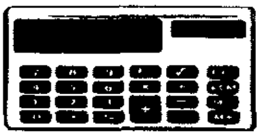
UNIVERSITY EXAMINATIONS



UNIVERSITEITSEKSAMENS

UNISA

PHY1506 (493951) October/November 2013

ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration 2 Hours 100 Marks

EXAMINERS
FIRST PROF M BRAUN
SECOND PROF MS DHLAMINI

Use of a non-programmable pocket calculator is permissible

Closed book examination

This examination question paper remains the property of the University of South Africa and may not be removed from the examination venue

1 This paper consists of two sections, SECTION A(30%) and SECTION B(70%).

2 Answer SECTION A (Multiple Choice) on the examination mark reading sheet.

3 Answer SECTION B (Written Solutions) in the examination answer book.

4 The mark allocation for each question is indicated in brackets to the right.

5 This paper consists of seven (7) pages plus instructions for the completion of the mark reading sheet.

6 The constants and formulae given at the end of SECTION B may be used without proof.

SECTION A (Multiple Choice)

[Total marks: 10x3=30]

1. Materials A, B and C are solids that are at their melting temperatures. Material A requires 200 J to melt 4 kg, material B requires 300 J to melt 5 kg, and material C requires 240 J to melt 6 kg. Rank the materials according to their heat of fusion, greatest first

   1) ABC
   2) BAC
   3) ACB
   4) CAB
   5) BCA

2. An air bubble doubles in volume as it rises from the bottom of a fresh water lake ($1000\,\text{kg/m}^3$) to the surface Ignoring any temperature changes, the depth of the lake is

   1) 0.76 m
   2) 0.99 m
   3) 4.9 m
   4) 10 m
   5) 21 m

3. A small object has charge Q. An amount of charge is removed from it and placed on a second small object. (You may assume, that the objects are spheres!) The two objects are placed 1 meter apart. For the force that each object exerts on the other to be a maximum, q should be

   1) $2Q$
   2) Q
   3) $Q/2$
   4) $Q/4$
   5) 0

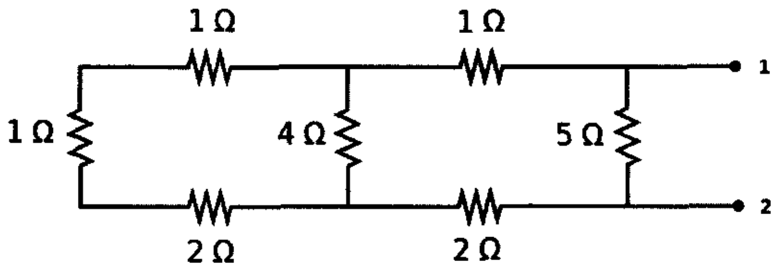
4. The flux of the electric field (24 N/C) $\hat{\imath}$ + (30 N/C) $\hat{\jmath}$ + (16 N/C) $\hat{k}$ through a $2.0\,\text{m}^2$ portion of the yz plane is:

   1) $32\,\text{N}\cdot\text{m}^2/\text{C}$
   2) $34\,\text{N}\cdot\text{m}^2/\text{C}$
   3) $42\,\text{N}\cdot\text{m}^2/\text{C}$
   4) $48\,\text{N}\cdot\text{m}^2/\text{C}$
   5) $60\,\text{N}\cdot\text{m}^2/\text{C}$

5. A 2.0 µC point charge and a 10 µC point charge are initially infinitely far apart. How much work does it take to bring the 2.0 µC point charge to x = 2.0 mm, y = 0.0 mm and the 10 µC point charge to x = -2.0 mm, y = 0.0 mm?

    1) 4.5 J
    2) 18 J
    3) 45 J
    4) 81 J
    5) 100 J

6. Consider the circuit shown below



The equivalent resistance between points 1 and 2 of the circuit is

    1) 1.0 Ω
    2) 2.5 Ω
    3) 3.5 Ω
    4) 4.0 Ω
    5) 4.2 Ω

7. Two parallel plates that are initially uncharged are separated by 1.0 mm. What charge must be transferred from one plate to the other if 20.0 kJ of energy are to be stored in the plates? The area of each plate is 30.0 mm^2

    1) 39 µC
    2) 56 µC
    3) 73 µC
    4) 103 µC
    5) 35 mC

8. In Ampere's law, $\oint \vec{B}\ \ \vec{ds} = \mu_0 i_{enc}$, the integration must be over any

   1) smooth surface
   2) closed surface
   3) round path
   4) closed path
   5) closed path that surrounds all the current producing $\vec{B}$

9 An electron (charge = $-1\ 6 \times 10^{-19}$ C) is moving at 3×10^5 m/s in the positive x-direction A magnetic field of 0 8 T is in the positive z-direction The magnetic force on the electron is

   1) 0
   2) 4×10^{-14} N, in the positive z-direction
   3) 4×10^{-14} N, in the negative z-direction
   4) 4×10^{-14} N, in the positive y-direction
   5) 4×10^{-14} N, in the negative y-direction

10. Two long straight wires are parallel and carry current in the same direction The currents are 8 0 and 12 0 A and the wires are seperated by 0 40 cm The magnetic field in tesla at a point midway between the wires is

   1) 0
   2) $4\ 0 \times 10^{-4}$
   3) $8\ 0 \times 10^{-4}$
   4) 12×10^{-4}
   5) 20×10^{-4}

SECTION B – (Written Solutions: [70])

1 A container holding a certain amount of an ideal gas at 1 5 atm pressure and 107 °C is compressed at constant temperature until the volume is halved It is then further compressed at constant pressure until the volume is halved again

a) What are the final pressure and final temperature of the gas (in °C)? (6)

b) Show the process on a pV diagram. (4)

[10]

2 (a) Define the triple point of water (4)

(b) Define the heat of vaporization (4)

[8]

3 A solid non-conducting sphere of radius $R = 5\ 60$ cm has a non-uniform charge distribution of volume density

$$\rho = \left(14.1\,\mathrm{pC/m^3}\right) r/R\,,$$

where r is the radial distance from the sphere's centre.

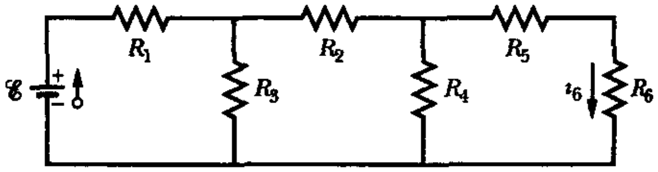
(a) What is the total charge on the sphere? (6)

(b) Determine the magnitude of the electric field $\vec{E}$ at $r = R$ (8)

[14]

4 In the figure below, the current in resistor R_6 is $i_6 = 1\ 40$ A and the resistors are $R_1 = R_2 = R_3 = 2\ 00\ \Omega$, $R_4 = 16\ \Omega$, $R_5 = 8\ \Omega$ and $R_6 = 4\ \Omega$ What is the emf of the ideal battery at the left? (Hint from known currents you can infer voltages that yield currents again, working your way from the right to the left)

[16]



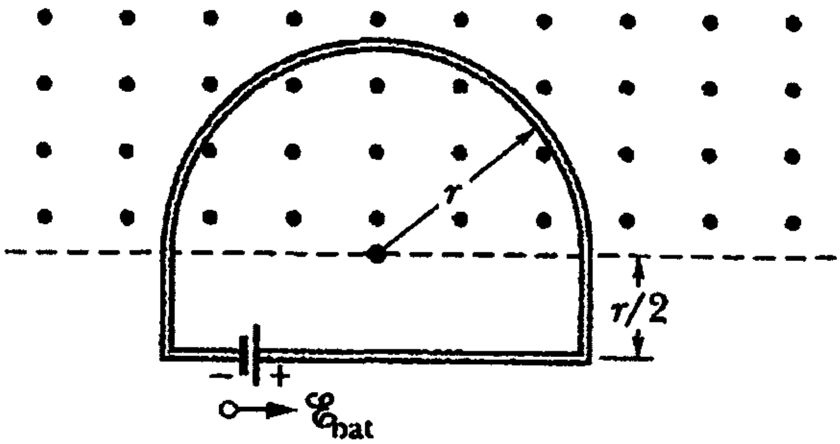
[TURN OVER]

5 (a) State Lenz's law (4)

(b) Explain the concept of displacement current using a capacitor with changing charge, i e through wich a current is flowing (4)

[8]

6. The figure shows a conducting loop consisting of a half circle of radius $r = 0.20$ m and three straight sections The half-circle lies in a uniform magnetic field $\vec{B}$, that is directed out of the page. The magnitude of the magnetic field is given by $B = 4\ 0t^2 + 2.0t + 3\ 0$ with B in Tesla and t in seconds An ideal battery with emf 2 0 V is connected to the loop The resistance of the loop is 2 0 Ω



(a) What are the magnitude and direction of the emf induced around the loop by the magnetic field at time $t = 10$ s? (10)

(b) What is the current in the loop at time $t = 10$ s? (4)

[14]

TOTAL [70]

USEFUL INFORMATION

$$
\begin{aligned}
Q &= \pm L_f M \\
pV &= nRT \\
k &= \frac{1}{4\pi\epsilon_0} = 9 \times 10^9\,\mathrm{Nm^2/C^2} \\
F &= k\frac{q_1 q_2}{|\mathbf{r}_1 - \mathbf{r}_2|^2} \\
U &= k\frac{q_1 q_2}{|\mathbf{r}_1 - \mathbf{r}_2|} \\
\epsilon_0 &= 8\,85 \times 10^{-12}\frac{\mathrm{C}}{\mathrm{V\ m}} \\
C &= \frac{\epsilon_0 A}{d} \\
U_C &= \frac{Q^2}{2C} \\
F_L &= q\vec{v} \times \vec{B} \\
\mu_0 &= 1\,26 \times 10^{-6}\,\mathrm{Tm/A} \\
B &= \frac{\mu_0 \imath}{2\pi r} \\
\Phi_e &= \int \vec{E}\ \ d\vec{A} = Q_{\mathrm{in}}/\epsilon_0 \\
\sum I_{\mathrm{in}} &= \sum I_{\mathrm{out}} \quad V = IR \\
I_{\mathrm{disp}} &= \epsilon_0 \frac{d\Phi_e}{dt} \\
\Phi_m &= BA \\
\mathcal{E}_{\mathrm{ind}} &= -\frac{d\Phi_m}{dt}
\end{aligned}
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EXAMINATION MARK READING SHEET EKSAMEN-MERKLEESBLAD

PART 1 (GENERAL/ALGEMEEN) DEEL 1

STUDY UNIT e.g PSY100-X
STUDIE-EENHEID bv PSY100-X

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PAPER NUMBER
VRAESTELNOMMER ❷

INITIALS AND SURNAME
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DATE OF EXAMINATION
DATUM VAN EKSAMEN ❹ ____________________

EXAMINATION CENTRE (E G PRETORIA)
EKSAMENSENTRUM (BV PRETORIA) ❺ ____________________

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For use by examination invigilator
Vir gebruik deur eksamenopsiener
◆

IMPORTANT

1 USE ONLY AN HB PENCIL TO COMPLETE THIS SHEET
2 MARK LIKE THIS
3 CHECK THAT YOUR INITIALS AND SURNAME HAS BEEN FILLED IN CORRECTLY
4 ENTER YOUR STUDENT NUMBER FROM LEFT TO RIGHT
5 CHECK THAT YOUR STUDENT NUMBER HAS BEEN FILLED IN CORRECTLY
6 CHECK THAT THE UNIQUE NUMBER HAS BEEN FILLED IN CORRECTLY
7 CHECK THAT ONLY ONE ANSWER PER QUESTION HAS BEEN MARKED
8 DO NOT FOLD

BELANGRIK

1 GEBRUIK SLEGS N HB POTLOOD OM HIERDIE BLAD TE VOLTOOI
2 MERK AS VOLG
3 KONTROLEER DAT U VOORLETTERS EN VAN REG INGEVUL IS
4 VUL U STUDENTENOMMER VAN LINKS NA REGS IN
5 KONTROLEER DAT U DIE KORREKTE STUDENTENOMMER VERSTREK HET
6 KONTROLEER DAT DIE UNIEKE NOMMER REG INGEVUL IS
7 MAAK SEKER DAT NET EEN ALTERNATIEF PER VRAAG GEMERK IS
8 MOENIE VOU NIE

PART 2 (ANSWERS/ANTWOORDE) DEEL 2

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