Student Number ______

MC /20	HUGHES /22	WARD /20	NOYES /28	ASTRO 10	QUANTA /10	TOTAL /100

Student Name ________________________

Sydney Technical High School

2013

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

Total marks – 100

Section I Pages 2 - 19

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

Part A – 20 marks
- Attempt Questions 1-20
- Allow about 30 minutes for this part

Part B –70 marks
- Attempt Questions 21-36
- Allow about 2 hours for this part

Section II Pages 28 - 30

10 marks
- Attempt **ONE** Question from Questions 37-38
- Allow about 30 minutes for this section

Section I
90 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 30 minutes for this part

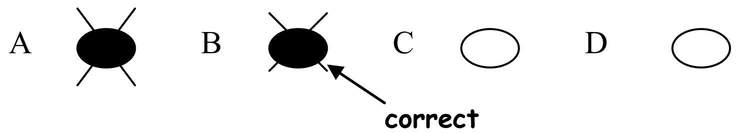
Use the multiple-choice answer sheet.

Select the alternative A,B,C or D that best answers the question. Fill in 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 the correct answer by writing the word **correct** and drawing an arrow as follows.



Student Number ______

TRIAL HSC EXAMINATION

Physics

Multiple Choice Answer Sheet

1.	A ◯	B ◯	C ◯	D ◯
2.	A ◯	B ◯	C ◯	D ◯
3.	A ◯	B ◯	C ◯	D ◯
4.	A ◯	B ◯	C ◯	D ◯
5.	A ◯	B ◯	C ◯	D ◯
6.	A ◯	B ◯	C ◯	D ◯
7.	A ◯	B ◯	C ◯	D ◯
8.	A ◯	B ◯	C ◯	D ◯
9.	A ◯	B ◯	C ◯	D ◯
10.	A ◯	B ◯	C ◯	D ◯
11.	A ◯	B ◯	C ◯	D ◯
12.	A ◯	B ◯	C ◯	D ◯
13.	A ◯	B ◯	C ◯	D ◯
14.	A ◯	B ◯	C ◯	D ◯
15	A ◯	B ◯	C ◯	D ◯
16.	A ◯	B ◯	C ◯	D ◯
17.	A ◯	B ◯	C ◯	D ◯
18.	A ◯	B ◯	C ◯	D ◯
19.	A ◯	B ◯	C ◯	D ◯
20.	A ◯	B ◯	C ◯	D ◯

Student Number ______

1. The gravitational potential energy of an object near Earth's surface is changed. This could be done by:

(A) applying a horizontal net force

(B) allowing the object to fall down 5 metres.

(C) holding the object stationary in the air

(D) ensuring the net force on the object remains zero.

2. A sign that the critical temperature of a material has been reached is when:

(A) all atomic motion ceases in the material except for electrons.

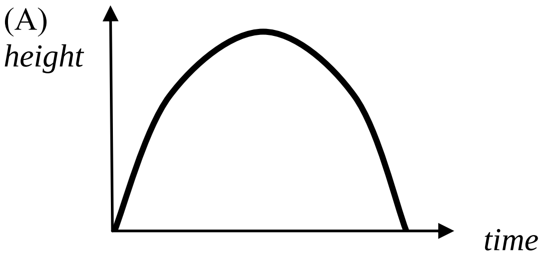
(B) the electrons cease moving in the lattice structure.

(C) the electrons all line up and move in one line through the material.

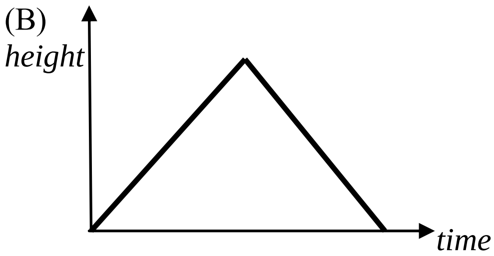
(D) electrons pair up and move unimpeded.

3. Which graph most closely resembles the path taken by a projectile fired from the Earth's surface, ignoring air friction?

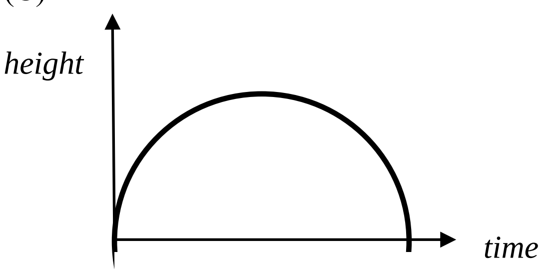
(A)



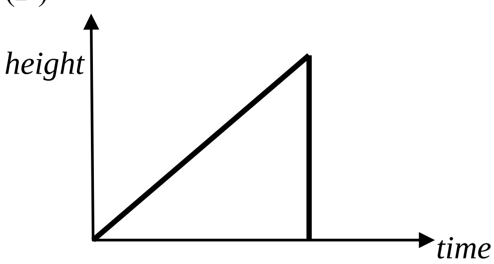
(B)



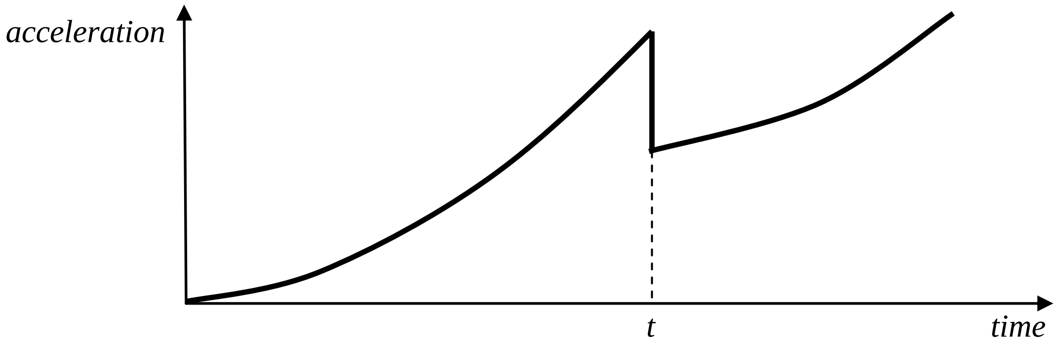
(C)



(D)



4. The acceleration of a rocket being used to transport astronauts to the International Space Station is shown for the minutes just after launch:



At time *t*, the astronauts:

(A) feel momentarily weightless.

(B) feel a sudden increase in their apparent weight.

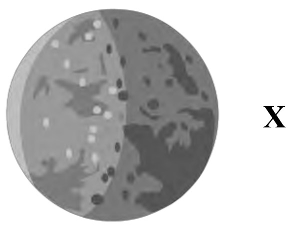
(C) feel no effect as they are still in Earth's gravity.

(D) feel a reduction in their apparent weight.

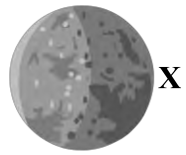
5. A gaseous planet expands and contracts in size while maintaining the same mass.

In which diagram is the object at "**X**" experiencing the greatest gravitational force? (The diagrams are to scale.)

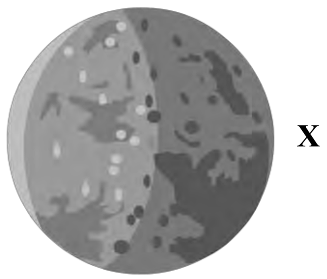
(A)



(B)



(C)



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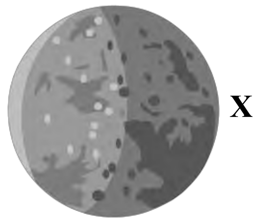


6. The wavelength of a photon of blue light is 540 nm.

How much energy does this photon carry?

(A) 1.19×10^{-39}J

(B) 3.68×10^{-19}J

(C) 3.68×10^{-25}J

(D) 162 J

7. The concept of time dilation is a direct consequence of:

(A) the constancy of the speed of light in a vacuum.

(B) the equivalence of mass and energy.

(C) the aether effect.

(D) nothing being able to exceed the speed of light.

8. The slingshot effect can be best summarised as:

(A) the launch of a rocket using less fuel.

(B) a method by which a space probe can re-enter Earth's atmosphere safely.

(C) a "free" head start to a rocket's speed launched to the east.

(D) a "free" change to a space probe's speed.

9. Hertz observed the photoelectric effect in his experiments with radio waves but he did not investigate this phenomenon further.

What did Hertz observe in relation to the photoelectric effect?

(A) Sparks could be made to jump a gap in another coil at a distance.

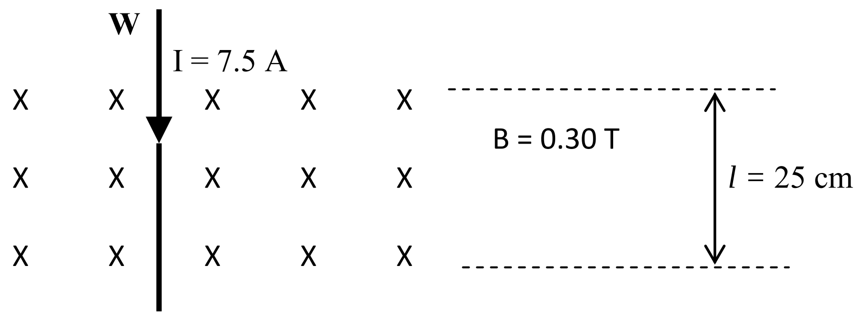
(B) The gap that sparks could jump across is larger when exposed to light.

(C) The radio waves producing the spark carried energy.

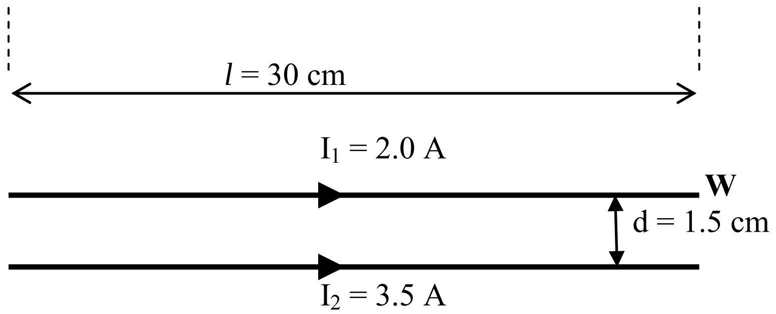
(D) The radio waves travelled at the speed of light.

10. In which arrangement is the force on wire **W** the greatest in magnitude?

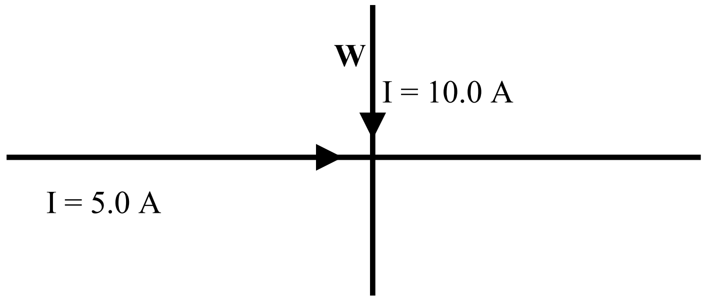
(A)



(B)



(C)



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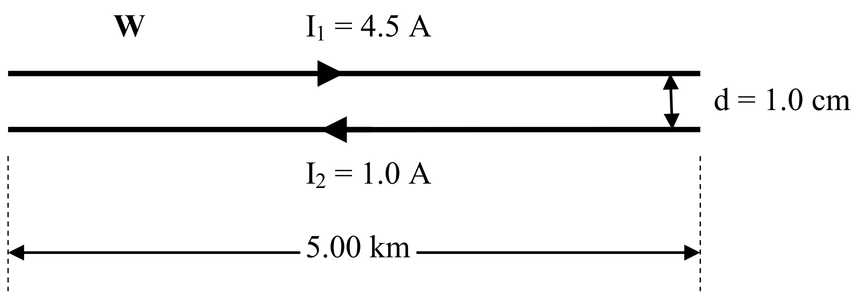
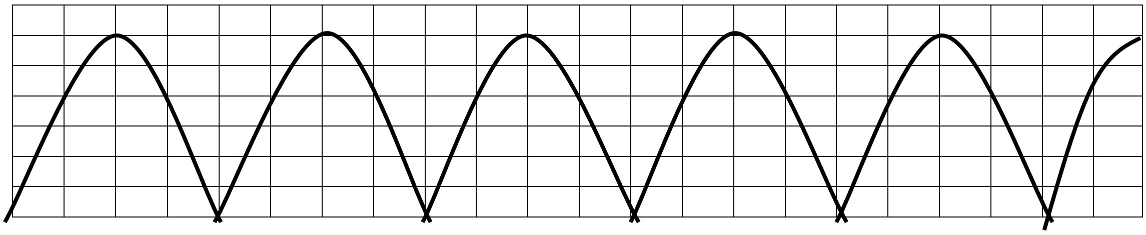
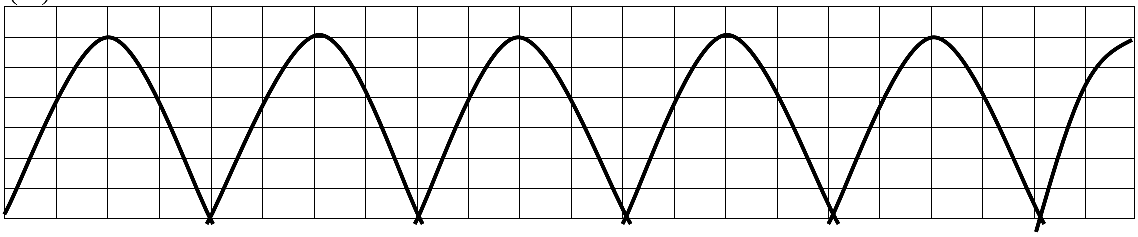


11. A hand-turned electric generator has its outputs connected to a CRO. The CRO screen appears below:

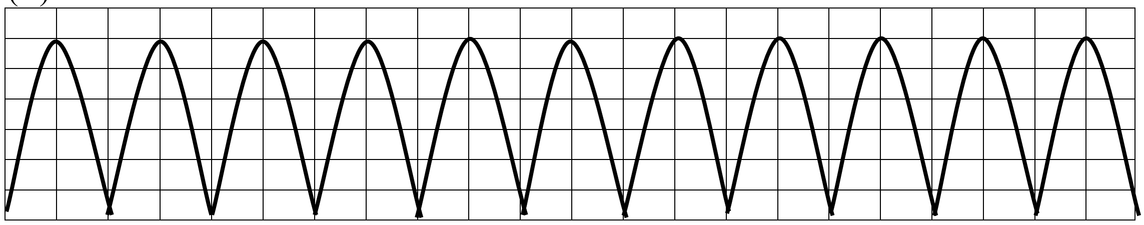


When the same generator is turned at a faster rate, the CRO output with the same settings would appear most similar to:

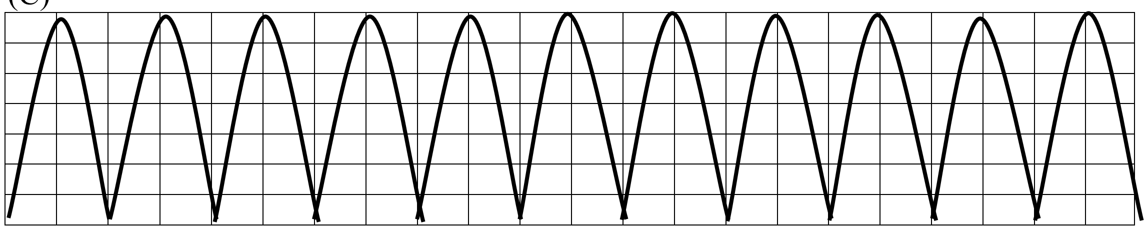
(A)



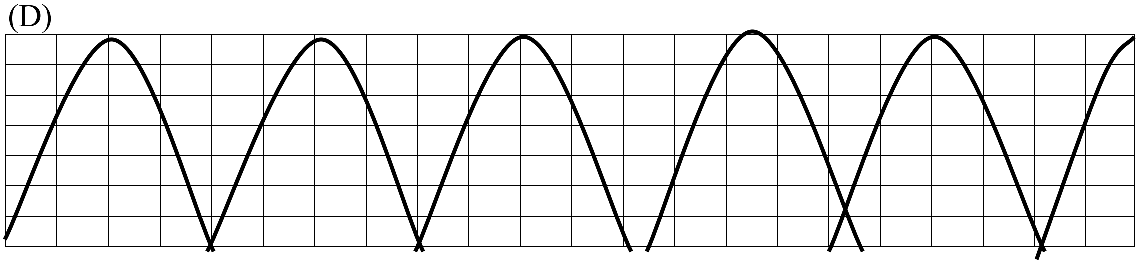
(B)



(C)

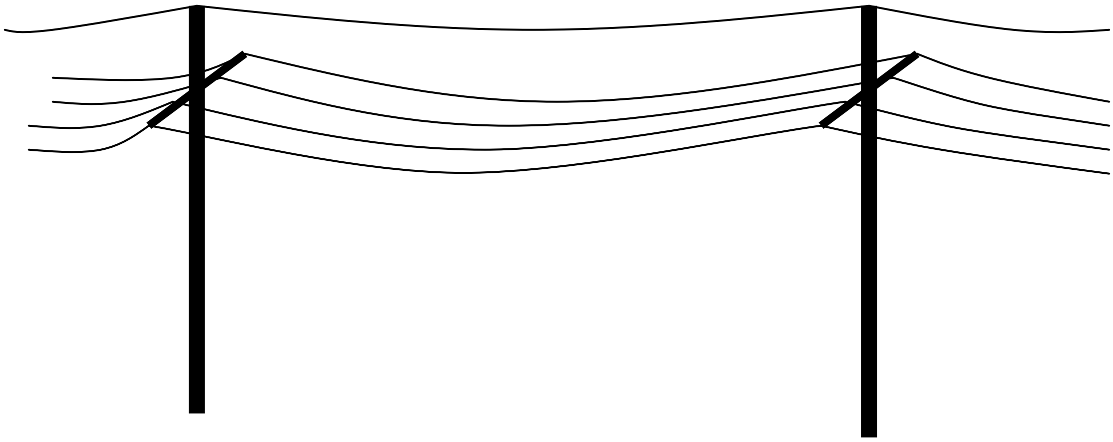


(D)



12. Wire **X** and structure **Y** are shown in the illustrations below.

wire **X**



structure **Y**

The purposes of the wire and structure are:

	Purpose of Wire X	Purpose of structure Y
(A)	protect wires from lightning	insulate supporting tower from wires
(B)	insulate supporting tower from wires	protect wires from lightning
(C)	returns the current in the wires to the power station	insulate supporting tower from wire
(D)	attracts lightning to the wire	prevents surges in voltage in wires

13. The maximum torque produced by a single-coil DC motor is 2.8 N m.

This torque could be produced if the motor had 200 turns on the coil and:

	Magnetic field intensity (T)	**Current in coil (A)**	**Dimensions of rectangular coil (cm x cm)**
(A)	0.10	5.0	10 x 20
(B)	1.0×10^{-3}	0.07	10 x 20
(C)	2.0×10^{-4}	0.5	10 x 15
(D)	0.10	7.0	10 x 20

14. An ideal transformer has 4000 turns on the primary coil and 250 turns on the secondary coil.

The input and output voltages for this transformer could be:

	Input voltage (volts)	**Output voltage (volts)**
(A)	2 000	32 000
(B)	1 600	10
(C)	32 000	2 000
(D)	20	100 000

15. One of the advantages of AC induction motors compared to other electric motors is that they:

(A) have fewer moving parts.

(B) produce greater torque at lower speeds.

(C) can rotate faster.

(D) have fewer parts to wear out.

16. A cathode ray tube with a rotating paddle wheel turns when the cathode rays strike the paddles. This is evidence that cathode rays possess:

(A) charge but no mass.

(B) mass but no charge.

(C) charge.

(D) mass.

17. In an experiment to demonstrate the photoelectric effect, it was found that when light with a frequency *f* and an intensity *I* was shone on the cathode, the voltage needed to completely stop the photoelectric current was *V* volts.

The effect of increasing the incident light intensity shining on the cathode is that the voltage *V* needed to be:

(A) dropped to zero.

(B) increased.

(C) kept the same.

(D) decreased.

18. The one spare seat at the back of the bus is taken by a passenger who moves from the second back row. Their seat is then taken by a passenger from the row in front who moves back a row, and so on until there is a spare seat at the front.

This movement is a model for the movement of electrons in:

(A) the photoelectric effect.

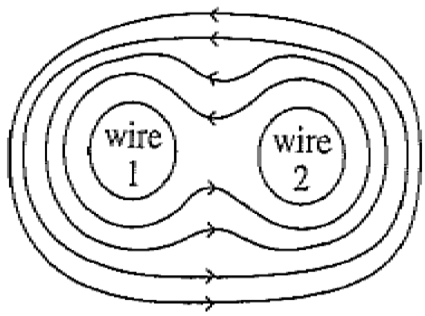
(B) a p-type semiconductor.

(C) an n-type semiconductor.

(D) a conductor.

19.

The following diagram shows magnetic field lines around two current-carrying wires.



Which statement describes the direction of the current AND the force between the wires?

(A) The currents are flowing in the same direction; the force between them is attractive.

(B) The currents are flowing in the same direction; the force between them is repulsive.

(C) The currents are flowing in opposite directions; the force between them is attractive.

(D) The currents are flowing in opposite directions; the force between them is repulsive.

20. What is the gravitational potential energy of an asteroid with a mass of 3.5×10^5 kg when it is at an altitude of 30 km above the ocean?

Use: radius of Earth = 6370 km

(A) -3.4×10^6 J

(B) -2.2×10^{16} J

(C) -2.2×10^{13} J

(D) -1.3×10^{-6} J

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Student Number ______

Part B –70 marks

HUGHES	/22

Attempt Questions 21-32

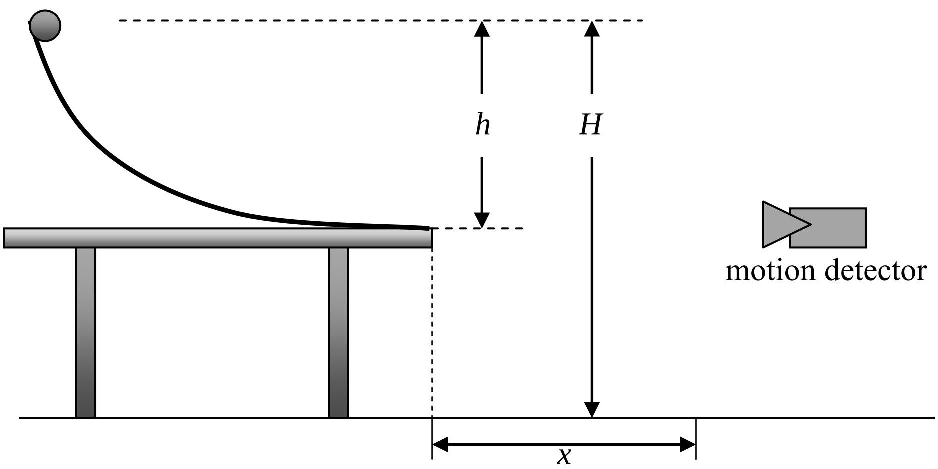
Allow about 1 hour and 40 minutes for this part.

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

Marks

Question 21 (6 marks)

An investigation was performed in which the motion of a projectile was analysed. The apparatus was set up as shown.



The aim of the investigation was to find the relationship between the variables *h* and *x* for the ball released on the ramp.

(a) Identify *two* ways to make this a more VALID investigation. **1**

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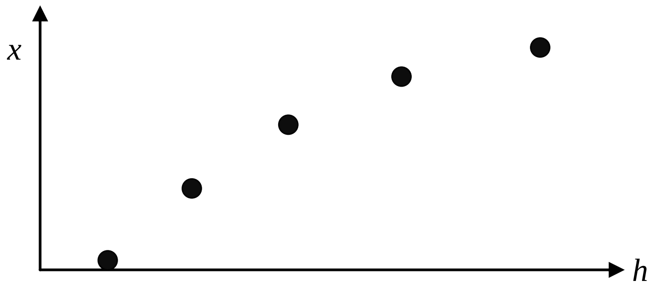
Question 21 continues on page 15.

Question 21 (continued) **Marks**

(b) The values of *h* and *x* were plotted on axes without labels, as shown.



Draw a line of best fit on this graph. **1**

(c) With reference to the apparatus as shown, suggest a reason why the line of best fit does not pass through the origin. **2**

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(d) The motion detector records the speed of the ball as it leaves the table.

Explain the relationship between this observation and the horizontal distance travelled by the ball, *x*? **2**

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Marks

Question 22 (7 marks)

A 4.00 x 10^2 kg satellite completes one orbit around Earth in 2 hours exactly.

(a) Calculate the radius of this satellite's orbit. **3**

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(b) What is the gravitational force acting on this satellite? **2**

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(c) Explain the nature of the force acting on the satellite in relation to its subsequent motion. **2**

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Marks

Question 23 (5 marks)

The Michelson-Morley experiments attempted to measure the relative velocity of the Earth through the aether.

(a) Explain why the Earth was believed to be travelling through the aether. **2**

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(b) Evaluate the effect that the result of the Michelson Morley experiment had on scientific thinking at the time. **3**

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Question 24 (4 marks)

Commercial DC motors have several features which are designed to increase the performance of the motor.

(a) Sketch the shape of a typical radial magnetic field produced by two magnets. **2**

(b) Explain why a radial magnetic field improves the performance of a motor. **2**

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Marks

Question 25 (3 marks)

Name a device that utilises the motor effect other than an electric motor and, with the aid of a diagram, describe how the motor effect is used. **3**

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Marks

Question 26 (5 marks)

Assess the role of transformers in the use of electrical energy in our modern society. **5**

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Question 27 (4 marks)

Early investigations using cathode rays resulted in uncertainty as to their nature.

Explain how the behaviour of cathode rays indicates their properties. Include particular observations and why early observations made their nature uncertain. **4**

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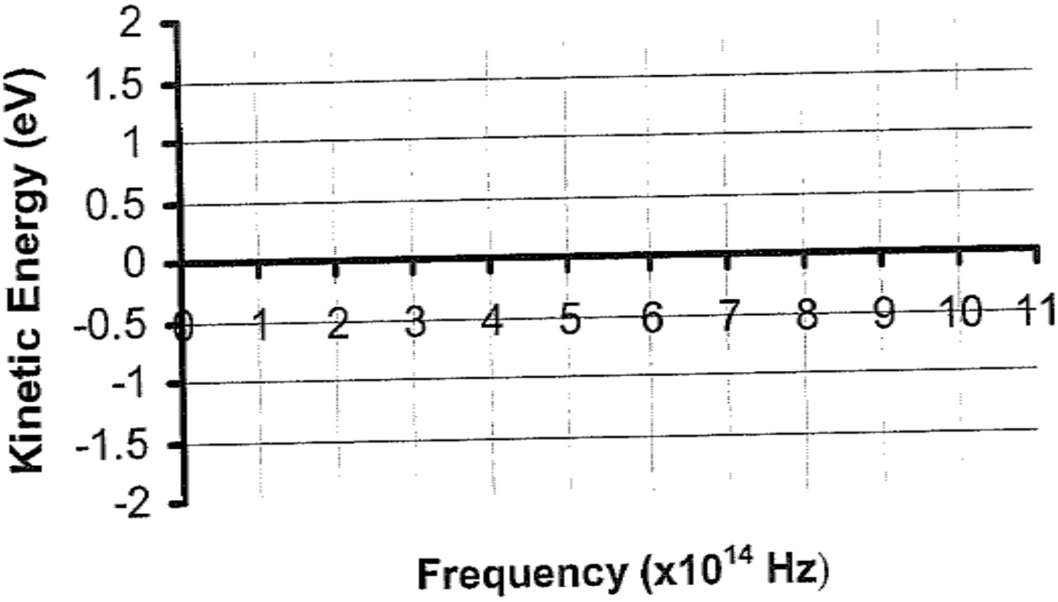
Question 28 (6 marks)

In an experiment to study the photoelectric effect, students shone light of different frequencies onto a metal plate. They used their observations to calculate the kinetic energy of the emitted photoelectrons and recorded their results in the table below.

Frequency of incident light ($\times 10^{14}$ Hz)	**Kinetic energy of photoelectrons (eV)**
5.6	0.20
6.5	0.55
7.8	1.10
9.3	1.70

(a) Graph these results on the axis below. **2**



Question 28 continued on page 21

(b) Define the threshold frequency of a photoemitter. **1**

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(c) Determine the threshold frequency of this emitter. **1**

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Question 29 (4 marks)

Early electronic appliances used thermionic devices which had severe limitations. The invention of the transistor resulted in the development of solid state devices that overcame these limitations.

4

Evaluate the advantages of solid state devices over thermionic devices in improving communication technologies.

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Student Number ______

NOYES /28

Question 30 (5 marks)

Justify the use of superconductors in ONE real-life application, with reference to their advantages and limitations in this application. **5**

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Question 31 (5 marks)

Discuss the effects of Earth's rotational motion on the launch of a rocket and compare low Earth with geostationary orbits. **5**

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Question 32 (4 marks)

Summarise Einstein's explanation of the results of Planck's radiation experiments.**4**

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Question 33 (3 marks)

Explain how different band structures of conductors and semiconductors account for their different electrical properties. **3**

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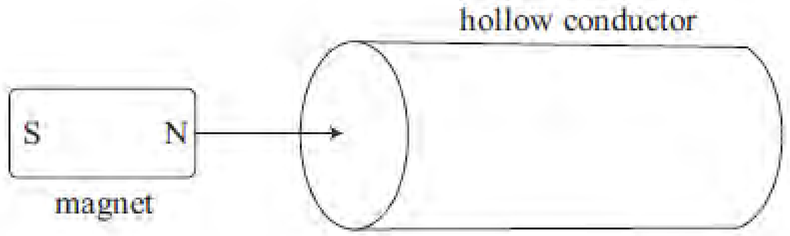
Question 34 (3 marks)
Draw on the diagram to describe the effect of moving a magnet into a hollow cylindrical conductor, and use the information to show why Lenz's Law is true. **3**



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Question 35 (6 marks)

Choose a practical investigation you carried out which demonstrates the principle of the AC induction motor **OR** a DC motor.

(a) Draw a labelled diagram of the apparatus, labelling which parts of an actual motor the parts of your model correspond to. **3**

Question 35 continued on next page

(b) Describe how you used the apparatus and what you observed. **2**

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(c) State one advantage of an AC induction motor over a DC motor. **1**

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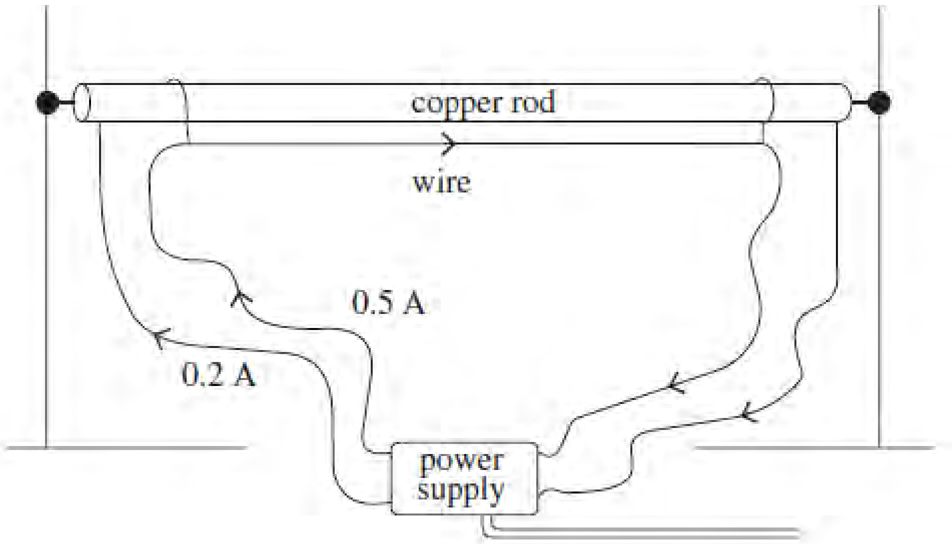
Question 36 (2 marks)

A student tries to suspend a wire against the force of gravity, using the motor effect. The student sets up a copper rod with a wire suspended 5 mm below, using thread which is to be cut once the wire is suspended.



The wire has length 1 m and mass 20 g.

The student passes a current of 0.2 A through the wire and 0.5 A through the rod.

Calculate the size of the attractive force between them. **2**

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Student Number ______

Section II

10 marks
Attempt ONE question from Questions 37-38

Allow about 30 minutes for this section

Answer the question in a writing booklet.
Show all relevant working in questions involving calculations.

Pages

Student Number ______

Question 37 Astrophysics (10 marks)

(a) Your friend in the Physics class is confused about star distance measurements in parsec. He asks you whether the distance to a star in parsecs increases as the angle of parallax increases.

Using both the formula and a diagram, provide an explanation for your friend. **4**

(b) Discuss how the development of interferometry has improved the resolution and sensitivity of ground-based astronomy. **4**

(c) Distinguish between the terms ***resolution*** and ***sensitivity*** as used in astrophysics. **2**

Student Number ______

Question 38 From Quanta to quarks (10 marks)

(a) Discuss how the concept of quantised energy fitted in with Bohr's postulates and how this in turn led to the mathematical model that accounted for the observed spectrum of hydrogen. **4**

(b) Use a labelled diagram to explain the production of the Balmer series spectrum according to Bohr's model of the atom. **3**

(c) Calculate the ionisation energy of the hydrogen atom. **3**

END OF PAPER

2013 Physics Trial HSC examination. Marking Guidelines and model Answers.

Section I A   Multiple Choice

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	D	A	D	B	B	A	D	B	A	C	A	D	C	D	D	C	D	A	C

Section I B

HUGHES

21. a.

Marking Criteria	Marks
• Two appropriate ways identified	1

The exprt is ALREADY valid, we need to improve it e.g. small ball, friction free ramp.

21.b.

Marking Criteria	Marks
• Correct curved line drawn through points (not straight)	1

It cannot be straight since PE =mgh is converted to KE= $1/2mv^2$. So 4x higher gives 2x speed etc. This will give a curve

21.c.

Marking Criteria	Marks
• Plausible reason given AND • Related to the investigation	2
• Plausible reason given	1

Note that the graph confused many students with the axes being swapped.
From a low height on the ramp, the ball moves more slowly due to FRICTION so needs some h to even roll off the edge, hence h has a value but x=0.

21.d.

Marking Criteria	Marks
• Correct relationship identified and reasons given	2
• Correct relationship given	1

The initial horizontal speed of the ball measured by the detector is directly proportional to the distance travelled, *x*, as the time taken to fall will be the same regardless of the initial horizontal speed. Equation is: $x = V_H \times t$

22.a.

Marking Criteria	Marks
• Correct answer calculated.	3
• Answer calculated with error in units or substitution	2
• Answer calculated with error made in units and one other error OR • Two steps of the calculation performed correctly	1

T = 2 x 60 x 60 = 7200 s

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

$$r = \sqrt[3]{\frac{GM}{4\pi^2} \times T^2}$$

$$= \sqrt[3]{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{4\pi^2} \times (7200^2)}$$

$$= 8.1\times10^6 \text{ m}$$

22.b

Marking Criteria	Marks
• Answer calculated correctly	**2**
• Calculation made with an error	**1**

$$F = G\frac{m_1 m_2}{d^2}$$

$$= 6.67\times10^{-11}\frac{(4.00\times10^2)\times(6.0\times10^{24})}{(8.07\times10^6)^2}$$

$$= 2.46\times10^3 \text{ N}$$

Note: Consequent error from part (a). shown as CE

22.c.

Marking Criteria	Marks
• All appropriate reasons given	**2**
• One appropriate reason given	**1**

The satellite"s orbit is circular and so must have a centripetal force acting on it. This is provided by the gravitational force of Earth on the satellite.

23.a

Marking Criteria	Marks
• Thorough explanation given	**2**
• A reason identified	**1**

The Earth was known to be moving through space as it orbits the Sun. Space was believed to be filled with the aether as light, being a wave, must have a medium to travel in, like all other waves known at the time. As Earth changes direction as it orbits around the Sun, at the same time it must be moving through the aether.

23,b.

Marking Criteria	Marks
• M-M experiment gave a null result • Einstein proposes Special relativity • Speed c is a constant but time/lengths dilate	**3**
• Two of the above •	**2**
• One of the above	**1**

The M-M experiment showed no changes to the interference pattern produced by the split beam of light recombining as the apparatus was rotated. Therefore, it was a null result – no difference in the speed of light moving into or sideways to the aether was detected by the apparatus. This split the scientific community until Einstein in his Theory of Special Relativity said that light moves at c not c + or – v. Time is dilated and lengths contract.

24.a.

Marking Criteria	Marks
• Radial B field entering and exiting coil • Curved pole pieces of magnets shown	**2**
• Only one of above	**1**

24.b

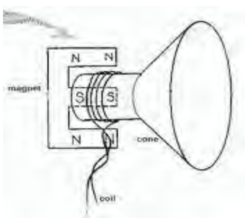
Marking Criteria	Marks
• Explanation refers to the interaction of the field and coil • Reference to torque being uniform	**2**
• One of the above	**1**

With a radial magnetic field, the field lines are perpendicular to the current in the sides of coil for a greater part of one whole revolution of the coil rather than at only one instance every half turn. Thus from F=BILsin theta, then theta =90 degrees and thus force is a max and also uniform. Or say that the plane of the coil is parallel to the B field . Thus in the Torque equation T=nIABcos theta then theta =zero so cos theta is 1 thus Torque a max and is more uniform as theta stays at zero.

WARD

25.

Marking Criteria	Marks
• An appropriate device is identified AND • reference is made to the correct application of the motor effect AND • diagram is provided that assists in explanation	**3**
• An appropriate device is identified AND • reference is made to the correct application of the motor effect OR • diagram is provided that assists in explanation	**2**
• Appropriate device is identified	**1**



e.g. loudspeaker : a coil that is connected to the output signal is wrapped around a magnet. Current in the coil causes motion of the coil due to the interaction with the magnetic field from the magnet, as shown. The coil is attached to the cone which vibrates with the coil and produces sound waves in the air. (NB other loudspeaker types also accepted.)

26

Marking Criteria	Marks
• A thorough assessment of transformers including electricity distribution, consumption and end use by appliances is provided • Broad and deep understanding is evident • Assessment is in a logical, sequential and cohesive structure	**5**
• Good understanding of the role of transformers evident	**4**

• The role of transformers in electricity distribution, consumption & appliances is discussed in detail	
• The role of transformers in electricity distribution, consumption and appliances is discussed	**3**
• The role of transformers in either electricity distribution, consumption or in appliances is outlined	**2**
• A purpose of transformers is identified	**1**

At power stations, transformers are used to step up the voltage from the generators to around 330 kV for long-distance transmission. At regional switchyards, more transformers step down the voltage to 33 kV or 11 kV for regional and suburban distribution. In local streets, this is finally stepped down again for domestic consumption or use by factories etc. Appliances in the home or in factories may also use transformers to step the supplied voltage up or down, e.g. microwave ovens (step up) or electronic devices (step down), battery chargers (step down) and so on. Without transformers, long distance electrical power distribution would not be possible and the large variety of final uses would not be possible either. Only a set voltage, determined by the generator (which would need to be close by) would be available. Thus transformers play a critical role in the distribution and use of electricity in our society.

27

Marking Criteria	Marks
• Observations supporting both wave & particle properties are thoroughly explained • CR behaviour used to clearly explain properties • Thomson‟s work included	**4**
• Observations supporting both wave & particle properties are explained & related to CRs	**3**
• Two observations supporting wave &/or particle properties are identified	**2**
• An observation supporting wave or particle properties is identified	**1**

Cathode Rays, waves or particles ?

Crookes investigations showed many particle properties, in particular

- Deflection of CR by B field (screen tube expt) according to RH palm rule (motor effect)
- CR carry energy & momentum (paddle wheel tube) wheel accelerated from cathode to anode

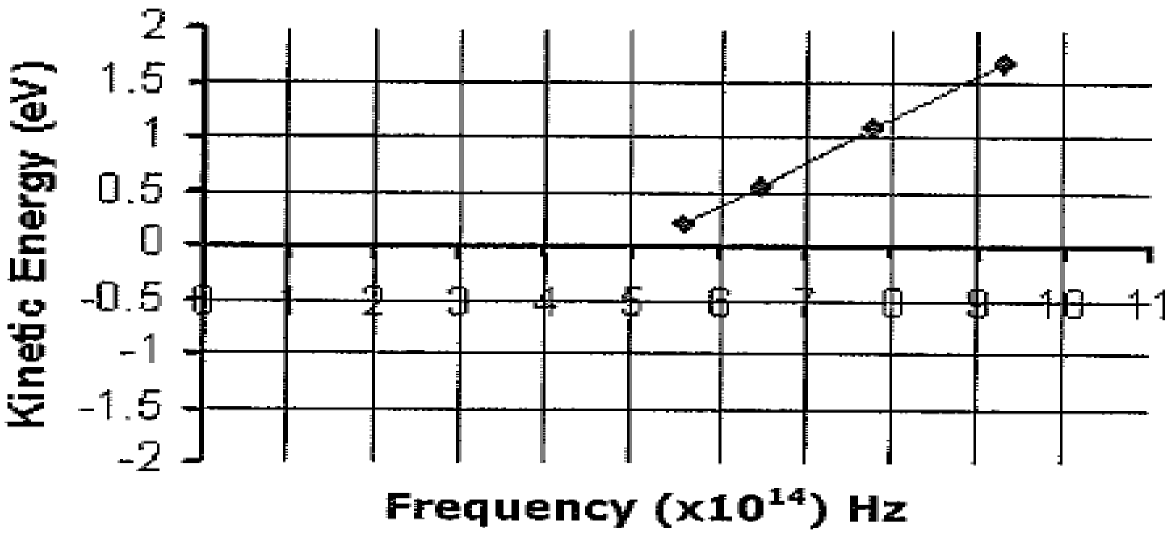
Crookes believed in but could not demonstrate the deflection of CR by E fields.

Hertz believed CR, like light, unaffected by E field….incorrect. Later, disproved by others.
He believed CR penetration of thin metal foils showed a wave nature……inconclusive. Later, Rutherford‟s gold foil expt & new model of the atom annul this contention.

Thomson determines charge / mass ratio for CR, settling dispute in favour of CR as particles, now called electrons.

28. a

Marking Criteria	Marks
• Plots four points correctly, one straight line of best fit	**2**
• Plots two points correctly OR 4 pts without LOBF	**1**



b

Marking Criteria	Marks
• Provides correct statement	**1**
• Answer does not state f_o to be the ***minimum*** freq. for photoemission	**0.5**

Threshold frequency is the lowest frequency of photons which will cause the emission of electrons from the surface.

c.

Marking Criteria	Marks
• Correctly identifies ***x*** intercept from student‟s own graph	**1**

29.

Marking Criteria	Marks
• Advantages of solid state devices evaluated thoroughly • response is in a logical, coherent and sequential style	**4**
• Advantages of solid state devices outlined • Evaluation not clearly stated	**3**
• Several aspects of solid state devices identified	**2**
• An advantage of solid state devices identified	**1**

Thermionic devices	Solid state devices
bulky and heavy – hard to carry around	much smaller and lighter – miniaturisation possible
delicate glass vacuum tubes easily broken	robust – can withstand impacts
high power requirement with high voltage	much lower power needed and lower voltages
much heat emitted	little heat emitted
take some time to warm up before being used	work instantly
unreliable – "valves" have short working life	very reliable – long life of devices

From the above comparison it can be concluded that solid state devices allowed for very significant improvements in the reliability and portability of communication technologies.

NOYES

30

Marking Criteria	Marks
• Identifies one application of superconductors • Justifies its use • Relates use to physical properties • Advantages & disadvantages • Assessment is in a logical, sequential and cohesive structure	**5**
• Identifies one application of superconductors • Describes its use • Relates use to physical properties • Advantages / disadvantages	**4-3**
• Identifies one application of superconductors a • Describes its use	**2**
• Identifies one application of superconductors	**1**

Superconductors are used in MRI scanners. They are used to make the induction coils that produce strong magnetic fields. These induction coils require very large electric currents. superconductors enable these large currents to be produced, without the need for hazardous high voltages and resistive heat losses. However, the superconducting coils must be kept below the critical temperature; this requires bulky insulation and energy input.

31

Marking Criteria	Marks
• Discusses eastward launch of rockets • Explains geostationary satellites • Explains low earth orbit satellites	**5**
• Discusses launch of rockets • Explains geostationary satellites OR • Explains low earth orbit satellites	**4**
• Describes launch of rockets AND • Describes geostationary satellites OR • Describes low earth orbit satellites	**2-3**
• Identifies eastward launch of rockets OR • Describes geostationary satellites OR • Describes low earth orbit satellites	**1**

Rockets are always launched to the east in order to receive a boost from the rotational speed of the Earth.

Satellites in low earth orbit are about 250 km-1000km high. This is the minimum height that satellites can exist to avoid significant atmospheric air friction. The space shuttle and spy satellites usually orbit in this region. These satellites orbit the earth once every 90 minutes.

Geostationary satellites orbit the earth over the equator with a period of 23 hours 56 minutes & 4 secs (a sidereal day). This is the time that it takes for the earth to rotate once on its axis. A geostationary satellite will occupy the same position in space above the earth. Geostationary orbits are useful for communications and weather satellites.

32

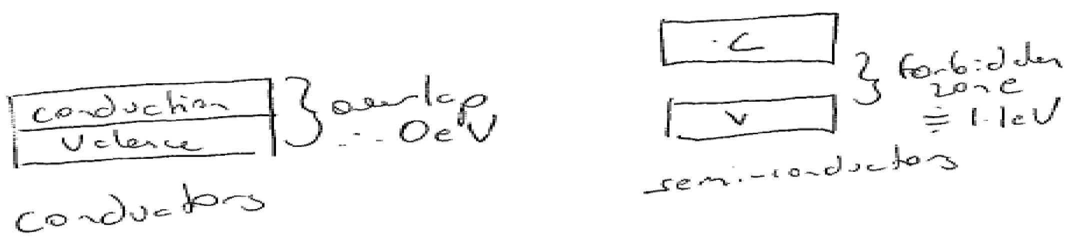
Marking Criteria	Marks
• Outlines the main features of the photon model : • quantisation of energy • energy of each photon is proportional to its frequency • photon cannot exchange part of its energy in an interaction • total energy is proportional to the frequency and the total number of photons	**4**
• Outlines 3 of the above	**3**
• Outlines 2 of the above OR • Partially outlines 3	**2**
• Outlines one of the above OR • Partially outlines 2	**1**

Einstein postulated that electromagnetic radiation is emitted in discrete units called photons. Photons of different frequency carry different amounts of energy; the frequency of a photon is proportional to the energy it carries. E=hf. When a photon interacts with matter, it can only exchange all or none of its energy, it cannot exchange part and keep part. The total amount of energy emitted by a source is proportional both to the frequency of the photons and the total number of photons emitted.

33

Marking Criteria	Marks
• Describes band structure for both • Describes relative conductivity of both • Relates conductivity to band structure	**3**
• Describes band structure for both AND • Describes conductivity of both OR • Relates conductivity to band structure	**2**
• Describes band structure for either OR • Describes relative conductivity of both	**1**

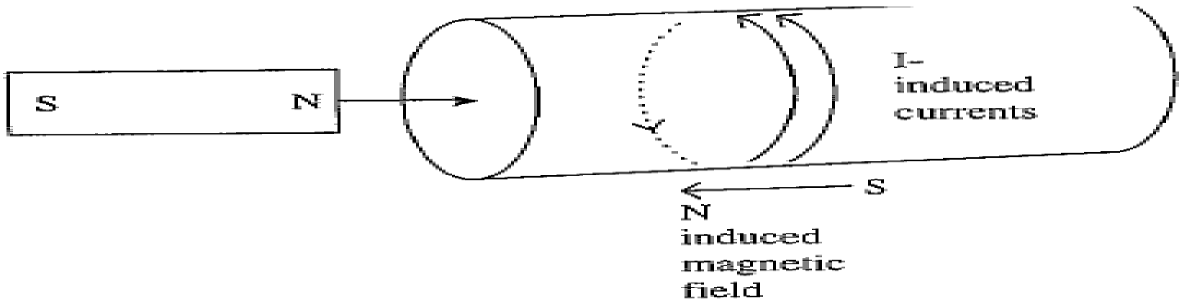
In metals there is no gap between the valence and conduction bands. This means that valence electrons are easily able to move into the conduction band, where they are free to move from one atom to another; that is conduct electricity.
Semiconductors have a small gap(1 eV) between the valence and the conduction bands. Electrons may jump the gap into the conduction band if they have enough energy, leaving behind a hole in the valence band. Therefore semiconductors can conduct an electric current but smaller than a metal.



34

Marking Criteria	Marks
• Correctly annotates diagram to show induced currents and magnetic fields. • Explains induced fields oppose magnet movement	**3**
• Correctly annotates diagram to show induced currents and magnetic	**2**

fields. • Partial explanation of induced fields opposing magnet movement	
• Annotates diagram to show either induced currents OR magnetic fields. • OR • Partial explanation of induced fields opposing magnet movement	**1**

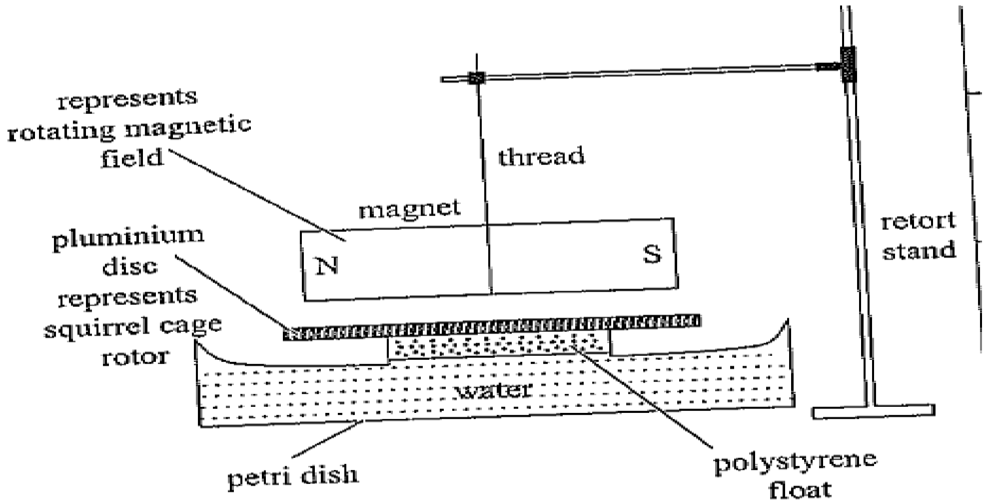


The moving magnet induces current loops in the conductor-in turn these induce a magnetic field that opposes the movement of the magnet.
If the induced field did not oppose the magnet‟s movement then they would have to accelerate it, resulting in increased currents, and therefore increased magnetic fields, and violating the law of conservation of energy.

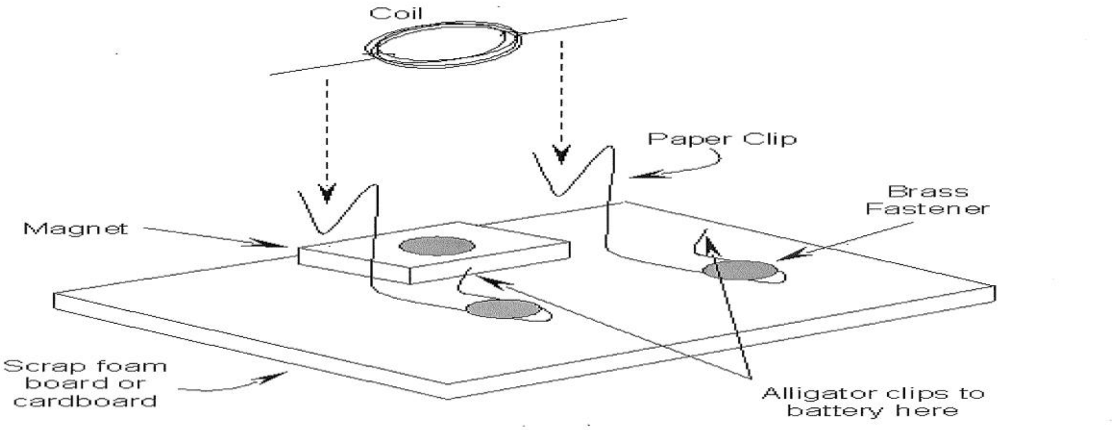
35.a.

Marking Criteria	Marks
• AC -Clear diagram of appropriate apparatus correctly labelled to show the rotating magnetic field & squirrel cage motor. • DC as above to show coil, magnet and input circuit.	**3**
• Clear diagram of appropriate apparatus correctly labelled to show the rotating magnetic field OR squirrel cage motor • DC –only 2 of above 3 parts labelled	**2**
• Clear but unlabelled diagram of either	**1**

AC Induction Motor



DC Motor



b.

Marking Criteria	Marks
• Full description of procedure and observation	**2**
• Partial description of procedure and observations.	**1**

AC -When the magnet was made to spin, the aluminium disc also rotated in the same direction. The speed of the disc matched that of the magnet.
DC –switch current on and give coil a slight push. It starts to rotate due to the motor effect. More current or stronger magnet gives faster rotation.

c

Marking Criteria	Marks
• States one correct advantage of an AC induction motor	**1**

AC induction motors do not require electrical connections to the armature, so there are no brushes to wear out or cause sparks. They are also self-starting and have little noise.

36.

Marking Criteria	Marks
• Uses correct formula with substitution; no errors; units correct	**2**
• Uses correct formula AND • correct substitution OR • correct answer with no working	**1**
• correct formula	**0.5**

$F/l = kI_1I_2 /r$ $F= l\, kI_1I_2 /r$

$F=1 \times 2\times 10^{-7} \times 0.2 \times 0.5 / 5 \times 10^{-3}$
$F= 2 \times 10^{-8} / 5 \times 10^{-3}$
$F= 0.4 \times 10^{-5} = 4 \times 10^{-6}$ N

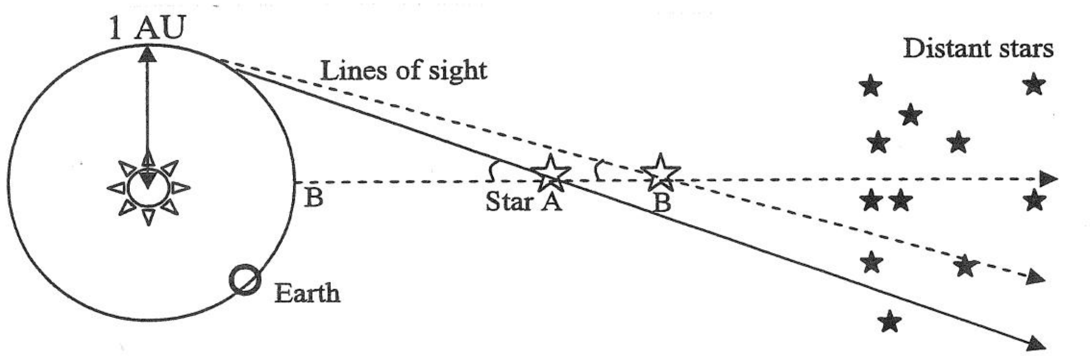
VOULALAS

OPTIONS
37 – Astrophysics.

37 (a)

Criteria	Marks
• Identifies correct relationship, provides reason based on formula and a clear diagram	**4**
• Identifies correct relationship, provides reason based on formula and attempts diagram	**3**
• Identifies correct relationship, provides reason based on formula OR draws unexplained diagram	**2**
• States formula OR attempts a diagram	**1**

Sample answer: The formula d (parsecs) = 1/p (where **p** is the angle of parallax in seconds of the arc). The relationship between distance and parallax are inversely proportional to each other.



The diagram shows that the angle subtended by the nearer star **A** is greater than the angle subtended by star **B**.

37 (b)

Marking Criteria	Marks
• Correctly defines interferometry; makes specific reference to how the resolution and sensitivity of the image is improved; outlines that interferometry can be used with both radio and optical telescopes; outlines that interferometry uses the interference patterns produced by the superposition of two out-of-phase signals.	**4**
• Correctly states ANY three of the above four points OR all four without discussion	**3**
• Correctly states ANY two of the four points OR any three without discussion	**2**
• Correctly states ANY one of the four points OR any two without discussion	**1**

Sample answer: Interferometry refers to the addition of images produced by several telescopes to produce a more accurate image. This is achieved with the help of the superposition of two out-of-phase signals. Interferometry can be used by both radio and optical telescopes although it is more commonly used in radio astronomy. Due to the wavelengths of radio waves (1mm – hundreds of km) it implies that the dishes of radio telescopes have to be many hundreds of kilometres in diameter in order to match the resolution of optical telescopes, something impractical. Instead two or more radio telescopes distance apart D are linked together by computers, which combine the incoming signals from each telescope to produce an interference pattern. This is further analysed and converted to an image with similar resolution to those of the largest optical telescopes. Each pair of telescopes provides good resolution in one direction. The greater the number of telescopes the greater the resolution produced in many directions, the better the image of the target. Furthermore, the rotation of the Earth helps to „synthesise‟ an even better image. {R (in arc seconds) = constant x λ/D}.

37 (c)

Marking Criteria	Marks
• Correctly defines ***sensitivity*** and ***resolution***	**2**
• Correctly defines ONE of the two.	**1**

Sample answer: The **sensitivity** of a telescope refers to its ability to pick up light or photons from stars etc., where the **resolution** is its ability to distinguish two close objects as separate images, measured as an angle.

38 – Quanta to Quarks.

38 (a)

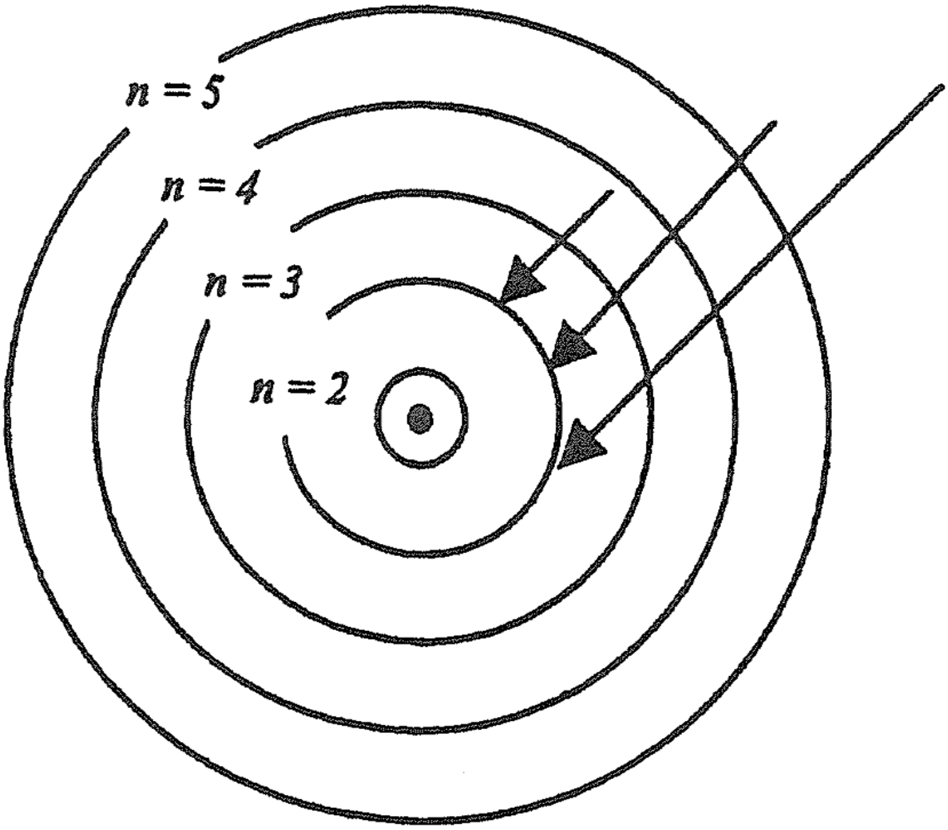
Marking Criteria	Marks
• The concept of energy quantisation is discussed • Bohr‟s postulates are related to quantised energy • The Rydberg equation is used with respect to hydrogen spectrum	**4**
• The concept of energy quantisation is outlined • Bohr‟s postulates are identified and a link is made	**3**
• An aspect of quantised energy is identified • AND • Bohr‟s postulates are identified • OR • Features of the hydrogen spectrum are identified	**2**
• ANY of the above is identified	**1**

Sample answer: Energy exists in discrete amount (quanta) can be applied to Bohr‟s postulates that state that electrons can only exist in certain energy levels in the hydrogen atom. For an electron to change energy levels it must absorb energy {E = hf} in the form of photons, moving to a higher energy level or emit photons of energy, moving to a lower energy level. The pattern of wavelengths observed in the hydrogen spectrum was used to develop the empirical Rydberg equation**:** $\mathbf{1/\lambda = R\{1/n_f^2 - 1/n_i^2\}}$ where $\mathbf{n_f}$ and $\mathbf{n_i}$ are the final and initial allowed orbitals and R is the Rydber‟s constant. The wavelength, $\boldsymbol{\lambda}$ associated with the transition between the final and initial orbital ($\mathbf{n_f}$ and $\mathbf{n_i}$**)** due to the absorption or emission of photons. If energy was not quantised then the hydrogen spectrum would be a continuous one.

38 (b)

Marking Criteria	Marks
• Provides details of a H atom with different energy levels for the electron and with the movement back to level 2 shown on the diagram	3
• Provides details of the electron movement and shows correct movement on a diagram	2
• Provides details of electron movement OR shows movement on the diagram	1

Sample answer: The electron of the H atom can move from one orbital to another of different energy levels. The Balmer spectrum was produced when excited electrons move from a higher orbit into the second lowest energy orbit, emitting the energy difference as a quantum of light.



38 (c)

Marking Criteria	Marks
• Provides correct formula, shows substitution and correctly calculates answer with correct units	**3**
• Provides correct formula with correct substitution and calculates answer without or wrong units, • OR • Calculates correct answer without showing working or with one incorrect substitution, • OR • Obtains wrong value for the wavelength **from correct substitution of 'n' values** in the Rydberg equation but substitutes correctly in E = hc/λ with correct answer and units • Calculates incorrect answer with correct substitution	**2**
• Substitutes wrong value of λ in E = hc/λ and gets correct answer with or without or wrong uits, • OR • Provides TWO relevant formulae	**1**

Sample answer: For ionisation $\mathbf{n_f = \infty}$ and $\mathbf{n_i = 1.}$

$\mathbf{1/\lambda = R\{1/n_f^2 - 1/n_i^2\}} = 1.097 \times 10^7\{0 - 1/1^2\}$

$1/\lambda = R = 1.097 \times 10^7\ m^{-1}$

$E = hc//\lambda = 6.626 \times 10^{-34} \times 3 \times 10^8 \times 1.097 \times 10^7 = 2.18 \times 10^{-18}$ J