assessment matters

GRADE 11 EXAMINATION
NOVEMBER 2007

PHYSICAL SCIENCE: PAPER I
(PHYSICS FOCUS)

Time: 3 hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of:
   - a question paper of 12 pages
   - a formulae sheet and
   - separate answer sheet for answering some of the questions on

2. Question 10 and 11 are **optional questions**.
   Question 10 can be done in place of Question 5.
   Question 11 can be done in place of Question 6.2.3.

3. All the other questions must be answered.

4. Write legibly.

5. Make neat diagrams where necessary.

6. Show the formulas and equations you use.

7. Show all calculations.

8. All answers should have the correct units.

QUESTION 1

A taxi driver seeks your advice about:
- driving on wet roads and
- speeding

You find that the coefficient of kinetic friction between new tyres and a dry road is 0,8 when the car skids.

1.1 Show that the magnitude of the frictional force acting on the taxi skidding across a dry horizontal road, if the mass of the taxi and the driver is 1 600 kg, is 12 800 N. (You must give an equation showing the relationship to get full credit for your answer to this question.) (2)

1.2 Draw a free body diagram of the taxi travelling on the dry horizontal road while skidding. Draw a rectangle to represent the taxi. Label the diagram and indicate the direction of motion. (3)

1.3 Write down Newton's second law of motion. (2)

1.4 Hence, or otherwise, calculate the acceleration of the taxi while skidding to rest. (3)

1.5 Show how to convert speed in $km \cdot h^{-1}$ to $m \cdot s^{-1}$ by showing that the speed at which the taxi is travelling, 86,6 $km \cdot h^{-1}$, is equivalent to 24 $m \cdot s^{-1}$. (2)

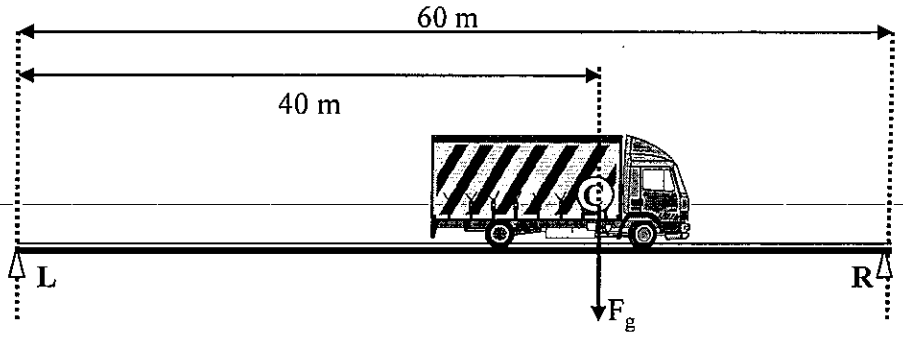
1.6 If the speed of the taxi is 24 $m \cdot s^{-1}$ when the driver applies the brakes, calculate the distance the taxi takes to come to rest, on a straight horizontal dry road. (4)

1.7 On a wet road with old tyres the coefficient of friction is reduced to 0,6. How will the distance the taxi needs to stop change? No calculation is required, but describe your reasoning. (3)

1.8 Use your knowledge of the equations of motion to deduce the relationship between speed and stopping distance. Use this to explain the slogan "SPEED KILLS" (Hint: to start you can calculate the stopping distance for a taxi moving at 48 $m \cdot s^{-1}$). (7)

26 marks

QUESTION 2



A truck of mass 3 600 kg crosses a light bridge as shown in the diagram. The centre of gravity of the truck is indicated with a 'C'.

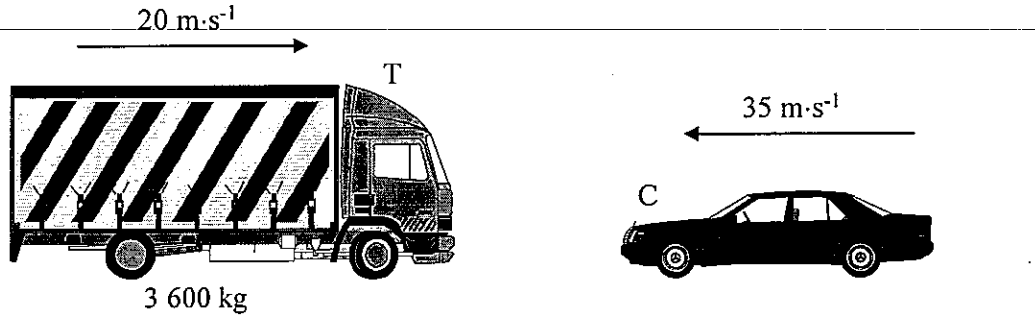
2.1 Calculate the downward force on each of the bridge supports, L and R, when the truck is 40 m from the left support, L. (5)

2.2 Draw a **sketch graph** showing the force on support L as the truck crosses the bridge. (2)

7 marks

QUESTION 3

The same truck T, of mass 3 600 kg, is travelling due North at 20 $m \cdot s^{-1}$ when it collides head on with a car C, overtaking on a blind rise. The mass of the car is 800 kg. It is travelling at 35 $m \cdot s^{-1}$ due south at the moment of impact. After the collision, the two vehicles are so intertwined that the wreck moves together as one.



3.1 Which conservation law can we use to calculate the velocity of the wreck after collision? State this law. (2)

3.2 Calculate the velocity of the wreck immediately after the collision. (4)

3.3

3.3.1 In this question you need to use your knowledge of force, impulse and momentum to illustrate the benefit of safety belts and a crumple zone. From the moment the vehicles first touch to the moment they move off together is 0,005 s. Assume the 65 kg truck driver is *not wearing his seat belt* and the *truck does not have a crumple zone*. When the driver makes contact with the windscreen, it brings him to the same speed as the wreck in 0,005 s. Calculate the force exerted on the truck driver by the windscreen. (4)

3.3.2 The front of the car has a crumple zone and the 50 kg driver is wearing a seat belt. After the collision the strong 'cell' containing the driver is essentially intact but the front of the car is pushed inwards a distance of 0,5 m as a result of the compression of the crumple zone. *The seat belt stretches* to allow the driver to move forward an additional 0,5 m. As a result the driver reaches the speed of the wreck after 0,08 s. Calculate the force exerted on the driver of the car. (4)

3.3.3 A road safety pamphlet includes this table:

Force	F < 10 000 N	10000N<F<85000N	F ≥ 85000N
Effect	pain, no permanent injury	severe to critical injury	fatal

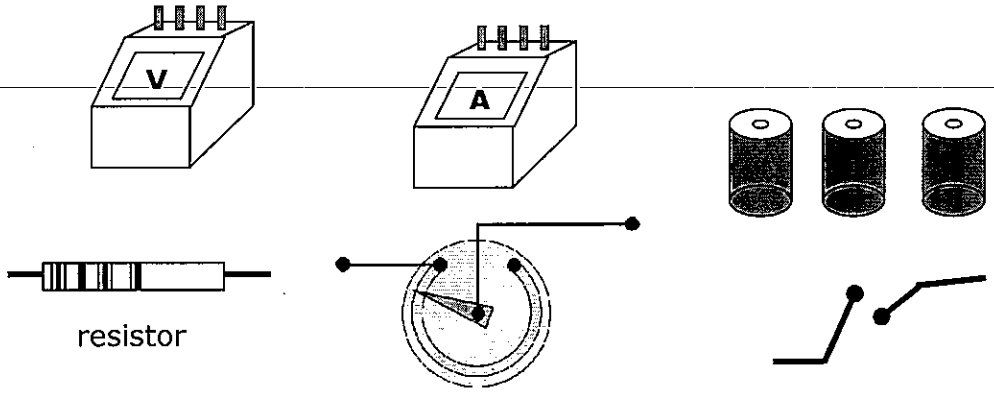
(a) Use the information in the table to describe the likely injuries to the two drivers in questions 3.3.1 and 3.3.2. (2)

(b) Give another safety feature built into modern cars and explain how it reduces the force exerted on a passenger or driver during a collision. (3)

19 marks

QUESTION 4

The teacher gives Paul and Linda the apparatus in the diagram below to investigate the relationship between the current (I) through a resistor and the potential difference (V) across the resistor.



4.1 Write down the question Paul and Linda are investigating. (2)

4.2 Answer question 4.2 on the answer sheet provided. Draw the connectors in the way that is required to join up the circuit components to carry out the investigation. (3)

4.3 Paul identifies the resistance of the variable resistance as the independent variable in this investigation. Linda claims it is the potential difference across the fixed resistor. Who is correct? Explain your answer. (2)

4.4 What is the dependent variable in this investigation? (1)

4.5 Identify a variable that must be controlled. (1)

4.6 How would you go about controlling this variable? (1)

4.7 Paul recorded the following notes as they carried out the investigation:

Voltmeter reads 0,00 when the ammeter reads 0,00; when V is 1,50, A is 0,30; when A is 0,85, V is 4,00; A is 0,58 when V is 3,00; V is 7,00 when A is 1,40 and A is 1,04 when V is 5,50

Tabulate these results. Credit will be given for correct labels and units. (4)

4.8 On the graph paper provided on your answer sheet draw a neat fully labelled graph of the results. (4)

4.9 What physical quantity does the gradient of the graph represent? (2)

4.10 Give the correct equation of the graph. (2)

4.11 What is the answer to the question Paul and Linda set out to investigate? (1)

4.12 Paul wishes to demonstrate his knowledge of the relationship he has found in this investigation. He uses the light bulb in his bed side lamp. It has the following specifications printed on the bulb: 100 W at 200 V. When the bulb is operating he calculates the resistance of the bulb as follows:

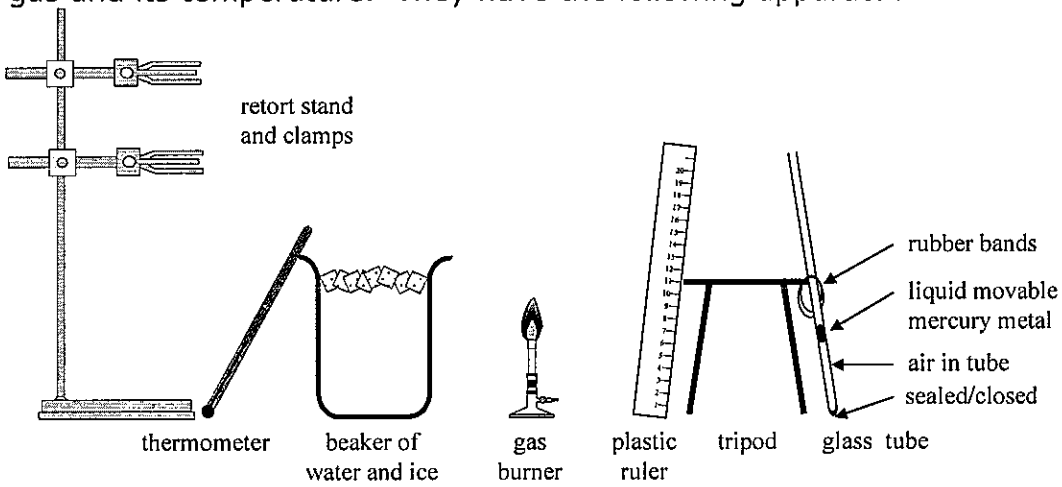
$$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{200^2}{100} = 400\,\Omega$$

He then unwraps a new 100 W ; 200 V light bulb and measures its resistance by connecting a multi-meter across the bulb and gets an answer of 40 Ω. Identify and explain the difference. (4)

27 marks

QUESTION 5

Temba and Jabu set out to investigate the relationship between the volume of a fixed mass of gas and its temperature. They have the following apparatus.



5.1 Make a neat labelled diagram of the apparatus as they set it up to carry out the investigation. (3)

5.2 Here follows an incomplete and jumbled set of instructions Temba and Jabu write down for carrying out the investigation.

1. Clamp the ruler, glass tube and thermometer vertically and immerse the trapped air in the ice water mixture.
2. Record the volume of the gas as indicated by the length of the column of air.
3. Read the height of the bottom of the 'bead' of liquid mercury.
4. Attach the glass tube and the thermometer to the ruler using the rubber bands.

Write down these four steps in the correct sequence. To answer just write down the numbers in the sequence you select. (3)

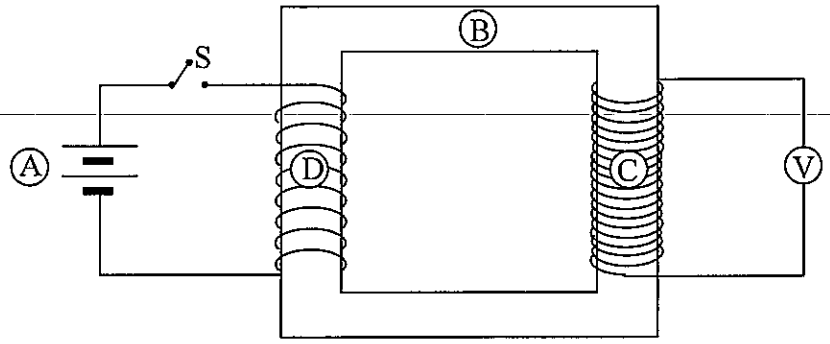
5.3 Give a variable they are controlling and describe how they are doing this. (2)

5.4 What is the question they are investigating? (1)

9 marks

QUESTION 6

6.1 What is the function of a transformer?
In the diagram below, certain parts have been labelled A, B, C and D.



(1)

6.2

6.2.1 The switch S is closed, the voltmeter needle flicks to the right and then returns to zero. What do you think may have caused this? Explain. (2)

6.2.2 What must be changed so that the diagram represents a transformer? Assume that change is made. Name the parts of the transformer labeled B, C and D. (3)

6.2.3 (If you intend to answer optional question 10 (Wheatstone Bridge) on page 11 you should not answer this question; 6.2.3)

Refer to the changed diagram and explain the principle on which the transformer operates. Refer to Faraday's Law of electromagnetic induction and the function of the various parts of the transformer in your answer. (5)

6.2.4 List two places where transformers are used in everyday life. (2)

6.2.5 Give two advantages of the use of transformers. (2)

6.2.6 Give two disadvantages of the use of transformers. (2)

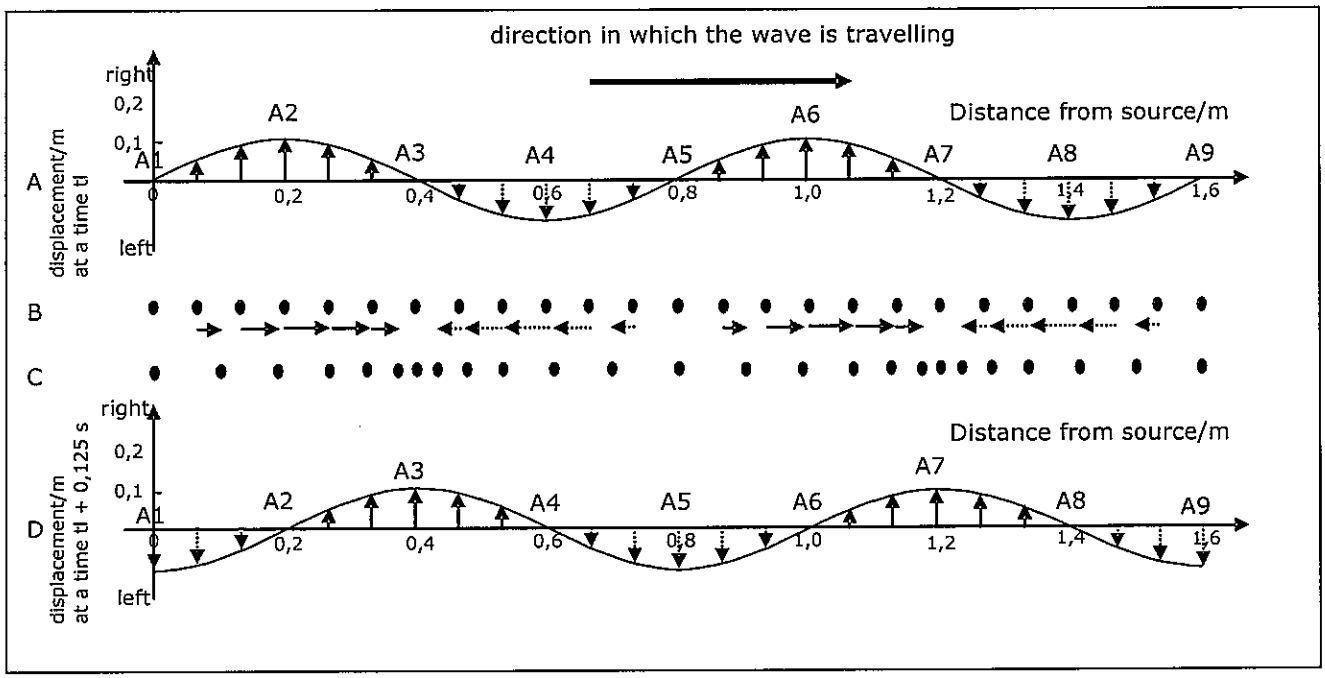
6.2.7 Decide whether the overall impact of transformers and their use by humans has been an advantage or not. Justify your opinion. (3)

20 marks

QUESTION 7

7.1 Study the diagram below.

- 'B' shows dots (could represent ribbon tied to a slinky) equal distances apart. This represents the medium when no wave is passing through the medium.
- 'C' shows the position of the dots in 'B' at time t1, when a wave is passing through the medium.
- The horizontal arrows show the extent to which the dots in the medium 'B' are displaced to get to their new position as shown in 'C'.
- 'A' is a graph of the displacement of the dots against time. 'A' gives the displacement of the dots as the wave passes through the medium as shown in 'C'. Up arrows on 'A' represent displacements to the left in 'B' to get 'C'. Down arrows on 'A' represent displacements to the right in 'B' to get 'C'.
- 'D' is the graph 'A' but 0,125 s later.



7.1.1 Explain why the wave represented in these diagrams is described as a longitudinal wave. (1)

7.1.2

(a) What term describes the maximum displacement of a particle of the medium? (1)

(b) Give the position of a rarefaction at time t1 + 0,125 s (refer to graph D and choose from A1 to A9). (1)

7.1.3

(a) Which other dot is in phase with the dot at A7? (1)

(b) What is the wavelength of the wave in meters? (1)

(c) What is the period of the wave? (2)

(d) What is the frequency of the wave? (2)

(e) What is the speed of the wave? (2)

[11]

7.2

7.2.1 Two travelling waves move in opposite directions through the same medium, a rubber tube, say. Give three conditions required for these travelling waves to give rise to a standing wave. (3)

7.2.2 A guitar string is fixed at both ends. The simplest mode of vibration of such a string is a standing wave with a node at each end and an anti-node in the middle. Draw a **labelled** sketch of such a vibrating string. (2)

7.2.3 A pitch of D5 (first harmonic = 587 Hz) is sounded out by a vibrating guitar string. The length of the string is 51,0 cm.

(a) What is the wavelength of the fundamental? (1)

(b) Calculate the speed of the standing wave in the guitar string. (2)

[8]

19 marks

QUESTION 8 (If you intend to answer optional question 11 (Forces between charges in two dimensions) on page 12 you should not answer this question; 8)

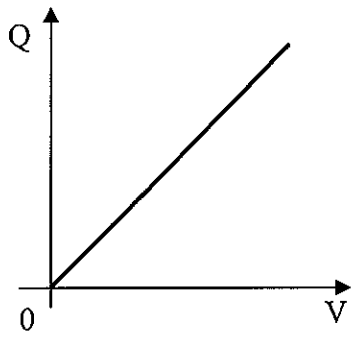
Capacitors typically consist of two parallel metal plates separated from each other by a non conducting material like plastic sheet or wax paper. The plates can carry charge and when they do we say the capacitor is charged. The camera flash unit is one of many devices that use capacitors.

John finds a small cylinder labelled 180 μF; 330 V in a disposable camera that he takes apart.

8.1 What brings John to the conclusion that this cylinder must be the capacitor? (1)

8.2 Calculate the charge stored by this capacitor if it is charged until the potential difference across it is 100 V. (3)

John surfs the Internet to find out more about capacitors. He comes across the following graph:



8.3 What is the mathematical relationship between Q and V? (1)

8.4 What physical quantity does the gradient of the graph represent? (1)

8.5 What physical quantity will the area under the graph represent? (1)

8.6 Calculate the energy stored by the capacitor when it is charged to a potential difference of 100 V. (3)

10 marks

QUESTION 9

9.1 Match the concepts (or ideas) related to the band theory of the electrical conductivity of metals, semi-metals and non-metals, given in column 1 of the following table, to the best description of the concept given in column 2. To answer, write down the number corresponding to the concept followed by the letter of the description you select to match the concept. (4)

	Concepts		Concept descriptions
1	Conduction band	A.	Orbitals, that have very small differences of energy, which form when orbitals of the individual atoms overlap when the individual atoms form a solid.
2	A "band" of orbitals	B.	The energy gap between the valence band and the conduction band
3	Valence band	C.	In nonmetals electrons in this band form strong directional bonds
4	Band gap	D.	In metals electrons in this band form non-directional bonds

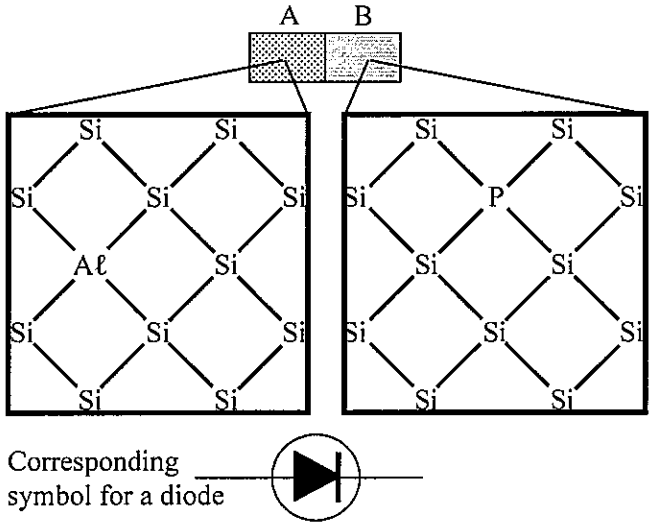
9.2 Use band theory to give one sentence descriptions of a:

9.2.1 Semimetal

9.2.2 Metal

9.2.3 Nonmetal (3)

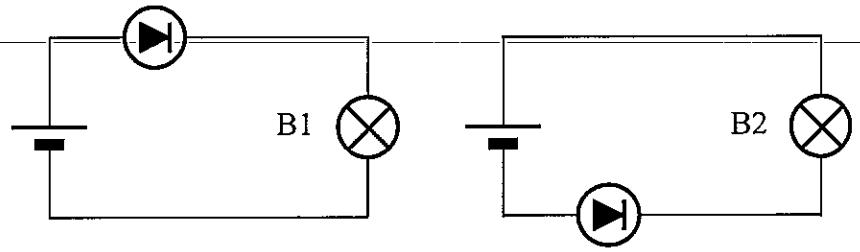
9.3 Study the representation of the pn-junction diode labelled, A B, in the diagram. Si, P and Aℓ are the symbols for a silicon, a phosphorus and an aluminium atom respectively. A portion of the crystal lattice on each side of the diode is represented in the large squares.



9.3.1 Which side, A or B, is 'p-type semiconductor material'? (1)

9.3.2 Explain what is meant by 'n-type semiconductor material'. (1)

9.3.3 Which of the light bulbs in these circuits light up? Explain your reasoning.



(4)

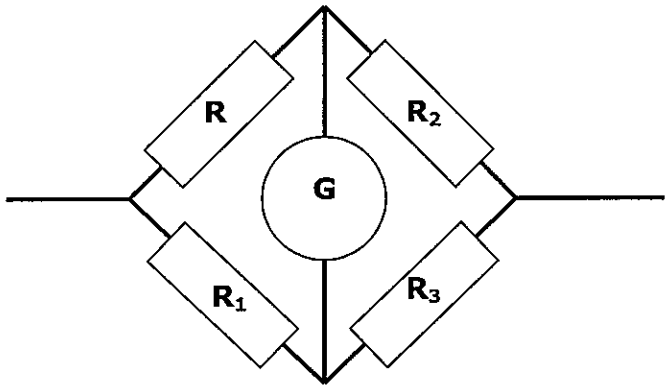
13 marks

Total: 150 marks

OPTIONAL QUESTIONS

QUESTION 10 Can be done as an option to question 6.2.3.

This is a diagram of a Wheatstone bridge.



10.1 Which of the resistors are in parallel? (1)

10.2 What is the function of the Wheatstone bridge? (1)

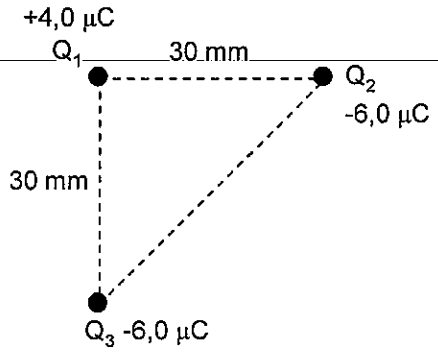
10.3 What does the symbol G in the circuit indicate and what is the function of this meter? (1)

10.4 The Wheatstone bridge is balanced when R_1 = 650 Ω and R_3 = 920 Ω. R_2 is a variable resistance and is set to 400 Ω. Calculate the unknown resistance of **R**. (2)

5 marks

QUESTION 11 Can be done as an option to question 8.

Three point charges Q_1, Q_2 and Q_3 are positioned at the vertices of a right angled triangle as shown in the diagram. The distance between Q_1 and Q_2 is 30 mm as is the distance between Q_1 and Q_3.



11.1 Calculate the force Q_1 and Q_2 exert on each other. (3)

11.2 Deduce the force Q_1 and Q_3 exert on each other. (1)

11.3 Make use of a force diagram and determine the magnitude of the net force on Q_1. (3)

11.4 Calculate the magnitude of the electric field at the position of Q_1. (3)

10 marks

Total: 150 marks