**THE UNIVERSITY OF NEW SOUTH WALES**
**SCHOOL OF PHYSICS**

**PHYS1169 PHYSICS 1A**
*(Chemical, Mechanical & Mining Engineering)*

**TEST 1**
**SESSION 1, 2002**

Time Allowed: 1.5 hours

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**INSTRUCTIONS**

1. Do not read or write on this paper until instructed to do so.

2. For each test attempted, answer all questions.

3. Answer questions in the spaces provided.

4. Questions are not necessarily of equal value.

5. For each question, full working and explanation must be shown.

6. Answers must be written in ink. Pencil may only be used for drawings, sketching or graphs.

7. Portable, solar powered electronic calculators will be supplied.

8. This booklet must be handed in at the end of the examination.

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<th>Question</th>
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**TOTAL**
DATA SHEET

1 atmosphere (Standard air pressure) ........................................ 1.01×10^5 Pa
Latent heat of vaporisation of water at constant pressure .......... 22.56×10^5 J kg⁻¹
Latent heat of fusion of ice, L_f ....................................................... 3.34×10^5 J kg⁻¹
Avogadro's constant, N .......................................................... 6.022×10^23 (g mol⁻¹)
Charge on electron, e .............................................................. 1.602×10⁻¹⁹ C (negative)
Gas constant, R ................................................................. 8.314 J K⁻¹(g mol⁻¹)
........................................................................................... 0.0821 litre-atm K⁻¹ (g mol⁻¹)
Molecular weight of hydrogen, M ........................................... 2.00×10⁻³ kg(g mol⁻¹)
Atomic mass unit, u ................................................................. 1.661×10⁻²⁷ kg = 931.5 MeV/c²
Mass of electron, m_e ............................................................... 9.109×10⁻³¹ kg = 5.486×10⁻⁴ u
Mass of neutron, m_n ............................................................... 1.675×10⁻²⁷ kg = 1.0087 u
Mass of proton, m_p ................................................................. 1.673×10⁻²⁷ kg = 1.0073 u
Velocity of sound in air (20°C and 1 atm) ................................. 343 ms⁻¹
Boltzmann's constant, k_B ....................................................... 1.381×10⁻²³ JK⁻¹
Permittivity of free space, ε₀ ...................................................... 8.854×10⁻¹² C² N⁻¹ m⁻²
Permeability of free space, μ₀ .................................................... 4π×10⁻⁷ NA⁻²
Earth's gravitational acceleration, g ........................................ 9.80 m s⁻²
Speed of light, c ................................................................... 2.998×10⁸ m s⁻¹
Coulomb's constant, k .............................................................. 8.99×10⁹ Nm² C⁻²
Universal gravitation constant, G ............................................. 6.673×10⁻¹¹N m² kg⁻²
Planck's constant, h ................................................................. 6.626×10⁻³⁴ J s
Rydberg's constant, R_H ........................................................ 1.097×10⁷ m⁻¹
Density of water, ρ ................................................................. 1.00×10³ kg m⁻³
Mass of Earth .................................................................. 5.98×10²⁴ kg
Average radius of Earth ....................................................... 6.37×10⁶ m
Mass of Moon .................................................................. 7.36×10²² kg
Average Earth-Moon distance ............................................... 3.84×10⁸ m
Mass of Sun .................................................................. 1.99×10³⁰ kg
Radius of Sun .................................................................. 6.96×10⁸ m
Average Earth-Sun distance ................................................ 1.496×10¹¹ m
Bohr radius, a₀ ................................................................. 5.29×10⁻¹¹ m
Hydrogen ground state, E₀ ................................................ -13.606 eV
Volume of 1 g mole ideal gas at 101.3 kPa (1 atm) and
at 0°C (273 K) .................................................................. 2.241×10⁻² m³
at 25°C (298 K) ................................................................ 2.447×10⁻² m³
Mechanical equivalent of heat, 1 cal ................................ 4.186 J
Stefan's Constant, σ ........................................................... 5.67×10⁻⁸ Js⁻¹m⁻²K⁻⁴
Wien's Constant, B ............................................................. 2.898×10⁻³ m.K
1 eV ........................................................................... 1.60×10⁻¹⁹ J
Threshold of hearing, I₀ ...................................................... 1×10⁻¹² W m⁻²
QUESTION 1

Two vectors are given by
\[ a = 2i - j \]
\[ b = i + 2j + k \]

(a) Calculate \( a + 3b \)

(b) Calculate \( a \cdot b \)

What do you deduce about the angle between \( a \) and \( b \)?

(c) Calculate \( a \times b \)
QUESTION 2

Two point charges, one of charge \(+q\) and the other of charge \(-2q\), are situated on the \(x\) axis as shown.

(a) Derive an expression for vector components of the electric field intensity at \(P\), in rectangular co-ordinates;

(b) Determine the direction of the electric field at \(P\) relative to the \(x\) axis;

(c) Find an expression for the electric potential at point \(P\).
QUESTION 3

For the circuit shown, showing all your reasoning and working, determine:

(a) the total equivalent capacitance of this combination of capacitors

(b) the total charge drawn from the battery

(c) the charge on the 3 µF capacitor

(d) the potential difference across the 3 µF capacitor
QUESTION 4

(a) State Kirchhoff's rules for direct current circuits.

(b) For the circuit shown, use Kirchhoff's rules to write down three equations from which the currents $i_1$, $i_2$ and $i_3$ could be determined, 

DO NOT GO ON TO SOLVE THOSE EQUATIONS.

(c) Given the current $i_2$ has a value 1A, determine:

(i) the potential difference across the 2Ω resistor

(ii) the value of the current $i_1$

(d) Is power supplied by, or delivered to the 12 V battery? Give your reasoning.
QUESTION 5

The diagram shows a plan view of a mass spectrometer. In it ions of mass \( m \) and charge \( +q \) are accelerated to \( S_2 \) from rest at \( S_1 \) by a potential difference of \( V \). They emerge through a small hole at \( S_2 \) and enter a uniform magnetic field, of magnetic induction \( B \), directed at right angles and into the plane of the paper. In the field they follow a semicircular path until they strike the detector D. Showing all your reasoning and working, derive expressions for

(a) The kinetic energy gained by the ions from \( S_1 \) to \( S_2 \)
(b) The velocity of the ions on entering \( S_2 \)
(c) The distance \( d \) from \( S_2 \) at which the ions strike the detector array.
QUESTION 6  

(Marks 10)

(a) State Faraday's Law of electromagnetic induction, defining all the symbols used.

(b) The diagram shows a conducting rod PQ making contact with parallel metal rails PS and QR, which are a distance d apart. Both the rails and the rod have negligible resistance.

The rails are connected at S and R by a resistor of resistance r. A uniform magnetic induction B is directed vertically down into the plane of the paper. The rod moves to the left at speed v, as shown in the diagram.

(i) Showing all your reasoning and working, derive an expression for the magnitude of the current in the loop PQRS.

(ii) What is the direction of this current? Justify your answer.