EXAMINATION PAPER CONTAINS STUDENT'S ANSW

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

The Handbook of Mathematics, Physics and Astronomy Data is provided

KEELE UNIVERSITY

EXAMINATIONS, 2010/11

Level I

Monday 16th May 2011, 13.00-15.00

PHYSICS/ASTROPHYSICS

PHY-10021

ELECTRICITY AND MAGNETISM

Candidates should attempt ALL of PARTS A and B, and ONE question from each of PARTS C and D. PARTS A and B should be answered on the exam paper; PARTS C and 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%, PART D yields 30%.

Please do not write in the box below

A		C1		Total
B		C2		
		D1		
		D2		

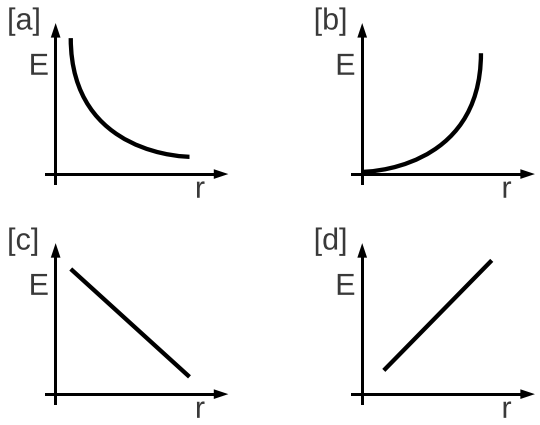
NOT TO BE REMOVED FROM THE EXAMINATION HALL

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

A1 The electrostatic force between two point charges is 30 N. If the charge of both charges is tripled, then the force will be:

☐ 3.3 N ☐ 10 N ☐ 90 N ☐ 270 N [1]

A2 Which of the following graphs illustrate the variation of the electrostatic field, E, with distance from a point charge.



☐ a ☐ b
☐ c ☐ d [1]

A3 The electrostatic potentials at a point P due to charges Q_1, Q_2, and Q_3 are +40 V, −10 V and −20 V, respectively. What is the net electrostatic potential at point P?

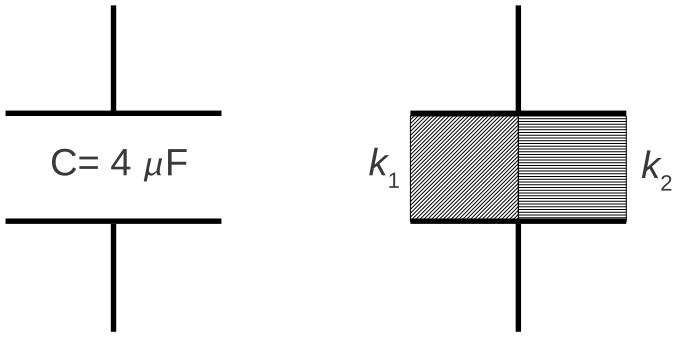
☐ −70 V ☐ −10 V ☐ 10 V ☐ +70 V [1]

A4 What is the electrostatic potential across a distance of 5 m in a uniform electric field, $E = 20\,\mathrm{V/m}$.

☐ 4 V ☐ 20 V ☐ 25 V ☐ 100 V [1]

/Cont'd

A5 The value of the capacitance of the parallel plate capacitor w the dielectric material is $4\,\mu$F. If the capacitor is filled equally w two dielectric materials with the dielectric constants k_1 and k_2, the capacitance is:



☐ $\frac{k_1 + k_2}{2k_1k_2}\,\mu$F ☐ $2k_1k_2\,\mu$F ☐ $\frac{2k_1k_2}{k_1 + k_2}\,\mu$F ☐ $2(k_1 + k_2)\,\mu$F [1]

A6 What capacitance would be required to store 5 J at a potential difference of 1000 V across the plates?

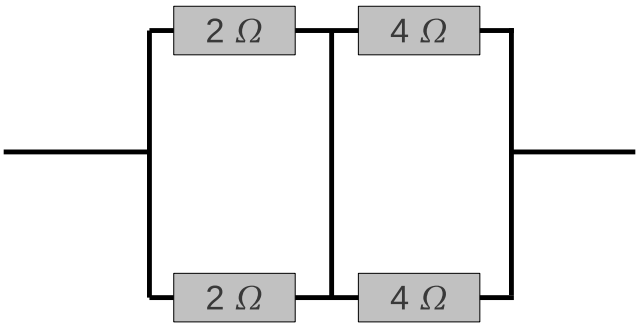
☐ 10^{-2} F ☐ 5×10^{-2} F ☐ 10^{-5} F ☐ 5×10^{-5} F [1]

A7 A transmission line carries a current of 10^3 A from west to east. The earth's magnetic field is horizontal, points to the north, and has a magnitude of 0.5×10^{-4} T. What is the force on one meter of the wire?

☐ 0.05 N ☐ 0.2 N ☐ 50 N ☐ 500 N [1]

/Cont'd

A8 What is the equivalent resistance of the following circuit:



☐ 2.67 Ω ☐ 3 Ω ☐ 6 Ω ☐ 12 Ω [1]

A9 The magnetic field 1 cm away from an infinitely long current-carrying wire is 1 T. What is the magnetic field 2 cm away from the wire?

☐ 0.25 T ☐ 0.5 T ☐ 2 T ☐ 4 T [1]

A10 Inside a toroidal coil of rectangular cross-section, the magnetic field is:

☐ proportional to the radial distance from the centre of the coil.
☐ inversely proportional to the radial distance from the centre.
☐ zero.
☐ uniform. [1]

A11 The induced emf in a circuit exposed to an external magnetic field does NOT depend on:

☐ the magnetic field.
☐ the area enclosed by the circuit.
☐ the orientation between the magnetic field and the circuit.
☐ the source of the magnetic field. [1]

/Cont'd

A12 A rectangular loop of cross section $2.0\,\text{m} \times 3.0\,\text{m}$ is exposed to a uniform $5\,\text{T}$ magnetic field perpendicular to the loop. The loop is rotated about an axis perpendicular to the field by 270^{o}. What is the magnitude of the change in the flux?

☐ 15 Wb ☐ 30 Wb ☐ 45 Wb ☐ 60 Wb [1]

A13 The time constant of an LR circuit is:

☐ LR ☐ L/R ☐ R/L ☐ 1/LR [1]

A14 The natural angular frequency of an ideal (non-resistive) LC circuit is ω_0. When the resistance of the circuit is taken into account, what happens to the angular frequency, ω?

☐ $\omega = 0$ ☐ $\omega < \omega_0$ ☐ $\omega = \omega_0$ ☐ $\omega > \omega_0$ [1]

A15 In an AC circuit, the reactance of an inductor is $10\,\Omega$. If the frequency is halved, the reactance of the inductor becomes:

☐ $5\,\Omega$ ☐ $10\,\Omega$ ☐ $20\,\Omega$ ☐ $40\,\Omega$ [1]

A16 In an AC circuit, the phase difference between the voltage and the current is $-\phi$. The power factor is:

☐ $-\sin(\phi)$ ☐ $\sin(\phi)$ ☐ $\cos(\phi)$ ☐ $-\tan(\phi)$ [1]

/Cont'd

PART B Answer all EIGHT questions

B1 The charge produced by rubbing a block of plastic with a cloth is 32 nC. Calculate the number of electrons that have been transferred in the process. [3]

B2 A proton is accelerated from rest using an electric field, $E = 10^5\,\mathrm{V/m}$. Calculate the velocity of the proton after it has undergone a displacement of 2 m. [3]

/Cont'd

B3 Sketch the electric potential for a pair of charges −q and −2
separated by 10 cm. [3]

B4 Calculate the magnetic and electric forces and the ratio of the two forces for a particle of charge 3 nC moving at 5000 m/s in the presence of an electric field, E= 10^4 V/m and a magnetic field, B= 2 T (both B and E being perpendicular to the motion of the particle). [3]

/Cont'd

B5 Two infinitely long parallel wires carry currents of 2 A and 3 A respectively, and are separated by a distance of 5 cm. Calculate the force per unit length exerted by one wire on the other. [3]

B6 A solenoid is composed of n turns per unit length and has a cross sectional area A. The wires of the solenoid carry a current that varies as follows: $I = I_0 \sin(\omega t)$. Obtain an expression for the self-induced emf. [3]

/Cont'd

B7 A 60-mH inductor is connected to a source with an rms potential difference of 30 V and a frequency of 120 Hz. Calculate the peak current. [3]

B8 Sketch two different circuit diagrams for a high-pass filter. [3]

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PART C Answer ONE out of TWO questions

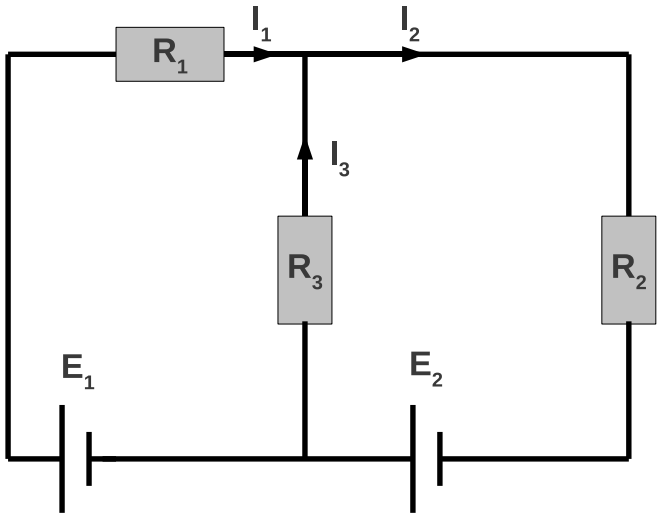
C1 (a) State and explain Gauss's law. [5]

(b) An infinite line of charge has a uniform charge per unit length, λ. Find the electric field at a perpendicular distance r from the line. [10]

(c) An infinite flat sheet of charge has a uniform charge per unit area, σ. Find the electric field at a perpendicular distance r from the sheet. [15]

C2 (a) State and explain Kirchhoff's rules for an electric circuit. [10]

(b) In the circuit diagram below, $I_1 = 3\,\text{A}$, $I_2 = 2\,\text{A}$, $E_1 = 10\,\text{V}$, $E_2 = 5\,\text{V}$, and $R_1 = 2\,\Omega$.



i. Calculate the power delivered by E_2. [2]

ii. Calculate the values for R_2 and R_3. [18]

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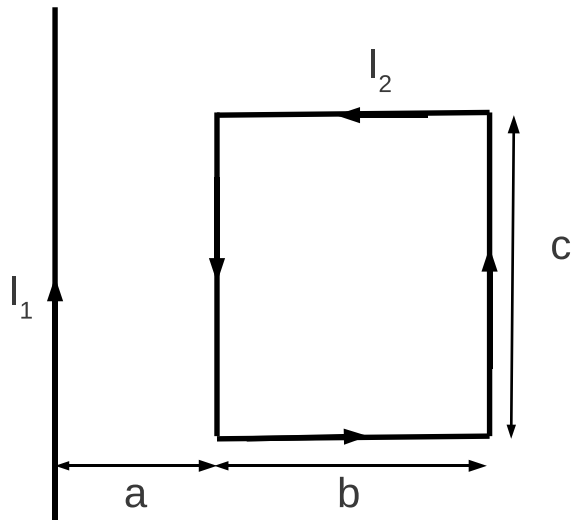
PART D Answer ONE out of TWO questions

D1 (a) State and explain Ampère's law. [5]

(b) A long straight wire and a rectangular loop lie in the same plane, as shown below. The dimensions and currents are indicated.



i. Determine the net magnetic force exerted on the loop by the wire. [10]

ii. Determine the magnetic flux through the loop due to the wire. [10]

iii. The current varies as $I = (5t + 1)$ A, where t is the time in seconds. Calculate the induced emf across the loop. [5]

/Cont'd

D2 (a) Explain what is meant by *resonance* in an AC-circuit and give an example application. [10]

(b) A series LCR circuit is connected to a variable frequency sinusoidal signal generator with a peak voltage of 100 V, L= 3 mH, and R= 20 Ω.

i. The resonance frequency is 1000 Hz. Determine the capacitance of the capacitor. [5]

ii. Calculate the amplitude of the current at resonance. [5]

iii. Calculate the current flowing through the circuit when the frequency is 5 times the resonance frequency. [7]

iv. Determine the phase angle and whether the voltage is leading or lagging the current [3]