UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

UNISA university of south africa

# PHY1506 ( 480857) May/June 2013

## ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration 2 Hours 100 Marks

EXAMINERS
FIRST PROF M BRAUN
SECOND PROF VS VALLABHAPURAPU

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*Use of a non-programmable pocket calculator is permissible*

**Closed book examination**



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 The coefficient of linear expansion of steel is $11 \times 10^{-6}$ /K A steel ball has volume of exactly 100 cm$^3$ at 0 °C When heated to 100 °C, its volume becomes

1) 100 33 cm$^3$
2) 100 0011 cm$^3$
3) 100 0033 cm$^3$
4) 100 000 011 cm$^3$
5) None of the above

2 The values of pressure and volume of five ideal gases, with the same number of molecules, are given below

a) $p = 1 \times 10^5$ Pa and $V = 10$ cm$^3$
b) $p = 3 \times 10^5$ Pa and $V = 6$ cm$^3$
c) $p = 4 \times 10^5$ Pa and $V = 4$ cm$^3$
d) $p = 6 \times 10^5$ Pa and $V = 2$ cm$^3$
e) $p = 8 \times 10^5$ Pa and $V = 2$ cm$^3$

Which ideal gas has the highest temperature?

1) a)
2) b)
3) c)
4) d)
5) e)

3 During a slow adiabatic expansion of a gas

1) the pressure remains constant
2) energy is added as heat
3) work is done on the gas
4) the temperature is constant
5) no energy enters or leaves as heat

4 A proton is located at $x = 4\,0$ nm, $y = 0\,0$ nm and an electron is located at $x = 0\,0$ nm and $y = 3\,0$ nm Find the attractive Coulombic force between them

1) $3\,5 \times 10^{-18}$ N
2) $9\,2 \times 10^{-12}$ N
3) $6\,5 \times 10^{-6}$ N
4) $6\,5 \times 10^{8}$ N
5) $6\,5 \times 10^{12}$ N

5 A thin wire 7 0 m long has a charge of 2 0 nC Find the electric field strength 2 0 mm from the end of the wire along the axis of the wire

1) 8 N/C
2) 16 N/C
3) 1260 N/C
4) $4\,6 \times 10^{6}$ N/C
5) $5\,8 \times 10^{9}$ N/C

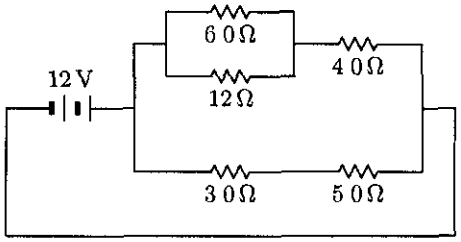
6 A long rod has a linear charge density of $\lambda = 2\,0\,\mu\text{C m}^{-1}$ Find the electric field strength 1 m from the center of the rod measured perpendicular to the axis Assume the radius of the rod is less than 1 m

1) $2\,8 \times 10^{-18}$ N/C
2) 2 0 μN/C
3) $0\,023 \times 10^{6}$ N/C
4) $0\,036 \times 10^{6}$ N/C
5) $2\,0 \times 10^{6}$ N/C

7 You wish to triple the rate of energy dissipation in a heating device To do this you could triple

1) the potential difference keeping the resistance the same
2) the current keeping the resistance the same
3) the resistance keeping the potential difference the same
4) the resistance keeping the current the same
5) both the potential difference and current

8 The current in the 5 0−Ω resistor in the circuit shown below is




1) 0 42 A
2) 0 67 A
3) 1 5 A
4) 2 4 A
5) 3 0 A

9 A 45 mH inductor is connected to an ac source of emf with a frequency of 400 Hz and a maximum emf of 20 V The maximum current is

1) 0 A
2) 0 18 A
3) 1 1 A
4) 360 A
5) 2300 A

10 A magnetic field exists between the plates of a capacitor

1) always
2) never
3) when the capacitor is fully charged
4) while the capacitor is being charged
5) only when the capacitor is starting to be charged

## SECTION B – (Written Solutions: [70])

1 A 2.0 kg ball is at rest on the floor of a 3.0 m × 3.0 m × 3.0 m room of Air at STP ( temperature of 0 °C and pressure of 1 atm)

a) What is the thermal energy of the air in the room (3)

b) What fraction of the thermal energy would have to conveyed to the ball for it to be spontaneously launched to a height of 1.0 m? (3)

c) By how much would the air temperature have to be decreased to launch the ball? (3)

d) Your answer to part c) is so small as to be unnoticeable, yet this event never happens Why not? (3)

**[12]**

2 (a) Define the coefficient of linear thermal expansion for a solid material (3)

(b) Define specific heat (3)

**[6]**

3 Two charged concentric spherical shells have radii of 10.0 cm and 15.0 cm The charge on the inner shell is $4.00 \times 10^{-8}$ C and that one on the outer shell is $2.00 \times 10^{-8}$ C Find the electric field

(a) at $r = 13.0$ cm and (5)

(b) at $r = 18.0$ cm (5)

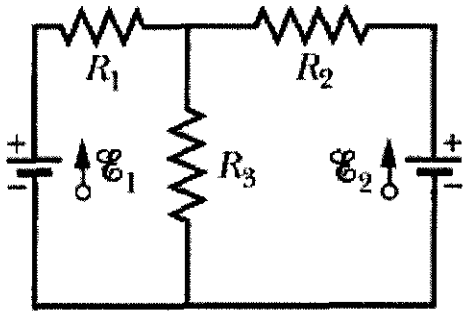
**[10]**

4 In the figure below, $\mathcal{E}_1 = 40$ V and $\mathcal{E}_2 = 10$ V, $R_1 = 30\Omega$, $R_2 = 20\Omega$, $R_3 = 50\Omega$, and both batteries are ideal ( *Hint use both the junction and loop rule!*)

a) What is the rate at which energy is dissipated in $R_1, R_2$ and $R_3$? (14)

(b) What power is provided by battery 1 and battery 2? (4)

**[18]**

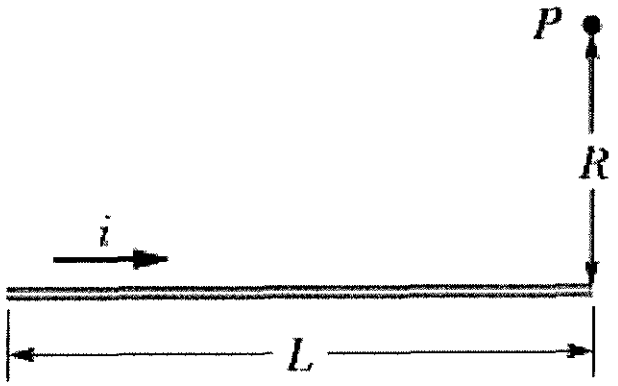



5 (a) State Ampere's law both as formula and verbally (5)

(b) State the capacitive time constant of a circuit containing a resistance $R$ and a capacitance $C$ Explain the physical meaning of the time constant (5)

**[10]**

6 In the figure below, point $P$ is at a perpendicular distance $R = 10$ cm from one end of a straight wire of length $L = 20$ cm This wire carries a current of $i = 0\,5A$ (Note that the wire is *not* long ) What is the magnitude of the magnetic field at $P$?




**[14]**

**TOTAL [70]**

# USEFUL INFORMATION

$$\epsilon_0 = 8\,85 \times 10^{-12}\frac{\mathrm{C}}{\mathrm{V\ m}} \quad k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9\,\mathrm{Nm^2/C^2}$$

$$\mu_0 = 1\,26 \times 10^{-6}\,\mathrm{Tm/A} \quad e = 1\,6 \times 10^{-19}\,\mathrm{C}$$

$$R = 8\,314\,\mathrm{J/molK} \quad k_\mathrm{B} = 1\,38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$$

$$pV = nRT \quad F = k\frac{q_1 q_2}{|\mathbf{r}_1 - \mathbf{r}_2|}$$

$$dq = \lambda dx \quad \int \frac{1}{(a-x)^2} = \frac{1}{a-x}$$

$$\Phi = \int \vec{E}\ d\vec{A} = Q_{in}/\epsilon_0$$

$$P = RI^2 \quad X_L = 2\pi f L$$

$$1\,\mathrm{atm} = 101\,325\,\mathrm{Pa} \quad E_\mathrm{th} = \frac{5}{2}Nk_BT$$

$$pV = nk_BT$$

$$\sum I_\mathrm{in} = \sum I_\mathrm{out} \quad V = IR$$

$$ax + by = e$$

$$cx + dy = f$$

$$x = \frac{ed - bf}{ad - bc} \quad y = \frac{af - ec}{ad - bc}$$

$$dB = \frac{\mu_0 i}{4\pi}\frac{\sin\theta}{r^2}dx$$

$$\int \frac{dx}{(x^2+R^2)^{\frac{3}{2}}} = \frac{1}{R^2}\frac{1}{(x^2+R^2)^{\frac{1}{2}}}$$

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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 — 1

PAPER NUMBER
VRAESTELNOMMER — 2

INITIALS AND SURNAME
VOORLETTERS EN VAN — 3

DATE OF EXAMINATION
DATUM VAN EKSAMEN — 4

EXAMINATION CENTRE (E G PRETORIA)
EKSAMENSENTRUM (BV PRETORIA) — 5

STUDENT NUMBER
STUDENTENOMMER — 6, 7

UNIQUE PAPER NO
UNIEKE VRAESTEL NR — 8, 9

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 — 10

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 36 | 37 | 38 | 39 | 40 |
| 6 | 7 | 8 | 9 | 10 | 41 | 42 | 43 | 44 | 45 |
| 11 | 12 | 13 | 14 | 15 | 46 | 47 | 48 | 49 | 50 |
| 16 | 17 | 18 | 19 | 20 | 51 | 52 | 53 | 54 | |
| 21 | 22 | 23 | 24 | 25 | 56 | 57 | 58 | 59 | 60 |
| 26 | 27 | 28 | 29 | 30 | 61 | 62 | 63 | 64 | 65 |
| 31 | 32 | 33 | 34 | 35 | 66 | 67 | 68 | 69 | 70 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 71 | 72 | 73 | 74 | 75 | 106 | 107 | 108 | 109 | 110 |
| 76 | 77 | 78 | 79 | 80 | 111 | 112 | 113 | 114 | 115 |
| 81 | 82 | 83 | 84 | 85 | 116 | | | | |
| | | | | | 121 | 122 | 123 | 124 | 125 |
| 91 | 92 | 93 | 94 | 95 | 126 | 127 | 128 | 129 | 130 |
| 96 | 97 | 98 | 99 | 100 | 131 | 132 | 133 | 134 | 135 |
| 101 | 102 | 103 | 104 | 105 | 136 | 137 | 138 | 139 | 140 |