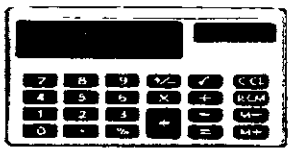
UNIVERSITY EXAMINATIONS



UNIVERSITEITSEKSAMENS

UNISA university of south africa

PHY1506 (499858) May/June 2014

ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration 2 Hours 100 Marks

EXAMINERS
FIRST DR EM BENECHA
SECOND PROF M BRAUN

Use of a non-programmable pocket calculator is permissible.

Closed book examination.

Instructions :

- This paper consists of two sections. SECTION A (30%) and SECTION B (70%)
- Answer all the questions in both sections.
- Answer section A (multiple choice questions) on the mark reading sheet provided.
- Answer section B (written solutions) in the examination booklet provided.
- The mark allocation for each question is indicated in brackets to the right of each question.
- The constants and formulae are given at the end of Section B may be used without proof.
- This paper consists of 6 pages plus a page of instructions for completing the mark reading sheet.

SECTION A (Multiple choice questions: 30%)
(Each question in this section carries 3 marks. TOTAL. [30])

1. An ideal gas is in a closed container If its pressure is 133 Pa initially, and its temperature is 20.0°C, what is its pressure after its temperature is raised to 60 0°C?
   1) 117 Pa
   2) 44 Pa
   3) 399 Pa
   4) 171 Pa
   5) 151 Pa

2 A steel container, equipped with a piston, contains 21 0 mol of an ideal gas at 465 0 K. The container is compressed isothermally to 0 90 of its original volume. How much work is done on the gas?
   1) 11 J
   2) -73000 J
   3) -8500 J
   4) 8600 J
   5) -8600 J

3. Figure 1 shows a cycle for a heat engine for which Q_H = 35 J. What is the thermal efficiency?
   1) 14 %
   2) 57 %
   3) 29 %
   4) 23 %
   5) 71%

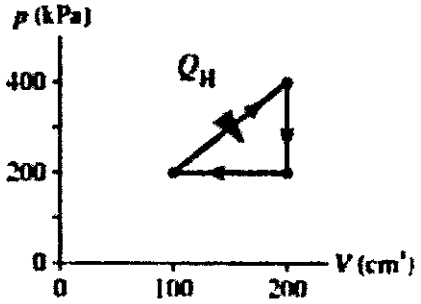


Figure 1

4. Four 20 Ohm resistors are connected in parallel to an ideal 20 V *emf* battery. The current through the battery is
   1) 0 25 A
   2) 4.0 A
   3) 1.0 A
   4) 5.0 A
   5) 80 A

5 A metal sphere is insulated electrically and is given a charge. If 25 electrons are added to the sphere in giving a charge, how many Coulombs are added to the sphere?
   1) $-4\,0 \times 10^{-18}$ C
   2) -4.0×10^{-20} C
   3) -40 C
   4) -25 C
   5) $+4.0 \times 10^{-20}$ C

[TURN OVER]

6. Figure 2 shows a thin rod of length $L = 5.0$ cm with total charge $Q = 8.4$ nC. What is the magnitude of the electric field E at $x = 3.0$ cm?

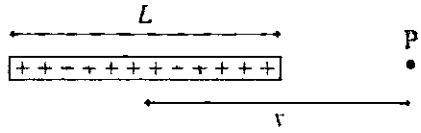


Figure 2

1) 2.7×10^5 N/C
2) 8.4×10^4 N/C
3) 1.8×10^5 N/C
4) 3.7×10^5 N/C
5) 2.0×10^3 N/C

7. A wire has a current of 6.0 mA in it. How many electrons pass a given point in a minute?
1) 360
2) 2.3×10^{18}
3) 6.3×10^{14}
4) 5.4×10^{-15}
5) 3.6×10^{11}

8. A particle with charge -5.00 C initially moves at $v = 1.00\,\mathbf{i} + 7.00\,\mathbf{j}$ m/s. If it encounters a magnetic field $B = 10.00$ T, what is the force on the particle?
1) $350\,\boldsymbol{i} + 50\,\boldsymbol{j}$ N
2) $-350\,\boldsymbol{i} - 50\,\mathbf{j}$ N
3) $-350\,\boldsymbol{i} + 50\,\boldsymbol{j}$ N
4) $350\,\boldsymbol{i} - 50\,\boldsymbol{j}$ N
5) $-50\,\boldsymbol{i} + 350\,\boldsymbol{j}$ N

9. For a long solenoid, the magnetic field strength within the solenoid is given by the equation $B = 5.0t$ T, where t is time in seconds. If the induced electric field outside the solenoid is 11 V/m a distance 2.0 m from the axis of the solenoid, find the radius of the solenoid
1) 9.0 m
2) 77.0 m
3) 0.9 m
4) 3.0 m
5) None of the above is correct

10. A charged particle moves along a circular path under the influence of a magnetic field, which is perpendicular to the plane of the circle If the velocity of the particle is reversed at some point along the path, which of the following statements is correct·
1) the particle retraces its path
2) the particle accelerates
3) the particle moves along a circle perpendicular to the initial plane
4) the particle slows down
5) the particle moves along a different circle in the same plane

[TURN OVER]

SECTION B (Written solutions: 70%)

Question 1

A mixture of 227 g of ice and 1773 g of water is in an initial equilibrium state at 0 0 °C The mixture is then, in a reversible process, brought to a second equilibrium state where the water ice ratio is 1:1 at 0 0 ^{0}C.

(a) Calculate the entropy change of the system during this process. (7)

(b) The system is then returned to the initial equilibrium state in an irreversible process (say by using a bunsen burner). Calculate the entropy change of the system during this process. (3)

(c) Are your answers for part (a) and (b) above consistent with the second law of thermodynamics? Briefly explain your reasoning. (4)

[14]

Question 2

A solid non-conducting Sphere of radius R=5.60 cm has a non-uniform charge distribution of volume density $\rho = (14.1\ \text{pC/m}^3)\, r/R$, where r is the radial distance from the sphere's centre.

(a) Calculate the total charge on the sphere. (6)

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

[14]

Question 3

(a) State Ohm's law (2)

(b) Figure 3 below shows an electric circuit consisting of two ideal batteries and three resistors. The batteries have emfs of $\varepsilon_1 = 10\,0\ \text{V}$ and $\varepsilon_2 = 0\,5\ \varepsilon_1$ The value of each of the resistances is 4.0Ω. Calculate the currents in resistor R_2 and R_3 (12)

[14]

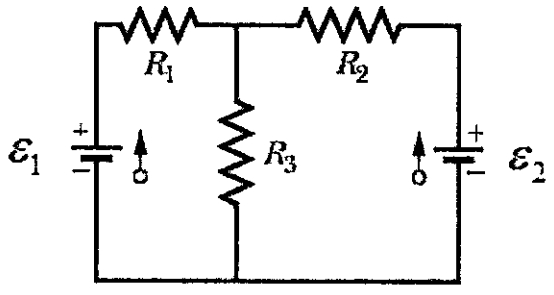


Figure 3

[TURN OVER]

Question 4

(a) State and explain Ampere's law. (4)

(b) Figure 4 below, a closed loop carries current of $\iota = 200\,mA$. The loop consists of two radial straight wires and two concentric circular arcs of radii 2.00 m and 4 00 m. The angle θ is $\pi/4$ rad. Determine the magnitude and the direction (into our out of the page) of the net magnetic field at the center of curvature P (10)

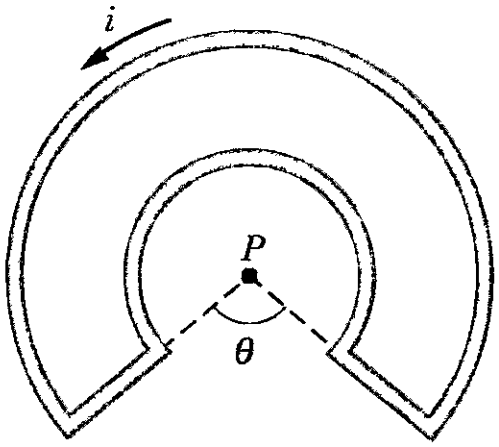


Figure 4

[14]

Question 5

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

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

[14]

TOTAL: **[100]**

[TURN OVER]

Formulae

$$Q = mc\Delta T$$

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

$$Q = \sigma T^4 At$$

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

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

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

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

$$PV = nRT$$

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

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

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

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

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

$$\Delta S = \frac{Q}{T} = m\frac{L_F}{T}$$

Constants

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

$R = 8\ 3J\ /\ (\text{mol K})$

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

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

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

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

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

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

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

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

Heat of fusion of water: 333 kJ/kg

Heat of vaporisation of water: 2300kJ/kg

Specific heat capacity of water: 4190 J/(kgK)

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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

UNIQUE PAPER NO
UNIEKE VRAESTEL NR

8

7

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	55
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	117	118	119	120
86	87	88	89	90	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