SYDNEY GRAMMAR SCHOOL

2001
HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and a Periodic Table are provided at the back of this paper
- Write your Class and Student Number in the boxes provided

Collection Instructions

Hand in the following sections in 3 separate bundles

- Section I - Part A Answer sheet
- Section I - Part B Question and Answer Booklet
- Section II - Answer Booklet

Section I Pages 3 - 20

Total marks (75)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**

- Attempt Questions 1 - 15
- Allow about 30 minutes for this part

Part B
Total marks **(60)**

- Attempt Questions 16 - 29
- Allow about 1 hour and 45 minutes for this part

Section II Pages 21- 23

Total marks **(25)**

- Attempt ONE Question from Questions 30 - 34
- Allow about 45 minutes for this section

Section I
Total marks (75)

Part A
Total marks (15)
Attempt Questions 1 - 15
Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

Select the alternative A, B, C or D that best answers the question. Fill the response oval completely.

Sample 2 + 4 =

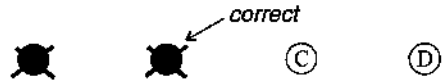
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

● ⊗ Ⓒ Ⓓ

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



Student Number

1 A spherical asteroid has a mass of 3.1×10^{22} kg and a radius of 5.3×10^{5} m. The gravitational field strength at the surface of the asteroid is:

(A) 0.81 Nkg^{-1}.
(B) 1.6 Nkg^{-1}.
(C) 7.4 Nkg^{-1}.
(D) 9.8 Nkg^{-1}.

2 A test pilot brings a jet-powered car to rest from a speed of 118 ms^{-1} in a time of 3 s. The acceleration of the pilot is equivalent to:

(A) g.
(B) 2g.
(C) 3g.
(D) 4g.

3 The unstable sub-atomic particle called the muon has an average life-time of 2.2 μs, when measured at rest in the laboratory. However, high speed muons produced in the upper atmosphere are measured to have:

(A) a shorter average lifetime, because of length contraction.
(B) a shorter average lifetime, because of time dilation.
(C) a longer average lifetime, because of time dilation.
(D) the same average lifetime, because the effects of time dilation and length contraction cancel out.

4 An astronaut orbiting the Earth in the space-shuttle feels weightless because:

(A) the effect of the Earth's gravity is negligible.
(B) the shuttle is rotating.
(C) the gravitational attraction of the Moon cancels the gravitational attraction of the Earth.
(D) the astronaut is accelerating at the same rate as the space shuttle.

5 Rockets are launched from sites near to the Equator because:

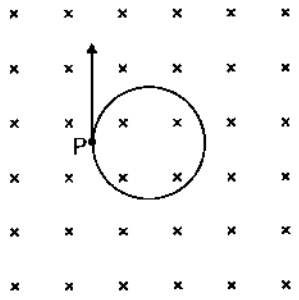
(A) the Earth's rotational velocity helps reduce the fuel required during the launch.
(B) most satellites are placed in geostationary, equatorial orbits.
(C) the distance into space is less than at the poles because the Earth is not a perfect sphere.
(D) there is less chance of the Earth's magnetic field affecting the rocket.

Student Number

6 An ideal transformer has 100 turns in its primary winding and 300 turns in its secondary. If the power input to the transformer is 60 W, the power output is:

(A) 20 W.
(B) 60 W.
(C) 180 W.
(D) 540 W.

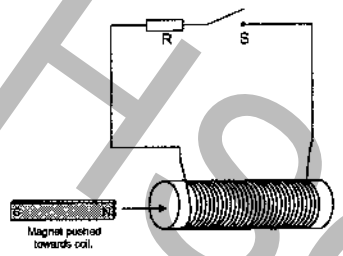
7 An electron moves in a circular path, perpendicular to a uniform magnetic field directed into the page.



A uniform electric field is turned on at a certain instant. The electric field is such that an electron, which was at P at that instant then, moves in a straight line shown by the arrow.
What is the direction of the applied electric field?

(A) Into the page.
(B) Out of the page.
(C) To the left.
(D) To the right.

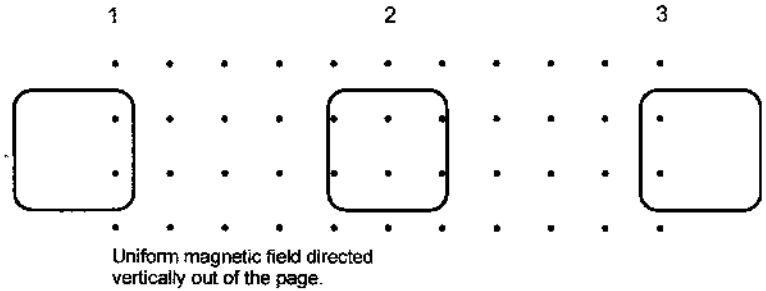
8 A bar magnet is placed so that it is initially outside a large coil. The coil is connected with a switch, S, and a resistor, R, as shown in the diagram below.



The magnet is pushed quickly into the coil in the direction shown by the arrow in the diagram.
The amount of energy required to push the North end of the magnet towards the coil is:

(A) zero, whether the switch is opened or closed.
(B) non-zero, but the same whether the switch is open or closed.
(C) more if the switch is closed than if it is open.
(D) more if the switch is open than if the switch is closed.

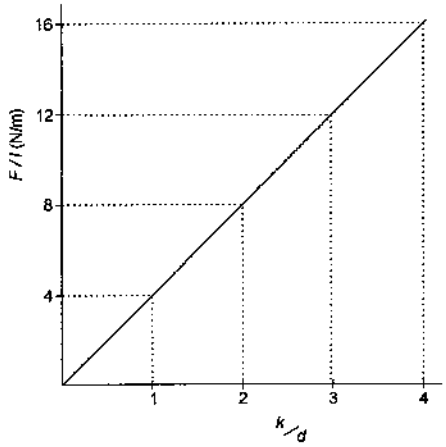
9 A loop of wire is moved from position 1 to position 3 at a constant speed in a magnetic field of uniform flux density.



As the loop moves from positions 1 to 2 to 3 the current in the loop is:

	Position 1	Position 2	Position 3
(A)	clockwise	clockwise	clockwise
(B)	anti-clockwise	anti-clockwise	anti-clockwise
(C)	clockwise	zero	anti-clockwise
(D)	anti-clockwise	zero	clockwise

10 The graph below shows the relationship between force per unit length (F/l) and $\frac{k}{d}$ of two parallel wires carrying equal currents where d is the distance between the wires and k is the magnetic force constant (Ampere's constant).



The value of the current flowing in each wire is:

(A) 1 A.
(B) 2 A.
(C) 3 A.
(D) 4 A.

11 The scientist who introduced the idea of quantisation of energy as a means of mathematically modelling black-body radiation was:

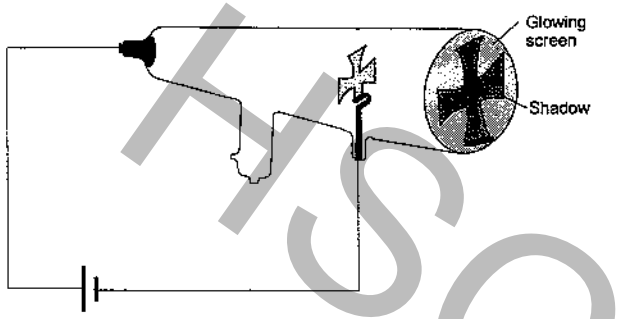
(A) Max Planck.
(B) Albert Einstein.
(C) Michael Faraday.
(D) Niels Bohr.

12 To minimise energy losses, electrical energy is transmitted along long distances at:

(A) high current, high voltage.
(B) low current, low voltage.
(C) high current, low voltage.
(D) low current, high voltage.

Student Number

13 The diagram below shows the famous Maltese Cross experiment into the nature of Cathode Rays.



The experiment demonstrates that:

(A) cathode rays are neutral.
(B) cathode rays travel in straight lines.
(C) cathode rays are undeflected by a magnetic field.
(D) cathode rays are high energy electrons.

14 Heinrich Hertz contributed to our understanding of electromagnetic radiation by:

(A) demonstrating the existence of black body radiation.
(B) theoretically linking visible light and electromagnetism.
(C) explaining the Balmer series.
(D) demonstrating the existence of radio waves which have a velocity equal to that of visible light.

15 J. J. Thompson is credited with the discovery of the electron because he was the first person to:

(A) measure the charge to mass ratio of the particles emitted as cathode rays.
(B) observe the emission of cathode rays.
(C) develop a theoretical model to explain the hydrogen spectrum.
(D) observe β emission from radioactive isotopes.

Student Number

Section I

Part B

Total marks (60)
Attempt Questions 16 - 29
Allow about 1 hour and 45 minutes for this Part

Answer the questions in the spaces provided
Show all relevant working in questions involving calculations

Question 16 (3 marks) **Marks**

In a moving coil galvanometer, the coil, which has 24 turns each of area 8.0 cm^2, is suspended in a radial field of flux density 0.20 Tesla.

(a) What torque does the coil experience when a current of 25 mA flows through it? **2**

The spring attached to the coil provides a restoring torque of 2.0×10^{-6} Nm for every degree that the coil turns through.

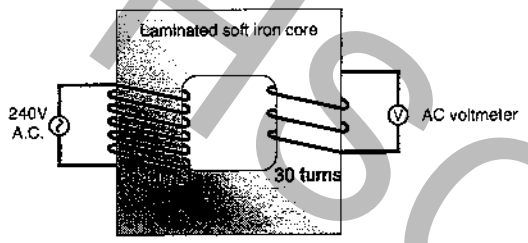
(b) How many degrees will the coil turn through before the spring brings it to rest at equilibrium? **1**

Class

Student Number

Question 17 (8 marks) **Marks**

The diagram below represents a simple ideal transformer.



(a) Explain why the soft iron core is laminated. **2**

(b) Explain why a transformer would not work if the AC power supply was replaced by a constant DC power supply. **2**

(c) Assuming the transformer has 100% efficiency, what is the reading on the voltmeter? **1**

Question 17 continued on page 10

Class

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Question 17 (continued) **Marks**

(d) Briefly discuss, with examples, why some electrical appliances in the home that are connected to the mains domestic supply use a transformer. **3**

Student Number

Question 18 (2 marks) **Marks**

The planet Mars has a mass of 6.42×10^{23} kg and a radius of 3.40×10^{6} m. Calculate the escape velocity at the surface of Mars. **2**

Question 19 (4 marks)

A satellite of mass 100 kg performs a circular orbit, 1000 km above the surface of the Earth. The radius of the Earth is 6.40×10^{6} m.

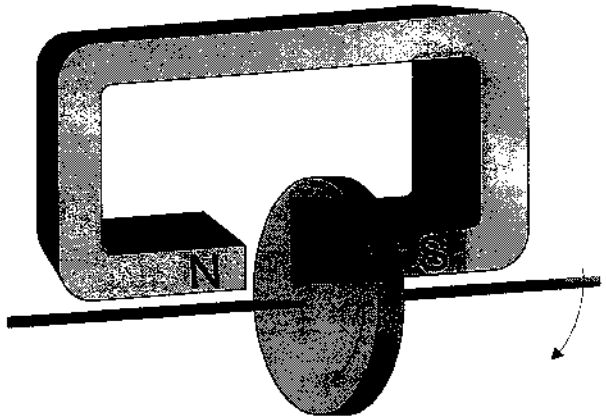
(a) Calculate the gravitational force acting on the satellite. **2**

(b) Calculate the time taken by the satellite to complete one revolution of the Earth. **2**

Student Number

Question 20 (3 marks) **Marks**

Electromagnetic braking can be achieved by applying a strong magnetic field to a spinning metal disc attached to a shaft as shown below.



(a) Identify and explain how the magnetic field slows the spinning of the disc. **2**

(b) Would the brakes work if the disc was plastic instead of metal? Explain your answer. **1**

Class

Student Number

Question 21 (2 marks) **Marks**

Light of wavelength 6×10^{-9} m is incident on a sodium surface. The work function (i.e. the minimum energy required to emit an electron) of sodium is 2.9×10^{-19} J. Calculate the maximum kinetic energy of the electrons ejected from the sodium by this light. **2**

Question 22 (4 marks)

Give an example of a modern device that uses a cathode ray tube and outline its operation. **4**

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Question 23 (5 marks) **Marks**

(a) What do physicists mean by the term 'black body'? **1**

(b) (i) Sketch a graph to show how the intensity of light emitted by a black body depends upon the frequency (or wavelength) of the light. **2**

(ii) Add to your graph a second sketch for the light intensity of the same body at a higher temperature. Make sure you distinguish clearly between the two sketches. **2**

Class

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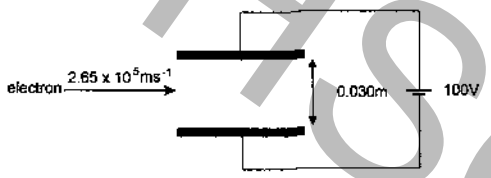
Question 24 (5 marks) **Marks**

An electron travelling at a velocity of 2.65×10^5 ms^{-1} passes horizontally between two parallel, horizontal electric plates 0.030 m apart and connected to a potential difference of 100 V.



(a) Calculate the electric field strength between the horizontal plates. **1**

(b) What is the electrostatic force acting on the electron in the region between the plates? **2**

(c) What magnetic field must be applied to the electron to allow it to pass between the plates undeflected? **2**

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Question 25 (3 marks) **Marks**

Assess the significance of the Michaelson-Morley experiment to Einstein's theory of special relativity. **3**

Question 26 (2 marks)

A spacecraft is 80 m long, as measured by an astronaut on board. The space craft appears to be 64 m long, when measured by a scientist working on a base on the Moon. Calculate the speed of the space craft relative to the Moon. **2**

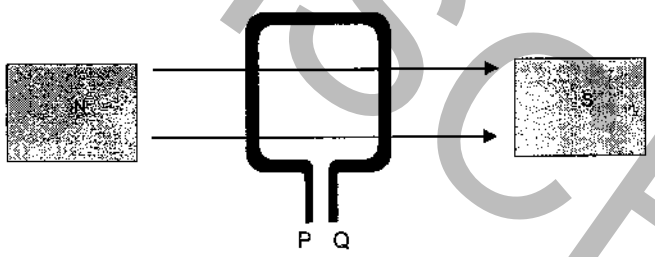
Class

Student Number

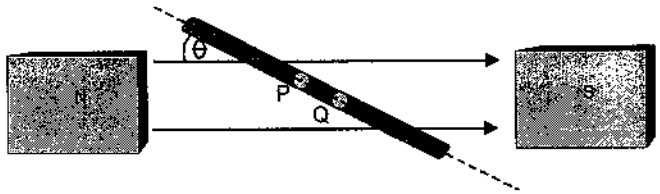
Question 27 (8 marks) **Marks**

A simple electric generator consists of a rotating rectangular loop of copper wire immersed in a magnetic field as shown in the diagram below.

TOP VIEW



SIDE VIEW



(a) For what value of θ is the magnetic flux, ϕ, through the loop a maximum? **1**

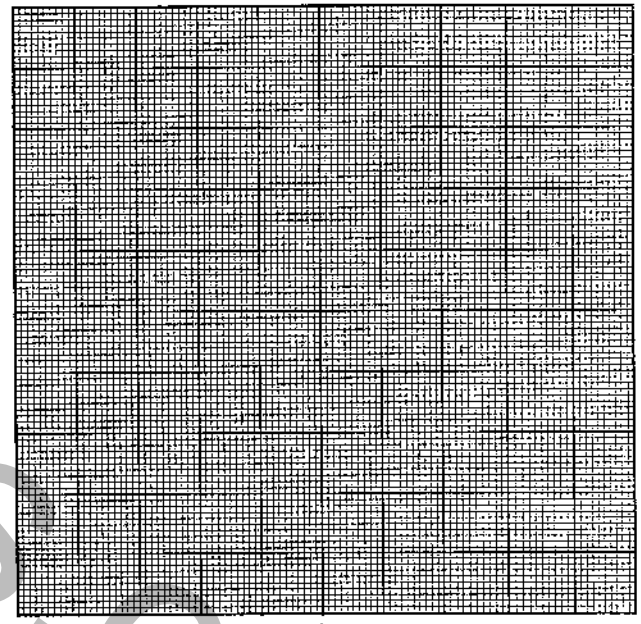
Question 27 continued on page 18

Class

Student Number

Question 27 (continued) **Marks**

(b) When the loop is rotating with a frequency of 10 Hertz, a maximum voltage of 0.5 V is produced. Sketch on the axes provided the voltage across the loop (y axis) as a function of time, taking t = 0 to be *the position of maximum flux as determined in part (a)*. Label the axes fully including numerical values and only sketch the first two complete rotations of the coil. **5**



(c) A hand-operated generator is easy to turn when it is not connected to a load such as a light bulb. However, when the light bulb is connected, the generator becomes quite difficult to turn. Briefly explain these observations. **2**

Student Number

Question 28 (5 marks) **Marks**

Describe an investigation you could carry out to demonstrate that the motion of a projectile can be analysed by separating the motion into independent horizontal and vertical components. **5**

Student Number

Question 29 (6 marks) **Marks**

Justify Einstein's use of the photon in explaining experimental observations of the photoelectric effect. **6**

Section II

Total marks (25)
Attempt ONE question from Questions 30 - 34
Allow about 45 minutes for this Part

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Marks

Question 33 - From Quanta to Quarks (25 marks)

(a) Outline the Rutherford model of the atom. Include a diagram in your answer. **3**

(b) Briefly describe the Davisson and Germer experiment and outline what it demonstrates about the nature of electrons. **2**

(c) The Balmer series is the series of spectral lines for Hydrogen when electrons jump from higher orbitals(n=3, n=4 etc) down to the n=2 orbital.

(i) Briefly describe Bohr's model of the atom and explain why it successfully accounts for the Balmer series. **3**

(ii) Calculate the maximum wavelength of the Balmer series for Hydrogen. **2**

(iii) Determine the frequency of the light produced by your transition in (ii). **1**

(d) (i) State the de Broglie hypothesis and explain why it was considered so startling when first proposed. **2**

(ii) Calculate the de Broglie wavelength for an electron travelling with a velocity of 10^4 ms^{-1}. **1**

Question 33 continues on page 23

Question 33 - (continued)

(e) The following is an example of a nuclear reaction.

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + X + 3{}^{1}_{0}n + Energy $$

(i) Determine the nature of X. **1**

(ii) What sort of nuclear reaction is depicted above? **1**

(iii) Another example of a nuclear reaction is the following. **3**

$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + energy $$

The rest masses of these nuclei are:

$${}^{2}_{1}H = 3.3440 \times 10^{-27} \text{ kg}$$
$${}^{3}_{1}H = 5.0089 \times 10^{-27} \text{ kg}$$
$${}^{4}_{2}He = 6.6463 \times 10^{-27} \text{ kg}$$
$${}^{1}_{0}n = 1.6749 \times 10^{-27} \text{ kg}$$

Calculate the mass defect for the above reaction.

(iv) Calculate the energy released in the reaction in part (iii). **1**

(f) Explain why Pauli found it necessary to postulate the existence of the neutrino. **3**

(g) Compare controlled and uncontrolled fission chain reactions. **2**

End of Question 35