor + locations. (You can ignore edge-effects).

5 Question 5 (/5)

hoe gaat de lorentztransformatie van de momentum 4-vector. Furthermore consider een systeem van deeltjes met momenta $p_1, p_2, \ldots$ strikt in de x-directie en energieën $E_1, E_2, \ldots$ Wat is de snelheid van het reference frame waarbij de snelheid van het centre of momentum nul is

6 Question 6 (/5)

A moving particle collides with a stationary particle, both particles have the same mass m. The energy of the moving particle is twice the energy of the stationary particle. If the 2 particles combine to one conglomerate, what will the mass and the velocity of this conglomerate be?

7 Question 7 (/5)

Two grounded conducting infinite half-planes meet at an angle of 60° as shown. A point charge q is located at position (r, $\theta = 30°$. The potential in the region between the planes can be found using the method of images.

a) How many image charges are needed and what are their positions? Explain your method.

b) Is it possible to construct a system of image charges in the case of a point charge q located at the position (r, $0° < \theta < 60°$)?

8 Question 8 (/5)

You were given a strange looking Force rule (similar to the Lorentz force law in tensor notation)

a) Calculate the right side of the equation for $\mu = 1$

b) Guess what the right side will be in the case of $\mu = 2$ and $\mu = 3$ and write the force law in vector notation (or something like that)

c) Try to interpret the meaning of $\tilde{q}$ in the given strange looking Force rule.

9 Question 9 (/5)

You were given a picture of a coaxial cable with in between the 2 conductors a material with a magnetic susceptibility χ_m. Calculte the magnetic field B in between the two conductors.

10 Question 10 (/5)

a) Give the Lorentz transformation of the 4-Energy-momentum vector in the case of a Lorentz boost in the x-direction.

b) If you have a system with n particles all moving to the right with different speeds v_1, v_2, ... Calcute the velocity of the system were the total impulse of all the particles combined is zero.

11 Question 11 (/5)

The fields E and B (with terms proportional to r^{-1},r^{-2} and r^{-3} and with a θ dependency) were given of a certain radiating source and we were asked to calculate the average intensity of the source far away.

12 Question 12 (/5)

The potential on a sphere is given by:

$$V(R,\theta) = V_0 \frac{1}{2}(3cos^2(\theta) - 1) \tag{1}$$

a) What is the potential inside and outside the sphere

b) Corresponds this potential in the leading digit to a monopole, a dipole, a quadrupole or an octodrupole?

13 Bonus question 1 (/2)

The nearest star is Proxima Centauri and is located 4.7 lightyears away. How long does a photon take in its OWN reference frame to reach Proxima from the earth?

14 Bonus question 2 (/2)

What is the electric susceptibility of a perfect conducter and what is the magnetic susceptibility of a superconductor?