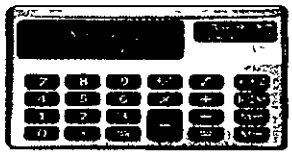
UNIVERSITY EXAMINATIONS



UNIVERSITEITSEKSAMENS

UNISA university of south africa

PHY1506 (478699) May/June 2018

Electromagnetism and Heat (Fisika)

Duration 2 Hours 100 Marks

EXAMINERS

FIRST	DR B MUKERU
SECOND	PROF BM MOTHUDI

Use of a non-programmable pocket calculator is permissible

Closed book examination

INSTRUCTIONS:

- This paper consists of 9 pages.
- The paper consists of 2 sections (A and B) for a maximum of 100 marks.
- Marks for each question or part are indicated in brackets on the right of the question
- Show all the necessary steps in carrying out your calculations
- Page 9 contains useful formulas
- For both sections, answer ALL questions in the answer book.

Section A (Multiple choice questions)
(Each question carries 3 marks TOTAL [30])

1) The ideal-gas law $pV = nRT$ can be transformed into $pV = Nk_BT$ if

(1) $n = \frac{R}{N}$ and $k_B = \frac{R}{N_A}$

(2) $R = \frac{n}{N_A}$ and $k_B = \frac{N_A}{R}$

(3) $n = \frac{N}{N_A}$ and $k_B = \frac{R}{N_A}$

(4) $n = \frac{N_A}{N}$ and $R = \frac{n}{N_A}$

(5) None of the above

2) The equation of the mean free path λ is given by $\lambda = \frac{1}{4\sqrt{2}\pi(N/V)r^2}$ Solving this equation for r one obtains

(1) $r = \frac{1}{2\sqrt{\sqrt{2}\pi(N/V)\lambda}}$

(2) $r = \frac{1}{4\sqrt{\sqrt{2}\pi(N/V)\lambda}}$

(3) $r = \frac{\lambda}{4\sqrt{\sqrt{2}\pi(N/V)}}$

(4) $r = \frac{\frac{N}{V}}{4\sqrt{\sqrt{2}\pi}}$

(5) None of the above

3) The following mathematical equation $\vec{B} = \frac{\mu_0}{4\pi\epsilon_0}\frac{q\vec{v}\times\hat{r}}{r^2}$ represents one of the following laws

(1) Biot-Savart law

(2) Lenz's law

(3) Second law of thermodynamics

(4) Faraday's law

(5) None of the above

[TURN OVER]

4) When a fixed amount of ideal gas goes through an isothermal expansion

   (1) its internal (thermal) energy does not change,

   (2) the gas does no work,

   (3) no heat enters or leaves the gas

   (4) its temperature must decrease,

   (5) none of the above

5) A point charge q is located a short distance from a point charge $3q$, and no other charges are present If the electrical force on q is F what is the electrical force on $3q$ when the distance between the two charges is reduced half ?

   (1) $4F$

   (2) $\frac{F}{4}$,

   (3) F,

   (4) $\frac{\sqrt{4}}{F}$,

   (5) none of the above

6) If a current of 2 4 A is flowing in a cylindrical wire of diameter 2 0 mm, what is the average current density in this wire?

   (1) $5\,2 \times 10^{-6}\,\mathrm{A/m^2}$,

   (2) $7\,6 \times 10^{5}\,\mathrm{A/m^2}$,

   (3) $1\,9 \times 10^{5}\,\mathrm{A/m^2}$,

   (4) $3\,6 \times 10^{5}\,\mathrm{A/m^2}$,

   (5) none of the above

7) Some of the following statements represent Kirchhoff's loop laws

(1) An equipotential surface due to an electrode must roughly match the shape of the electrode

(2) The sum of currents entering a junction is equal to the sum of currents leaving the junction

(3) There is an induced current in a closed, conducting loop if and only if the current is such that the induced magnetic field opposes the change in the flux

(4) The sum of all the potential differences in a closed path is zero

(5) (2) and (4) are correct

8) The potential of a ring of radius R and charge Q is given by $V_{\text{ring}} = \dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{\sqrt{z^2+R^2}}$ The z-component of the corresponding electric field E_z is

(1) $E_z = \dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{(z^2+R^2)^{3/2}}$

(2) $E_z = \dfrac{1}{4\pi\epsilon_0}\dfrac{zQ}{(z^2+R^2)^{3/2}}$

(3) $E_z = \dfrac{1}{4\pi\epsilon_0}\dfrac{z^2Q}{(z^2+R^2)^{5/2}}$

(4) $E_z = 0$

(5) None of the above

9) In an LR circuit, the current is given by $I = I_0 e^{-t/\tau}$, where τ is the time constant Solving this equation for t, we obtain

(1) $t = -\tau \ln\left(\dfrac{I}{I_0}\right)$

(2) $t = \tau \ln\left(\dfrac{I}{I_0}\right)$

(3) $t = -\dfrac{1}{\tau}\ln\left(\dfrac{I}{I_0}\right)$

(4) $t = -\tau\dfrac{I}{I_0}$

(5) None of the above

[TURN OVER]

10) Which one of the following statements is incorrect?

(1) In an LRC circuit, the resonance occurs when $\omega L = \dfrac{1}{\omega C}$

(2) The resonance frequency is given by $\omega_0 = \dfrac{1}{\sqrt{LC}}$

(3) At resonance, the current an RLC circuit is minimum

(4) The phase angle is 0° at resonance

(5) All the statements above are incorrect

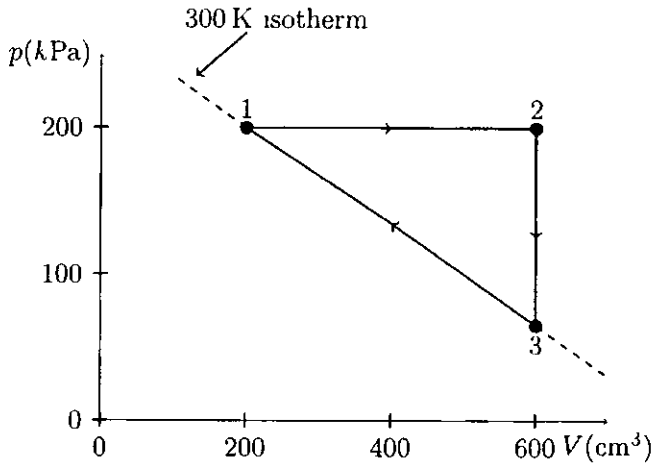
SECTION B (Written solutions)

Question 1

Analyze the heat engine of the figure below to determine

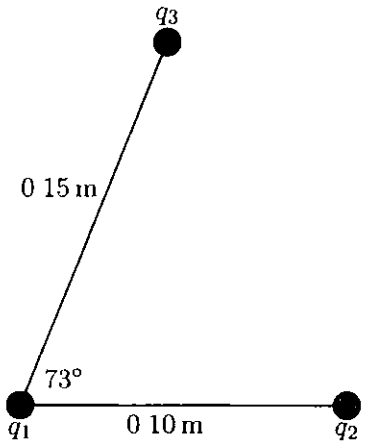
(a) the net work done per cycle (W_{out}) **(12)**

(b) the engine's thermal efficiency The engine contains a monoatomic ideal gas **(8)**
[20]



Question 2

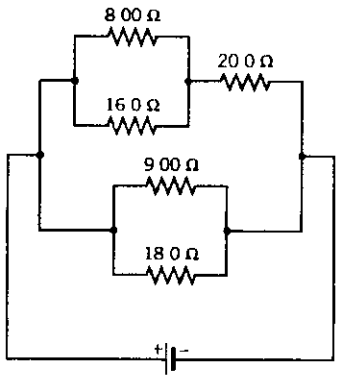
The figure below shows three point charges that lie in the x,y plane Determine the magnitude and direction of the net electrostatic force on q_1, if $q_1 = +4\,\mu$C, $q_2 = -6\,\mu$C and $q_3 = -5\,\mu$C **[10]**



[TURN OVER]

Question 3

The drawing below shows an electric circuit, where resistors are connected to a battery If the current in the 8 0 Ω resistor is 0 5 A, calculate



(a) the equivalent resistance, **(6)**

(b) the current in each resistor, **(6)**

(c) the total current flowing in the circuit, **(3)**

(d) the voltage of the battery, **(3)**

(e) the electric power of the circuit **(2)**

[20]

Please summarize your results in a table for a better reading

Question 4

An AM radio antenna picks up a 1000 kHz signal with a peak voltage of 5 0 mV The tuning circuit consists of a 60 μH inductor in series with a variable capacitor The inductor coil has a resistance of 0 25 Ω, and the resistance of the rest of the circuit is negligible

(a) To what value should the capacitor be tuned to listen to this radio station? (Note that the capacitor needs to be tuned to where it is in resonance with the inductor) **(4)**

(b) Calculate the peak current through the circuit at resonance **(3)**

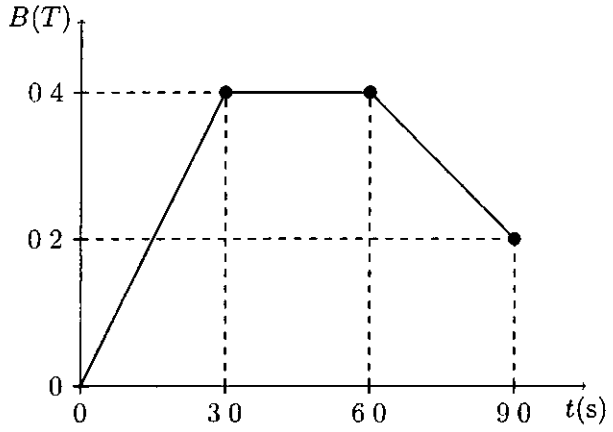
(c) A stronger station at 1050 kHz produces 10 mV antenna signal Calculate the current at this frequency and the corresponding phase angle when the radio is tuned to 1000 kHz **(4)**

[10]

[TURN OVER]

Question 5

A magnetic field passes through a stationary wire loop, and its magnitude changes in time according to the graph in the drawing The direction of the field remains constant however There are three equal time intervals indicated in the graph $0-3\,0$ s, $3\,0-6\,0$ s, and $6\,0-9\,0$ s The loop consists of 50 turns of wire and has an area of $0\,15\,\mathrm{m}^2$ The magnetic field is oriented parallel to the normal to the loop (i e the angle $\phi = 0°$)



(a) For each interval, determine the induced emf **(5)**

(b) The wire has a resistance of $0\,50\,\Omega$ Determine the induced current for the first and last intervals **(5)**

[10]

TOTAL: 70 MARKS

[TURN OVER]

FORMULAE

$PV = nRT$

$U_{\text{el}} = \frac{kq}{r}, \quad F = \frac{kq_1q_2}{r^2}$

$E_r = -\frac{dV}{dr}$

$Q_C + W_{\text{out}} = Q_H$

$R = R_1 + R_2$

$f = \frac{\omega}{2\pi}$

$V_R = IR$

$X_C = \frac{1}{\omega C}$

$Q_P = nC_P\Delta T$

$W = p\Delta V$

$\Delta E_{\text{th}} = Q - W$

$\frac{P_iV_i}{T_i} = \frac{P_fV_f}{T_f}$

$Q = mC\Delta T$

$Q_H = \frac{W_{\text{out}}}{\eta}$

$J = \frac{I}{A}$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\omega_0 = \frac{1}{\sqrt{LC}}$

$I = \frac{\mathcal{E}_0}{\sqrt{R^2 + (X_L + X_C)^2}}$

$V_C = IX_C, \quad \mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}, \quad \Phi = AB\cos\phi$

$Q_V = nC_V\,\Delta T$

$W = nRT\ln(V_f/V_i)$ (isothermal)

$\Delta E_{\text{th}} = Q$

$\Delta E_{\text{th}} = \eta C_V\Delta T$ (any process)

$E_{\text{th}} = \frac{5}{2}nRT$ (diatomic gas)

USEFUL INFORMATION

$k_B = 1.38 \times 10^{-23}\,\text{J/K}$

$e = 1.60 \times 10^{-19}\,\text{C}$

$K = 9.0 \times 10^{9}\,\text{Nm}^2/\text{C}^2$

$C_P = \frac{5}{2}R, \quad C_V = \frac{3}{2}R$ (monoatomic ideal gas)

$\mu_0 = 4\pi \times 10^{-7}\,\text{Tm/A}$

$N_A = 6.02 \times 10^{23}\,\text{mol}^{-1}$

$R = 8.31\,\text{J/mol K}$

$1\,\mu\text{C} = 10^{-6}\,\text{C}$

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

UNIQUE PAPER NO / UNIEKE VRAESTEL NR — 8

For use by examination invigilator

Vir gebruik deur eksamenopsiener

7 9

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
11	46	81	116
12	47	82	117
13	48	83	118
14	49	84	119
15	50	85	120
16	51	86	121
17	52	87	122
18	53	88	123
19	54	89	124
20	55	90	125
21	56	91	126
22	57	92	127
23	58	93	128
24	59	94	129
25	60	95	130
26	61	96	131
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

MARK READING SHEET INSTRUCTIONS

Your mark reading sheet is marked by computer and should therefore be filled in thoroughly and correctly

USE ONLY AN HB PENCIL TO COMPLETE YOUR MARK READING SHEET

PLEASE DO NOT FOLD OR DAMAGE YOUR MARK READING SHEET

Consult the illustration of a mark reading sheet on the reverse of this page and follow the instructions step by step when working on your sheet

Instruction numbers ❶ to ❿ refer to spaces on your mark reading sheet which you should fill in as follows

❶ Write your paper code in these eight squares, for instance

P	S	Y	1	0	0	-	X

❷ The paper number pertains only to first-level courses consisting of two papers

WRITE | 0 | 1 | for the first paper and | 0 | 2 | for the second If only one paper, then leave blank

❸ Fill in your initials and surname

❹ Fill in the date of the examination

❺ Fill in the name of the examination centre

❻ WRITE the digits of your student number HORIZONTALLY (from left to right) Begin by filling in the first digit of your student number in the first square on the left, then fill in the other digits, each one in a separate square

❼ In each vertical column mark the digit that corresponds to the digit in your student number as follows [-]

❽ WRITE your unique paper number HORIZONTALLY
NB Your unique paper number appears at the top of your examination paper and consists only of digits (e g 403326)

❾ In each vertical column mark the digit that corresponds to the digit number in your unique paper number as follows [-]

❿ Question numbers 1 to 140 indicate corresponding question numbers in your examination paper The five spaces with digits 1 to 5 next to each question number indicate an alternative answer to each question The spaces of which the number correspond to the answer you have chosen for each question and should be marked as follows [-]

♦ For official use by the invigilator Do not fill in any information here