NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2013

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 13 pages;
   - a yellow Answer Booklet of 5 pages (i – v); 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 Booklet.**

3. ALL of the questions must be answered.

4. Read the questions carefully.

5. Use the data and formulae whenever necessary.

6. QUESTION 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the inside front 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.

7. **Questions 3.2 and 4.1.3 must be answered in the yellow Answer Booklet**.

8. Start each question on a new page.

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

10. An approved calculator (non-programmable, non-graphical) may be used.

11. Show your working in all calculations.

12. 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 inside front cover of your Answer Book. Make a cross (X) on the letter of the response which you consider to be the most correct.

1.1 What name is given to the ability of a wave to spread after it passes through a small gap?

A refraction
B diffraction
C interference
D reflection

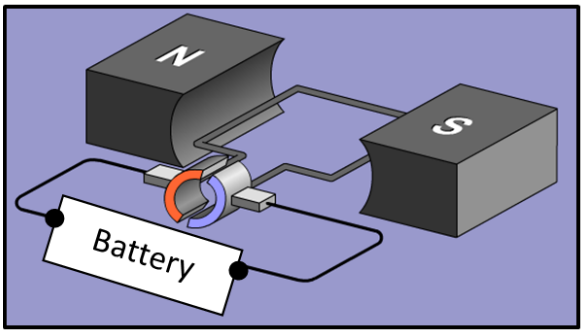
1.2 Which one of the following correctly describes the speed of the source and the type of interference, when a **shock wave** is formed by a moving sound source?

	Speed of sound source	**Type of interference**
A	Subsonic	Constructive
B	Subsonic	Destructive
C	Supersonic	Constructive
D	Supersonic	Destructive

1.3 Which one of the following correctly places the given electromagnetic waves in order of increasing wavelength?

A infra-red, microwaves, ultra-violet
B microwaves, gamma rays, visible light
C radio waves, microwaves, visible light
D ultra-violet, visible light, microwaves

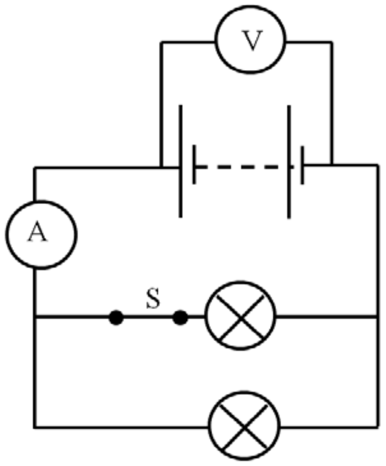
1.4 What type of electrical machine is represented in the diagram below?



[Adapted from PLATO MSS 11 – 16]

A d.c. motor
B a.c. motor
C d.c. generator
D a.c. generator

1.5 In the circuit shown below the resistances of the battery, ammeter, switch and connecting wires are negligible. The voltmeter has a very high resistance.

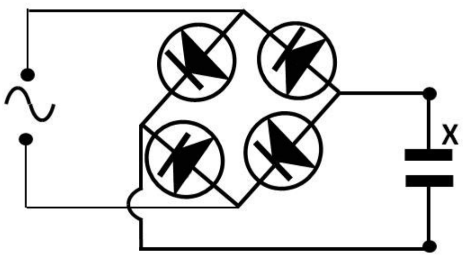


How are the readings on the ammeter and voltmeter affected if switch **S** is opened?

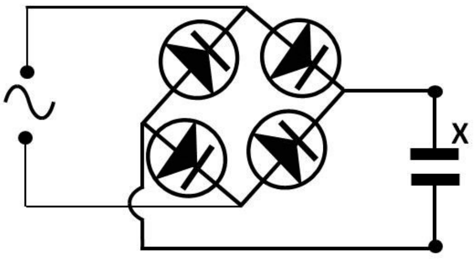
	AMMETER	**VOLTMETER**
A	Decrease	Increase
B	Decrease	No change
C	Increase	No change
D	Increase	Decrease

1.6 Which one of the following arrangements of diodes will change the a.c. input current to d.c. in such a way that the top plate (X) of the capacitor is always negative?

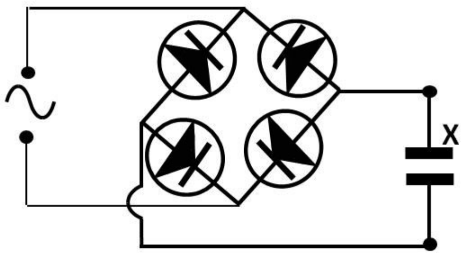
A



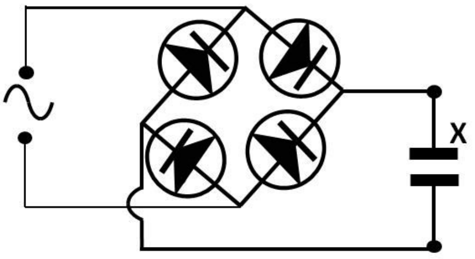
B



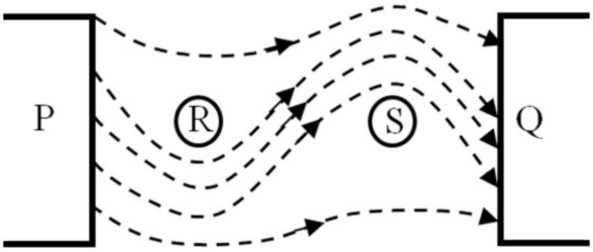
C



D



1.7 The diagram represents a cross-section through a rectangular current carrying coil of lengths R and S, of a motor, between magnetic poles, P and Q. The magnetic field lines are shown.

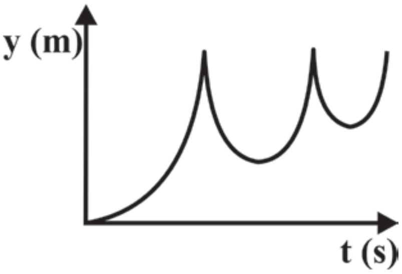


Which one of the following correctly gives the polarity of the pole P and the direction of the current inside R of the coil?

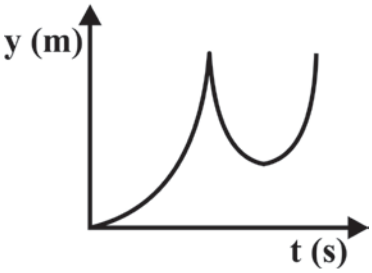
	Polarity of P	**Current in R**
A	South	Into page
B	South	Out of page
C	North	Into page
D	North	Out of page

1.8 Which one of the following position vs time graphs represents a ball that is dropped and bounces TWICE before coming to rest? The frame of reference is the **starting point**.

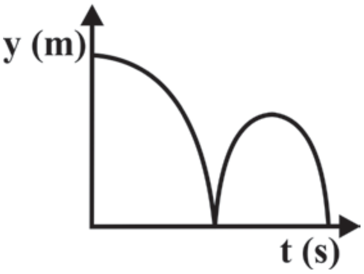
A



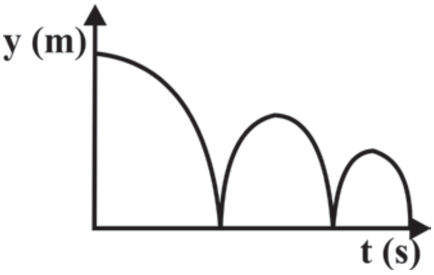
B



C



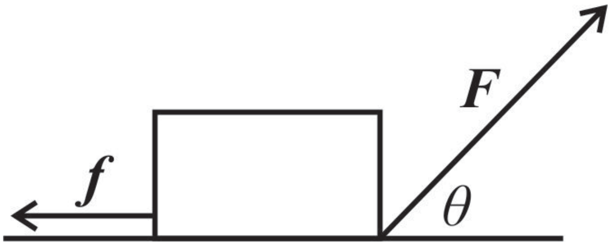
D



1.9 Two identical bodies are dropped from rest from different heights in a vacuum. After they have both fallen for the same time which one of the following physical quantities will be different for the two bodies?

A velocity
B kinetic energy
C gravitational potential energy
D acceleration

1.10 A box is pulled in a straight line, a distance Δx, across a horizontal rough surface by means of a rope inclined at an angle θ to the horizontal. The constant applied force is F and the constant frictional force is f.



The work done by the rope on the box in moving it a distance Δx is:

A $F.\Delta x$
B $(F\cos\theta - f).\Delta x$
C $(F\cos\theta + f).\Delta x$
D $F\cos\theta.\Delta x$

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QUESTION 2 ACCIDENT

Two cars, A and B, have a head-on collision and lock together on impact, as represented in the sketch below. Ignore frictional effects during the collision but not after the collision.

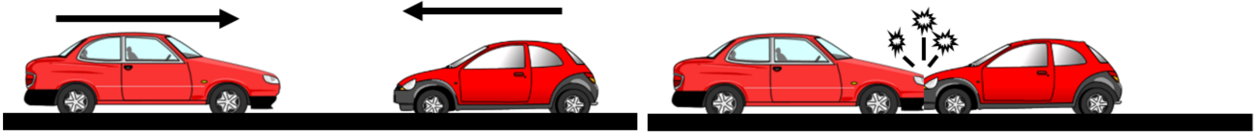
BEFORE COLLISION

Car A
mass = 1 500 kg
velocity = 20 m.s^{-1} right

Car B
mass = 1 000 kg
velocity = ?

AFTER COLLISION

Wreck A + B
mass = 2 500 kg
velocity = 6 m.s^{-1} right



2.1 State *the law of conservation of momentum*. (2)

2.2 Calculate the speed of car B immediately before it collided with car A. (4)

2.3 Use suitable calculations to determine whether or not the collision was elastic. (6)

2.4 Calculate the magnitude of the driving force on car A **before** the collision if the power used is 38 kW. (4)

2.5 Define *relative velocity*. (2)

2.6 What is the velocity of car B relative to car A before they collided? (2)

2.7 Define *impulse*. (2)

2.8 2.8.1 Which car, if any, experiences the greater magnitude of impulse during the collision? (1)

2.8.2 Justify your answer to Question 2.8.1 by referring to relevant physical principles and/or supplying supporting calculations. You must refer to or make use of a suitable formula. (3)

2.9 The drivers of both cars have the same mass. Both drivers are wearing seatbelts which stretch slightly to bring the drivers to rest, relative to the car, in the same time period. Neither car has air bags.

2.9.1 Which driver is likely to experience the greater force during the collision, *driver A*, *driver B* or *both the same*?

Explain your answer with reference to one or more suitable formulae. (4)

2.9.2 Airbags are important safety features in cars. Using principles of physics, explain how airbags protect the driver during a collision. (3)

2.10 The wreck (A + B) skids for a distance of 9 m before coming to rest.

2.10.1 Calculate the time taken for the wreck to come to rest. (4)

2.10.2 Calculate the frictional force exerted by the road on the wreck. (6)

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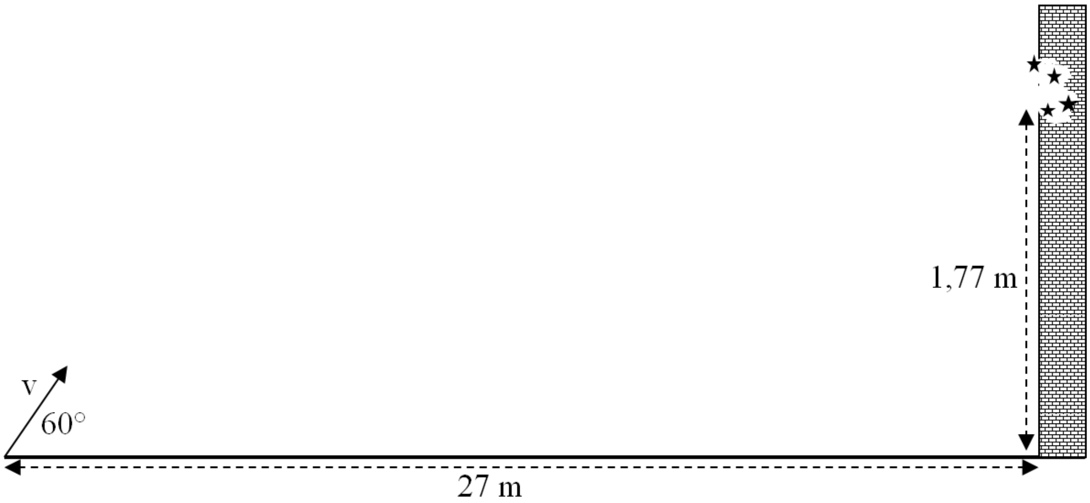
QUESTION 3 PROJECTILE MOTION

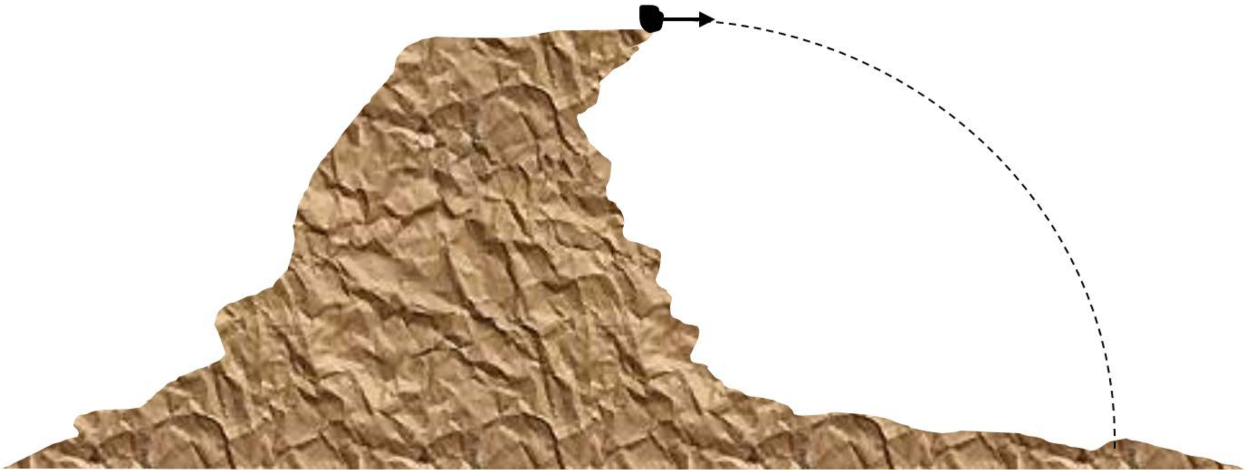
3.1 A missile is projected upwards from the ground with a speed 'v' at an angle of 60° above the horizontal. It hits a wall at a height of 1,77 m above the ground. The wall is a horizontal distance of 27 m from the launch point. Ignore air resistance.

Diagram is NOT drawn to scale.



Calculate the launch speed 'v' of the missile. (6)

3.2 A stone is projected horizontally from rest from the top of a rock on an unknown planet. No air resistance acts on the stone.



The graph on page ii of the Answer Booklet represents the relationship between the horizontal and vertical position of the stone at consecutive time intervals of 0,2 s.

ANSWER THE REST OF THIS QUESTION IN THE ANSWER BOOKLET. (26)

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QUESTION 4 DOPPLER EFFECT

4.1 An experiment is conducted to determine how the speed of a sound source moving towards a stationary observer affects the apparent frequency of the sound heard by the observer. The results of the experiment are tabulated below.

Speed of source (m.s^{-1})	**Apparent frequency (Hz)**
30	197
50	210
70	225
100	252
150	316
200	423

4.1.1 When representing these results on a graph which of the variables should be plotted on the *x*-axis? Justify your choice. (2)

4.1.2 Two other variables relating to the Doppler effect should be kept constant in this experiment. Name one of these variables and explain why this variable should be kept constant. (3)

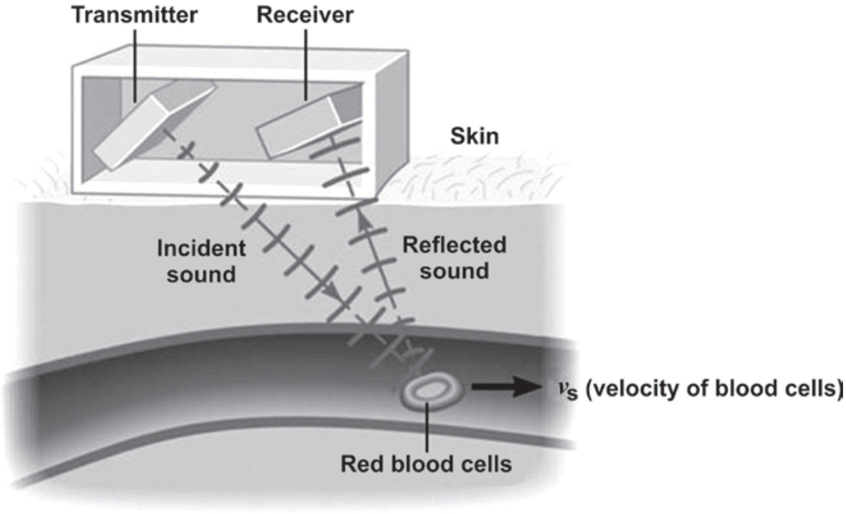
4.1.3 On the graph paper provided in your Answer Booklet plot a best fit curve to represent the results of this experiment. **Start both of the axes at 0**. (7)

4.1.4 Use your graph to determine the speed of the source when the apparent frequency heard by the observer is 300 Hz. (2)

4.1.5 Use your graph to determine the true frequency of the source. (2)

4.1.6 Use the results of the experiment conducted at a source speed of 100 m.s^{-1} to calculate the speed of sound in air on the day the experiment was conducted. (4)

4.2 Scientists have made use of the Doppler Effect in various forms of technology for the benefit of society. Consider the diagram of the Doppler Flow Meter which is used to measure the speed of blood flow.



[<http://s3.amazonaws.com>]

4.2.1 Make use of the diagram to explain, in point form, how the Doppler Flow Meter makes use of the Doppler Effect to measure the speed of blood flow. Your explanation must include how the frequency of the reflected waves compares with the frequency of the transmitted (incident) waves. (4)

4.2.2 Name one other form of technology that makes use of the Doppler Effect. (1)

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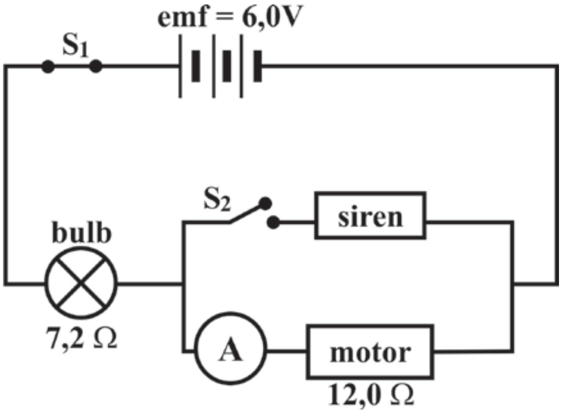
QUESTION 5 AMBULANCE

Tommy has a toy ambulance which has a light, a siren and a motor. The circuit diagram for the electric circuit of the ambulance is given below. The resistances of the battery, ammeter, switches and connecting wires can be ignored.



When Tommy closes ONLY switch 1 (S_1) (with switch 2 (S_2) open), the light comes on while the ambulance moves at a constant speed.

5.1 Calculate the reading on the ammeter when only switch 1 (S_1) is closed. Give your answer to 2 decimal places. (4)

5.2 Calculate the rate of energy transfer (power) in the bulb when only switch 1 is closed. Give your answer to 2 decimal places. (4)

When Tommy closes both switches 1 (S_1) and 2 (S_2) the siren sounds and the reading on the ammeter is 200 mA.

5.3 Calculate the potential difference across the motor. (3)

5.4 Calculate the new current through the bulb. (3)

5.5 Calculate the total resistance of the circuit. (3)

5.6 Calculate the resistance of the siren. (4)

5.7 How will the following change when the siren sounds? (Write only *increase, decrease* or *no effect*)

5.7.1 The brightness of the bulb (1)

5.7.2 The speed of the ambulance (1)

5.8 Explain your answer to Question 5.7.1 with reference to one or more suitable formulae. (2)

5.9 Explain your answer to Question 5.7.2 with reference to one or more suitable formulae. (2)

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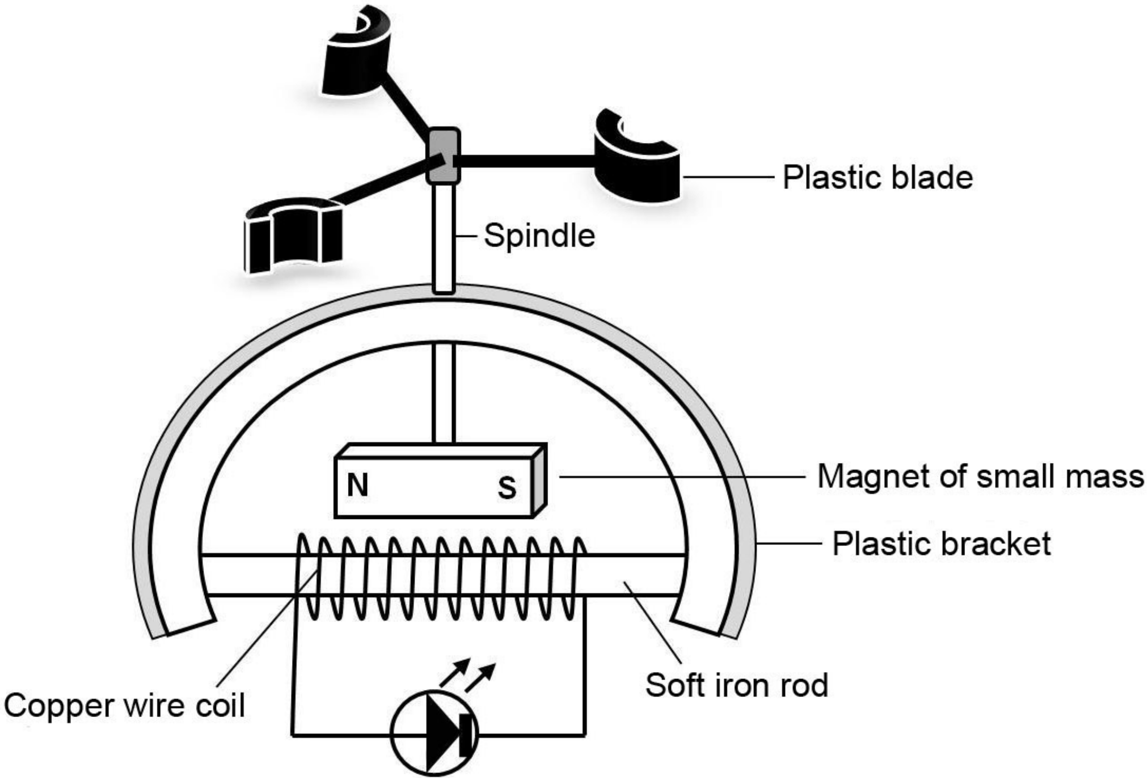
QUESTION 6 GENERATOR

Tawanda makes a small wind generator as shown in the diagram below. The plastic blades catch the wind which causes the spindle and magnet to turn. Below the magnet is a copper coil of wire wound around a soft iron rod and attached to a light emitting diode.

Diagram NOT drawn to scale.



Tawanda makes the following observations:

- As the magnet turns the LED flashes on and off regardless of the speed of rotation.
- When the LED is replaced with a small filament globe,
  - the globe shines brighter when the magnet spins faster.
  - when the magnet rotates fast enough the bulb glows continuously.

6.1 State the energy conversions that take place in this generator. (2)

6.2 Explain why an emf is induced in the coil when the magnet rotates. (2)

6.3 Explain why the LED flashes on and off, regardless of the speed of rotation of the magnet. (4)

6.4 Use Faraday's Law of Electromagnetic Induction to explain why the globe is brighter when the magnet turns faster. (4)

6.5 What is the advantage of using a magnet of **small mass** rather than a **heavy** magnet? (2)

6.6 Suggest TWO more design changes that Tawanda could make to his generator that would cause it to produce a greater emf, other than changing the mass of the magnet. (2)

6.7 Wind generated power is an example of a renewable energy source which does not produce greenhouse gases whilst generating electrical power.

6.7.1 Give TWO other examples of renewable energy sources that do not produce greenhouse gases whilst generating electrical power. (2)

6.7.2 Why are wind turbines considered an unreliable source of power generation? (1)

6.7.3 State TWO complaints that environmentalists may have against wind generated power. (4)

[23]

QUESTION 7 AUTOMATIC CAMERA

Read the following information regarding the use of light meters in fully automatic cameras.

> A fully automatic camera has a built-in light meter. When light comes into the light meter, it strikes a metal object that releases electrons and creates a current. This automatically opens and closes the lens to adjust for high and low lighting conditions.

[Adapted from <http://discover.edventures.com>]

7.1 What name is given to the physical phenomenon whereby electrons are released from a metal when light strikes the metal? (1)

7.2 **Bright** light (high intensity) produces a greater current than **dim** light (low intensity).

7.2.1 How is the maximum kinetic energy of the electrons that are emitted affected by using brighter light? (State *increase, decrease* or *no effect*) (1)

7.2.2 How is the number of electrons that are emitted per second affected by using a brighter light? (State *increase, decrease* or *no effect*) (1)

7.2.3 Explain your answers to Question 7.2.1 and Question 7.2.2 and hence explain why bright light produces a greater current than dim light. (4)

7.3 What happens to the maximum speed of the electrons that are emitted, as the frequency of the incident light is increased? (State only *increases, decreases* or *no effect*) Assume that the intensity remains constant. (1)

7.4 Explain your answer to Question 7.3 with reference to one or more suitable formulae. (3)

7.5 A certain metal has a work function of $3{,}8 \times 10^{-19}$J. Light of wavelength 480 nm strikes the metal surface.

7.5.1 Calculate the frequency of a photon of this light. (4)

7.5.2 Calculate the maximum speed of the electrons emitted when light of wavelength 480 nm strikes the metal surface. (7)

7.5.3 When light of a certain wavelength strikes the metal surface, no electrons are emitted. Suggest a reason why no electrons are emitted. (2)

7.6 When the light intensity is too low the camera flash is activated. The circuit for the flash contains a capacitor which has a capacitance of 220 μF. The potential difference across the plates of the fully charged capacitor is 360 V.

7.6.1 Define *capacitance*. (2)

7.6.2 Calculate the charge stored on the capacitor when fully charged. Give your answer to 3 decimal places. (4)

[30]

Total: 200 marks