NABBEM05E.2012-2013.1A Exam November 7 2012

Elektriciteit en magnetisme 2
Instructor: A.M. van den Berg
Nederlandse versie: zie pagina's 3-4

You don't have to use separate sheets for every question.
Write your name and S number on every sheet
There are **6 questions** with a total number of marks: 80

WRITE CLEARLY

(1) (Total 15 marks)

- (5 marks) An electric field $\vec{E}$ points away from you, and its magnitude is decreasing. Will the induced magnetic field be clockwise or counterclockwise? What if $\vec{E}$ points toward you and is decreasing? Explain your choices.
- (5 marks) The electric field in an electromagnetic field wave traveling north oscillates in an east-west plane. What is the direction of the polarization? And what is the direction of the magnetic field vector in this wave?
- (5 marks) The electric field of a plane electromagnetic wave is given by
  $\vec{E}_x = E_0 \cos(kx + \omega t)$, $E_y = E_z = 0$.
  Determine the direction of the propagation of this wave and the magnitude and direction of the magnetic field vector $\vec{B}$.

(2) (Total 10 marks)
A square loop 27.0 cm on each side has a resistance of 7.5 Ω. It is initially in a 0.755 T homogeneous magnetic field, with its plane perpendicular to $\vec{B}$. It is removed from the field in 40.0 ms. Calculate the electric energy dissipated in this process.

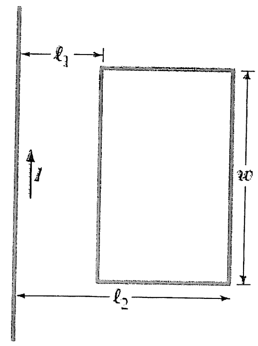
(3) (Total 20 marks)
The electric and magnetic fields of an electromagnetic wave in free space are given by:
$\vec{E} = E_0 \sin(kx - \omega t)\hat{y} + E_0 \cos(kx - \omega t)\hat{z}$ and
$\vec{B} = B_0 \cos(kx - \omega t)\hat{y} - B_0 \sin(kx - \omega t)\hat{z}$.

- (5 marks)
  Show that $\vec{E}$ and $\vec{B}$ are perpendicular to each other at all times.
- (5 marks)
  For this wave, $\vec{E}$ and $\vec{B}$ are in a plane parallel to the yz plane. Show that the wave moves in a direction perpendicular to both $\vec{E}$ and $\vec{B}$.
- (5 marks)
  At any arbitrary choice of position x and time t, show that the magnitudes of $\vec{E}$ and $\vec{B}$ always equal E_0 and B_0, respectively.
- (5 marks)
  At $x = 0$, draw the orientation of $\vec{E}$ and $\vec{B}$ in the xy plane at $t = 0$. Then qualitatively describe the motion of these vectors in the yz plane as time increases.

(4) (Total 15 marks)
Suppose that a circular parallel-plate capacitor has radius $R_0 = 3.0$ cm and a plate-to-plate distance $d = 5.0$ mm. A sinusoidal potential difference $V = V_0 \sin(2\pi f t)$ is applied across the plates, where $V_0 = 150$ V and $f = 60$ Hz.

- (5 marks)
  In the region in between the plates, show that the magnitude of the induced magnetic field is given by $B = B_0(r)\cos(2\pi ft)$, where r is the radial distance from the central axis of the capacitor.
- (5 marks)
  Determine the expression for the amplitude $B_0(r)$ of this time-dependent field when $r \leq R_0$, and when $r > R_0$.
- (5 marks)
  Plot $B_0(r)$ for the range $0 \leq r \leq 10$ cm.

(5) (Total 10 marks)
A long straight wire and a small rectangular wire loop lie in the same plane. Determine the mutual inductance in terms of ℓ_1, ℓ_2, and w. Assume that the wire is very long compared to ℓ_1, ℓ_2, and w. Perform the following steps. First calculate the magnetic field induced by the long wire as a function of the radial distance s. Then determine the flux of the magnetic field through the rectangular wire loop. Finally, determine the mutual inductance.



(6) (Total 10 marks)
In a circular region, there is a uniform magnetic field $\vec{B}$ pointing into the page. An xy coordinate system has its origin at the center of this circular region. A free positive point charge $+Q = 1.0\ \mu$C is initially at rest at a position $x = +10$ cm on the x-axis. If the magnitude of the magnetic field at a certain time ($t = 0$) starts to decrease at a rate of -0.10 T/s, what is the ELECTRIC force (magnitude and direction) acting on $+Q$? Describe the orbit of the charge qualitatively.