EXAMINATION PAPER CONTAINS STUDENT'S ANSWERS

Please write your 8-digit student number here: ☐☐☐☐☐☐☐☐

The Handbook of Mathematics, Physics and Astronomy Data is provided

KEELE UNIVERSITY

EXAMINATIONS, 2009/10

Level I

Thursday 27th May 2010, 13.00-15.00

PHYSICS/ASTROPHYSICS

PHY-10021

Electricity and Magnetism

Candidates should attempt ALL of PARTS A and B, and ONE question from PART C and ONE question from PART D.
PARTS A and B should be answered on the exam paper; PART C AND PART D should be answered in the examination booklet which should be attached to the exam paper at the end of the exam with a treasury tag.
PART A yields 16% of the marks, PART B yields 24%, PART C yields 30 and PART D yields 30%. You are advised to divide your time in roughly these proportions.
Figures in brackets [ ] denote the marks allocated to the various parts of each question.

Please do not write in the box below

A		C1		Total
B		C2		
		D1		
		D2		

NOT TO BE REMOVED FROM THE EXAMINATION HALL

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PART A Tick the box by the answer you judge to be corr
(marks are not deducted for incorrect answers)

A1 The electrostatic force between two point charges is 8 N. If the separation betwee these two charges is doubled, the force will be:

☐ 16 N ☐ 4 N ☐ 2 N ☐ 1 N [1]

A2 A 1 m long wire is placed in a 0.1 T magnetic field which is perpendicular to the length of the wire. If the current through the wire is 1 A, the force on the wire is:

☐ 1.0 N ☐ 0.1 N ☐ 1.1 N ☐ 2.0 N [1]

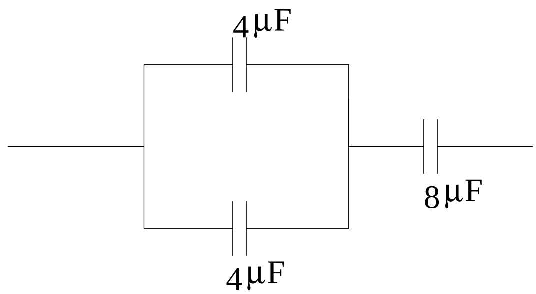
A3 The electric fields at a point due to charges Q_1, Q_2, Q_3 are $10\vec{i}+8\vec{j}$, $-20\vec{i}+16\vec{j}$ and $40\vec{i}-32\vec{j}$ respectively. The electric field at the same point due to all the charges is:

☐ $70\vec{i}+56\vec{j}$ ☐ $-20\vec{i}-32\vec{j}$ ☐ $50\vec{i}+24\vec{j}$ ☐ $30\vec{i}-8\vec{j}$ [1]

A4 An electrical conductor carries 10 coulombs in 5 seconds, the current is:

☐ 10 amps ☐ 2 amps ☐ 0.5 amps ☐ 50 amps [1]

A5 The equivalent capacitance of the following circuit is:



☐ 16 μF ☐ 4 μF ☐ 6 μF ☐ $\frac{8}{5}$ μF [1]

A6 The force acting on charge q moving in a magnetic field $\vec{B}$ with a velocity $\vec{v}$ is:

☐ $q\vec{v}\times\vec{B}$ ☐ qvB ☐ $q\vec{v}.\vec{B}$ ☐ $-qvB$ [1]

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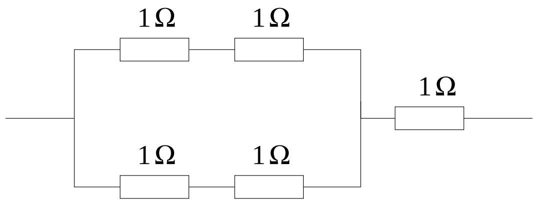
A7 The equivalent resistance of the following circuit is:



☐ 2Ω ☐ 5Ω ☐ 1.25Ω ☐ 3Ω [1]

A8 The density of the charge carriers in an electrical conductor is q Cm^{-3} and the drift velocity is v ms^{-1}. If the area of cross section is A m^2, the current flow through the conductor is given by:

☐ $\frac{q}{v}$ ☐ $\frac{q}{vA}$ ☐ $\frac{v}{q}$ ☐ vAq [1]

A9 A magnetic loop has an area A and carries a current I. The magnitude of the magnetic dipole moment is:

☐ IA ☐ $\frac{A}{I}$ ☐ $\frac{I}{A}$ ☐ I^2A [1]

A10 The force per unit length between two parallel wires carrying identical current in the same direction is 20N. If the separation of these wires is halved, the force per unit length is:

☐ 20N ☐ 10N ☐ 5N ☐ 40N [1]

A11 A rectangular loop of a conducting wire with area A is in a magnetic field B. The plane of the loop is perpendicular to the magnetic field. If the loop is rotated by 180^o, magnetic flux through the loop changes by:

☐ BA ☐ $\frac{BA}{2}$ ☐ $2BA$ ☐ 0 [1]

A12 In an ac-circuit, the phase difference between the voltage and the current is 60^o. The power factor is:

☐ 0.87 ☐ 0.50 ☐ 1.0 ☐ 0 [1]

A13 In an ac-circuit, the peak input voltage is 230 V. The equivalent *root mean square* voltage (rms) is:

☐ 162.6 V ☐ 230.0 V ☐ 325.3 V ☐ 115 V [1]

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A14 In an ac-circuit, the impedance a capacitor is 2000 Ω. If the frequen d, the impedance of the capacitor is:

- [ ] 2000 Ω
- [ ] 1000 Ω
- [ ] 4000 Ω
- [ ] 500 Ω

A15 Magnetic flux through a loop of conducting wire is given by $\phi = 20 + 5t$ Wb. The magnitude of the induced voltage in the loop is:

- [ ] 5 V
- [ ] 20 V
- [ ] 0 V
- [ ] 25 V

[1]

A16 The time-constant of an RC circuit is 4 seconds. If the value of the capacitance is halved, the time-constant will become:

- [ ] 4 s
- [ ] 8 s
- [ ] 2 s
- [ ] 16 s

[1]

/Cont'd

B1 Calculate the ratio of the forces due to the gravitational field and an electric field on an electron near the earth's surface. Assume that $\frac{e}{m}$ for an electron is 1.756×10^{11} Ckg^{-1}, the electric field is 10^6 Vm^{-1} and the gravitational field is 9.8 ms^{-2}. [3]

B2 Sketch the electric field lines for a pair of charges +2q and +q separated by 0.1m. [3]

B3 A 24 μC electric charge is placed at the centre of a cubic box of side 0.6 m. What is the electric flux through one side of the cubic box? [3]

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B4 During a lightning flash, 50 C of electric charge is transferred through a poten-
tial difference of 10^6V. Calculate the electrical energy involved in this pro
How long could this electrical power be used to light a 100W light bulb? [3

B5 A conducting wire of length l travels at speed v perpendicular to both its length and to a magnetic field B. Calculate the induced emf in the wire. [3]

B6 A closed loop encircles several electrical conductors. The line integral $\oint \vec{B} \cdot \vec{dl}$ around the loop is 12.566×10^{-5}T m. Calculate the net current in the conductors. [3]

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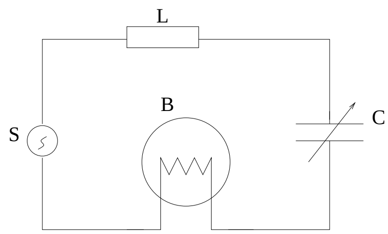
B7 In the ac-circuit shown below, C is a variable capacitor, L is an induc
a light bulb and S is a voltage supply. Explain, how the brightness of the
changes as C is varied?



[3]

B8 A motor draws current of 4 A (*rms* current) from a 250 V (*rms* voltage) source. The average power consumption is 500 W. Calculate the phase angle between the voltage and the current. [3]

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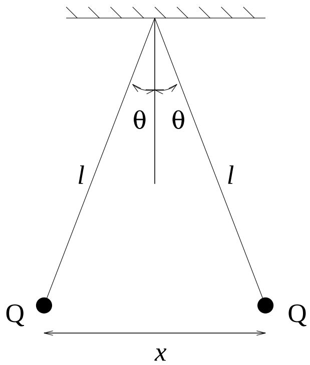
PART C ANSWER ONE OUT OF TWO QUESTIONS

C1 (a) Using Coulomb's or Gauss's law derive an expression for the electric field and the electric potential V at a distance r from a point charge Q. [8]

(b) Two similar conducting balls of mass M are hung from silk threads of length l and carry similar charges Q as shown in figure below. Assume that θ is so small that $\tan\theta$ can be replaced by its approximate equal, $\sin\theta$.



i. Sketch a diagram showing the forces acting on either of the balls. [6]

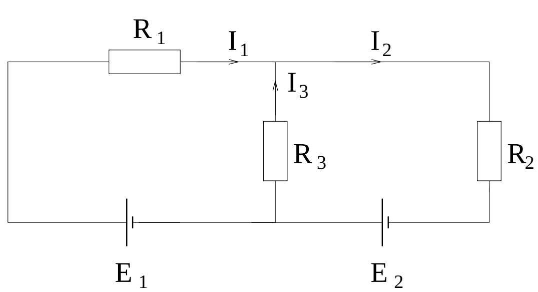
ii. Show that,

$$x = \left[\frac{Q^2 l}{2\pi\epsilon_o M g}\right]^{\frac{1}{3}}$$

where x is the equilibrium separation between the balls. [16]

C2 (a) State and explain Kirchhoff's current and voltage laws for electric circuits. [10]

(b) In the circuit diagram shown below, $R_1 = 10\Omega$, $R_2 = 12\Omega$, $R_3 = 4\Omega$, $E_1 = 4$V and $E_2 = 8$V.



i. calculate the values for I_1, I_2, and I_3; [16]

ii. calculate the power dissipated in R_2; [2]

iii. calculate the power delivered by E_2. [2]

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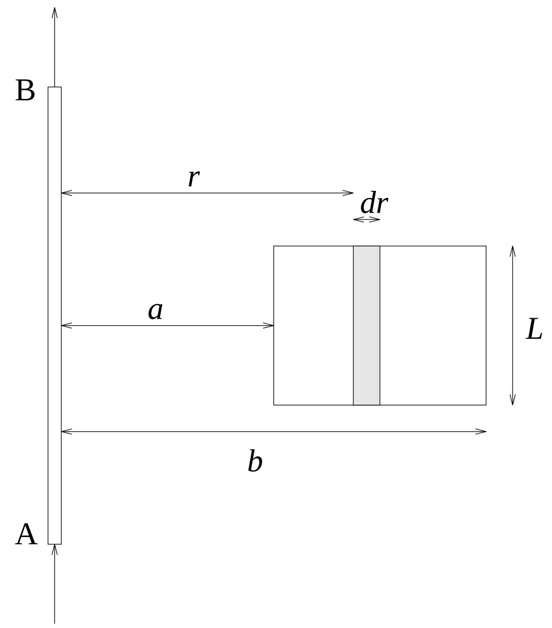
PART D ANSWER ONE OUT OF TWO QUESTIONS

D1 (a) State and explain the laws of electromagnetic induction.

(b) The current in the infinitely long wire AB (see figure below)is $i = i_o\ cos(\omega t)$.



i. calculate the magnitude of the field $\vec{B}$ at a distance r from the wire; [4]

ii. calculate the flux $d\phi$ through the narrow shaded strip; [4]

iii. calculate the total flux through the loop; [8]

iv. calculate the induced emf in the loop. [6]

D2 (a) Explain the terms *root mean square (rms)* and *power factor* in an ac-circuit. [8]

(b) The values of the components in a series LCR circuit are:

$R = 400\Omega, L = 50mH,\ C = 0.5\mu F$.

The input voltage is 200V(rms) and the angular frequency $\omega = 10^4 rad\ s^{-1}$.

i. calculate the total impedance of the circuit; [6]

ii. calculate the *rms* current in the circuit; [5]

iii. calculate the phase angle between the voltage and the current in the circuit; [5]

iv. calculate the power dissipated in R and in C. [6]