NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2012

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 14 pages;
   - a yellow Answer Sheet of 1 page; 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 Shee**t.
   Question 7.1 must be answered on the Answer Sheet.

3. ALL of the questions must be answered.

4. Start each question on a new page.

5. Read the questions carefully.

6. Question 1 consists of 10 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 for you.

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

8. Use the data and formulae whenever necessary.

9. Show your working in all calculations.

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

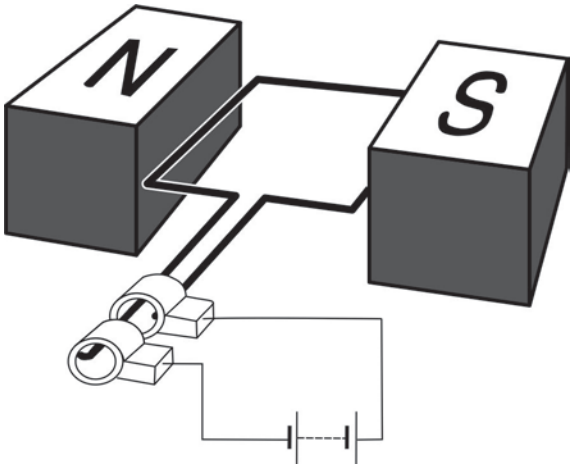
QUESTION 1 MULTIPLE CHOICE QUESTIONS

Select the answer that you consider to be the most correct and mark the letter representing your choice with a cross (X) on the Answer Sheet provided on the inside cover of your Answer Book.

1.1 The name given to a component in an electric circuit which stores charge is …

A a diode.
B a resistor.
C an ammeter.
D a capacitor.

1.2 The diagram shows a current-carrying coil of wire in a magnetic field.



Which one of the following statements concerning the movement of the coil is true?

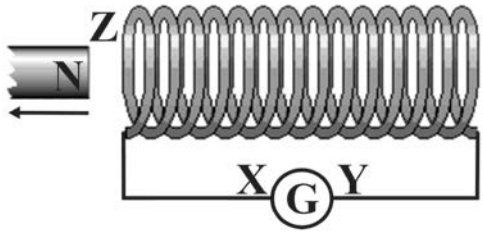
The coil will rotate …

A	clockwise	continuously
B	clockwise	for less than half a revolution
C	anticlockwise	continuously
D	anticlockwise	for less than half a revolution

1.3 Which one of the following will NOT increase the torque (turning force) of an electric motor?

A Using bigger brushes
B Using stronger magnets
C Increasing the number of coils
D Passing a stronger current through the coils

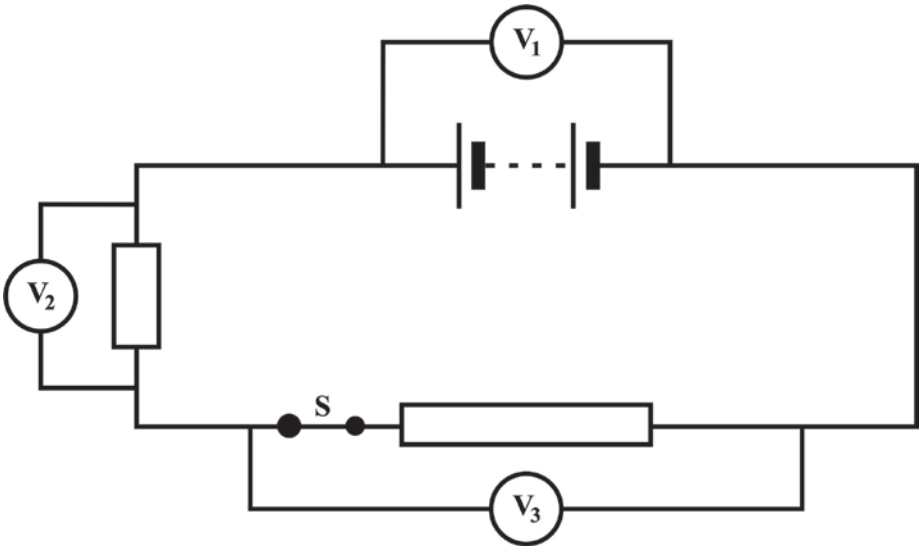
1.4 The diagram shows a magnet leaving a coil. The coil is connected to a galvanometer.



Which one of the following correctly describes the polarity of the coil at **Z** and the direction of the induced (conventional) current through the galvanometer?

	Polarity at Z	**Direction of induced (conventional) current through galvanometer**
A	North	X to Y
B	North	Y to X
C	South	X to Y
D	South	Y to X

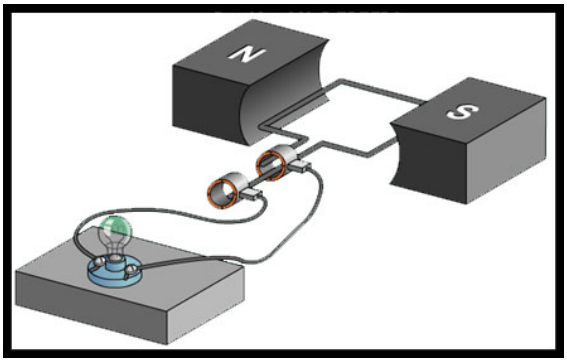
1.5 In the circuit shown below the resistance of the switch and connecting wires is negligible. The voltmeters have very high resistance. The battery has significant internal resistance.



How are the readings on the voltmeters V_1 and V_2 affected when switch S is opened?

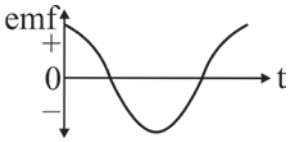
	V_1	**V_2**
A	No change	Increase
B	No change	Decrease
C	Increase	Decrease
D	Increase	Increase

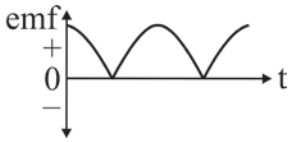
1.6 The diagram represents a simple generator.

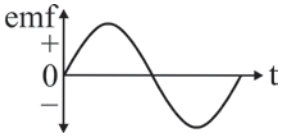


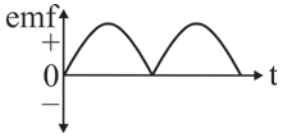
[Plato Learning MSS 11 – 16]

Which one of the following graphs represents the induced emf against time for one full revolution of the coil starting in the horizontal position as shown?

A 

B 

C 

D 

1.7 Which one of the following will NOT work when connected to a dc battery?

A Galvanometer
B Capacitor
C Forward biased diode
D Transformer

1.8 Which one of the following statements does NOT apply to electromagnetic radiation? All electromagnetic waves ...

A travel at 3×10^8 m.s^{-1} in a vacuum.
B are longitudinal waves.
C are generated by accelerating charged particles.
D undergo diffraction and interference.

1.9 Which one of the following statements about microwave radiation is FALSE? Microwaves have …

A longer wavelengths than X-rays.
B more energy than radio waves.
C a higher frequency than ultra-violet light.
D less penetrating ability than gamma rays.

1.10 Which one of the following types of electromagnetic radiation, when incident on a metal, is most likely to cause electrons to be released?

A Microwaves
B Ultra violet
C Visible light
D Infrared

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QUESTION 2 TUGELA FALLS

A group of hikers climbs to the top of Tugela Falls in the Drakensberg Mountains. At a height of 948 m the Tugela Falls is the second highest waterfall in the world. The average mass of water passing over the top of the falls is 6×10^4 kg per minute.

[<http://www.drakensberg-tourist-map.com>]

Ignore any loss in energy due to frictional forces and air resistance.

2.1 Define *gravitational potential energy*. (2)

2.2 Calculate the gravitational potential energy of 6×10^4 kg of water at the top of the falls relative to the bottom of the falls. (3)

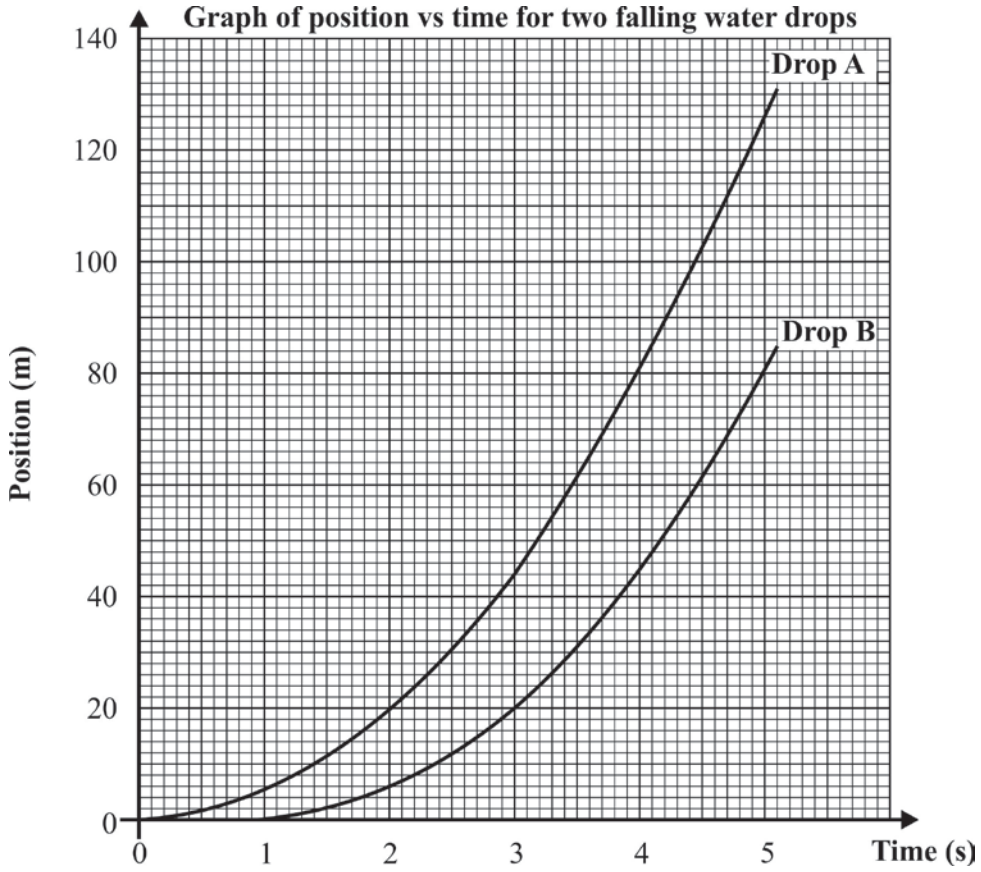
2.3 The gravitational potential energy stored in this water could be used to turn a turbine connected to an electrical generator at the bottom of the falls.

2.3.1 Describe the energy conversion that takes place in a generator. (2)

2.3.2 80% of the power that the water has due to its gravitational potential energy is converted into electrical power by the generator. Calculate the output power of the generator. (5)

2.4 The position-time graphs below show the vertical motion of two drops of water, A and B, as they fall from the top of the falls over a time period of 5 s. Down has been taken as the positive direction.

- **Drop A fell from the top at time t = 0 s.**
- **Drop B fell from the top exactly one second after drop A (t = 1 s).**



2.4.1 What frame of reference was used for the position of the water drops as shown in the graph? (1)

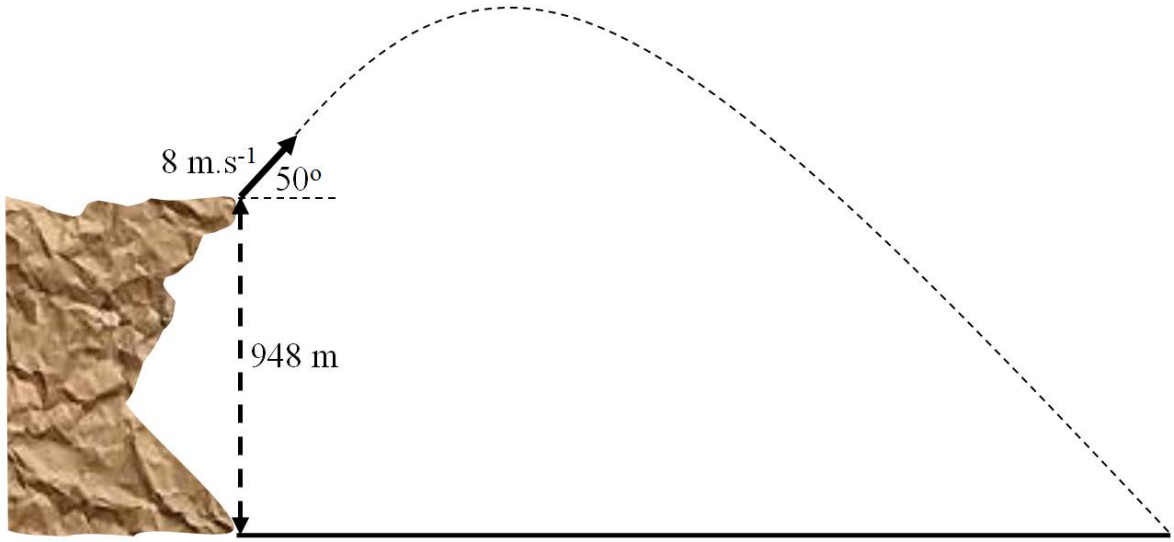
2.4.2 Use your graph to determine the distance between the drops at time t = 4 s. (3)

2.4.3 How is the distance between the drops changing as they are falling? Answer either *increasing, decreasing* or *remains constant.* (1)

2.4.4 Draw velocity-time sketch graphs, on the same set of axes, to represent the motion of the drops. No values need to be shown. Clearly label your graphs A and B. (2)

2.4.5 What is the magnitude and direction of the velocity of drop A relative to drop B at any point in time while the drops are falling? (2)

2.5 A hiker shoots a stone from a catapult from the top of the falls. The stone has an initial velocity of 8 $m.s^{-1}$ at an angle of 50° to the horizontal. The diagram below shows the path of the stone after it is launched.



Ignore the effect of air resistance.

2.5.1 Calculate the maximum height above the top of the falls that the stone reaches. (5)

2.5.2 Calculate the time taken for the stone to reach the bottom of the falls from when it was shot. (5)

2.5.3 Calculate the horizontal distance that the stone lands from the foot of the falls. (4)

2.5.4 Draw an acceleration vs time sketch graph to represent the vertical motion of the stone from the time it left the catapult to the time it landed. Label the acceleration axis with relevant values. Take down as the positive direction. (2)

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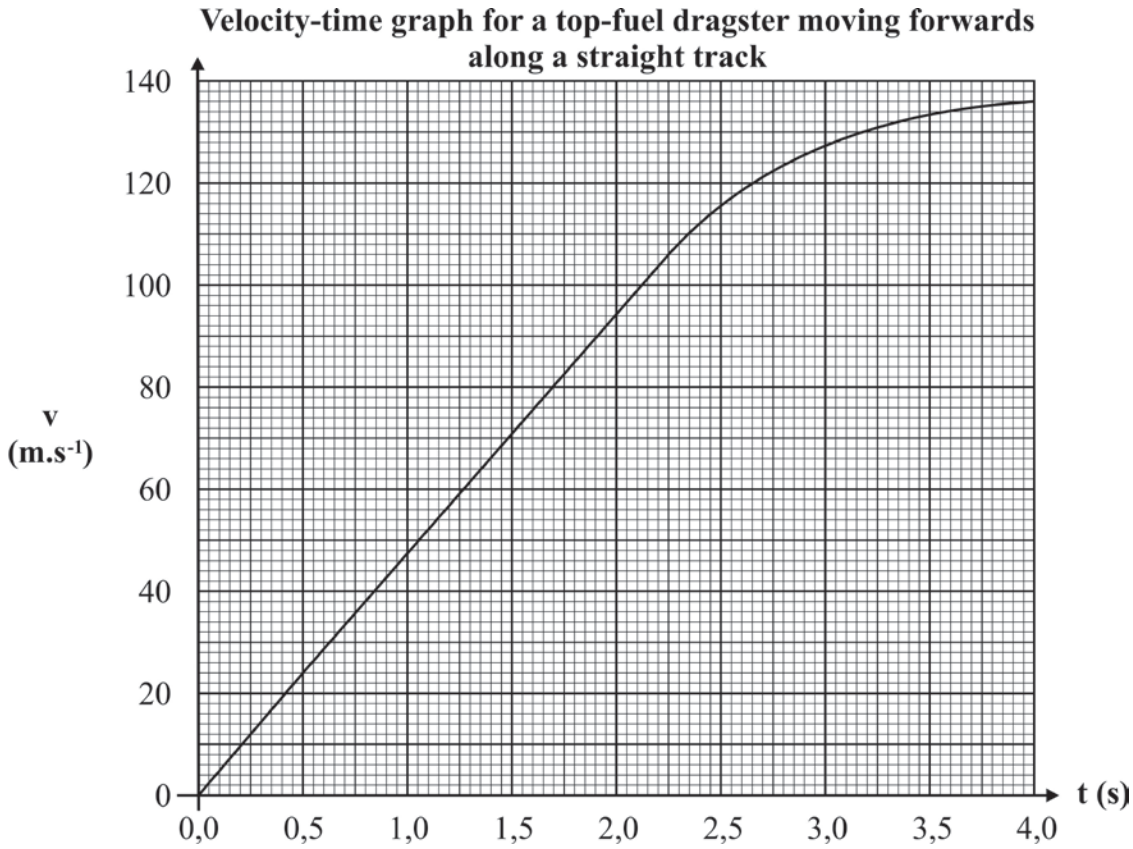
QUESTION 3 TOP-FUEL DRAGSTER

Top-fuel dragsters are the fastest category of drag racing cars.

[<http ://www.el-buskador.com>]



3.1 What physical quantity is represented by the gradient of the graph? (1)

3.2 Calculate the gradient of the graph between 0,5 s and 2,0 s. Give suitable UNITS for your answer. (4)

3.3 Describe the motion of the dragster between:

3.3.1 0,0 s and 2,0 s (2)

3.3.2 2,0 s and 4,0 s (2)

3.4 Use the graph to calculate the distance travelled by the dragster in the first 2,0 s. (4)

3.5 3.5.1 Use the graph to find the speed of the dragster at 4,0 s. (1)

3.5.2 Convert your answer to Question 3.5.1 to $km.h^{-1}$. (1)

3.6 A dragster of mass 1 000 kg can come to rest from a speed of 145 $m.s^{-1}$ in a distance of 150 m. Calculate the magnitude of the net force acting on the dragster over this 150 m braking distance. (6)

3.7 EXPLAIN with reference to a suitable labelled diagram how the pitch of the sound produced by the dragster's engine will change as the car moves at constant speed to the right, away from a stationary observer. Mark the position of the sound source (dragster) with the letter D and the position of the observer with the letter X. (5)

3.8 Read the following information about top-fuel dragster racing before answering Questions 3.8.1 to 3.8.4.

Top-fuel dragster racing

- One race lasts under 4 s, during which time the dragster consumes 23 litres of nitromethane fuel and emits vast quantities of greenhouse gases.
- The g-force produced on acceleration and deceleration can cause detached retinas in the eye.
- Scott Kalitta was killed when his dragster, which was travelling at about 480 $km.h^{-1}$, exploded into flames near the finish line.
- The engine noise produced at top speeds of 480 $km.h^{-1}$ is likened to a 'shock wave' and can cause physical pain or even permanent ear damage in some individuals.
- The extreme internal forces mean that the entire engine has to be replaced after one race.

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

3.8.1 Give TWO reasons why environmental groups may call for the banning of top-fuel dragster racing. (4)

3.8.2 Give ONE reason why human rights organisations may call for the banning of top-fuel dragster racing. (2)

3.8.3 What is a shock wave? (2)

3.8.4 Is it possible for the engine noise of a dragster travelling at 480 $km.h^{-1}$ to cause a shock wave? Explain your answer with reference to a suitable calculation. *(The speed of sound in air is 340 $m.s^{-1}$.)* (3)

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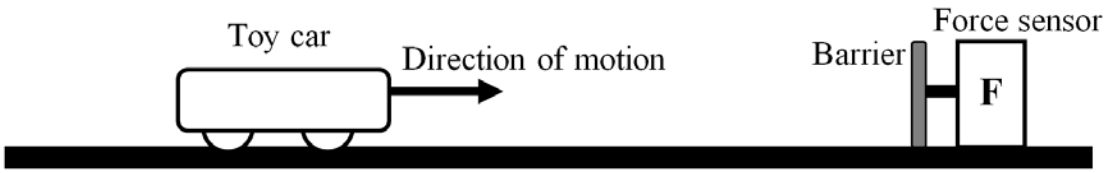
QUESTION 4 CAR CRASH

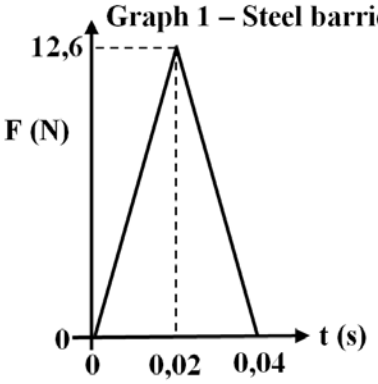
Rob and Kate design an experiment to determine how the hardness of the barrier into which a car crashes affects the maximum force exerted on the car during the collision. They use a toy car which moves along a frictionless track at constant speed and crashes into different barriers attached to a force sensor (as shown in the diagram below).

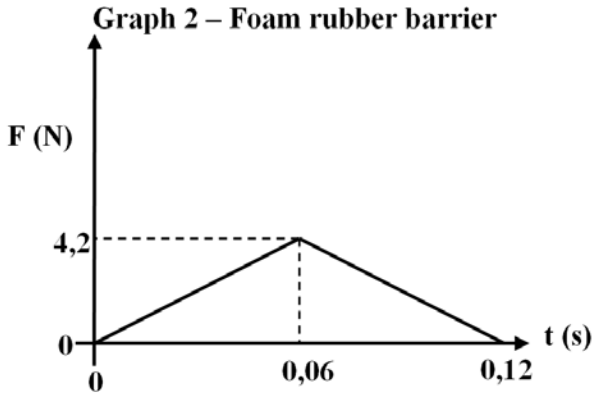


4.1 Name the independent variable in this experiment. (2)

4.2 State TWO variables that would need to be kept constant in order to ensure a fair test. (4)

Simplified sketch graphs to show the relationship between force and time for two different barriers.





4.3 Define *impulse.* (2)

4.4 Rob and Kate make the following conclusions:

*'The collision of the car with the **steel** barrier results in the greatest change in momentum since the car experiences the greatest maximum force.' (Rob)*

*'The collision of the car with the **foam rubber** barrier results in the greatest change in momentum since the force acts on the car for a longer period of time .' (Kate)*

By means of suitable calculations prove who is correct *(Rob, Kate or neither)*. Clearly show the method that you use to arrive at your answer. (6)

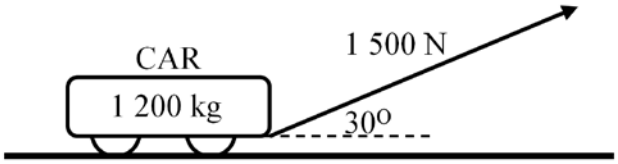
4.5 'The car bumper is designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles in low-speed collisions.'

[<http://www.nhtsa.gov>]

Bumpers on older cars are made from steel. Newer models of cars have plastic bumpers lined with a foam cushioning material. Refer to the results of the experiment, as shown in the graphs, to explain how plastic-foam bumpers protect the car from damage more than steel bumpers do. (3)

4.6 A car of mass 1 200 kg crashes into a lamp post while moving at 20 $m.s^{-1}$ and it rebounds from the lamp post at 8 $m.s^{-1}$. The net force exerted by the lamp post on the car is $2{,}1 \times 10^5$ N backwards. Calculate the time that the car was in contact with the lamp post. (5)

4.7 After the collision the car is towed away at a constant horizontal speed of 15 $m.s^{-1}$. The tow bar applies a force of 1 500 N inclined at an angle of 30^o to the horizontal on the car. The diagram below represents the situation.



4.7.1 Define *work*. (2)

4.7.2 Calculate the total work done on the car by the tow bar when the car is towed for a distance of 180 m. (4)

4.7.3 Define *power*. (2)

4.7.4 Calculate the rate at which the tow bar does work on the car over this distance of 180 m. (4)

4.7.5 The road surface changes from tar to dirt which increases the magnitude of forces acting against the car. The tow bar continues to apply a constant force of 1 500 N, at 30^o to the horizontal, on the car. The car moves a further 180 m along the dirt road. Consider how the change of surface will affect the total work done on the car by the tow bar over the 180 m.

(a) Is the total work done whilst travelling on the dirt road *greater than*, *less than* or *equal to* the total work done on the tar road? (1)

(b) Explain your answer to Question 4.7.5 (a). (3)

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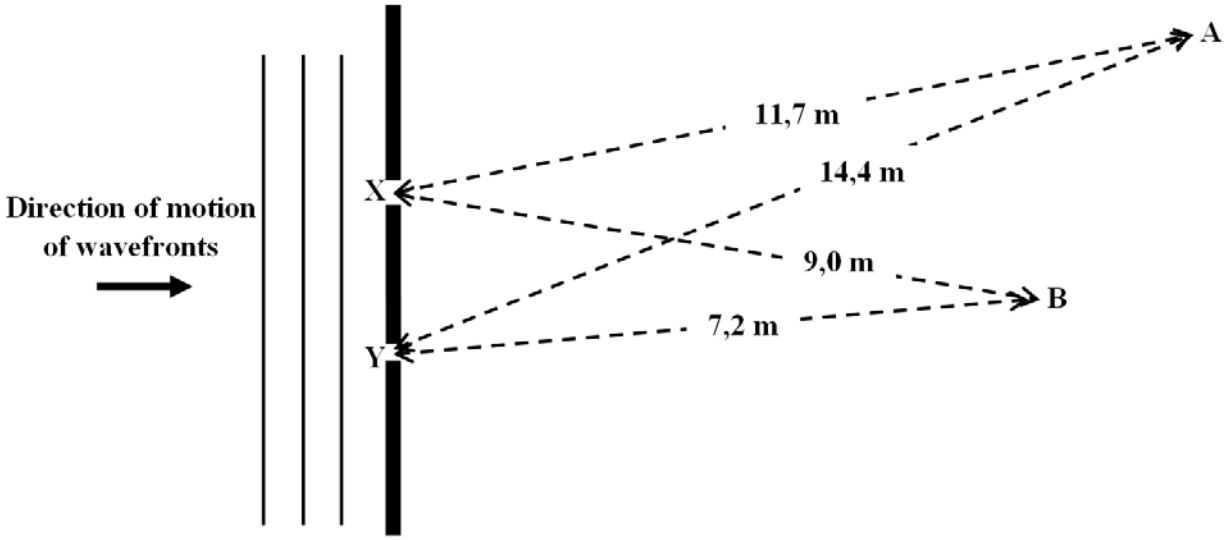
QUESTION 5 WATER WAVES

Plane parallel water waves of wavelength 1,8 m pass through two gaps, X and Y, in a solid barrier into a large pool of water. A model fishing boat is anchored at position A and another identical model fishing boat is anchored at position B as shown in the diagram below.



5.1 What is a wavefront? (2)

5.2 An observer on the banks of the pool notices that one of the boats is in a region of calm water while the other boat is undergoing large changes in vertical displacement as it bobs up and down in the water. By means of suitable calculations explain what type of interference is experienced by the water waves arriving:

5.2.1 at A and (3)

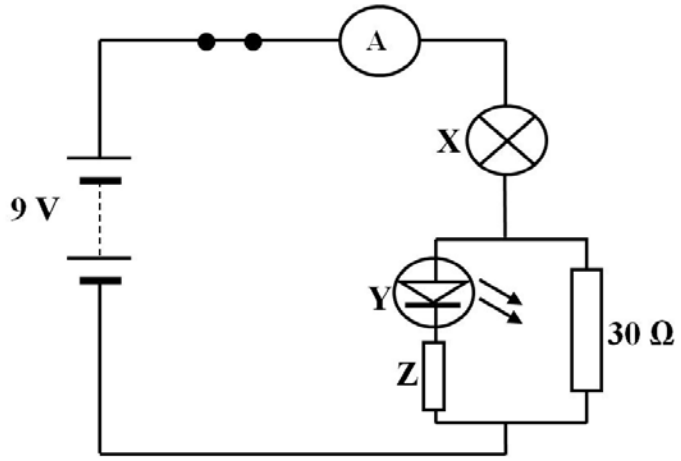
5.2.2 at B. (3)

5.3 Which boat will undergo large changes in vertical displacement, bobbing up and down in the water? (2)

[10]

QUESTION 6 ELECTRIC CIRCUIT

In the circuit shown below the resistance of the battery, ammeter, switch and connecting wires can be ignored.



NOTE:

- When the switch is closed the reading on the ammeter is 200 mA.
- The combined resistance of LED Y and resistor Z is 270 Ω.
- LED Y is damaged if the potential difference across it is greater than 3 V.

6.1 What is an LED? (2)

6.2 Calculate the total resistance of the circuit. (4)

6.3 Calculate the effective resistance of the parallel combination. (3)

6.4 Calculate the resistance of the small filament globe X. (2)

6.5 Calculate the power of globe X as connected in this circuit. (4)

6.6 Calculate the current passing through LED Y. (4)

6.7 Suggest a reason why resistor Z has been placed in series with LED Y. (3)

6.8 The connections to the terminals of the battery are now reversed. State how this will affect each of the following:

6.8.1 reading on ammeter *(increase, decrease* or *no effect)* (1)

6.8.2 brightness of globe X *(brighter, dimmer* or *no change)* (1)

6.9 Clearly explain your answers to Question 6.8. Where necessary make reference to suitable formulae to assist your explanation. Further calculations are not required. (5)

6.10 These days LEDs are replacing the use of filament globes in torches. Give TWO advantages that LEDs have over filament globes. (4)

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QUESTION 7 PHOTOELECTRIC EFFECT EXPERIMENT

Electromagnetic radiation of varying frequency is shone on the sodium metal cathode of a photocell. The maximum kinetic energy of the photoelectrons emitted is recorded.

Table to show how the maximum kinetic energy (E_k) of a photoelectron emitted from sodium metal varies with the frequency (f) of the electromagnetic radiation.

Frequency (x 10^{14} Hz)	Maximum kinetic energy (eV)
7	0,59
8	1,00
9	1,42
10	1,83
11	2,24

7.1 Plot a graph of maximum kinetic energy versus frequency as represented by these results for sodium metal. Use the GRAPH PAPER PROVIDED on your Answer Sheet. The scale on the y-axis has been marked for you. You must fill in your own scale for the x-axis which must start at ZERO. (6)

7.2 Define *threshold frequency.* (2)

7.3 Read off the threshold frequency for sodium metal from the graph. (2)

7.4 If the maximum kinetic energy of the photoelectrons emitted is 2,0 eV then determine:

7.4.1 the **frequency** of the radiation incident on the sodium metal cathode. (1)

7.4.2 the **wavelength** of the radiation incident on the sodium metal cathode. (3)

7.4.3 the **energy** of the radiation incident on the sodium metal cathode (in joules). (3)

7.5 State and explain how the graph would change (if at all) when the intensity of the light is increased for each of the frequencies used. (3)

7.6 The magnitude of the value given by the **y-intercept is equal to the work function (W_f)** of the metal.

7.6.1 Extend your graph backwards to cut the y-axis and hence state the work function of the metal (in eV). (1)

7.6.2 Convert your answer to Question 7.6.1 to joules. (1)

7.6.3 Use the photoelectric effect equation, $\mathbf{E = W_f + \frac{1}{2} mv^2}$, to explain why the y-intercept is equal to the work function (W_f). (3)

[25]

Total: 200 marks