Student Number

Examiner's Use only

Book 1_____

Book 2_____

Book 3_____

Book 4 _____

Nor th Sydney Girls High School

2004

TRIA . HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Gen ral Instructions

* R ding Time – 5 minutes
* W rking time – 3 hours
* W te in black or blue pen
* Dr w diagrams in pencil
* Bo rd-approved calculators may be u ed
* A ata sheet, formulae sheets and Periodic Table are provided at t back of this paper.
* W te your Student Number on ea h answer sheet or book.

Total Marks – 100

Section I Pages 1- 23

90 marks
This section has two parts, **Part A and Part B**

Part A – 15 marks
*Attempt Questions 1 – 15
*Allow about 30 minutes for this part

Part B – 75 marks
*Attempt Questions 16 –32
*Part B contains three booklets

Section II Page 24 (attached to Book 3)
10 marks
*Attempt Question 33
*Allow about 18 minutes for this section

This paper contains 4 books. Books 1, 2 and 3 contain questions. Answer spaces follow the questions, except for the multiple choice (questions 1 to 15) and elective question 33. Shade in your multiple choice answers and write your elective answers in the separate buff coloured book.

The words END OF PAPER appear after the last question, which is question 33 (b).

This paper does not have the same content or structure as the HSC examination paper in physics.

Put your answers for the multiple choice questions 1 to 15 on the cover sheet of book 4.

Questions

1. What was Galileo's greatest contributions to the analysis of projectile motion?

   (A) Dropping a feather and a hammer to show that the acceleration due to gravity was the same for both.
   (B) He was able to analyse the vertical component of a falling object by using an inclined plane that had bells that could be moved to different positions so that constant time intervals could be measured.
   (C) He used a natural timing device (his wrist pulse) to analyse and produce mathematical formulae for the regular swinging motion of the chandeliers in the cathedral at Pisa.
   (D) He divided the motion into two vector components at right angles and analysed them separately.

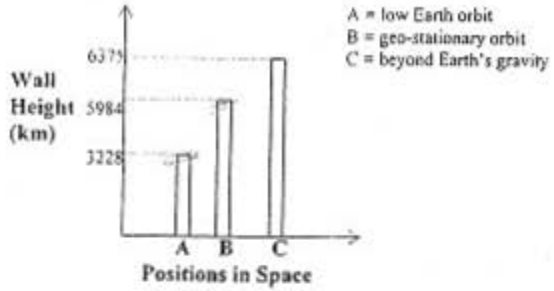
2. Nineteenth-century physicists viewed the material world in terms of the laws of mechanics, so it was natural for them to assume that because light behaved as a wave it must travel in some medium like other waves. They called this medium the aether (ether). Which of the alternatives best describes the aether?

   (A) Transparent, permeating all space, zero density yet incredibly elastic.
   (B) Essentially a vacuum containing minute amounts of 'solar wind.'
   (C) Permeating all matter and yet completely permeable to immaterial objects.
   (D) The aether is a universal fluid extended beyond the atmosphere and across the Universe, leaving no void. Swirling vortices in the aether enable the movement of planets and stars as well as light.

3. What is the acceleration due to gravity of objects allowed to fall freely on the top of Mt Everest, 8848 m above the Earth's surface? (Diameter of the Earth is 12782 km)

   (A) 9.80 ms^{-2}
   (B) 9.77 ms^{-2}
   (C) 9.70 ms^{-2}
   (D) There is insufficient data to work this out

4. The science fiction author Arthur C. Clarke once stated the energy gain necessary to get into space in terms of the height of the wall you would have to climb under constant sea-level gravity.



How much energy would need to be expended to lift a satellite, of a total average mass of 1000 kg, from a low earth orbit to a position where it remained in the same relative position above the Earth's equator?

(A) 2.70×10^{10} J
(B) 2.70×10^{7} J
(C) 3.09×10^{10} J
(D) 2.76×10^{6} J

5. The speed of electrons in an accelerator used for cancer therapy is 0.98c. How many times heavier or lighter are these fast moving electrons than the rest mass of an electron?

(A) 0.2
(B) 5
(C) -5
(D) The difference is too small to compute on your calculator

Question 6 is on the next page.

6. Space pirates kidnap an astronaut and take her to a planet in the solar system. While in her cell, the astronaut passes her time by dropping a spoon (mass = 50.0 g) from eye level (1.5m) to the floor. She measures the time of fall as 0.50s. What planet was she on and what was the gravitational potential energy of this planet within the Sun's gravitational field?

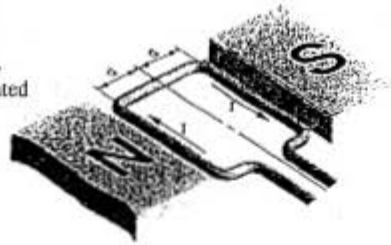
Mass of Sun = 1.99×10^{30} kg
Mass of spoon = 0.05 kg

PLANET	MASS ($\times 10^{24}$ kg)	AVERAGE PLANET – SUN DIST. (m)	GRAVITATIONAL ACCELERATION (ms^{-2})
Mercury	0.33	5.80×10^{10}	3.7
Venus	4.9	1.10×10^{11}	8.9
Earth	6.0	1.50×10^{11}	9.8
Moon	0.007	1.50×10^{11}	1.6
Mars	0.64	2.30×10^{11}	3.7
Jupiter	1900	7.80×10^{11}	24.0
Saturn	569	1.40×10^{12}	12.0
Uranus	86.8	2.90×10^{12}	11.0
Neptune	102	4.50×10^{12}	12.2
Pluto	0.013	5.90×10^{12}	2.0

(A) Jupiter, -6.8×10^{28} J
(B) Saturn, -1.0×10^{28} J
(C) Jupiter, -3.2×10^{35} J
(D) Saturn, -5.4×10^{34} J

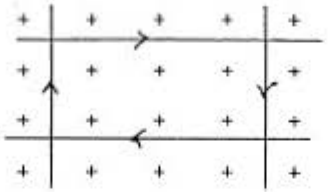
Question 7 is on the next page

7. A motor has a coil of 200 turns and is positioned in a uniform magnetic field as shown in the diagram. In this diagram d = 0.02m and L = 0.03m. The magnetic field strength is 1.5T and the current flowing in the coil is 7A. Calculate the torque on the coil at the moment it has rotated by 90 degrees from the position shown.



(A) 2.52 Nm
(B) 2.18 Nm
(C) 1.26 Nm
(D) 0.63Nm

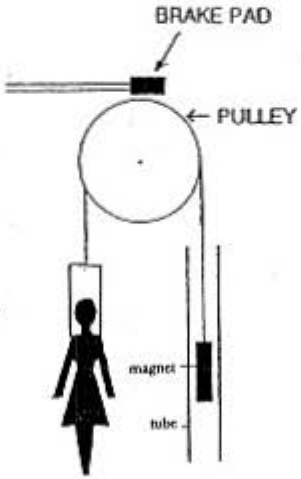
8. The diagram shows four pieces of wire which have been placed on each other to form a rectangle.
The wires are free to move in directions at right angles to their length. A uniform field exist inside the rectangle.
A clockwise conventional current is turned on in the rectangle.



Which of the following changes occurs to the flux and flux density after the current is turned on?

	flux	flux density
(A)	increases	increases
(B)	decreases	decreases
(C)	decreases	constant
(D)	increases	constant

9. In an amusement park ride a 60kg girl sits on a chair high above the ground. The chair is attached to a cable which passes over a pulley to a 20kg powerful magnet on the other side. When the brake is released the girl falls down. The magnet is lifted up through an aluminium tube. Which of the following is true?



(A) the changing field in the tube increases the velocity of the girl.
(B) the changing field in the tube reduces the velocity of the girl.
(C) the changing field in the magnet increases the velocity of the girl.
(D) the changing field in the magnet reduces the velocity of the girl.

10. The role of laminations in a soft iron core is to:

(A) reduce field changes in the core.
(B) restrict the flow of eddy currents.
(C) prevent the movement of heat from one part of the core to another
(D) stop the production of eddy currents.

Question 11 is on the next page.

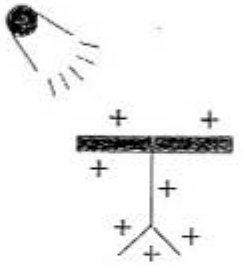
11. A generator is used to produce an electric current. The handle of the generator is now turned more quickly. What will be the effect of this on the emf produced?

(A) Increase the emf because it increases the rate of change of flux.
(B) Increase the emf because it increases the flux change.
(C) Decrease the emf because it decreases the rate of change of flux
(D) Decrease the emf because it reduces the flux change.

12. Which of the following statements relating to the operation of DC electric motors and galvanometers which measure DC current is **NOT** correct?

(A) DC motors require brushes but a galvanometer does not.
(B) DC motors require a commutator but a galvanometer does not.
(C) Galvanometers can operate with a spiral spring but a motor cannot.
(D) Galvanometers can operate with a radial field but a motor cannot.

13. The diagram shows a positively charged electroscope.

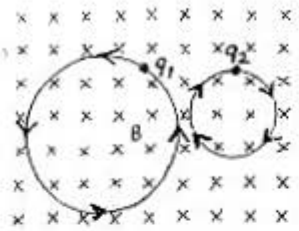


What will happen to the leaves of the electroscope when ultraviolet light is shining on the discharge plate?

(A) The ultraviolet light provides photoelectrons to the plate of the electroscope so the leaves will converge.
(B) The leaves will diverge as photoelectrons are leaving the surface making it more positive.
(C) Nothing will happen unless the ultraviolet light is replaced by infra-red light.
(D) The ultraviolet light will ionize the air particles above the electroscope causing the leaves to converge.

Question 14 is on the next page.

14. Charged particles describing circular paths are shown in the diagram below. They are in a uniform magnetic field B and have equal masses and equal kinetic energies. What is the sign and magnitude of the charge on each particle?



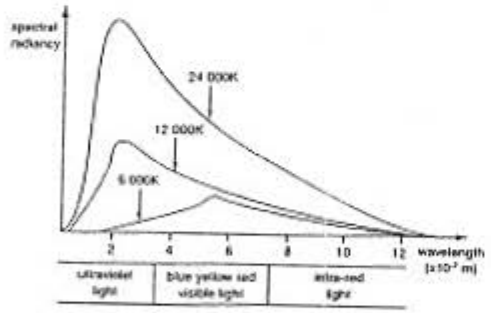
(A) $q_1 = +, q_2 = -; \quad q_1 > q_2$

(B) $q_1 = +, q_2 = -; \quad q_1 = q_2$

(C) $q_1 = -, q_2 = +; \quad q_1 < q_2$

(D) $q_1 = +, q_2 = -; \quad q_1 < q_2$

15. The range of emitted radiation from a black body when heated at different temperatures is shown in the graph below.



What is a possible conclusion that can be drawn from this graph?

(A) The wavelengths emitted depend on the temperature of the black body.
(B) Black bodies will only absorb certain radiation frequencies.
(C) Quantised energy can be absorbed and emitted between quantum levels.
(D) The spectral radiancy is the result of an electron moving from one energy level to another.

This is the end of the multiple choice questions

Physics

Student Number

Section I (continued)

Part B – 75 marks
Attempt Questions 16 –32

Answer Book 1
This book contains questions 16 to 24.

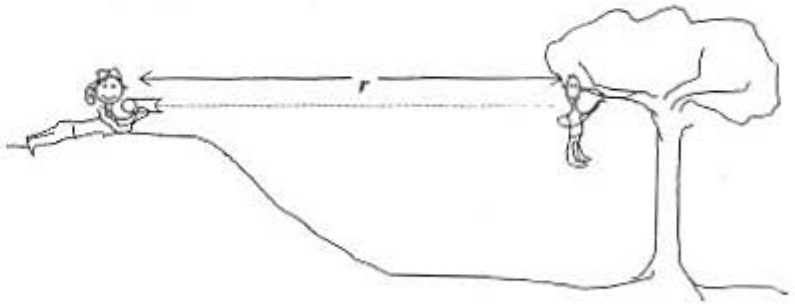
Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

Marks

Question 16

A girl on a small hill aims her paint-ball gun horizontally, straight at a boy from the opposite team hanging from a tree branch, a distance r ($r = 13.0$ m) away, see figure below. At the instant the paint-ball is fired, the boy lets go to avoid being splattered with paint, and falls from the tree. The paint-ball was fired horizontally at 20.0 ms^{-1}, and took 0.65 s to travel the horizontal distance r. First calculate how far the boy falls in 0.65s, and also how far the paint-ball falls in the same time, and then assess whether the boy made the right or wrong decision. 3



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Turn to the next page

Question 17 Marks

A friend of yours travels by you in her very fast sports vehicle at a speed of 0.580c. How many seconds would you say elapsed on your friend's watch when 20.0 s passed on your watch? 2

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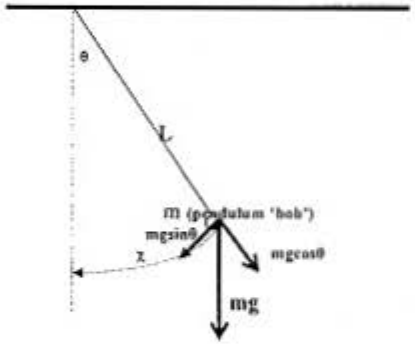
Question 18

In the study of this course you carried out an investigation to determine the value of the acceleration due to gravity (g) using pendulum motion. You may even have attempted to improve the measurements involved by using computer assisted technology. Use the figure and data below to answer the following questions:

The period equation for a pendulum: $T = 2\pi\sqrt{(L/g)}$



Collected data:

Length of pendulum string, ℓ (m)	Mass of pendulum 'bob', m (kg)	Angle of swing, θ (°)	Trial Number	Period of swing, T (s)
0.45	0.025	30	1	1.45
0.45	0.025	30	2	1.50
0.45	0.025	30	3	1.52
0.45	0.025	30	4	1.49

(a) Which of the three controlled variables would directly effect the period of swing of the pendulum if it was altered? 1

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Parts (b) and (c) continue on the next page.

Marks

(b) Compute the value of g (acceleration due to gravity) from the above set of data. 2

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(c) The accepted value for g is 9.8 ms^{-2}. Identify three experimental reasons why your computed value for g may have varied from the expected. In each case make a recommendation to overcome this source of error. 3

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Question 19

Complete the blank for <u>one</u> these scientists: 1

Scientist	Birth/death	Nationality	Contribution to development of space exploration
Tsiolkovsky	1857-1935	Russia	
Oberth	1894-1989	Germany	
Goddard	1882-1945	U.S.A.	
Esnault-Pelterie	1881-1957	France	
O'Neill	? - 1992	U.S.A.	
Von Braun	1912-1977	Germany andU.S.A.	

Marks

Question 20

Use Kepler's third law, the mass of the Sun and other relevant information from the data table below to calculate the period of the Earth in seconds exact to 3 significant figures. You must show all your working. 2

Mass of Sun = 1.99×10^{30} kg

PLANET	MASS ($\times 10^{24}$ kg)	AVERAGE PLANET – SUN DIST. (m)	GRAVITATIONAL ACCELERATION (ms^{-2})
Mercury	0.33	5.80×10^{10}	3.7
Venus	4.9	1.10×10^{11}	8.9
Earth	6.0	1.50×10^{11}	9.8
Moon	0.007	1.50×10^{11}	1.6
Mars	0.64	2.30×10^{11}	3.7
Jupiter	1900	7.80×10^{11}	24.0
Saturn	569	1.40×10^{12}	12.0
Uranus	86.8	2.90×10^{12}	11.0
Neptune	102	4.50×10^{12}	12.2
Pluto	0.013	5.90×10^{12}	2.0

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Marks

Question 21

A returning moon rocket (with astronauts) has a very large potential energy because of its position in the gravity field of the Earth. It also has kinetic energy by virtue of its motion and mass.

Discuss what happens to this energy as the rocket re-enters the Earth's atmosphere and how this has influenced rocket design. Also discuss the safety/health issues of the astronauts and the strategy used to ensure their safe return to Earth. 4

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Question 22

In 1989 a space probe (Galileo) was launched from the Earth's surface. Its destination was Jupiter. It did not carry sufficient fuel, nor was its rocket engine powerful enough for it to be launched directly at Jupiter. It was originally designed to be launched from an orbiting space shuttle but after the Challenger disaster this was thought to be too dangerous. Instead, without significantly altering its design or size, it was launched from the Earth's surface. It was directed to flyby Venus. Later it also had two flybys of the Earth, before eventually heading off to Jupiter.

(a) Explain why this extended manoeuvring around Venus and Earth was necessary. 1

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Part (b) is on the next page

Marks

(b) Use the law of conservation of momentum to calculate the effect the 2000kg Galileo probe had on the Earth's velocity on its second encounter when the probe picked up a speed of 5 kms^{-1}. Assess the impact of continuing this practice many times over the long term. 4

Mass of the Earth = 6.0×10^{24} kg

Question 23

In 1887, Albert Michelson and Edward Morley attempted to measure the motion of the Earth through the aether. The direction of the aether wind was not known, so the experimenters did not know in which direction to point their equipment.

(a) Briefly describe how they overcame this problem. 1

(b) If their hypothesis was that light and the Earth both move relative to the aether, briefly describe the type of experimental observations that would have supported the notion. 1

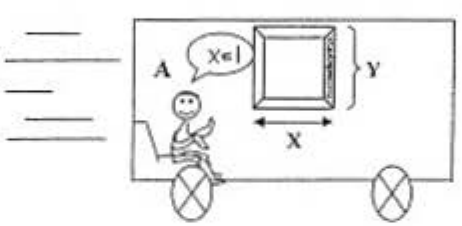
Part (c) is on the next page.

Marks

(c) State a conclusion arising from the Michelson & Morley experiment and assess its impact on our understanding of reality. 2

Question 24

(a) Use the following information to give a reason, based on the use of a relevant equation, why length contraction is not noticeable in everyday life. 2



(Observer B is standing further along the tram track)

Speed of tram car = 80 kmh^{-1}
Length x as seen by A = 1.0m
Height y as seen by A = 1.0m

(b) When the velocity of the tram car was 0.9c, Observer B would note that the width of the painting in the tram was only 0.44m wide. Estimate the height of the painting at the same very high speed. 1

THIS IS THE LAST QUESTION FOR BOOKLET ONE

Answer Book 2
This book contains questions 25 - 29

Student Number

Marks

Question 25 4

You have performed a first hand investigation to demonstrate the motor effect. Desribe the results of your experiment, explaining how the results illustrate the motor effect.

Question 26 4

The use of AC generators and power grids has become widespread since they were first developed by Westinghouse. Discuss the environmental implications of this growth in AC generators and power grids.

Question 27 (8 marks)

A model electric generator is often used in schools to demonstrate the production of an alternating current. This device can also be easily made to operate as a DC electric motor.

(a) List the essential components which such a model must have, apart from the handle. Underline one component which is essential to the operation of the DC motor but not the AC generator. 2

The most fundamental concept in understanding the model's operation as a generator is the rate of change of flux. However, to understand how it operates as a motor the fundamental concept is the creation of torque.

(b) Explain the cause of the flux change created in a model AC generator.

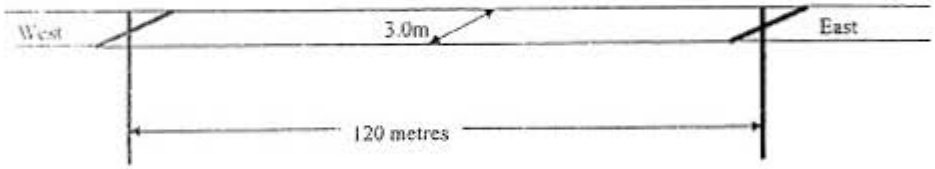
(c) Explain the cause of the torque created in a model DC motor.

(d) Torque is of greatest importance in a motor and change of flux in a generator. Despite this, a torque is also produced in the generator and a change of flux occurs in the motor. Describe the consequences of these two effects, relating them to Lenz's law. 3

Question 28 (8 marks)

Electricity is carried by transmission lines from power stations to cities and their buildings. The transmission lines consist of long parallel cables which are strung between towers that are some distance apart.

(a) Suppose two such cables hang between two towers which are120 metres apart. One cable carries a current of 50A and the other 70A. The cables are seperated by a distance of 3.0 metres. The transmission line runs from west to east across Sydney.



(i) Calculate the magnitude of the magnetic force between the cables. 2

(ii) The strength of the earth's magnetic field in this location is 2.5×10^{-5} tesla and points in a direction N10°E (10 degrees east of north). Calculate the magnitude of the force on the 70A current, due to the earth's magnetic field. 2

(i) .....

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(ii) .....

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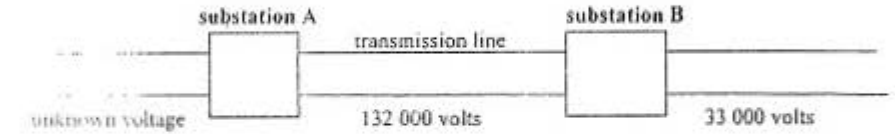
(b) This transmission line runs between substations A and B at either end. At the start of this transmission line voltage is converted to 132 000 volts by transformers in substation A. At the end of the transmission line voltage is converted from 132 000 volts to 33 000 volts in substation B.



Both substations have identical transformers. The number of turns in the secondary coils is 50 000. Calculate the value of the unknown voltage at which power is supplied to substation A. 2

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Part (c) is on the next page

Mark

(c) Suppose that the generator feeding another transmission line produces 24 000 volts and produces 300 MW (300×10^6 watts) of power. The transformer which joins the power station to the transmission line has 12 times as many turns in one coil as the other. Calculate the current which leaves the power station into the transmission line after passing through this transformer. 2

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Question 29 (6 marks)

One of the impediments to the introduction of the power distribution system proposed by George Westinghouse was that there was no AC motor available which could be used on his system.

(a) Identify one other objection that was raised against Westinghouse's system. 1

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(b) The most common type of AC motor which is used today is the induction motor. The loudspeaker could be regarded as an example of an unusual type of "AC motor" because it is driven by alternating current and produces motion.

Identify the objects which ultimately move in the induction motor and loudspeaker.

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Parts (c) and (d) are on the next page.

Marks

(c) (i) Draw a sketch to illustrate the difference between the magnetic fields in the induction motor and loudspeaker. 1

(ii) Identify the different ways in which the fields change over time. 1

(i)

(ii)

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(d) ...e force exerted on the loudspeaker coil is determined by the current supplied ...it. However, the torque developed on the rotor of the induction motor can also ...pend on how much the load resists the motion of the rotor, slowing it down.

...xplain why the load on an induction motor rotor can affect the torque it ...periences. 2

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THIS IS THE LAST QUESTION FOR BOOKLET TWO

Physics

Section I

Part B – continued

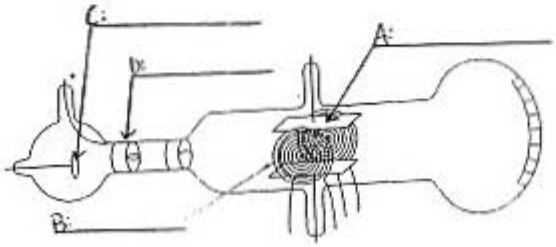
Answer Book 3
This book contains questions 30 - 32.

Student Number

Marks

Question 30 (5 marks)
The discovery of cathode rays had far reaching implications. These included a greater understanding of the structure of the atom as well as a wide variety of applications for science and technology.

a) Label the parts of the cathode ray tube shown below. 1



b) With reference to the diagram, describe how cathode rays are able to move through the tube. 1

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c) How did Thomson use the properties of cathode rays to determine the ratio of the charge of cathode rays to their mass? Use formulae where appropriate. 3

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Turn to the next page.

Question 31 (5 marks) **Marks**

Maxwell developed mathematical relationships connecting light, electricity and magnetism and predicted a complete spectrum of electromagnetic radiation of which only light and infra-red were known at the time.

a) Describe the experiment performed by Hertz which led to the discovery of other forms of electromagnetic radiation. Include a diagram. 2

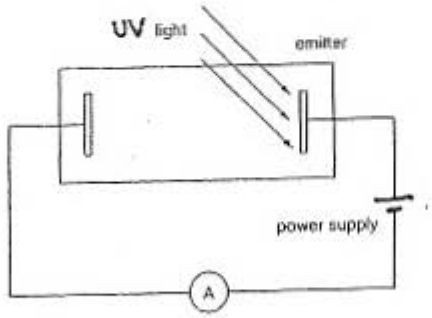
b) These electromagnetic waves were later called radio waves. How was he able to show that they were related to light? 1

c) Describe how the production and reception of radio waves may be demonstrated in a school laboratory. Use diagrams where appropriate. 2

Turn to the next page

Question 32 (5 marks) **Mark**

The photoelectric effect, which was first observed by Hertz, was investigated in greater detail by other scientists. A diagram of the apparatus used to observe the effect is shown below.



a) Complete the table by *describing* what will happen to the ammeter reading when the following changes are made. 2

CHANGE	PREDICTION OF AMMETER READING
Voltage on power supply is increased	
Ultraviolet light is replaced by red light	
The intensity of ultraviolet light is increased	
The polarity of the anode voltage is reversed	

Part (b) is on the next page.

Marks

1 Outline how Einstein's ideas about the nature of light contradicted the theory at the time and how they provided credibility to Planck's ideas about quanta. 3

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THIS IS THE LAST QUESTION FOR BOOKLET THREE

Physics

Section II

10 marks
Attempt Question 33
Allow about 18 minutes for this section.

Answer the questions in the writing book 4. Extra writing books are available.

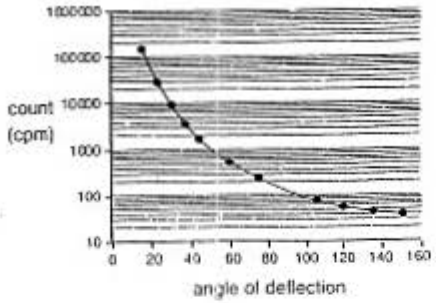
Show all relevant working in questions involving calculations.

Questions on the electives Geophysics, Medical Physics, Astrophysics, and The Age of Silicon are not provided in this examination.

Option – Quanta to Quarks (10 marks)

Marks

a) The graph below shows the relationship between the angle of deflection and the number of counts recorded during a Rutherford scattering experiment using a thin gold foil.



Counts vs angle of deflection

i) Estimate the number of counts at 5° deflection. 1
ii) Contrast the deflections at small and large angles. 1
iii) Outline the significance of this difference in terms of Rutherford's atomic model. 3

b) i) Discuss the main postulates of the Bohr theory of the hydrogen atom and how it explains the atomic spectrum of hydrogen. 4
ii) Calculate the wavelength of the first line of the Balmer series (ie n=3 to n=2) 1

End of Paper

M.C.

1 D	5 B	9 B	13 A – But it is unlikely to work.
2 A	6 D	10 B	14 D
3 B	7 B	11 A	15 A
4 A	8 A	12 C	

BOOK 1 ANSWERS

16

Vertical component of Paint-Ball's motion:

$\Delta y = u_y t + \frac{1}{2} a_y t^2$

$= 0 + \frac{1}{2} a_y t^2$

$\therefore \Delta y = \frac{1}{2} \times 9.8 \times 0.65^2$

$= 2.07$ m ← 1

Hor. component of Paint-Ball's motion:

$\Delta x = V_x \times t = 20 \times 0.65 = 13.0$ m

Vertical component of Boy's motion

$\Delta y = u_y t + \frac{1}{2} g t^2$

$= \frac{1}{2} \times 9.8 \times 0.65^2$

$= 2.07$ m ← 1

As the paintball falls vertically by the same amount as the boy and, in this case, travels the hor. dist in the same time, then he made the wrong decision as he would be splattered. 1

17

$t_v = \dfrac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$ ← observer in the "rest frame" ie in the car

t_v ← Observer beside the car

$\frac{1}{2}$ + $\frac{1}{2}$

$\therefore t_o = t_v \sqrt{1 - \frac{v^2}{c^2}}$ ←

$= 20 \sqrt{1 - \frac{(0.580c)^2}{c^2}}$ ← $\frac{1}{2}$

$= 20 \sqrt{1 - 0.580^2}$ (0.3364) (Correct substitution in)

$= 16.3$ s

16.29232948

($-\frac{1}{2}$ if other than 3 sig fig) ← $\frac{1}{2}$

18 (a) Length ← 1

(18) continued...

8) b) $T = 2\pi\sqrt{\frac{L}{g}}$

$$\frac{T^2}{4\pi^2} = \frac{L}{g}$$

$$\therefore g = \frac{4\pi^2 L}{T^2} \longleftarrow 1$$

- Given $\pi = 3.1416$

$L = 0.45$

$T = \frac{1.45 + 1.50 + 1.52 + 1.49}{4}$

$= 1.49$ s

$$\therefore g = \frac{4\pi^2 0.45}{1.49^2} \longleftarrow \frac{1}{2}$$

$= 8.0$ ~~or~~ 7.9 ms^{-2} $\longleftarrow \frac{1}{2}$

---

18 (c) Three experimental reason for variation from expected:

Reason	Recommendation
1. human reaction time → error e.g. greater in 1 swing + on 10 swings	Time 10 swings and divide by 10 to reduce rel. error. Use more sophisticated measuring device eg light gate connected to computer
(bot) Air resistance would increase T	1. Make the mass as large and dense as possible 2. Keep the vibration angle small 3. Do in a vacuum
One set of data is too limiting: No confidence in small amount/restricted data.	Collect more data eg. varying length, mass, angle of swing
Fulcrum resistance would increase T	1. Larger denser mass 2. Small angles

Marking:

$3 \times \left(\frac{1}{2} \text{ mark for reason} + \frac{1}{2} \text{ mark for its solution (must relate to problem)} \right)$

19

one the se scientists: (1 mark)

	Nationality	Contribution to development of space exploration
Tsiolkovsky	Russia	Gyroscopic stabilization, Escape velocity, Liquid propellants for rockets, Formula relating rocket speed to speed of exiting gas etc
Oberth	Germany	Recoil rocket - propelled by expelling exhaust gases STAGED ROCKETS to maintain high ratio between propellant and rocket mass. Additive speeds of staged roc
Goddard	U.S.A.	Modern rocket propulsion - 1st liquid propellant rocket 1926 Film cooling, variable thrust motor + controlled fuel delivery. Gyroscopically controlled vanes
Esnault-Pelterie	France	Suggests atomic energy for rockets Publicised problems and prospects of space travel
O'Neill	U.S.A.	Popularised space migration/settlement Founder of Space Studies Institute. Space habitats study: rotating cylinder, solar power, L5
von Braun	Germany and U.S.A.	German V2 rocket (WWII) Saturn 5 rocket for Apollo moon missions

Marking: for (20)

not 3 sig fig $-\frac{1}{2}$

no unit $-\frac{1}{2}$

wrong calculation $-\frac{1}{2}$

wrong substitution $-\frac{1}{2}$

wrong formula -2

20

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$\therefore T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

3.375×10^{33}

$$= \sqrt{\frac{4\pi^2 (1.5\times10^{11})^3}{6.67\times10^{-11} \times 1.99\times10^{30}}}$$

$$= 31683073.28\ s$$

$$= 3.17 \times 10^7\ s$$

21

1 What happens to the energy?

Turned into Heat through friction with inc. density of air molecules

2 Rocket design to ablate heat?

Blunt nose cone - producing shock wave in the air in front which absorbs most of the heat

Ceramic tiles on the outside that vaporise (ablate) during re-entry heating e.g. fibreglass.

Insulating tiles (glass fibre + 70% air) to keep heat away from cabin

Retrorockets to slow the speed of the rocket

(more over)

(cont.)

3. Safety/Health Issue

Deceleration rate can kill (max. g force x 8g) ½

Heart can fail by destroying ' or main - eyes pop out ½
- energy in cells - blood from brain etc.
(or other reason)

4. Strategies

Spread g force by lying ' astronauts down, facing backwards (eyes don't pop out) greater S.A.

Contoured seats to support body

Low angling ~~velocity~~ trajectory to spread the deceleration over a longer distance + time

22

K.E
momentum

(a) Increase velocity sufficient to get to destination — by 'robbing' energy from planets and not using its valuable fuel. 1

(not just: inc. energy)

(b) $m_g u_g + M_E u_E = m_g v_g + M_E v_E$ ← some form of this ½

$\therefore v_E - u_E = \frac{m_g(v_g + u_g)}{M_E}$ ← rearranged ½

$= \frac{2000 \times 5}{6.0 \times 10^{24}}$ ← substitution 1

$= -1.7 \times 10^{-21}$ kms^{-1} ← answer 1

22) cont

So small that even a million ← effect
protons would only slow the Earth
by 1.7×10^{-15} kms^{-1} ie Negligible effect 1
or
Over time the velocity of the (cv) ½
Earth would decrease ½

23

(a) Repeating the experiment at different angles - through 90° ← 1

(b) A change in the interference pattern should occur 1

(c) There is no action or a NULL HYPOTHESIS concluded ½
- light does not have to have a transport medium
- light has a constant speed in time, length, mass (vary in c) ½
- others.

24

(a) A sees the width $x = 1$ m

B sees the width x:

as $l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$ ½

$= 1\sqrt{1-\frac{22.2^2}{(3\times10^8)^2}}$ ½

$= 1$ m (to the limits of student calc.)

i.e. When velocity of moving object are small relative to the speed of light the effect of length contraction cannot be detected. 1

(b) 1 m 1

Question 25 (4 marks)

You have performed a first hand investigation to demonstrate the motor effect. Describe the results of your experiment, explaining how the results illustrate the motor effect.

Essential

The motor effect refers to the fact that when a current flows in a magnetic field the current will experience a force. This was illustrated in our experiment because when a current flowed in a wire/rod/foil hanging between pairs of bar magnets with opposing poles it experienced a deflection. (Sketch helps here)

Additional

1. The deflection was at right angles to the field and the current.
2. Reversing the direction of the current/field reversed the force.
3. Relating the direction of the deflection to the LHR or RHPR
4. Reversing the direction of the current/field reversed the force.

The variables affecting the motor effect are given by F = BIL this was illustrated by:

5. When the current was increased the deflection was greater.
6. When the magnets were moved further apart the deflection was weaker.
7. When less of the wire was in a magnetic field the deflection was weaker.
8. Length & Field strength were kept constant while current was varied.(Method rather than results)

Question 26 (4 marks)

The use of AC generators and power grids has become widespread since they were first developed by Westinghouse. **Discuss** the environmental implications of this growth in AC generators and power grids.

Benefits

- *Electricity can be produced away from cities resulting in less concentrated pollution.*
- *The use of renewable energy sources such as hydroelectricity & wind power has become possible because power must be brought from sites which are distant from cities.*
- *The use of generators reduces the use of batteries and the materials used to make them and reduces the need to dispose of them and the toxic heavy materials many contain.*
- *The use of AC generators (compared to DC) results in less energy loss with transmission and so less fossil fuel is used and less pollution of the environment occurs.*
- *Power grids make the use of nuclear power possible which reduces fossil fuel pollution and requires much less mining of minerals.*
- *Reduction of pollution from combustion heating can improve the environment(eg problem in Launceston)*
- *Reduction in pollution from steam and diesel trains in cities by using electric trains*

Problems

- *Massive air pollution has resulted from the burning of fossil fuels used to generate power.*
- *Destruction of the environment has occurred because of the flooding of rivers which supply hydroelectric plants.*
- *The generation of electricity has produced massive amounts of CO_2 which has added to the greenhouse effect.*
- *Coal mining to supply generators ravages the landscape and can damage rivers (eg Hunter River)*
- *Nuclear plants produce dangerous wastes which are very hard to dispose of.*
- *Coal fired and Nuclear plants cause considerable thermal pollution.*
- *Accidents in nuclear plants results in widespread fallout of radioactive wastes.*
- *Transmission lines require the clearing of land.*
- *There has been an explosion of disposable appliances creating non degradable rubbish and consuming natural resources.*
- *Sparks from transmission lines can cause fires.*

estion 27 (8marks)

A model electric generator is often used in schools to demonstrate the production of an alternating current. This device can also be easily made to operate as a DC electric motor.

(a) List the essential components which such a model must have. Underline one component which is essential to the operation of the DC motor but not the AC generator. (2marks)

Magnets Armature = Coil+ Laminated soft iron core brushes
Slip rings split ring commutator

The most fundamental concept in understanding the model's operation as a generator is the rate of change of flux. Whereas to understand how it operates as motor the fundamental concept is the creation of torque.

(b) Explain the cause of the torque created in a model DC motor. (2marks)

*When the current flows through the coil in the magnetic field the **motor effect** produces **opposing forces** on opposite sides of the coil. When these **forces have a component at right angles** to the plane of the coil which is **some distance from the axle a torque is created**.*

(c) Explain the cause of the flux change created in a model AC generator. (1mark)

***A magnetic field pass through the coil.** As the coil **rotates the area** through which the field passes **changes, causing the change in flux**.*

(d) Torque is of greatest importance in a motor and change of flux in a generator. Despite this, a torque is also produced in the generator and a change of flux occurs in the motor.
Describe the consequences of these two effects, relating them to Lenz's law. (3 marks)

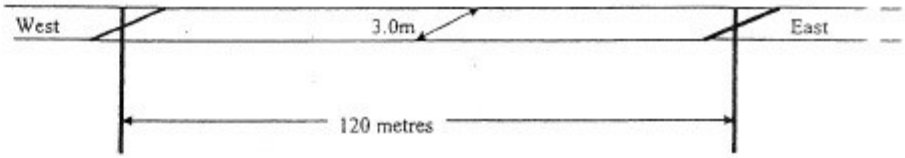
*The consequence of the change of flux caused by the rotation of the motor coil is the production of a **back emf, which reduces the current** supplied to the motor.*

*The consequence of the torque produced by the effect of the magnetic field on the induced current in a generator **is resistance to the rotation of the handle** that causes the generator to turn.*

*In the motor the supplied current is opposed and in the generator the applied rotation is opposed. Both of these effects are thus examples of Lenz's law which requires **that there is a opposition to the cause** of flux change.*

Question 28 (8 marks)
Electricity is carried by transmission lines from power stations to cities and their buildings. The transmission lines consist of long parallel cables which are strung between towers that are some distance apart.

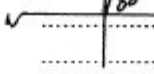
(a) Suppose two such cables hang between two towers which are120 metres apart. One cable carri ; a current of 50A and the other 70A. The cables are separated by a distance of 3.0 metres. The transmission line runs from west to east across Sydney.



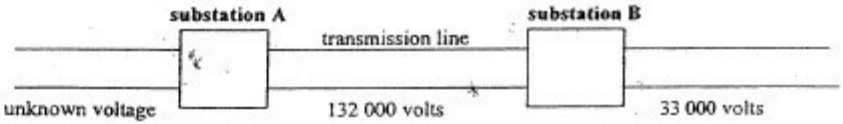
(i) Calculate the magnitude of the magnetic force between the cables. 2
(ii) The strength of the earth's magnetic field in this location is 2.5×10^{-5} tesla and points in a direction N10°E (10 degrees east of north). Calculate the magnitude of the force on the 70A current, due to the earth's magnetic field. 2

(i) $F = k\frac{I_1 I_2 \ell}{d} = 2\times10^{-7} \times \frac{70\times50\times120}{3}$
$= 2.8\times10^{-2}\ N$
$(0.028\ N)$

(ii) $F = BI\ell\sin\theta = 2.5\times10^{-5}\times70\times120\times\sin 80°$
$= 0.21\ N$
$\theta = 80°$



(b) This transmission line runs between substations A and B at either end. At the start of this transmission line voltage is converted to 132 000 volts by transformers in substation A. At the nd of the transmission line voltage is converted from 132 000 volts to 33 000 volts in substation B



Both substations have identical transformers. The number of turns in the secondary coils is 50 000. Calculate the value of the unknown voltage at which power is supplied to substation A. 2

$\frac{V_p}{V_s} = \frac{n_p}{n_s}$ $\frac{132}{33} = \frac{n_p}{50\,000}$ $\therefore n_p = \frac{132\times50000}{33} = 2\times10^5$

$\frac{V_p}{V_s} = \frac{2\times10^5}{5\times10^4} = 4$ $\therefore V_p = 4\times132\,000 = 528\,000$ V

(c) Suppose that the generator feeding another transmission line produces 24 000 volts and produces 300 MW (300×10^6 watts) of power. The transformer which joins the power station to the transmission line has 12 times as many turns in one coil as the other. Calculate the current which leaves the power station into the transmission line after passing through this transformer. 2

$P = VI$ $\therefore I_1 = \frac{3\times10^8}{24\times10^4} = 1.25\times10^4\ A$

$I_2 = I_1/12 = \frac{1.25\times10^4}{12} = 1042\ A$

Question 29 (6 marks)

One of the impediments to the introduction of the power distribution system proposed by George Westinghouse was that there was no AC motor available which could be used on his system.

( ) Identify one other objection that was raised against Westinghouse's system. 1

Edison claimed that the system was unsafe because of the high voltages used.

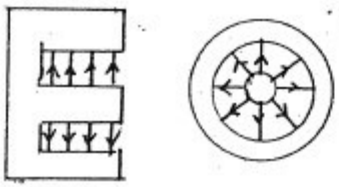
( ) The most common type of AC motor which is used today is the induction motor. The loudspeaker could be regarded as an example of an unusual type of "AC motor" because it is driven by alternating current and produces motion.

Identify the objects which ultimately move in the induction motor and loudspeaker. 1

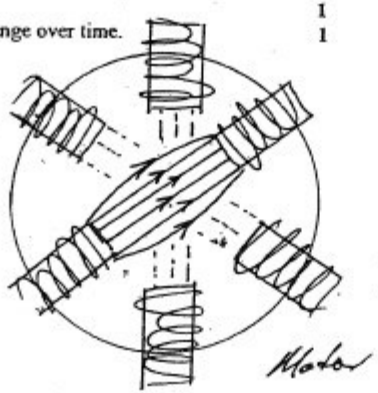
loudspeaker — speaker cone
induction motor — squirrel cage (rotor)

((i) Draw a sketch to illustrate the difference between the magnetic fields in the induction motor and loudspeaker. 1
(ii) Identify the different ways in which the fields change over time. 1

(i



Side View OR End View
Speaker



Motor

(ii

The field in the loudspeaker is constant whereas the field in the induction motor rotates by having different pairs of magnets at full strength at different times.

(d) The force exerted on the loudspeaker coil is determined by the current supplied to it. However, the torque developed on the rotor of the induction motor can also depend on how much the load resists the motion of the rotor, slowing it down.

Explain why the load on an induction motor rotor can affect the torque it experiences. 2

The change of flux in the rotor caused by the rotating field is reduced if the rotor chases the field. The load limits the rotation of the rotor, increases the flux change and hence increasing the induced current in it and hence its torque

OPTION

Candidates may ask for an extra Option Answer Book if extra space is required for the answer. This practice is not encouraged, as marks are awarded on the *content* of the answer and *not* on the *length* of the answer.

Examiner's Use Only

a) i) >1 100 000 (1 000 000 → 1 200 000) 1

ii) Small angles – very many deflections
large angles – very few deflections 1

iii) Significance: ~~small angles of deflection mean that most particles~~
most particles experienced small angles of deflection. Whilst only a very small number experienced large deflections(!)
This suggests that the majority of the atom is made up of empty space(!).
with a very dense, small nucleus which experiences large deflections (only a few large deflections) (!) 3

b) i) Bohr Theory of the atom. Main postulates

- electrostatic forces provide the centripetal force needed to make negative electrons orbit a positive nucleus, there are stable circular orbits.
- an electron orbits around a nucleus in stable, non-radiating orbits of fixed energy
- an atom absorbs or emits photons (quanta) of light when the electron changes its energy by a discrete amount (a quantum). In the process it moves from one energy level to another that is higher or lower in energy 2

How they explained observations of the H atom

* the H spectrum is not continuous; H atoms are stable

* the atom is stable, the e^- does not spiral into the nucleus

* H spectrum, not all lines taken in the absorption spectrum. Electrons in an excited atom will be in the ground state so absorb E to go to higher levels

Predicted other series in the H spectrum.
Predicted IE for H.
Equation was able to predict wavelengths

Examiner's Use Only

2

Marks

b) Outline how Einstein's ideas about the nature of light contradicted the theory at the time and how they provided credibility to Planck's ideas about quanta. 3

Classical theory held that any light frequency would eventually cause photoemission - just had to wait until the electrons absorbed enough energy from the light. The energy carried depended on the ~~frequency~~ intensity. Einstein's idea was that light was quantised - in 'packets' - and if there was not enough energy in one packet, then the electron would not be emitted regardless of intensity. (1)
He also claimed that all the energy in the photon was transferred to the electron, not just some of it. (1)
His explanations, using Planck's quanta idea, but extending it to light, readily explained all the observations that the classical theory did not. (1)

THIS IS THE LAST QUESTION FOR BOOKLET THREE