



NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2010

PHYSICAL SCIENCES: PAPER I

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - a question paper of 16 pages;
 - a yellow Answer Sheet of 2 pages (i – ii); and
 - a green booklet of data and formulae of 4 pages (i – iv).

Please make sure that your question paper is complete.

2. Remove the booklet of data and formulae and the Answer Sheet from the middle of this question paper.

Write your examination number on the yellow Answer Sheet.

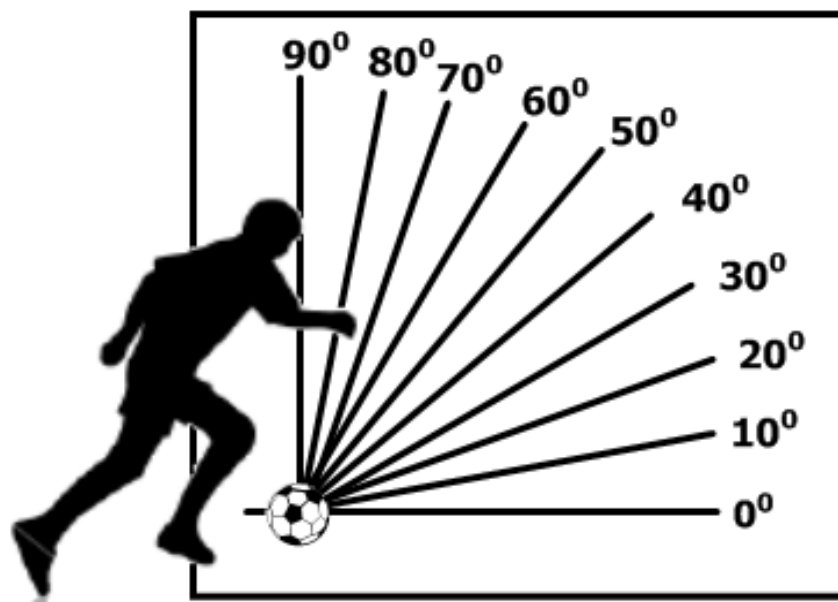
Questions 5.2.3, 6.4.2 and 6.4.3 must be answered on the Answer Sheet.

3. Start each question on a new page.
 4. Read the questions carefully.
 5. It is in your own interest to write legibly and to set your work out neatly.
 6. Use the data and formulae whenever necessary.
 7. Show your working in all calculations.
 8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
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QUESTION 1 APPLYING PHYSICS TO SOCCER

Inspired by all the action of the World Cup, Siya and Ruan decide to use their physics knowledge to improve their soccer skills.

- 1.1 Siya and Ruan conduct an experiment to determine how the angle with respect to the horizontal at which a soccer ball is kicked, affects the horizontal displacement of its first bounce from its starting position.



They used the following procedure as shown below:

Method

1. Mark angles on a large board as shown in the diagram.
2. Place the board parallel to the direction in which the person kicks the soccer ball.
3. Set up a video camera at right angles to the kicker and the board in order to be able to record the angle at which the ball is kicked.
4. Place the ball on a marked spot directly in front of the board as shown in the diagram.
5. Kick the ball and mark the spot of its first bounce on the ground.
6. Use a long tape to measure the horizontal displacement of the ball from its starting position to the place where it first bounced on the ground.
7. Play back the video and stop the playback (freeze the frame) at the frame which shows the angle to the horizontal that the ball was launched. Record this launch angle.
8. Repeat steps 4 to 7, attempting to kick the ball at different launch angles each time, while trying to maintain the same force for each kick. Each boy must obtain three readings for each angle.

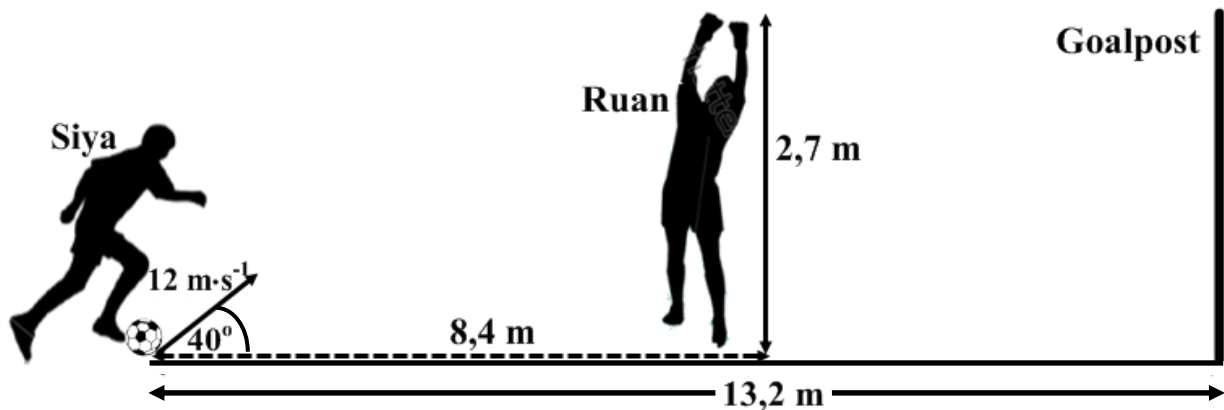
Table of results showing launch angle of the soccer ball and horizontal displacement of its first bounce from its starting position.

Launch angle (°)	Siya's displacement (m)				Ruan's displacement (m)			
	Reading 1	Reading 2	Reading 3	Average	Reading 1	Reading 2	Reading 3	Average
20	7,2	7,1	7,3	7,2	8,0	8,9	7,7	8,2
30	10,0	10,1	9,9	10,0	10,5	10,0	11,0	10,5
40	11,4	11,3	11,2	11,3	12,0	12,6	13,2	12,6
50	11,2	11,1	11,3	11,2	12,7	12,4	13,0	12,7
60	10,0	9,9	10,1	10,0	11,2	10,3	10,6	10,7

- 1.1.1 Name the independent variable in this investigation. (2)
- 1.1.2 What conclusion can Siya and Ruan draw from these results? (2)
- 1.1.3 Whose results were more precise, Siya's or Ruan's? Explain. (3)
- 1.1.4 Suggest ONE reason why Ruan's average displacement for each angle was greater than Siya's. (2)
- 1.1.5 Comment on the design of this experiment. (Is it a fair test? Are these results reliable?) (3)
- 1.1.6 Suggest ONE way that Siya and Ruan could improve their method in order to make their experiment more accurate. (2)
- 1.2 During a soccer game Siya attempts a shot at goal but unfortunately kicks the ball into the goal post. The ball hits the goal post whilst moving horizontally at $26 \text{ m}\cdot\text{s}^{-1}$ and bounces back horizontally at $22 \text{ m}\cdot\text{s}^{-1}$ along the same line of action.
- 1.2.1 Define *net (resultant) force* in terms of momentum. (2)
- 1.2.2 The mass of the ball is 430 g. If the ball is in contact with the goal post for 0,05 s, calculate the magnitude of the net (resultant) force exerted by the goal post on the ball. (5)

- 1.3 Ruan agrees to play goalkeeper while Siya practices his soccer skills. Ruan is able to jump and catch a ball at a maximum height of 2,7 m. Siya wants to kick the ball over Ruan at a height greater than 2,7 m without it bouncing before it crosses the goal line. The goal line is 13,2 m from where the ball is kicked. The diagram below shows the situation.

Diagram NOT to scale



Ruan stands 8,4 m from the position where the ball is kicked. Siya kicks the ball straight through its centre of gravity with an initial velocity of $12 \text{ m}\cdot\text{s}^{-1}$ at 40° to the horizontal.

Ignore the effects of air resistance.

- 1.3.1 Show by means of suitable calculations that Ruan is unable to save the ball if he remains 8,4 m from the point at which the ball was kicked. (8)
- 1.3.2 Does Siya achieve his aim of kicking the ball across the goal line without it bouncing beforehand? Show all working in support of your answer. (8)
- 1.3.3 Draw the following sketch graphs to represent the motion of the ball from the time it was kicked until it landed (no values need to be shown):
- (a) Horizontal velocity vs time (2)
 - (b) Vertical velocity vs time (2)

41 marks

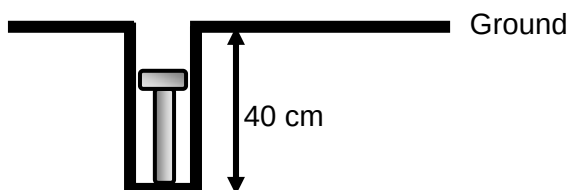
QUESTION 2 CONSTRUCTION OF MOSES MABHIDA SOCCER STADIUM

The arch over the new Moses Mabhida soccer stadium in Durban rises to a height of 106 m above the pitch. The photograph below shows the last 60 tonne ($6,0 \times 10^4$ kg) block being positioned on the arch by a crane.



[<<http://blog.hartford.co.za/storage/sport/moses-mabhida-stadium.jpg>>]

- 2.1 Define *power*. (2)
- 2.2 Calculate the gravitational potential energy of the block relative to the ground when it is suspended at a height of 106 m above the ground. (4)
- 2.3 It took 5 minutes to raise the block at constant speed from the ground to a height of 106 m. Calculate the minimum power required to raise the block. Ignore air resistance. (4)
- 2.4 A steel bolt (mass 2,5 kg) falls from rest from the top of the arch to the ground 106 m below.
- 2.4.1 Calculate the speed of the bolt just before it strikes the ground. (Give your answer in $\text{km} \cdot \text{h}^{-1}$). Ignore effects of air resistance. (5)
- 2.4.2 State in words the Work Energy Theorem. (2)
- 2.4.3 Use the Work Energy Theorem to calculate the magnitude of the net (resultant) force acting on the bolt while it penetrates 40 cm into the soil before coming to rest. (Assume uniform acceleration while the bolt comes to rest.) (6)



- 2.4.4 What is the magnitude of the force applied **by the ground** on the bolt while it is moving through the soil? (2)
- 2.4.5 Sketch a position vs time graph to represent the motion of the bolt from the time it left the arch until it came to rest, using the **ground as your frame of reference**. Mark with the letter P, the point on your graph at which the bolt struck the ground. No values need be shown on your graph and the scale is not important. It is the shape of the graph which is relevant. (4)
- 2.4.6 Consider your answers to the questions (2.4.1, 2.4.3 and 2.4.4) and justify the need to wear hard hats on construction sites. (3)



[<<http://graphics8.nytimes.com.jpg>>]



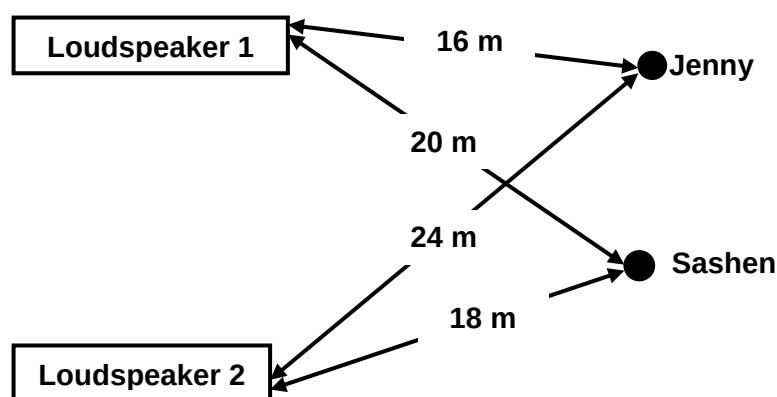
[<<http://us.123rf.com.jpg>>]

32 marks

QUESTION 3 SOUND PROBLEMS AT SOCCER CITY

Jenny joins the crowds outside Soccer City whilst waiting for her friend Sashen to arrive by bus. As the bus approaches Jenny at a constant speed of $16 \text{ m}\cdot\text{s}^{-1}$ Sashen blows his vuvuzela (horn). The note that Jenny hears whilst standing still on the pavement has an apparent frequency of 820 Hz.

- 3.1 Calculate the true frequency of the note produced by the vuvuzela. Take the speed of sound in air to be $340 \text{ m}\cdot\text{s}^{-1}$. (5)
- 3.2 When Jenny sees Sashen sitting in the bus, she runs along the pavement towards the approaching bus at a constant speed of $4 \text{ m}\cdot\text{s}^{-1}$ relative to the ground. State the velocity of Jenny relative to Sashen. (2)
- 3.3 Jenny and Sashen stand outside the stadium where they listen to the National Anthem being played through loudspeakers that are vibrating in phase. They notice that at times the anthem sounds extra loud and at other times they can hardly hear it. They move apart to see if they can hear better from different positions. The diagram below indicates their positions relative to the loudspeakers.



- 3.3.1 Describe what is meant by the **interference** of waves. (3)
- 3.3.2 Calculate the frequency of the note produced when the loudspeakers emit a note with a wavelength of 0,8 m. Take the speed of sound in air to be $340 \text{ m}\cdot\text{s}^{-1}$. (3)
- 3.3.3 **Explain** how the loudness of the sound heard by Jenny and by Sashen will differ for a note with a wavelength of 0,8 m. Support your answer by means of suitable calculations. (8)

- 3.4 Andile and Thandi live in a rural area in a valley surrounded by hills. They are unable to travel to Soccer City for the big match, but are keen to listen to it on the radio. Considering the diffraction of waves, state whether they would be more likely to pick up the broadcast on medium wave (MW) radio or on short wave (SW) radio. Explain. (4)
- 3.5 The vuvuzela is uniquely South African and many feel that it is an integral part of the soccer experience. However, there has been much controversy surrounding the use of vuvuzelas at soccer stadiums.

Read the article that follows.

Vuvuzela – good for your team, bad for your ears

By De Wet Swanepoel 24 July 2009 (University of Pretoria)

Researchers at the Department of Communication Pathology at the University of Pretoria are investigating the possible hearing health risk posed by the vuvuzela. Professor James Hall, Professor De Wet Swanepoel and Doctor Dirk Koekemoer are documenting sound intensity and frequency spectrum measurements of the vuvuzela to quantify the risk for hearing loss. Results indicate that the vuvuzela's output intensity is dangerously loud. Anyone in the nearby vicinity is at a severe risk of permanent noise-induced hearing loss and associated tinnitus (ringing in the ears). According to occupational noise standards, people should not be exposed to the intensities produced by the vuvuzela for more than a couple of minutes if they are within a radius of 1 to 2 metres.

Comment

Untrustworthy research – Tshabalala Molifi 26 July 2009

I totally disagree with this research. We have been exposed to vuvuzela sound output for a long period but it hasn't hampered our hearing. Did the researchers meet anyone whose hearing has been damaged by the vuvuzela?

[<<http://web.up.ac.za>>]

- 3.5.1 In his comment Tshabalala Molifi states that the research is untrustworthy. In your opinion can the research be trusted? Justify your response. (3)
- 3.5.2 Discuss the impact on human health of using vuvuzelas in packed soccer stadiums and give your opinion as to whether or not there should be rules governing the use of vuvuzelas. Consider the ethics of the situation and back up your opinion with scientific facts. (4)



[<<http://newshopper.sulekha.com>>]

32 marks

QUESTION 4 CAMERA FLASH

Rachel is eager to capture all of the action of the soccer game on her new camera. She is frustrated because she has to wait between taking pictures whilst the capacitor in the camera's flash unit recharges.

- 4.1 Define *capacitance*. (2)
- 4.2 The potential difference across the plates of a $160\ \mu\text{F}$ capacitor is 300 V. Calculate the charge stored on the capacitor. (4)
- 4.3 Why is a capacitor used in the electric circuit of a photographic flashlight? (2)
- 4.4 In order to gain access to the stadium Rachel needs to pass her camera bag through a security checkpoint which irradiates her bag with low intensity x-rays.

Rachel does not want her photographic film to be damaged by the x-rays so she has placed her camera and films into a small protective box made of material which shields them from x-rays.

- 4.4.1 Name the type of material from which the box should be made. (1)
- 4.4.2 Why are '**low intensity**' x-rays used in this security check? (2)

11 marks

QUESTION 5 MOTORS AND GENERATORS

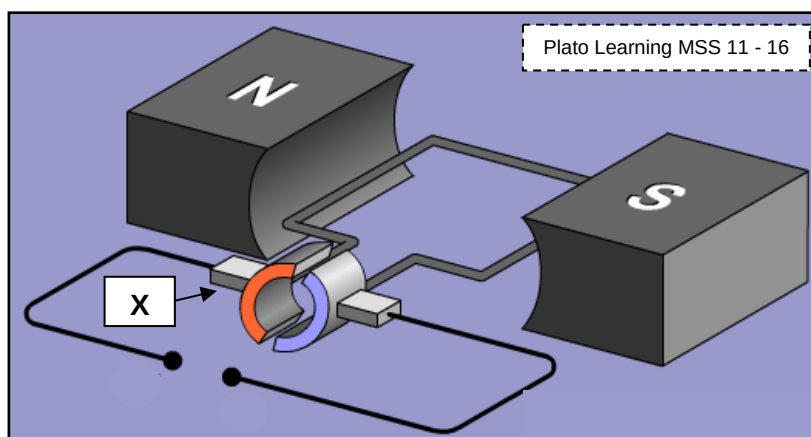
The FIFA World Cup Soccer stadiums were designed to meet best environmental performance standards. Some of the measures taken to ensure the use of 'green' energy at Green Point Stadium includes generators which are biodiesel compatible and the option to purchase power from Darling Wind Farm.

- 5.1 Briefly explain why these two energy sources are considered 'green' (environmentally friendly). (2)
- 5.2 Alex reads the following statement in his Physics textbook.

'All motors are also generators, so if you spin a motor using another motor, a wind turbine or a water turbine, it will generate electricity'

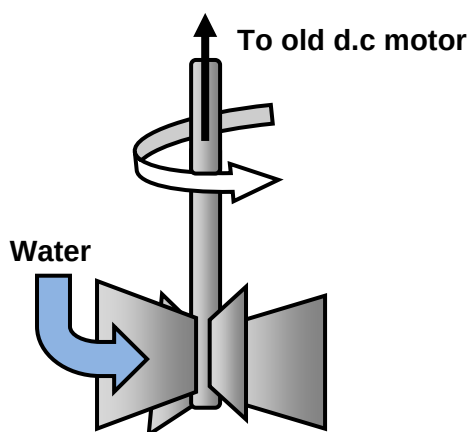
[X-Kit Physical Science, Physics, p. 97]

The diagram shows a simple direct current electric motor.

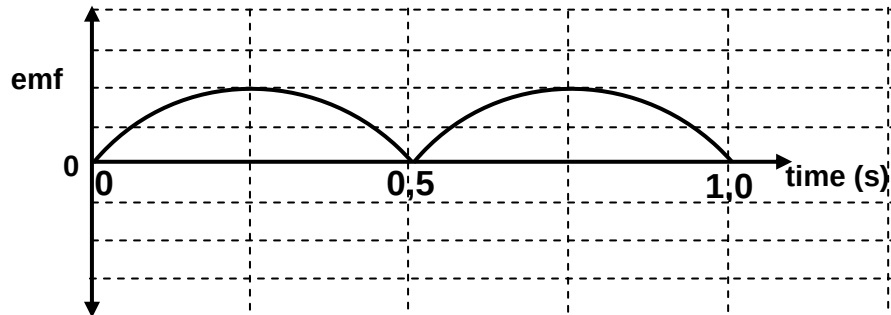


- 5.2.1 To which terminal of the power source (positive or negative) is the brush labelled X connected if the coil rotates in a clockwise direction? (1)

Alex attempts to make his own generator using an old direct current motor attached to a water turbine. As the water flows over the blades of the turbine it causes the coil of the motor to spin.



- 5.2.2 Suggest TWO possible changes that Alex could make to the water turbine that may result in the production of a greater emf by his generator. (4)
- 5.2.3 The graph shown below represents the change in emf with time for ONE complete revolution of the generator coil.



Complete the graphs of emf versus time **given on the Answer Sheet** for a time interval of 1,0 s to represent the changes indicated in the questions that follow. Assume that the coil always starts moving parallel to the magnetic field.

- (a) The coil is rotated at the same speed in the **opposite direction**. (2)
- (b) The coil is rotated at **twice the speed** in the original direction. (2)
- (c) **The split ring commutator is replaced with slip rings** and the coil is rotated at the original speed in the original direction. (2)

13 marks

QUESTION 6 SOLAR POWERED LED SOCCER FLOODLIGHTS

Today about 500 million people in Africa have no access to electricity. This affects education, security, productivity, employment and the quality of life. Unlike traditional relatively high voltage halogen floodlights, LED floodlighting can run off solar power thus allowing communities and villages to be active and productive after dark.



[<<http://www.lighting.philips.com>>]

Read the article that follows.

Philips Unveils Solar LED Floodlighting in Time for FIFA 2010 World Cup

This mini floodlighting system consisting of eight LED floodlights on four portable poles has been designed for rural regions without access to electricity. The power comes from batteries, which are powered from solar panels. The system is therefore completely sustainable and will light an area of approximately 40 m x 20 m which is big enough to allow a '5-a-side' game of soccer. The system can also be used for non-sporting applications such as evening classes in remote villages, safety and security, shops or outdoor markets, or emergency lighting for disaster situations.

[Adapted from: <<http://www.cooltribe.com>>]

- 6.1 Why is it that LED floodlights can operate from a solar powered system but solar powered batteries cannot supply enough energy to operate halogen floodlights? (2)
- 6.2 Consider the advantages that solar powered LED lights have over traditional portable lighting systems (e.g. paraffin lamps and candles) used in communities without access to electricity, and give
 - 6.2.1 ONE environmental advantage, and (2)
 - 6.2.2 ONE health advantage. (2)
- 6.3 State THREE ways that solar powered floodlighting can positively impact and upgrade the lives of people living in communities without access to electricity. (6)

- 6.4 Thabo and Thembi live in a remote village where the new solar powered LED floodlights have been installed. They observe that the sports field close to the floodlights is well lit, but as they move into the region behind the sports field the light dims quickly. They decide to carry out an investigation to determine how light intensity changes with distance from the light source. The local university allows them access to apparatus in the physics laboratory. They set up the apparatus as shown in the diagram below and record the light intensity at set distances from the light source. The sensor measures the light intensity in lux (a unit of measurement of light energy emitted per m^2).

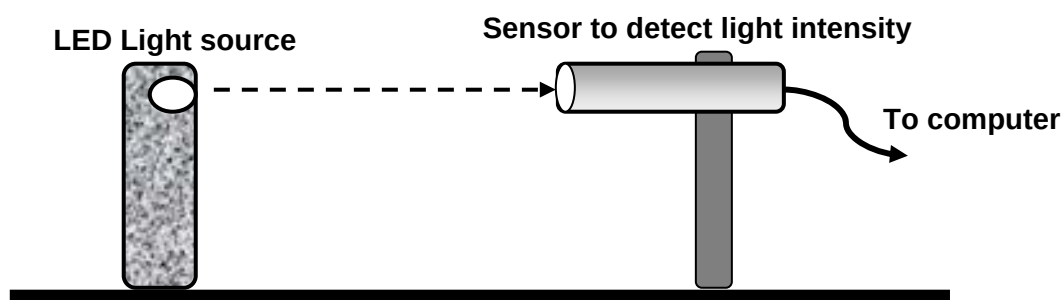


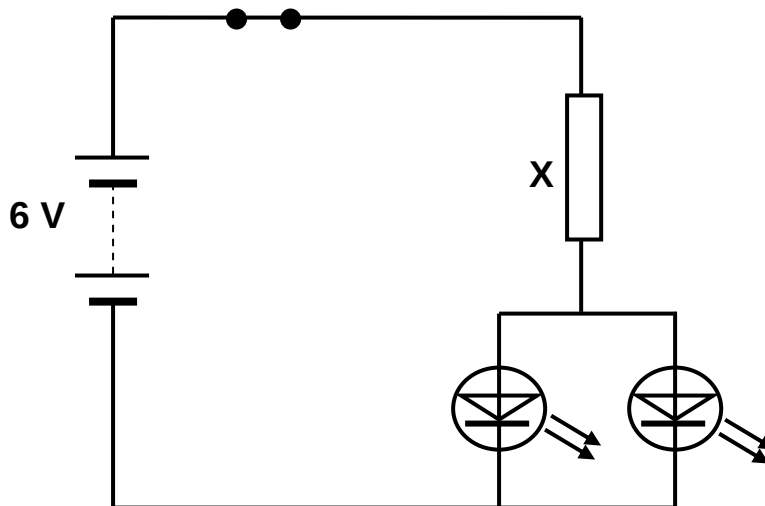
Table of results to show the relationship between light intensity and distance from the source.

Distance from source (m)	Light Intensity (lux)
0,10	144
0,12	100
0,14	74
0,16	56
0,18	44
0,20	36

- 6.4.1 State a suitable hypothesis for this investigation. (2)
- 6.4.2 The above results table has been reproduced on the **Answer Sheet**. Complete the column for distance from the light source squared and include UNITS in the column heading. Record your answers as decimals correct to 3 places. (3)
- 6.4.3 On the graph paper provided on the **Answer Sheet** plot a graph to show the relationship between light intensity and distance from the source squared. *The scale for light intensity has been marked for you.* (6)
- 6.4.4 Use your graph to determine the distance from the light source that would give a light intensity of 80 lux. (2)
- 6.4.5 Thabo and Thembi want to represent the data obtained from their investigation by means of a straight line graph. If they plot light intensity on the y-axis what quantity must they plot on the x-axis? (2)

Thabo and Thembi's light source consists of two identical LEDs connected to a resistor and a 6 V battery as shown in circuit diagram 1. The internal resistance of the battery and the resistance of the connecting leads and switch can be ignored.

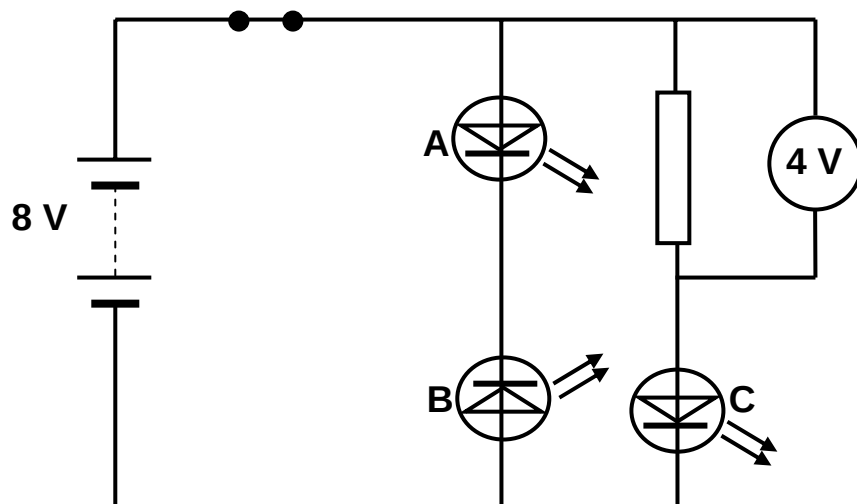
Circuit diagram 1



- 6.4.6 These LEDs operate optimally when the potential difference across them is 4 V and the current in each of them is 25 mA. Calculate the resistance of resistor X that is required for the LEDs to operate as specified. (5)

Thabo and Thembi set up a second circuit using three of the same identical LEDs with various other components as shown in circuit diagram 2. The internal resistance of the battery and the resistance of the connecting leads and switch can be ignored. The voltmeter has a very high resistance.

Circuit diagram 2



- 6.4.7 Thabo and Thembi observe that not all of the LEDs in circuit 2 light up. Which of the LEDs will light up? Fully explain your answer. (5)

37 marks

QUESTION 7 STREETLIGHTS

Nick notices that when he reads his soccer programme whilst standing under a yellow street lamp some of the colours of the FIFA emblem appear to change.



[<www.fifa.com>]

- 7.1 State and EXPLAIN the appearance of the following colours when viewed under the yellow light by considering the absorption and reflection of light.
- 7.1.1 Red (3)
- 7.1.2 Cyan (3)
- 7.2 His programme was printed using an ink jet printer. Which TWO coloured ink pigments were used to produce the blue colour of the FIFA emblem on the programme? (2)
- 7.3 Read the article that follows.

Why are streetlamps yellow?

Yellow streetlights are high pressure sodium discharge lamps. The lamp is a transparent tube with electrodes embedded in either end. The tube contains an inert gas along with a bit of sodium metal.

When a current is passed through the tube, the gas becomes very hot and the sodium vaporises. The vaporised sodium atoms absorb energy. As the excited electrons relax back down to a lower energy state the atoms emit photons of bright yellow light.

Sometimes mercury is added to street lamps to introduce some blue and violet lines into the spectrum so that colours can be distinguished under the lamp.

[Adapted from: <<http://antoine.frostburg.edu>>]

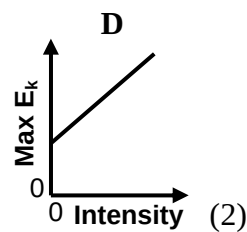
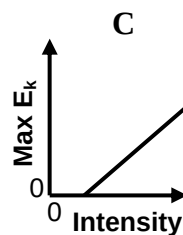
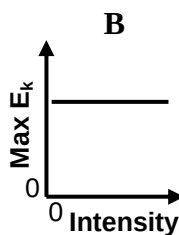
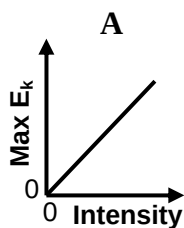
- 7.3.1 What type of spectrum is formed by a high pressure sodium discharge lamp? (2)
- 7.3.2 Does the spectrum produced by a sodium discharge lamp give evidence for the wave nature of light or for the particle nature of light? (1)
- 7.3.3 Calculate the energy of a photon of light produced by a sodium lamp if the wavelength of the light is $5,89 \times 10^{-7}$ m. (5)
- 7.3.4 Explain why the addition of mercury to the street lamps makes it easier to distinguish colours under the street lamp when compared to a pure sodium lamp. (4)
- 7.4 The work function of the metal cathode of a photocell is 2,3 eV.
- 7.4.1 Explain what is meant by the **work function** of a metal. (2)
- 7.4.2 Calculate the work function of the metal cathode in **joules**. (2)
- 7.4.3 Calculate the maximum speed of the photoelectrons emitted when the metal cathode is illuminated with monochromatic light of frequency $6,38 \times 10^{14}$ Hz. (6)

7.5 Multiple Choice

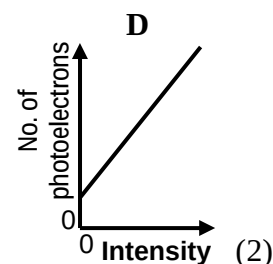
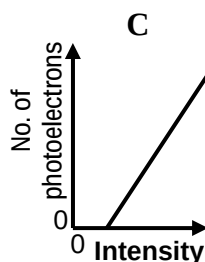
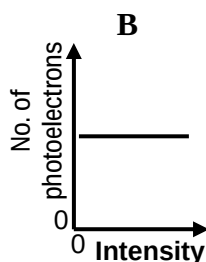
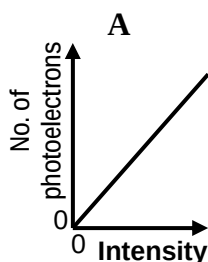
Using capital letters, write the letter of the most correct response.

The cathode of a photocell is illuminated with monochromatic light. The energy of the photons exceeds the work function of the metal cathode.

7.5.1 Which one of the following graphs best shows the way in which the maximum value of the kinetic energy of the photoelectrons varies with the intensity of the light?



7.5.2 Which one of the following graphs best shows the way in which the number of photoelectrons emitted varies with the intensity of the light?



34 marks

Total: 200 marks