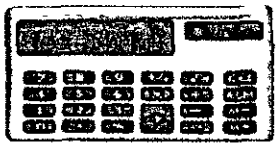
UNIVERSITY EXAMINATIONS



UNIVERSITEITSEKSAMENS

UNISA university of south africa

PHY1506 (499954) May/June 2015

ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration 2 Hours 100 Marks

EXAMINATION PANEL AS APPOINTED BY THE DEPARTMENT

Use of a non-programmable pocket calculator is permissible

Closed book examination

Instructions :

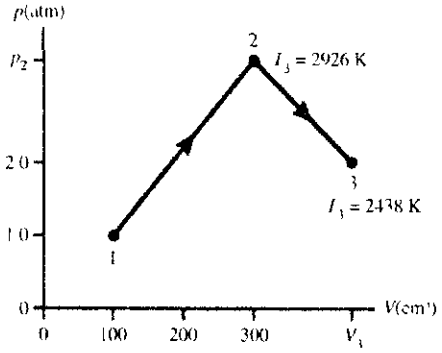
- This examination paper consists of seven (7) pages
- The paper consists of two sections, **Section A (30%)** and **Section B (70%)**
- Answer **Section A** (**Multiple choice**) on the examination mark reading sheet
- Answer **Section B** (**Written solutions**) in the examination answer book
- Show **all** steps in carrying out the calculations
- The mark allocation for each question is indicated in brackets to the right
- The information given at the end of **Section B** may be used without proof

SECTION A (Multiple Choice Questions)

Each question in this section contains 3 marks

1 The figure shows a pV diagram for 0 0066 mol of gas that undergoes the process 1 → 2 → 3 What is the pressure p_2

1) 5 3 atm
2) $5\,3 \times 10^{5}$ atm
3) 16 atm
4) $1\,6 \times 10^{6}$ atm
5) 0 atm

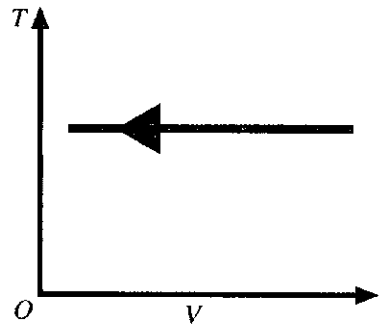


2 A small glass bead has been charged to 8 0 nC What is the magnitude of the electric field 2 0 cm from the center of the bead?

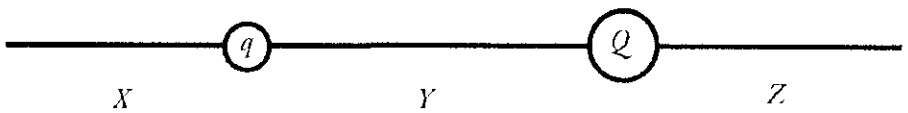
1) $1\,8 \times 10^{5}$ N/C
2) $3\,6 \times 10^{3}$ N/C
3) $1\,4 \times 10^{-3}$ N/C
4) $3\,6 \times 10^{-6}$ N/C

3 The thermodynamic process shown in the T-V diagram in the figure is an

1) adiabatic compression
2) isothermal compression
3) isochoric compression
4) isobaric compression
5) isothermal expansion



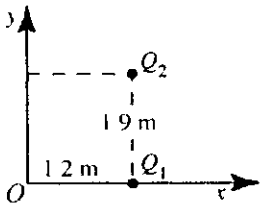
4 The figure shows two unequal point charges, q and Q, of opposite sign Charge Q has greater magnitude than charge q In which of the regions X, Y, Z will there be a point at which the net electric field due to these two charges is zero?



1) only regions X and Z
2) only region X
3) only region Y
4) only region Z
5) all three regions

5 Two point charges, $Q_1 = -1\ 0\ \mu C$ and $Q_2 = +\ 4\ 0\ \mu C$, are placed as shown in the figure below What is the y component of the electric field at the origin O

1) $6\ 0 \times 10^{-3}$ N/C
2) $-6\ 0 \times 10^{-3}$ N/C
3) $3\ 8 \times 10^{-3}$ N/C
4) $-3\ 8 \times 10^{-3}$ N/C
5) $7\ 1 \times 10^{-3}$ N/C



6 A charge Q is uniformly spread over one surface of a very large nonconducting square elastic sheet having sides of length d At a point P that is 1 25 cm outside the sheet, the magnitude of the electric field due to the sheet is E If the sheet is now stretched so that its sides have length $2d$, what is the magnitude of the electric field at P?

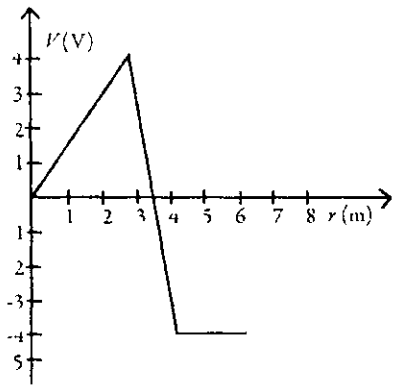
1) $4E$
2) $2E$
3) E
4) $E/2$
5) $E/4$

7 A negative charge is moved from point A to point B along an equipotential surface Which of the following statements must be true for this case?

1) The negative charge performs work in moving from point A to point B
2) Work is required to move the negative charge from point A to point B
3) No work is required to move the negative charge from point A to point B
4) The work done on the charge depends on the distance between A and B
5) Work is done in moving the negative charge from point A to point B

8 The graph in the figure shows the variation of the electric potential V as a function of the radial direction r For which range or value of r is the magnitude of the electric field the largest?

1) from $r = 0$ m to $r = 3$ m
2) from $r = 3$ m to $r = 4$ m
3) from $r = 4$ m to $r = 6$ m
4) at $r = 3$ m
5) at $r = 4$ m

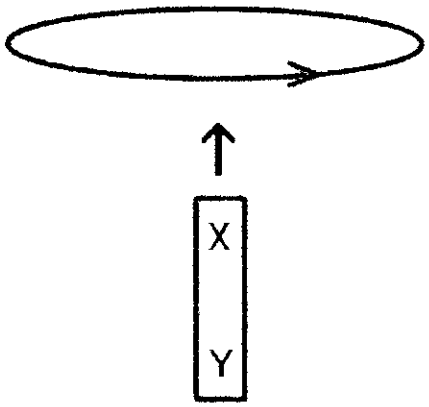


9 A particle with charge -5 00 C initially moves at $\vec{v} = (1\,00\,\hat{\imath} + 7\,00\,\hat{\jmath})$ m/s If it encounters a magnetic field $\vec{B} = 10\,00\ \text{T}\,\hat{k}$, what is the magnetic force vector on the particle?

1) $(-350\,\hat{\imath} + 50\,0\,\hat{\jmath})$ N
2) $(-350\,\hat{\imath} - 50\,0\,\hat{\jmath})$ N
3) $(350\,\hat{\imath} + 50\,0\,\hat{\jmath})$ N
4) $(350\,\hat{\imath} - 50\,0\,\hat{\jmath})$ N
5) $(750\,\hat{\imath} - 150\,0\,\hat{\jmath})$ N

10 The figure shows a bar magnet moving vertically upward toward a horizontal coil The poles of the bar magnets are labeled X and Y As the bar magnet approaches the coil it induces an electric current in the direction indicated on the figure (counter-clockwise as viewed from above) What are the correct polarities of the magnet?

1) The polarities of the magnet cannot be determined from the information given
2) X is a north pole, Y is a south pole
3) Both X and Y are north poles
4) Both X and Y are south poles
5) X is a south pole, Y is a north pole



SECTION B (Written solutions [70])

1 A cylinder containing nitrogen gas has a volume of 10,000 cm^3 and a pressure of 120 atm

(a) Calculate the thermal energy of this gas at room temperature? (6)

(b) Calculate the mean free path of the gas? (5)

(c) The valve is opened and the gas is allowed to expand slowly and isothermally until it reached a pressure of 1 0 atm What is the change in the thermal energy of the gas? (3)

[14]

2 (a) The equation below gives a relationship, between the magnetic field and current in a conductor

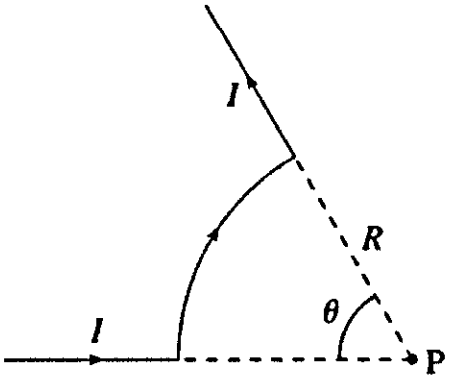
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{s}\times\hat{\mathbf{r}}}{r^3}$$

(i) What is the name of the law represented by the equation? (1)

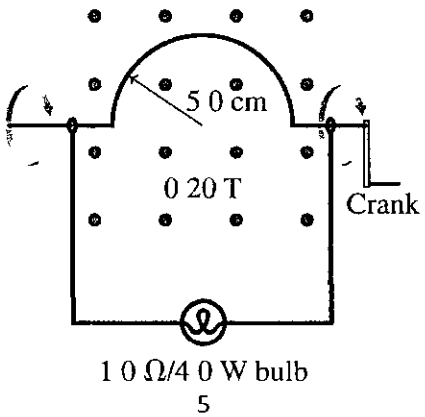
(ii) State and explain the meaning of all the symbols used in the equation (3)

(b) A conductor carrying a current I, consists of a circular arc of radius R and two straight sections, as shown in the figure below Find an expression for the total magnetic field strength at the centre (point P) of the circular arc (10)

[14]



3 The figure below illustrates a hand-cranked generator consisting of a semi-circular loop of radius 5 0 cm placed in a uniform magnetic field of 0 20 T



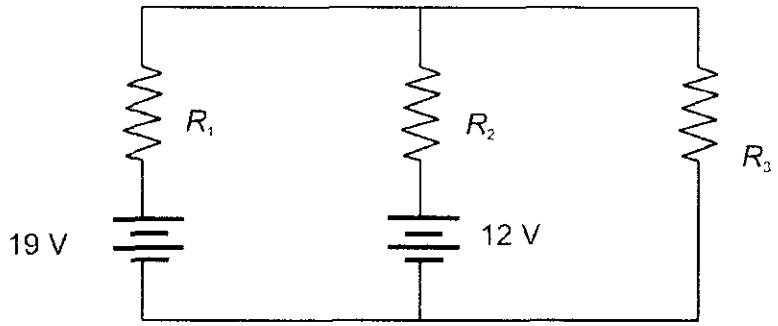
(a) Find an expression for the induced current as a function of time if the crank is turned at a frequency of f Hz (Assume that the loop is at its highest point at $t = 0$ s) (8)

(b) At what frequency will the crank turn for the maximum current to fully light a 10Ω/40 W bulb? (6)

[14]

4 (a) State Kirchhoff's current law and voltage law (4)

(b) Three resistors, $R_1 = 300\ \Omega$, $R_2 = 100\ \Omega$ and $R_3 = 200\ \Omega$ are connected to two ideal batteries, as shown in the figure below



Calculate the current through and potential difference across R_2 (10)

[14]

5. (a) State the first and second law of thermodynamics (5)

(b) Explain the following thermodynamic processes with aid of graphical illustrations
(i) Isochoric (3)
(ii) Isobaric (3)
(iii) Isothermal (3)

[14]

Total **[100]**

Formulae

$Q = mc\Delta T$

$Q = k\dfrac{A\Delta Tt}{L}$

$Q = \sigma T^4 At$

$PV = \dfrac{2}{3}N\overline{KE}$

$KE = \dfrac{3}{2}kT$

$W = nRT\ln\left(\dfrac{V_f}{V_i}\right)$

$W = \dfrac{3}{2}nR\left(T_i - T_f\right)$

$PV = nRT$

$C = \dfrac{\kappa\varepsilon_0 A}{d}$

$\vec{F} = q\vec{v}\times\vec{B}$

$d\vec{E} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{dq}{r^3}\vec{r}$

$d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{id\vec{s}\times\hat{\mathbf{r}}}{r^3}$

$\int\vec{B}\ d\vec{A} = \Phi_B$

$\vec{\tau} = \vec{\mu}\times\vec{B}$

$\mathrm{E} = \left|\dfrac{d\Phi}{dt}\right|$

Constants

$k_B = 1\ 38\times10^{-23}\ J/K$

$R = 8\ 3\ \mathrm{J/(mol\ K)} = 0\ 0821\ \mathrm{L\ atm/mol\ K}$

$N_A = 6\ 0\times10^{23}\ \mathrm{mol^{-1}}$

$m_e = 9\ 1\times10^{-31}\ \mathrm{kg}$

$m_p = 1\ 7\times10^{-27}\ \mathrm{kg}$

$e = 1\ 6\times10^{-19}\ \mathrm{C}$

$k = 9\times10^9\ \mathrm{Nm^2/C^2}$

$\varepsilon_0 = 8\ 85\times10^{-12}\ \mathrm{F/m}$

$\mu_0 = 1\ 26\times10^{-6}\ \mathrm{H/m}$

$c = 3\ 0\times10^8\ \mathrm{m/s}$

Mathematics

Surface Area of a sphere $A = 4\pi r^2$

Volume of a Sphere $V = \dfrac{4}{3}\pi r^3$

$\int\dfrac{dr}{r} = \ln r + \text{constant}$

$\int\dfrac{dr}{r^2} = \dfrac{1}{r} + \text{const}$

EXAMINERS

FIRST DR EM BENECHA

SECOND PROF BM MOTHUDI

UNIVERSITY OF SOUTH AFRICA UNISA university of south africa UNIVERSITEIT VAN SUID-AFRIKA

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	36	71	106
2	37	72	107
3	38	73	108
4	39	74	109
5	40	75	110
6	41	76	111
7	42	77	112
8	43	78	113
9	44	79	114
10	45	80	115
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27	62	97	132
28	63	98	133
29	64	99	134
30	65	100	135
31	66	101	136
32	67	102	137
33	68	103	138
34	69	104	139
35	70	105	140