Total Mark

2008 Physics Challenge

Name:	
School:	
Town:	

Time Allowed: One Hour

Attempt all questions
Write your answers on this question paper
You may use any calculator

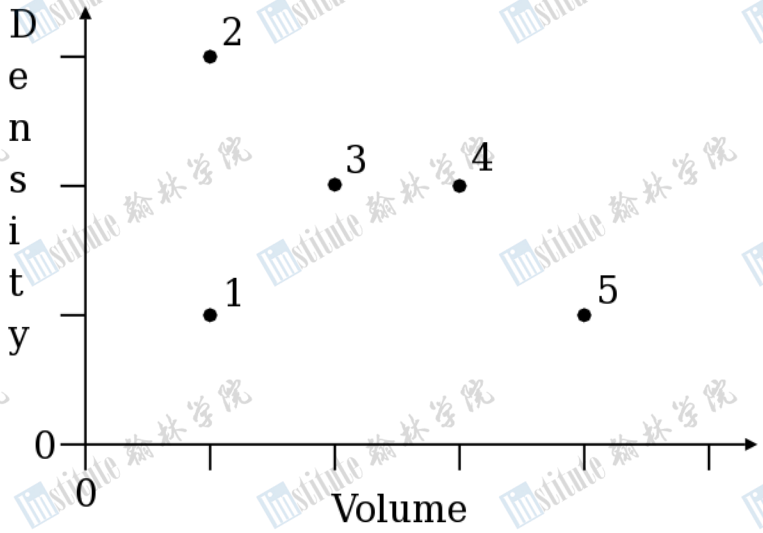
Section A: Ten Multiple Choice questions worth 1 mark each.
Allow about 10 minutes for this section.
Section B: Two Short Answer questions.
These questions require a clear explanation of the underlying physical principles.
Allow about 10 minutes for this section.
Section C: Longer Answer questions requiring calculation.
Allow about 40 minutes for this section.

Mark allocations for sections B & C are shown in brackets; total 50 marks.

Section A: Multiple Choice Questions
Tick the box in the grid which contains the correct answer to each question.
The first row has been done as an example if the answer to question zero were C

Question	A	B	C	D	E
0 (example)			✓		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

1. The density and volume of five samples of material are plotted on the graph as shown. Which two samples have the same mass?



A. 3 & 5
B. 3 & 4
C. 1 & 2
D. 1 & 3
E. 1 & 5

2. A student performs an experiment to measure the half life of a radioactive isotope. First they use a suitable detector and counter and measure the average background radiation to be 120 counts per minute (cpm). Next they measure the activity with the radioactive isotope in place and the record a reading of 1080 cpm. Finally they repeat the experiment 12 hours later with the radioactive isotope still in place and record a count rate of 240 cpm.

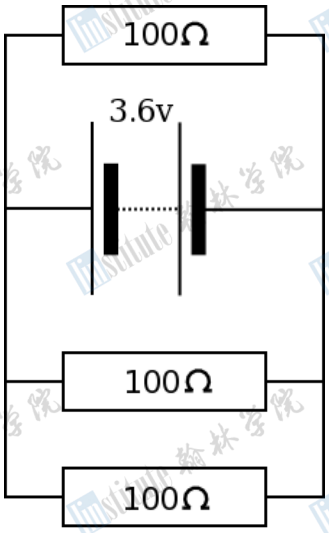
The half life of the sample is approximately:

A. 6 hours
B. 4 hours
C. 3 hours
D. 2 hours
E. cannot be determined from the given information

3. Blue light passes from air into a block of glass. Which line in the table correctly describes the behaviour of the light as it enters the glass?

A.	Frequency remains unchanged	Wavelength increases	Velocity increases
B.	Frequency decreases	Wavelength remains unchanged	Velocity decreases
C.	Frequency increases	Wavelength decreases	Velocity remains unchanged
D.	Frequency remains unchanged	Wavelength decreases	Velocity decreases
E.	Frequency remains unchanged	Wavelength remains unchanged	Velocity remains unchanged

4. A 3.6v battery is connected to three 100Ω resistors connected in parallel as shown. In the battery, chemical energy is transferred to electrical energy at a rate of approximately:



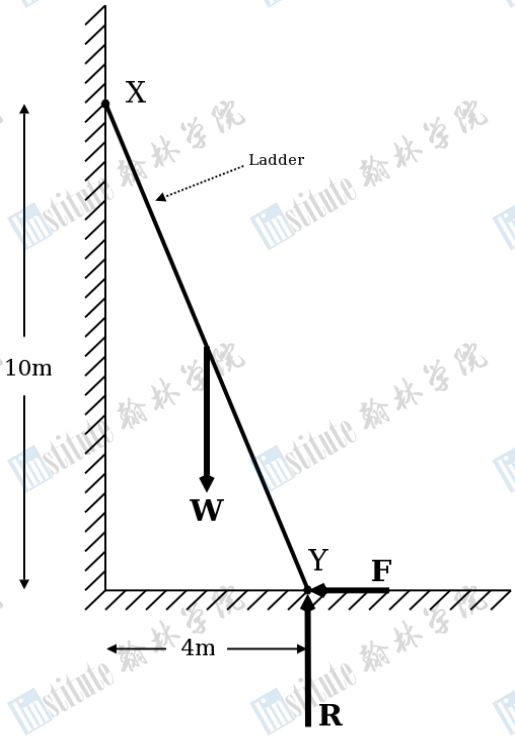
A. 120 J/s
B. 0.4 J/s
C. 0.13 J/s
D. 0.108 J/s
E. 0.04 J/s

5. A 3kW electric kettle contains 500g of boiling water (i.e. water at 100°C). The amount of energy required to turn 1kg of water at 100°C into steam at 100°C is 2270 kJ.

The best estimate of the time taken for the kettle to boil dry (i.e. turn all the water into steam) is:

A. less than 1 minute
B. 5 minutes
C. 7 minutes
D. 15 minutes
E. 1 hour 40 minutes

6. The simplified diagram shows three forces acting on a uniform ladder that is leaning against a wall. The ladder is in equilibrium and the vertical wall is frictionless. The weight of the ladder is 400N.



There must be a force acting on the ladder at the point X. By taking moments about point Y, the force acting on the ladder at point X can be shown to be approximately:

A. zero
B. 160N to the left
C. 160N to the right
D. 80N to the left
E. 80N to the right

7. The intelligent gerbils of Rodentland measure force in Gerbils and length in tails where 1 Gerbil = 0.4 N and 1 tail = 5cm.

Atmospheric pressure is 100000N/m^2 or 10 N/cm^2. How would the gerbils represent it?

A. 625 Gerbil / $tail^2$
B. 125 Gerbil / $tail^2$
C. 25 Gerbil / tail
D. 1.25 Gerbil / $tail^2$
E. 1 Gerbil / $tail^2$

8. Which of the five parachutists below is experiencing the largest upward force?

A. 100kg parachutist falling at a constant 6 m/s, normal sized parachute.
B. 100kg parachutist falling at 1 m/s, downward acceleration 8 m/s^2
C. 60kg parachutist falling at a constant 4 m/s, normal sized parachute
D. 60kg parachutist falling at a constant 2 m/s, extra-large parachute
E. 100kg parachutist falling at 0 m/s and accelerating (just left the plane)

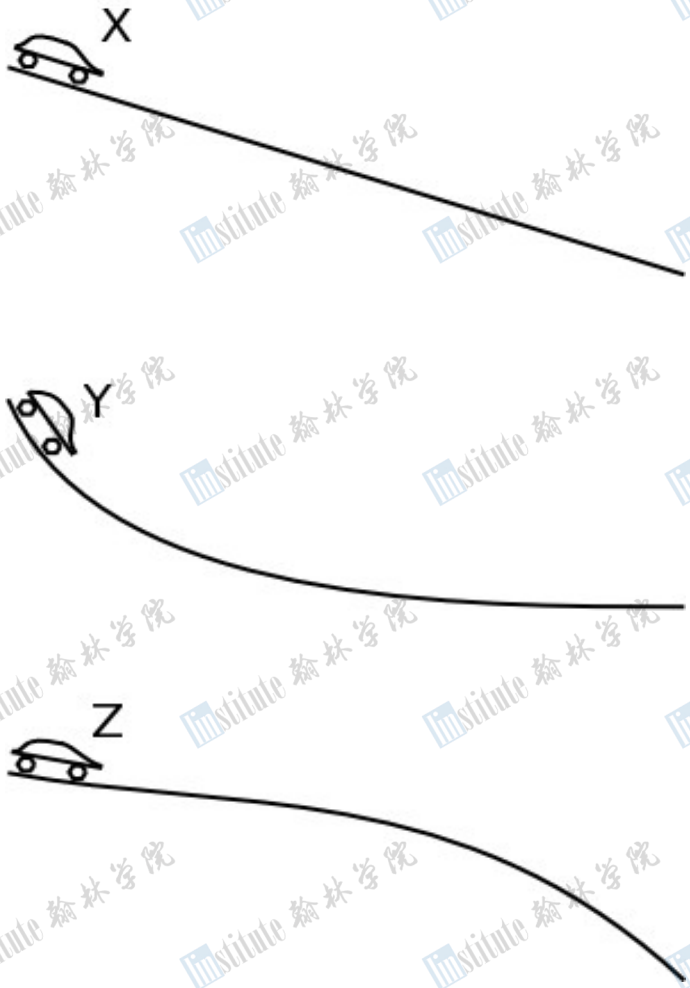
Question 9 & 10 both involve three toy cars X, Y and Z.

The cars roll down different shape ramps as shown.

The cars all:

- start at the same height
- start from rest
- end at the same height

Assume that the effects of friction and air resistance can be ignored



9. Consider how long each car takes to travel down the ramp from the top to the bottom:

A. X takes the least time
B. Y takes the least time
C. Z takes the least time
D. All three cars take approximately the same time
E. Which car takes the least time cannot be determined from the information given

10. Now the speeds of the cars are measured as they reach the end of the ramp:

A. X is fastest
B. Y is fastest
C. Z is fastest
D. All three cars have approximately the same speed.
E. Which car is fastest at the bottom of the ramp cannot be determined from the information given.

Short Answer Questions

Question 11. A student is standing on the floor. They then jump vertically upwards in to the air. In terms of the **forces** exerted by, and acting on the student, explain how they are able to leave the ground.

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Question 12. A hand-cranked generator can be connected to a number of light-bulbs by a switch. The handle of the generator is turned and then the switch is turned on so that the bulbs are connected. The light bulbs glow but the handle is much more difficult to turn than when the switch was off and the bulbs were therefore disconnected.

Explain why the handle is more difficult to turn with the bulbs connected.

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Longer Answer Questions

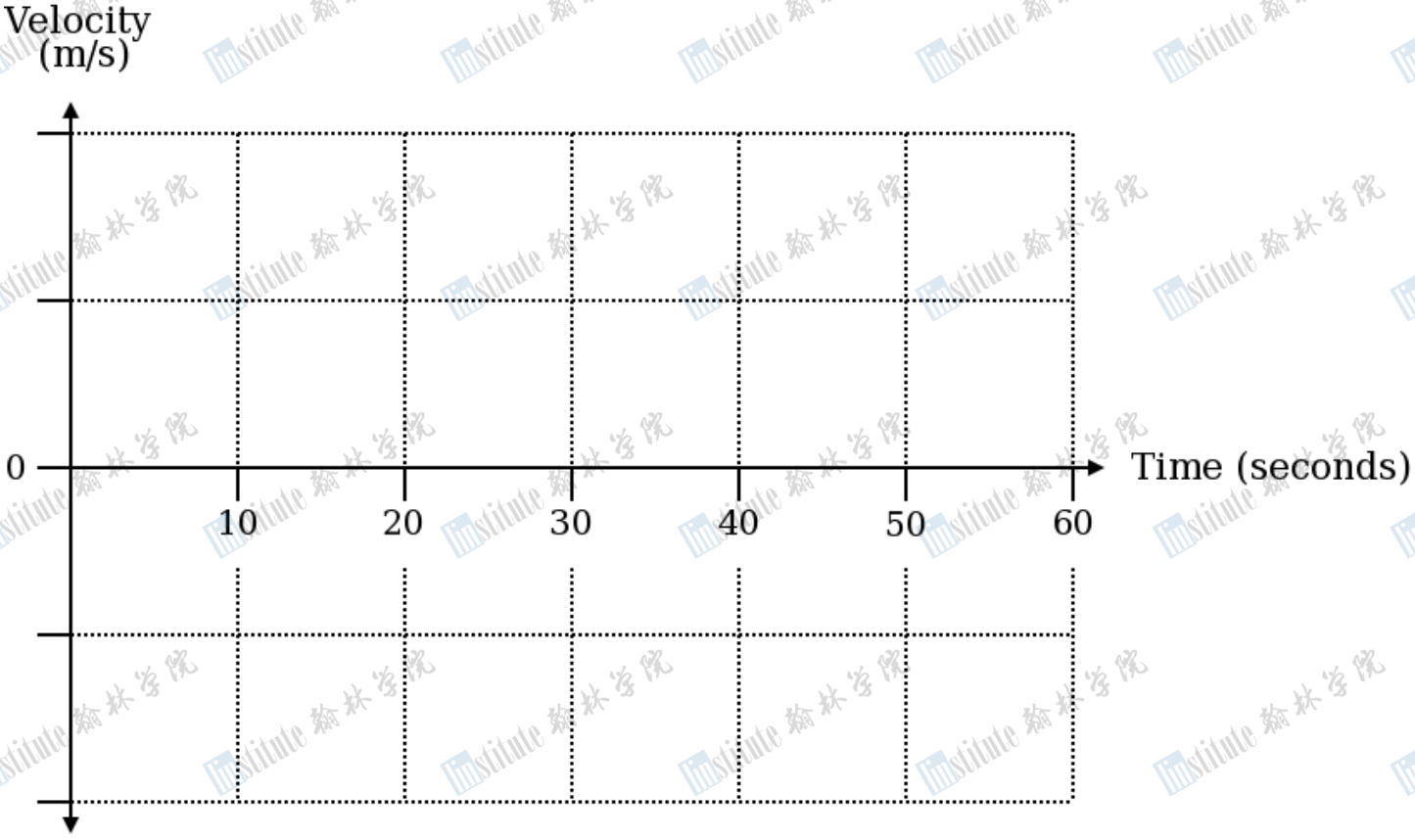
Question 13. Relative velocity is the velocity of one object as observed from another object. For example, if car A is travelling at 10 mph and car B is travelling, in the same direction, at 15 mph then the velocity of car B relative to car A is 5mph. The driver of car A observes car B moving ahead at 5 mph.

Two cars are next to each other. They start from rest and travel along a straight road in the same direction. Their subsequent motion over the next 60 seconds is shown in the table below:

Car A	***Car B***
Acceleration = 2 m/s^2 for 10 seconds	Acceleration = 2 m/s^2 for 20 seconds
Acceleration = 0 m/s^2 for 40 seconds	Acceleration = 0 m/s^2 for 10 seconds
Acceleration = -1 m/s^2 for 10 seconds	Acceleration = -3 m/s^2 for 10 seconds
	Acceleration = 0 m/s^2 for 20 seconds

(a) Draw a velocity – time graph for the velocity of car B relative to car A i.e. the velocity of car B as observed by the driver of car A.

Add an appropriate scale to the velocity axis. [4]



(b) For the velocity - time graph drawn in part (a), what does the area under the graph represent?

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(c) Hence, using the graph that you have drawn or otherwise, calculate the separation of the cars after 60 seconds.

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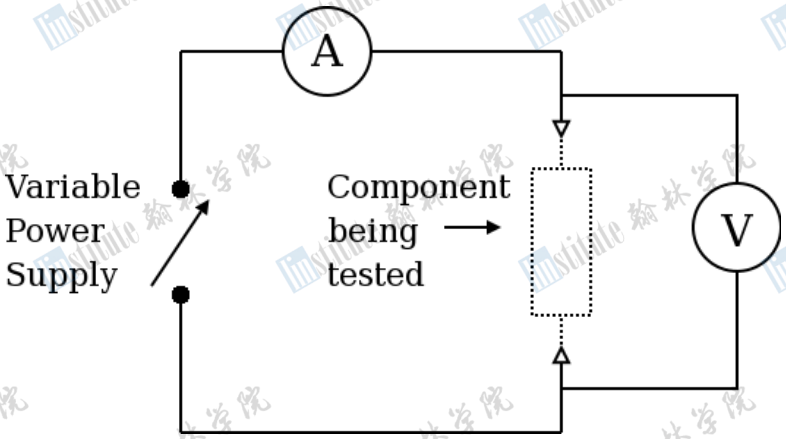
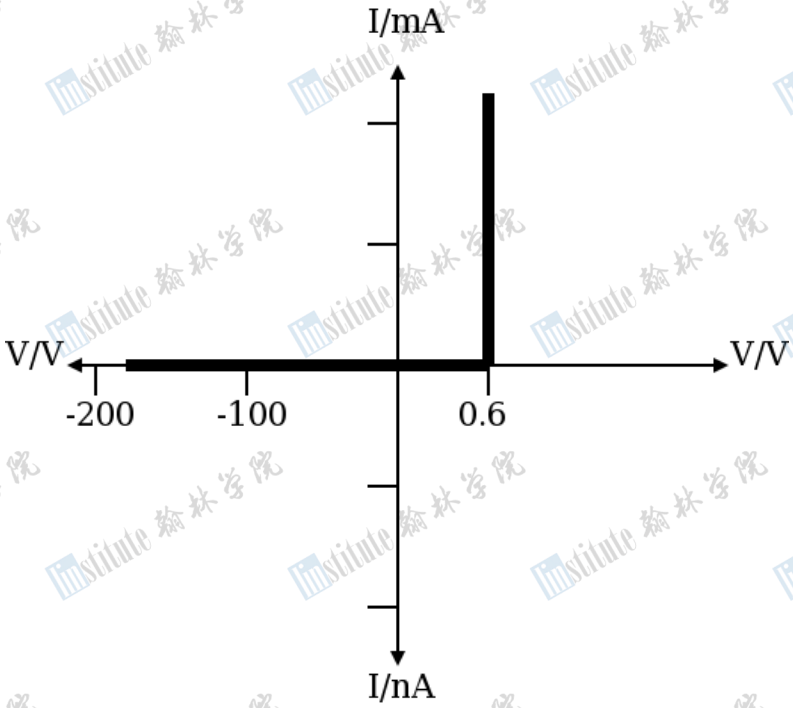
Question 14.

A student uses a simple circuit containing a voltmeter and an ammeter to investigate the behaviour of different electrical components.



(a) They test an ideal silicon diode and obtain the voltage – current graph as shown

Note that there are different scales on each axes:



Describe the behaviour of the Silicon diode shown by the graph:

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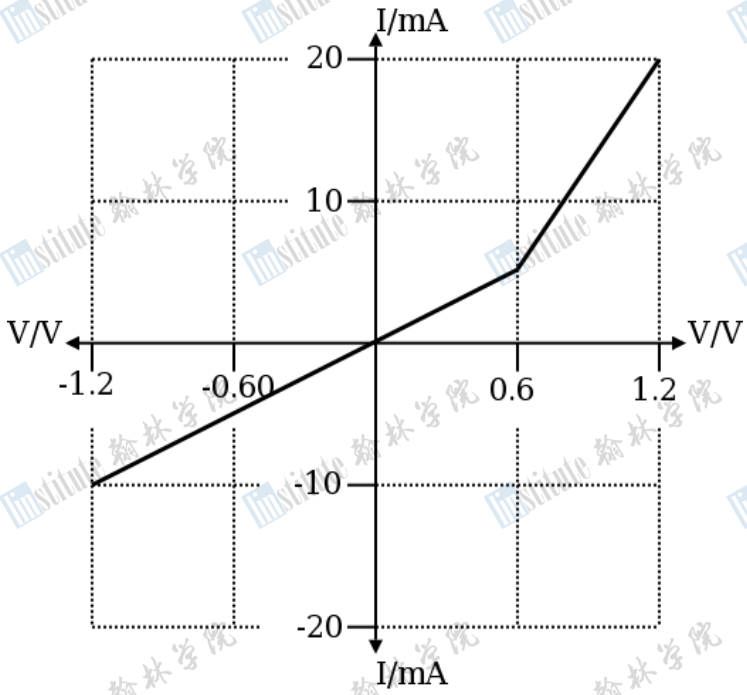
(b) Next they test a 'black box' component. This is a circuit containing only a silicon diode and two resistors, but the student cannot see how the three components are connected.

They test the 'black box' and obtain the voltage – current graph show:



(i) In the space below suggest a possible circuit diagram for the 'black box'. [2]

(ii) By taking readings from the graph, determine the values of the two resistors.

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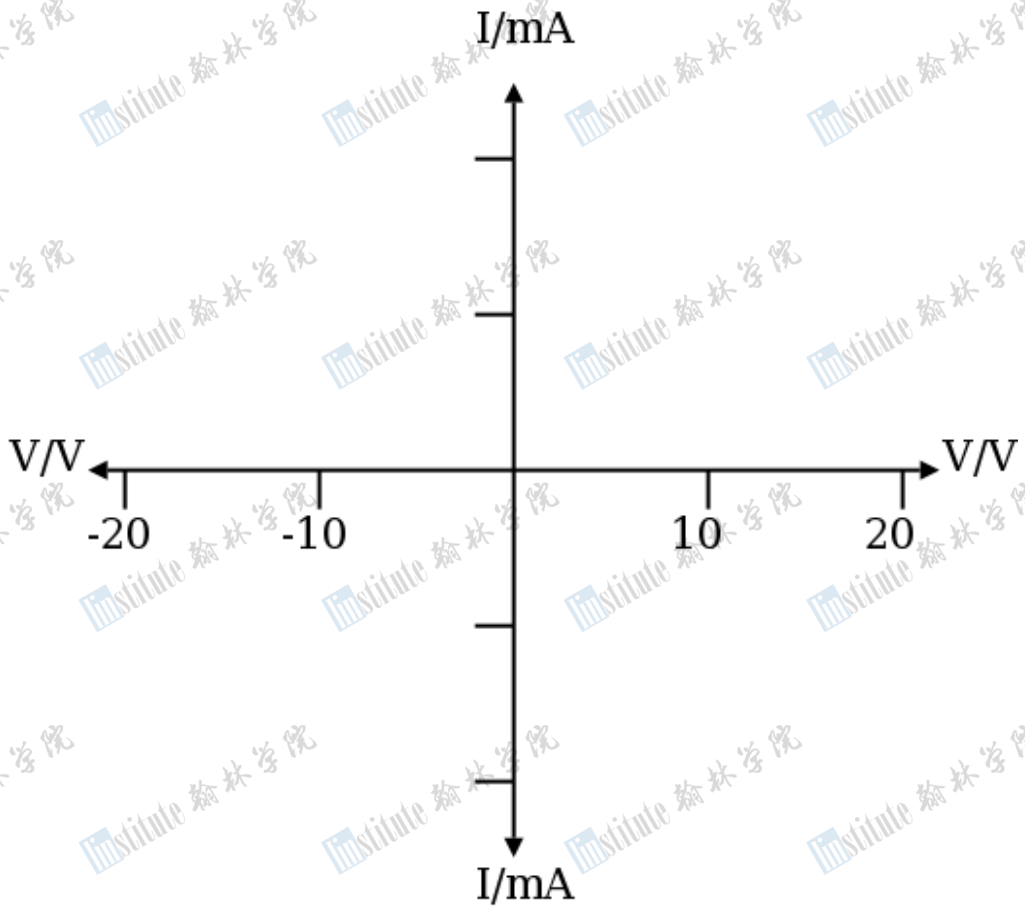
(c) Finally they investigate the behaviour of a thermistor. The resistance of a thermistor reduces as the temperature of the thermistor increases.

(i) On the axes below, sketch the voltage – current graph you would expect the student to obtain. [3]



(ii) Explain the shape of graph.

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In reality testing a thermistor in this way could damage it.

It is often desirable to include a low value resistor in series with the thermistor.

(iii) Explain how the thermistor might be damaged without a series resistor.

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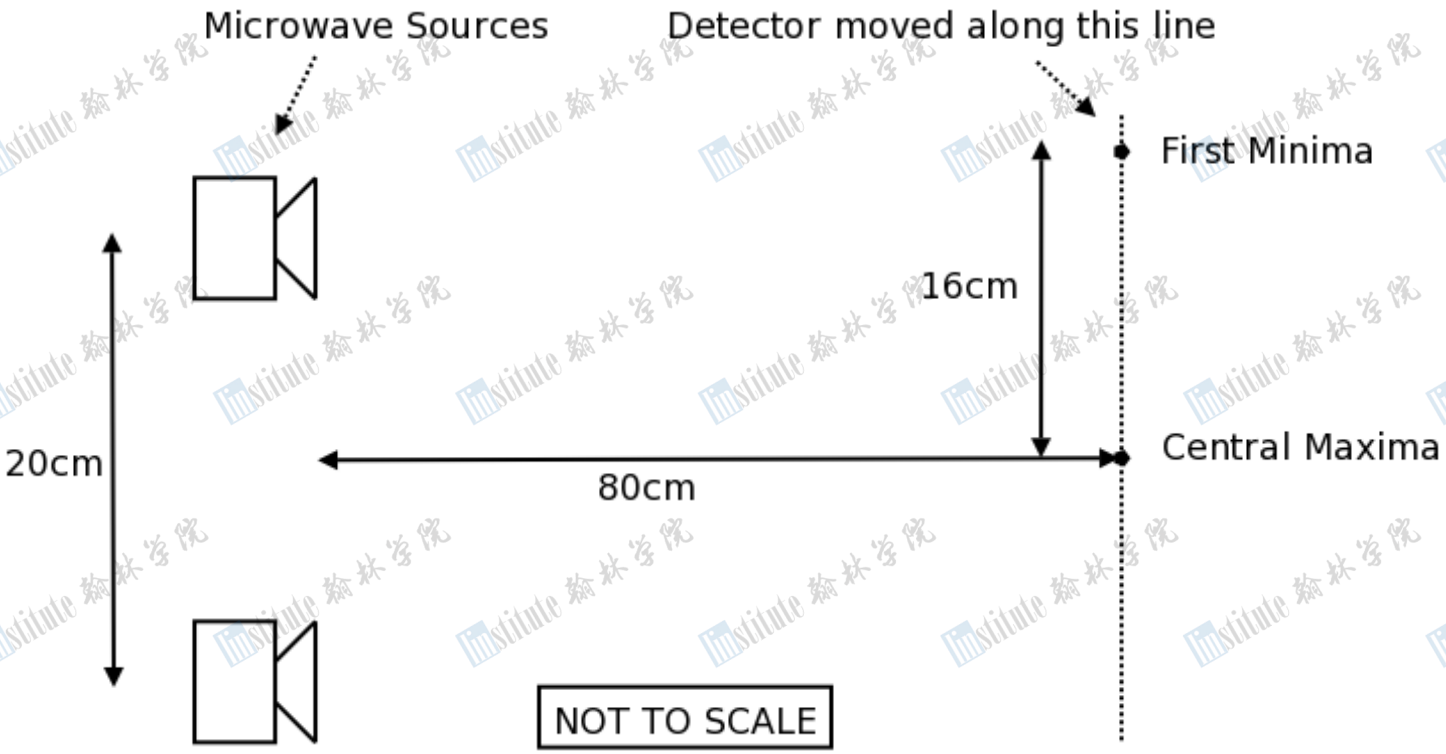
Question 15.

Some students are interested in the wavelength of the microwave radiation used in mobile phone communication. Their teacher advises them to carry out an experiment to measure the interference effects between two microwaves beams from two special sources. The students don't know anything about interference effects so their teacher gives them the following useful information:

- The microwaves from the two sources have to have exactly the same frequency, wavelength and amplitude and be in phase (which means that both sources give out a 'peak' at the same time as each other).
- If the distance travelled by the two microwaves beams (from the source to the detector) is the same, or different by a whole number of wavelengths, then the microwaves add up and a 'maxima' is detected.
- If the distance travelled by the two microwaves beams (from the source to the detector) is different by **half** a wavelength then the microwaves cancel out and a 'minima' is detected.

The students successfully complete the experiment and produce the following sketch (not to scale) of their results:



(a)(i) By drawing a scale diagram or otherwise, determine the **difference** in the distance travelled by the two microwave beams from the sources to the position of the first minima.

(The graph paper can be used to draw a scale diagram)

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(ii) Therefore suggest a value for the wavelength of the microwaves.

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(iii) Calculate the frequency of the microwave radiation ($c = 3x10^8$ m/s)

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(b) Suggest a reason why using two identical mobile phones as the microwave sources would probably not have worked in this experiment.

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Graph paper for use with Question 15 (a)(i)