NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2011

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 17 pages;
   - a yellow Answer Sheet of 2 pages (i – ii); and
   - a green Data and Formulae booklet of 4 pages (i – iv).

   Please make sure that your question paper is complete.

2. Remove the Data Booklet and Answer Sheet from the middle of this question paper. **Write your examination number on the yellow Answer Sheet.**

3. Read the questions carefully.

4. Use the data and formulae whenever necessary.

5. Question 1 consists of 7 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D

   Here the answer C has been marked.

6. Start each question on a new page.

7. It is in your own interest to write legibly and to set your work out neatly.

8. Show your working in all calculations.

9. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.

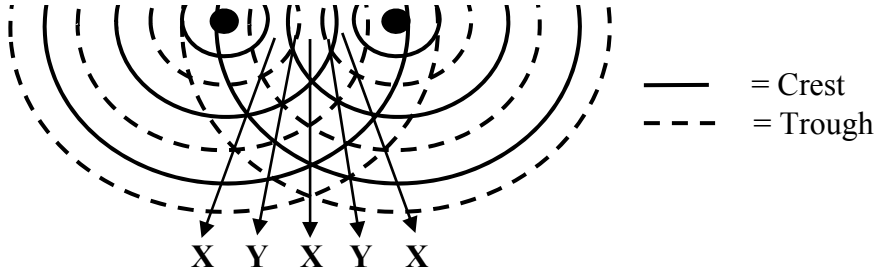
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple Choice Answer Sheet in your Answer Book. Make a cross (X) on the letter of the response which you consider to be the most correct.

1.1 Which one of the following types of electromagnetic radiation has the highest energy?

A X-rays
B Gamma rays
C Infra-red
D Ultra-violet (2)

1.2 The diagram represents the interference of water waves from two coherent sources with the same amplitude.



Which of the following descriptions correctly describes the points where the wave-fronts from each source meet (on the diagram)?

A The lines labelled X are antinodal lines and they join points of constructive interference.
B The lines labelled X are nodal lines and they join points of destructive interference.
C The lines labelled Y are nodal lines and they join points of constructive interference.
D The lines labelled Y are antinodal lines and they join points of destructive interference. (2)

1.3 Which of the following pairs of phenomena, both provide conclusive evidence for the wave nature of light, in each case?

A photoelectric effect and reflection
B diffraction and interference
C reflection and refraction
D photoelectric effect and interference (2)

1.4 A police car with its siren on, accelerates towards a stationary observer. How will the observed frequency and pitch differ from the original sound?

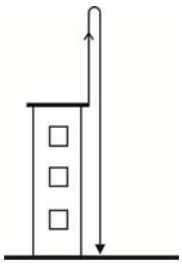
	FREQUENCY	PITCH
A	higher	lower
B	lower	higher
C	higher	higher
D	lower	lower

(2)

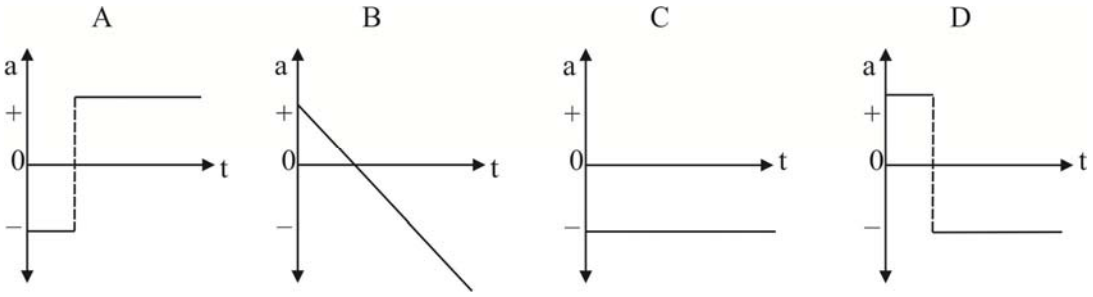
1.5 What name is given to an imaginary line that connects points on a wave, that are in phase?

A wavelength
B shock wave
C node
D wavefront (2)

1.6 An object is projected vertically upwards from the roof of a building and it hits the ground some time later. The effects of air resistance are negligible. Up is taken as the positive direction.

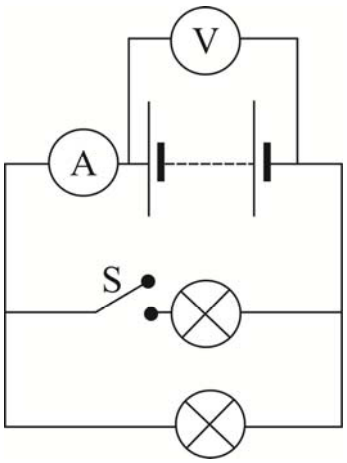


The acceleration-time graph which best represents the vertical motion of the object from the time it was projected up until it hit the ground is:



(2)

1.7 In the circuit shown below the resistance of the ammeter, switch and connecting wires is negligible. The voltmeter has a very high resistance. The battery has **significant** internal resistance.



How are the readings on the ammeter and voltmeter affected if switch **S** is closed?

	AMMETER	VOLTMETER
A	Decrease	Increase
B	Decrease	No change
C	Increase	No change
D	Increase	Decrease

(2)
[14]

QUESTION 2 MONKEY BUSINESS

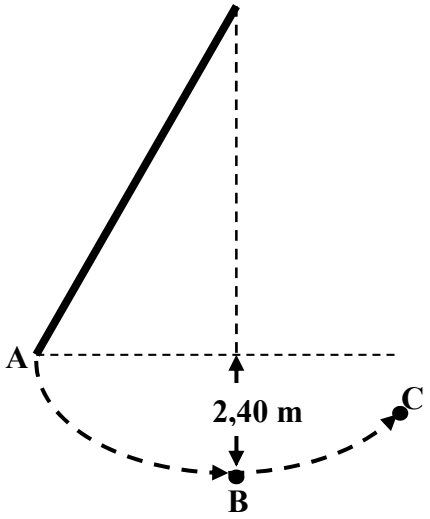
There are some monkeys playing in a camp site at the Kruger National Park.

2.1 One of the adult monkeys which is sitting on a log (position A) at some height above the ground, swings on a rope towards its baby on the ground (position B). While swinging it grabs its baby and continues to swing upwards onto a wall (position C).

The diagram below shows a simplified picture of the motion.

[<http://www.crowkzn.co.za>]

Mass of adult monkey = 5,80 kg



Mass of baby monkey = 1,20 kg

[<http://www.callofafricatours.com>]

Adult and baby monkey

Ignore the effects of air resistance.

2.1.1 State the law of conservation of mechanical energy. (2)

2.1.2 Use the above law to calculate the speed of the adult monkey (mass 5,80 kg) just as it reaches its baby (mass 1,20 kg) at B. Give your answer to two decimal places. (4)

2.1.3 State the principle of conservation of linear momentum. (2)

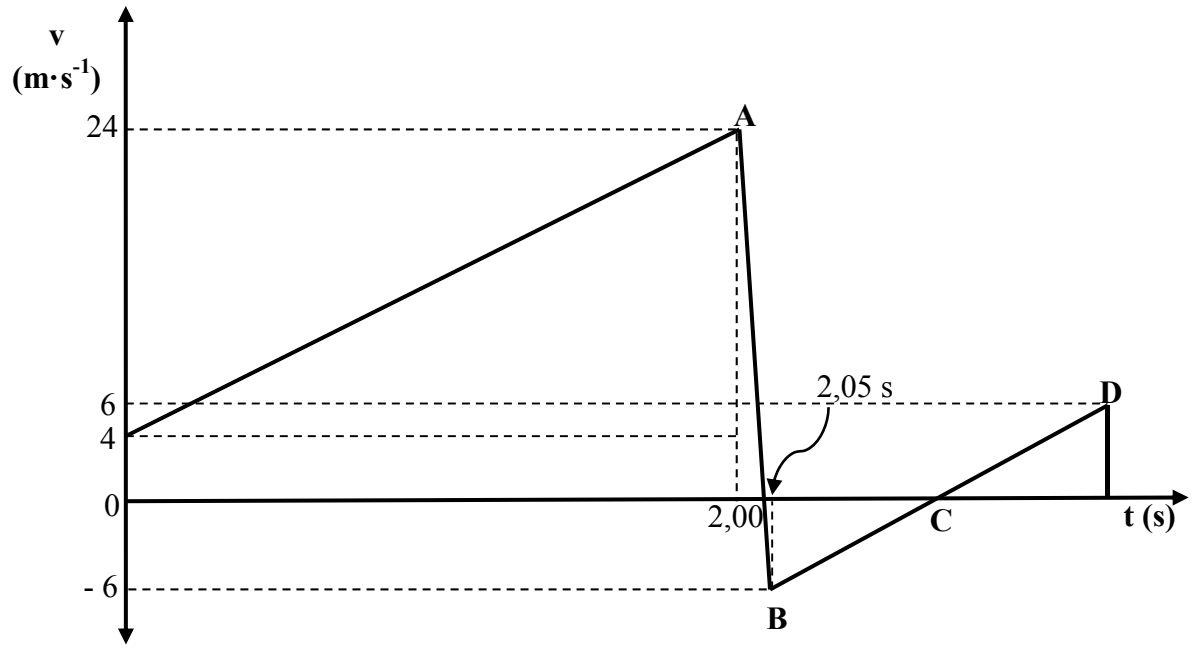
2.1.4 Calculate the speed of the monkeys immediately after they join and start to move off together from position B. (Assume the 'collision' at B is linear.) Give your answer to two decimal places. (4)

2.1.5 **Explain** why the height of the wall at position C must be lower than the height of the log at position A. (No further calculations are required.) (2)

2.2 The monkeys climb a tree with a bag of apples which they have stolen from the camp site. One monkey throws an apple straight down towards the ground with an initial speed of 4 $m \cdot s^{-1}$.

[<http://www.vervet.za.org>]

The velocity-time graph below represents the motion of the apple



Note: Down is the positive direction.

2.2.1 At which point on the graph (A, B, C or D) did the apple hit the ground for the first time? (1)

2.2.2 At which point on the graph (A, B, C or D) did the apple reach the top of its first bounce? (1)

2.2.3 Describe the motion of the apple between B and C. (3)

2.2.4 Use the graph to calculate the height, **relative to the ground**, from which the apple was thrown. (4)

2.2.5 Use the graph to calculate the magnitude and direction of the average net (resultant) force acting on the apple between A and B. The mass of the apple is 150 g. (6)

2.2.6 Draw a displacement-time sketch graph to represent the change in position of the apple for the same time period given in the velocity-time graph. No values need to be shown, but the positions A, B, C and D must be clearly marked. **Take the ground as your frame of reference**. (6)

[35]

QUESTION 3 GAME CAPTURE

Phineas and Andre work for the game capture unit of the National Parks. Their job is to assist in the capture and relocation of wild life.

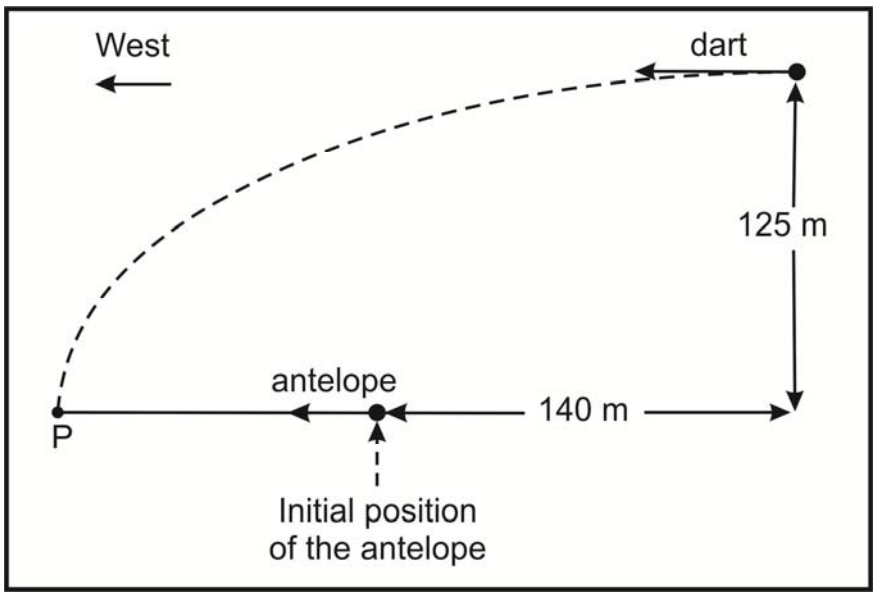
3.1 The picture below shows them flying in a helicopter on an assignment to capture a sable antelope.

[<http://www.bassair-aviation.co.za/dart.jpg>]

The sable antelope is running at 15 $m \cdot s^{-1}$ west and the helicopter is flying horizontally at 23 $m \cdot s^{-1}$ west, with all the velocities measured relative to the ground.

When the helicopter is a horizontal distance of 140 m behind the sable antelope and at a steady height of 125 m above the sable antelope, Phineas fires a dart horizontally with a velocity of 20 $m \cdot s^{-1}$ west relative to the helicopter.

Diagram to show the relative position of the dart and the sable antelope at the time that the dart is fired. (Diagram NOT to scale)



Ignore the effects of air friction.

3.1.1 Show that the time taken for the dart to reach the position labelled P in the diagram is 5 s. (3)

3.1.2 What is the initial velocity of the dart relative to the ground? (2)

3.1.3 Assuming that the sable antelope continues to run at a constant velocity of 15 $m \cdot s^{-1}$ west after the dart is fired, show by means of suitable calculations that the dart hits the sable antelope at position P. (6)

3.1.4 Calculate the magnitude of the velocity of the dart as it strikes the sable antelope at position P. (5)

3.2 In another assignment Phineas and Andre assist in the relocation of a rhinoceros. The photograph shows the rhinoceros lying on a platform which is raised by means of a crane.

[<http://www.sanparks.org>]

The rhinoceros and platform (combined mass 3 000 kg) are accelerated uniformly upwards from rest to a speed of 0,4 $m \cdot s^{-1}$ through a distance of 0,5 m. They are then raised a further 0,8 m at a constant velocity of 0,4 $m \cdot s^{-1}$.

Ignore the effects of air friction.

3.2.1 Calculate the magnitude of the acceleration of the rhinoceros and platform when raised upwards from rest through a distance of 0,5 m. (4)

3.2.2 Define *work*. (2)

3.2.3 Calculate the work done by the crane's motor when accelerating the rhinoceros and platform upwards from rest through a distance of 0,5 m. (6)

3.2.4 Calculate the minimum output power of the motor used by the crane when raising the rhinoceros at constant velocity. (4)

[32]

QUESTION 4 WATER HOLE

The Etosha National Park (Game Reserve) in northern Namibia has no rivers and the rainfall is unpredictable, therefore the animals rely on waterholes. In some of the very arid (dry) areas boreholes have been sunk. Initially windmills were used to pump the water but these have all been replaced with either diesel or solar pumps.

[<http://www.nwf.org>]

4.1 Suggest one possible reason why the windmill pumps were replaced. (1)

4.2 Suggest one advantage and one disadvantage of using diesel powered pumps. (2)

4.3 Suggest one advantage and one disadvantage of using solar powered pumps. (2)

One of the pumps needs to be replaced and Karl and Helga are given the task of finding out which solar pump should be used. They test three different pumps by measuring the time taken to raise 50 litres (50 kg) of water from a depth of 80 m. They test each pump four times. They test pumps A and B on the same afternoon at the end of a sunny day and they test pump C on a cloudy morning three days later. Their results are tabulated below.

Table to show the time taken to pump 50 kg of water from a depth of 80 m.

	Time (s)		
	Pump A	**Pump B**	**Pump C**
Reading 1	22,8	27,4	36,6
Reading 2	34,1	27,3	37,2
Reading 3	27,3	27,5	36,8
Reading 4	15,4	27,4	37,0
Average	**24,9**	**27,4**	**36,9**

4.4 What was the dependent variable in their investigation? (2)

4.5 Identify two important variables that they controlled. (2)

4.6 Identify a variable that they did not control and state how this may have affected the validity of their results. (3)

4.7 Which pump (A, B or C) gave the most precise results? Briefly explain why you consider the results for this pump to be precise. (3)

4.8 Which pump (A or B) gave the least reliable results? Briefly explain why you consider the results for this pump to be unreliable. (3)

4.9 Which pump (A or B) would you recommend to be installed? Justify your choice. (3)

[21]

QUESTION 5 WAVES

5.1 The average hearing range of a healthy young human adult lies between 20 Hz and 20 kHz. Sound waves with frequencies below 20 Hz are classified as **infrasonic**. Sound waves with frequencies above 20 kHz are classified as **ultrasonic**. Rhinoceroses call each other with sounds that have a wavelength of 68 m.

5.1.1 Calculate the frequency of the rhinoceros's call and hence classify it as either infrasonic, ultrasonic or within the human hearing range. Take the speed of sound in air to be 340 $m \cdot s^{-1}$. (4)

5.1.2 What type of sound waves will diffract around an obstacle to a greater extent: infrasonic or ultrasonic? Briefly explain your answer. (2)

5.2 There is a military air-force base near the game reserve. Seshni is watching a herd of impala when a jet flying at Mach 2 passes overhead producing a sonic boom that causes the herd to scatter in all directions.

5.2.1 Is the jet flying at a subsonic or supersonic speed? (1)

5.2.2 What is a sonic boom? (2)

5.2.3 The pressure from sonic booms caused by aircraft can vary as shown in the table below. An aircraft flying at greater altitude will generate lower pressures on the ground, because the shock wave reduces in intensity as it spreads out away from the aircraft. Larger aircraft generate higher pressures. The sonic booms are less affected by aircraft speed.

Aircraft	Speed	Altitude (m)	Pressure at the ground (Pa)	Length (m)	Wing area (m^2)
SR-71 reconnaissance plane	Mach 3	24 000	43	33	170
Concorde	Mach 2	15 600	93	62	358

[Adapted from: <http://en.wikipedia.org>]

[<http://en.wikipedia.org>]

[<http://www.airlinersairlinersairliners.net>]

(a) Give **two** possible reasons why the pressure produced by the Concorde is so much greater than that produced by the SR-71 reconnaissance plane even though the Concorde is flying at a lower speed. (2)

(b) In your opinion what rules should there be concerning the flight of military jets from air-force bases located near game reserves? Propose **two** rules that you would make to lessen the impact of the sonic boom. (4)

5.3 Seshni and Rajesh are sitting out under the night stars in the game reserve.

Rajesh comments, *"The stars seem to be moving towards us."*

Seshni argues, *"You're wrong. The universe is expanding so the stars and the Earth are actually getting further apart."*

Diagram 1 shows the position of a spectral line of hydrogen as observed from a hydrogen discharge tube in a laboratory on the Earth. Diagram 2 shows that of the same spectral line of hydrogen received from the light of a star in a distant galaxy.

Diagram 1: Spectral line of hydrogen from hydrogen discharge tube

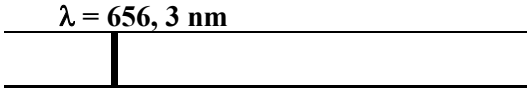
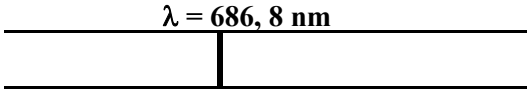


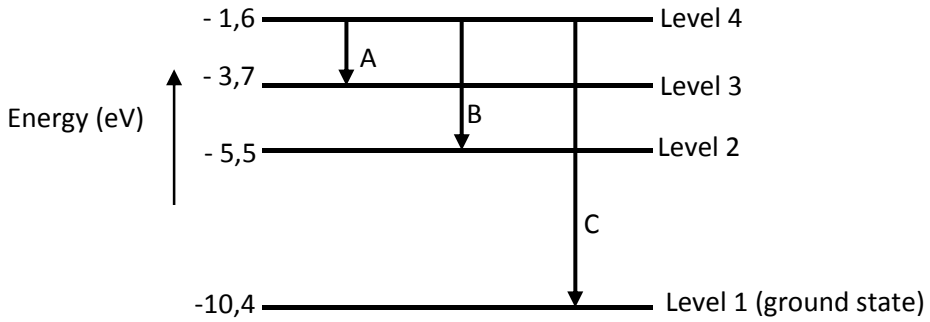
Diagram 2: Same spectral line of hydrogen from star in a distant galaxy



Who is more correct, Rajesh or Seshni? Use evidence given in Diagrams 1 and 2 to support your answer. (4)

5.4 Line emission spectra are produced as a result of electron transitions between energy levels of the atom. Diagram 3 shows some of the outer energy levels of the mercury atom. An electron has been excited to the – 1,6 eV energy level (Level 4). The diagram shows three possible ways that it can return to the -10,4 eV energy level (Level 1, ground state).

Diagram 3: Energy levels of the mercury atom



5.4.1 The three energy transitions produce three different spectral lines. Which transition (A, B or C) will produce the spectral line with:

(a) the longest wavelength? (1)
(b) the most energy? (1)

5.4.2 Calculate the frequency of the electromagnetic radiation emitted when an electron falls from Level 4 back to its ground state (Level 1) as shown by the transition labelled C. (5)

[26]

QUESTION 6 CAMPING FRIDGE

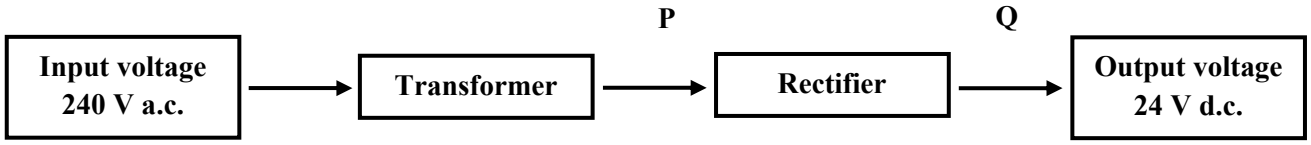
Mike and Sue have a camping fridge which requires a 24 V d.c. power source. Two 12 V car batteries can be used to provide the required voltage.

6.1 How should the batteries be connected to each other in order to provide the 24 V required by the fridge? (1)

6.2 When the batteries are connected correctly the fridge draws a current of 6 A. Calculate the power input to the fridge. Ignore the internal resistance of the batteries. (3)

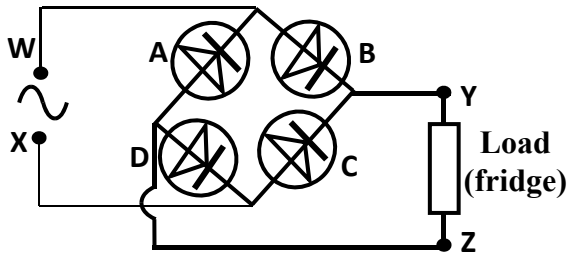
6.3 The fridge can also be connected via a transformer and rectifier to a 240 V a.c. source as shown in the simplified flow chart in Diagram 1 below.

Diagram 1: Flow chart to show how voltage is changed from 240 V a.c. to 24 V d.c.



The rectifier consists of a combination of diodes connected as shown in Diagram 2.

Diagram 2: Arrangement of diodes in rectifier



6.3.1 What is a diode? (2)

6.3.2 What is the function of the rectifier? (2)

6.3.3 Describe the path taken by conventional current in the circuit shown in Diagram 2 **when W is positive**. Indicate which diodes (A, B, C, D) the current passes through and the direction of the current through the load (Y to Z or Z to Y). (3)

6.3.4 What type of transformer (step-up or step-down) is required in Diagram 1? (1)

6.3.5 Ignoring actual values of emf and time, draw sketch graphs to represent the change in emf with time

(a) immediately **before** the current passes through the rectifier (position P on Diagram 1) and

(b) immediately **after** the current passes through the rectifier (position Q on Diagram 1) (4)

6.3.6 What circuit component can be placed directly after the rectifier to 'smooth' the current? (1)

[17]

QUESTION 7 KINETIC TORCH

Natalie has a kinetic torch which she finds very useful when she goes camping as it produces electricity when it is shaken. When she shakes the torch a magnet moves back and forth through a hollow solenoid that is connected via a simple circuit to an LED.

[<http://www.choiceful.com>]

She decides to conduct an experiment to determine how the speed at which a magnet moves through a solenoid affects the emf induced across the ends of the solenoid. She makes use of apparatus available in her school science laboratory and follows the method outlined below.

Method

1. Set up the apparatus as shown in the diagram.
2. Release the magnet from a height of 5 cm above the top of the solenoid so that it falls through the centre of the solenoid.
3. Record the maximum induced emf as the magnet enters the solenoid.
4. Repeat steps 1 to 3 dropping the magnet from heights of 10 cm, 15 cm, 20 cm and 25 cm respectively above the top of the solenoid.
5. Calculate the speed of the magnet on entry to the solenoid.

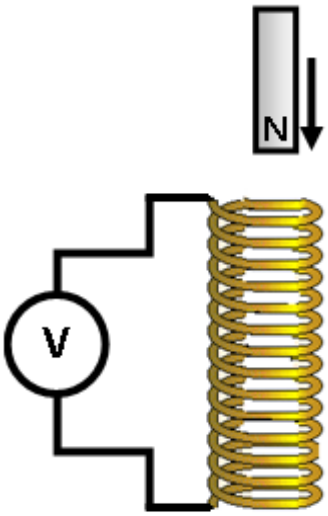


Table to show the magnitude of the maximum induced emf on entry, for a magnet falling through a solenoid at different speeds.

Height (m)	Entry Speed ($m \cdot s^{-1}$)	Maximum induced emf on entry (V)
0,05	1,00	0,27
0,10	1,41	0,39
0,15	1,73	0,46
0,20	2,00	0,53
0,25	2,23	0,60

7.1 On the **diagram provided on your Answer Sheet** use clear arrows to mark the direction of the current induced in the solenoid as the magnet enters. (2)

7.2 On the **graph paper provided on your Answer Sheet** plot a graph of maximum induced emf on entry against entry speed for the magnet falling through the solenoid. (7)

7.3 Use your graph to determine the maximum induced emf on entry when the magnet enters the solenoid at a speed of 1,30 $m \cdot s^{-1}$. (2)

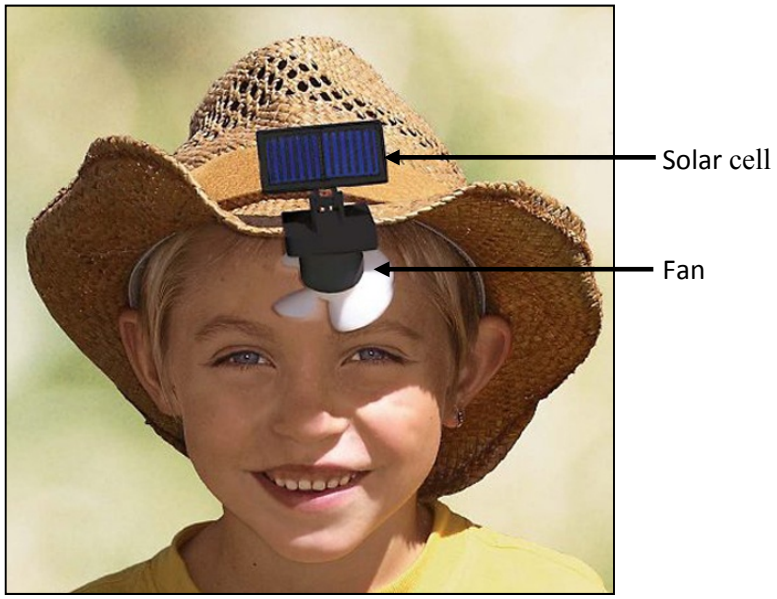
7.4 What can you conclude about the relationship between the entry speed of the magnet and the maximum induced emf? (2)

7.5 Suggest **two** changes that could be made to the design of the kinetic torch to produce a larger emf. (4)

[17]

QUESTION 8 SOLAR FAN

Nicky has a solar fan which can be clipped onto the front of her hat as shown in the picture.



[<http://www.geeky-gadgets.com>]

The advert for the solar hat fan says the following:

> 'The solar cell can convert solar energy directly into electric power which can turn on the fan. Its fanning speed can change automatically depending on the availability of sunlight. The emission of electrons from the metal cathode of the solar cell is an application of the photoelectric effect.'

[Adapted from: <http://www.net-china.com>]

8.1 Explain why the fan turns faster when the sunlight intensity increases. (2)

8.2 The metal cathode of the solar cell, in the hat fan, has a work function of 2,13 eV.

8.2.1 Define *threshold frequency*. (2)

8.2.2 Calculate the threshold frequency of the metal cathode. (5)

8.2.3 Nicky shines green light from a 60 W bulb onto the solar cell. The maximum speed of the photo-electrons emitted is $2{,}39 \times 10^5$ $m \cdot s^{-1}$. Calculate the energy of a photon of green light. (4)

8.2.4 Nicky replaces the 60 W green light bulb with a 60 W ultra-violet light bulb and holds it the same distance from the solar cell of the hat fan. How will this affect the maximum speed of the emitted electrons? *(Increase, decrease or no change)* (2)

8.3 Nicky conducts further experiments using a 60 W green bulb and a 100 W green bulb, each of which is designed to operate from a 240 V power source.

8.3.1 Define *resistance.* (2)

8.3.2 Calculate the resistance of each of the bulbs. (4)

She connects the two bulbs as shown in the circuit diagrams.

Diagram 1

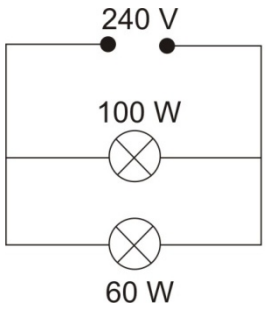
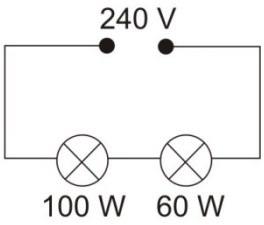


Diagram 2



8.3.3 Which bulb will glow brightest in the circuit shown in Diagram 1? (1)

8.3.4 Which bulb will glow brightest in the circuit shown in Diagram 2? Justify your answer with reference to one or more suitable formulae. (4)

[26]

QUESTION 9 ELECTRIC LAND ROVERS

Read the following article adapted from *Popular Mechanics* (Nov 2009).

GO SILENT go green by Sean Woods

South African vehicles emit over 44 million tonnes of CO_2 per year. Londolozi Game Reserve decided to reduce their carbon footprint by converting their diesel engine Land Rovers to electric. The engine was replaced with an electric motor powered by a number of 12 V batteries, which can be charged within 6 hours. They are exploring the possibility of using solar panels to charge the batteries. The dashboard has an ammeter to measure the current.

The electric vehicle handles just like the conventional Land Rover in 4 x 4 mode. It can be driven at 70 $km \cdot h^{-1}$ for about 2,5 hours on dirt roads. The general manager, states, "We are able to approach closer to birds and nocturnal (night-time) animals than with a conventional vehicle owing to silence and a lack of poisonous emissions. It might be a small project in the greater scheme of things, but it is by no means inconsequential (unimportant). We believe that global warming is not a problem for the future but a crisis for the present moment."

9.1 Why is it necessary to measure the current whilst travelling in the electric Land Rover? (1)

9.2 Does the replacement of a diesel engine with a 12 V battery and an electric motor actually reduce the carbon footprint? Justify your answer. (3)

9.3 Consider the following response to the final paragraph of the article:

The advantages to the environment of converting a small fleet of Land Rovers to electric are negligible when compared with the damage caused by the millions of conventional vehicles on our roads. The money, time and effort spent on this project would be better invested somewhere else.

Construct a reasoned response to the above statement in which you identify the pros and cons to the environment (air/animals/plants) of using electric Land Rovers as opposed to diesel Land Rovers in the game reserve. Consider also the impact on the game viewing experience of the visitors to the game reserve.

Use the following format for your answer:
Pros *(maximum of 2 points)*
Cons *(maximum of 2 points)*
Overall opinion
I think that the conversion of Land Rovers from diesel to electric is a (valuable/ meaningless) project because ... (8)
[12]

Total: 200 marks