



PHY1506

(480857)

May/June 2013

ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration 2 Hours

100 Marks

EXAMINERS
FIRST
SECOND

PROF M BRAUN
PROF VS VALLABHAPURAPU

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 The coefficient of linear expansion of steel is $11 \times 10^{-6}/\text{K}$. 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) 100.000011 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) $p = 1 \times 10^5 \text{ Pa}$ and $V = 10 \text{ cm}^3$
 - b) $p = 3 \times 10^5 \text{ Pa}$ and $V = 6 \text{ cm}^3$
 - c) $p = 4 \times 10^5 \text{ Pa}$ and $V = 4 \text{ cm}^3$
 - d) $p = 6 \times 10^5 \text{ Pa}$ and $V = 2 \text{ cm}^3$
 - e) $p = 8 \times 10^5 \text{ Pa}$ and $V = 2 \text{ cm}^3$

Which ideal gas has the highest temperature?

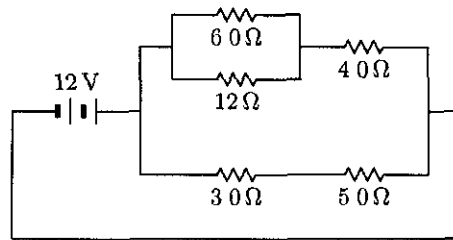
- 1) a)
 - 2) b)
 - 3) c)
 - 4) d)
 - 5) e)
- 3 During a slow adiabatic expansion of a gas
- 1) the pressure remains constant
 - 2) energy is added as heat
 - 3) work is done on the gas
 - 4) the temperature is constant
 - 5) no energy enters or leaves as heat

[TURN OVER]

- 4 A proton is located at $x = 4.0 \text{ nm}$, $y = 0.0 \text{ nm}$ and an electron is located at $x = 0.0 \text{ nm}$ and $y = 3.0 \text{ nm}$. Find the attractive Coulombic force between them
- 1) $3.5 \times 10^{-18} \text{ N}$
 - 2) $9.2 \times 10^{-12} \text{ N}$
 - 3) $6.5 \times 10^{-6} \text{ N}$
 - 4) $6.5 \times 10^8 \text{ N}$
 - 5) $6.5 \times 10^{12} \text{ N}$
- 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) $4.6 \times 10^6 \text{ N/C}$
 - 5) $5.8 \times 10^9 \text{ N/C}$
- 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) $2.8 \times 10^{-18} \text{ N/C}$
 - 2) $2.0 \mu\text{N/C}$
 - 3) $0.023 \times 10^6 \text{ N/C}$
 - 4) $0.036 \times 10^6 \text{ N/C}$
 - 5) $2.0 \times 10^6 \text{ N/C}$
- 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

[TURN OVER]

- 8 The current in the $5.0\text{-}\Omega$ 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

[TURN OVER]

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 be 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 4.00×10^{-8} C and that one on the outer shell is 2.00×10^{-8} C. Find the electric field
- (a) at $r = 13.0$ cm and (5)
- (b) at $r = 18.0$ cm (5)
- [10]

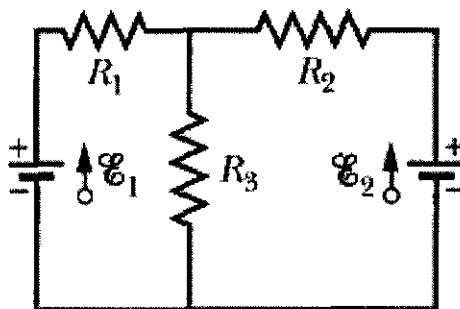
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4 In the figure below, $\mathcal{E}_1 = 4.0 \text{ V}$ and $\mathcal{E}_2 = 1.0 \text{ V}$, $R_1 = 3.0 \Omega$, $R_2 = 2.0 \Omega$, $R_3 = 5.0 \Omega$, and both batteries are ideal (*Hint use both the junction and loop rule*)

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]



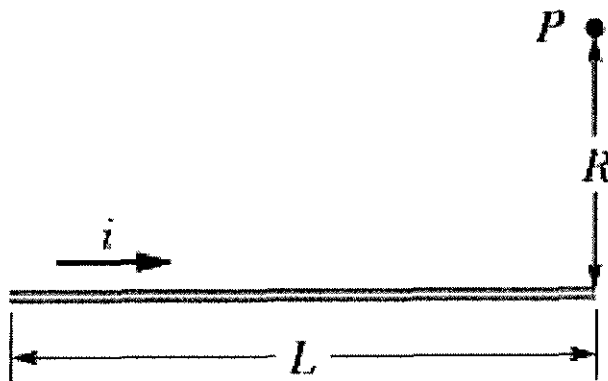
5 (a) State Ampere's law both as formula and verbally (5)

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

C Explain the physical meaning of the time constant (5)

[10]

6 In the figure below, point P is at a perpendicular distance $R = 10 \text{ cm}$ from one end of a straight wire of length $L = 20 \text{ cm}$. This wire carries a current of $i = 0.5 \text{ A}$. (Note that the wire is *not* long) What is the magnitude of the magnetic field at P ?



[14]

TOTAL [70]

[TURN OVER]

USEFUL INFORMATION

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\text{C}}{\text{V m}} \quad k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

$$\mu_0 = 1.26 \times 10^{-6} \text{ Tm/A} \quad e = 1.6 \times 10^{-19} \text{ C}$$

$$R = 8.314 \text{ J/molK} \quad k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

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

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

$$\Phi = \int \vec{E} \cdot d\vec{A} = Q_m/\epsilon_0$$

$$P = RI^2 \quad X_L = 2\pi fL$$

$$1 \text{ atm} = 101325 \text{ Pa} \quad E_{\text{th}} = \frac{5}{2} Nk_B T$$

$$pV = nk_B T$$

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

$$ax + by = e$$

$$cx + dy = f$$

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

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

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

PART 1 (GENERAL/ALGEMEEN) DEEL 1

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

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INITIALS AND SURNAME
 VOORLETTERS EN VAN

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 DATUM VAN EKSAMEN

EXAMINATION CENTRE (E.G. PRETORIA)
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c9	c9	c9	c9	c9	c9	c9	c9

For use by examination invigilator
 Vir gebruik deur eksamenopsiener

IMPORTANT

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

BELANGRIK

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

PART 2 (ANSWERS/ANTWOORDE) DEEL 2

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Specimen only