NO. OF COPIES: **45**

Dr. M. Jeffreys
Mr. P. Krautil

PYMBLE LADIES' COLLEGE

SEMESTER 2, 2005

YEAR 11 ~ PHYSICS

TIME ALLOWED: 2 HOURS

DIRECTIONS TO CANDIDATES:

ALL Questions are compulsory

PART A: (12 marks)
12 Multiple Choice questions, each worth one mark.
Indicate all answers on the grid on the Multiple Choice Answer Sheet provided.

PART B: (56 marks)
Questions 13 – 22
Written response questions.
Marks for each question are clearly indicated.
All answers are to be written in the spaces provided with each question.

Please write your name on the Multiple Choice Answer Sheet and on page 7.

Formulae and Data Sheets are provided at the back of this paper.

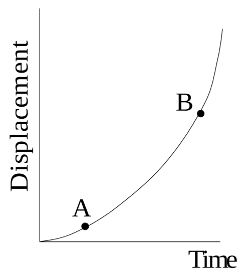
Part A

Total marks **(12)**

• Attempt **Questions 1–12**
• Allow about **20 minutes** for this part

Question 1:

The following diagram is the displacement-time graph for a moving object



Which of the following statements is true?

(A) The average speed of the object over the interval from A to B is less than the instantaneous speed of the object at point A.

(B) The average speed of the object over the interval from A to B is equal to than the instantaneous speed of the object at point A.

(C) The average speed of the object over the interval from A to B is greater than the instantaneous speed of the object at point A.

(D) The speed of the object over the interval from A to B is changing so we cannot find an average.

Question 2:

A sled of mass m is coasting on the icy surface of a frozen river. While it is passing under a bridge, a large person of equal mass m drops straight down and lands on the sled (without causing any damage). The sled plus the added load then continue along the original line of motion.
How does the kinetic energy of the sled + load compare with the original kinetic energy of the sled?

(A) It is 1/4 the original kinetic energy of the sled.

(B) It is 1/2 the original kinetic energy of the sled.

(C) It is the same as the original kinetic energy of the sled.

(D) It is twice the original kinetic energy of the sled.

Question 3:

A stunt person jumps from the roof of a tall building, but no injury occurs because the person lands on a large, air-filled bag. Which one of the following best describes why no injury occurs?

(A) The bag provides the necessary force to stop the person.

(B) The bag reduces the impulse to the person.

(C) The bag increases the amount of time the force acts on the person and reduces the change in kinetic energy.

(D) The bag increases the amount of time during which the kinetic energy is changing and reduces the average force on the person.

Question 4:

A standing wave with a 36 centimetre wavelength is established along a horizontal string. If point P on this string is a trough or crest (antinode), what is the horizontal distance between point P and the closest node (equilibrium point)?

(A) 36 cm

(B) 18 cm

(C) 27 cm

(D) 9 cm

Question 5:

The following table gives the values for some wave variables.

type of wave	frequency (Hz)	wavelength (m)	speed (ms^{-1})
sound in air (bass guitar)	220	1.5	**X**
sound in air (whistle)	**Y**	0.1	330
sound in water (whale)	50	**Z**	1500

The value for X, Y and Z respectively are:

(A) 330, 3300, 30

(B) 30, 330, 3300

(C) 3300, 30, 330

(D) 330, 30, 3300

Question 6:

All of the following statements are true of light waves, sound waves, and radio waves EXCEPT:

(A) Their wavelengths depend upon the medium in which they are travelling.

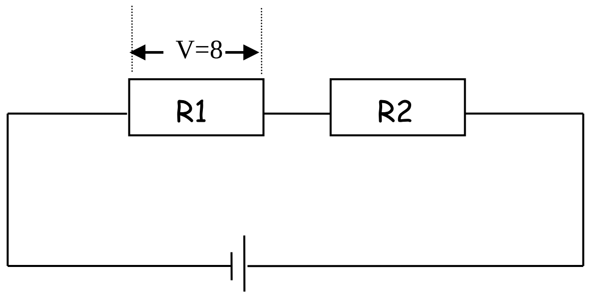
(B) They belong to the electromagnetic spectrum.

(C) They undergo refraction in accordance with Snell's law.

(D) For point sources, they obey the inverse-square law of intensity.

Question 7:

A circuit is set up with two resistors of equal value in series, as shown below. The voltage across R1 is 8V. What is the voltage provided by the power supply?



(A) 4 V

(B) 8 V

(C) 12 V

(D) 16 V

Question 8:

Which of the following would decrease the resistance of a piece of wire?

(A) changing its material from gold to iron

(B) increasing its cross sectional area

(C) increasing its length

(D) increasing its temperature

Question 9:

A circuit contains two 100 Ω globes connected in series with a battery. What is the total circuit resistance?

(A) 50 Ω

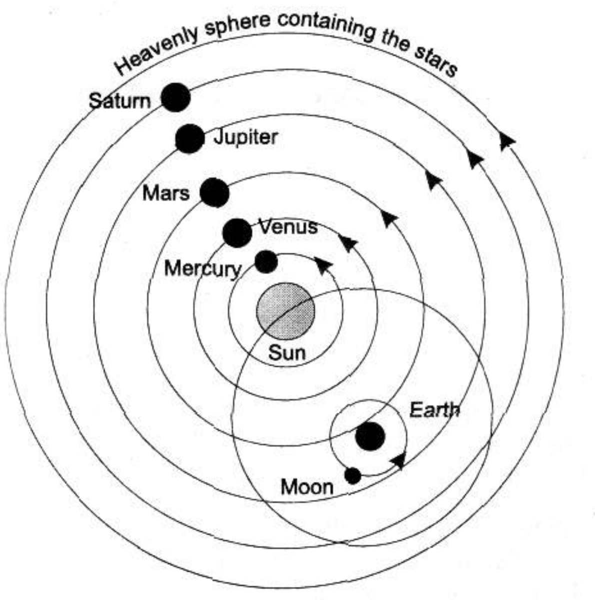
(B) 100 Ω

(C) 200 Ω

(D) 250 Ω

Question 10:

The diagram below shows a model of the Universe as developed by Tycho Brahe.



What is its main problem, when judged from a modern perspective?

(A) It shows the planets going around the Sun

(B) It shows the stars outside the planets

(C) It shows the Sun going around the Earth

(D) It shows the planets travelling in circular paths

Question 11:

How can we explain the formation of the heaviest elements observed in the Universe with our current understanding of matter and energy?

(A) The conversion of radiant energy into mass soon after the Big Bang

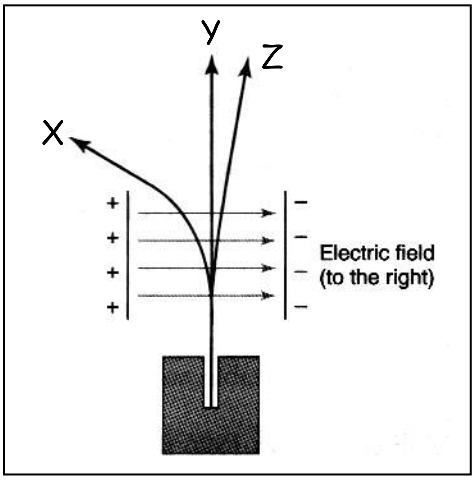
(B) Nuclear fusion during a supernova explosion

(C) Nuclear fusion inside Main Sequence stars

(D) Nuclear fusion inside Supergiant stars

Question 12:

The diagram below shows three kinds of nuclear radiation X, Y and Z, passing through an electric field.



Which kinds of nuclear radiation are X, Y and Z?

(A) alpha, beta, gamma

(B) alpha, gamma, beta

(C) beta, alpha, gamma

(D) beta, gamma, alpha

Name ....

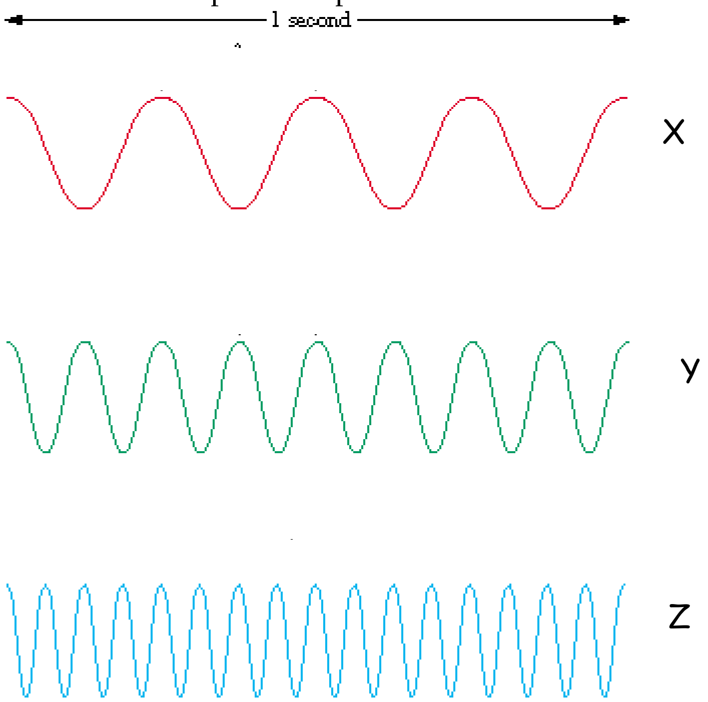
Part B

Total marks **(56)**

• Attempt **Questions 13 – 22**
• Allow about **1 hour and 40 minutes** for this part

Question 13: (3 marks)

The following diagram depicts three waves X, Y and Z over a period of one second as seen on an oscilloscope. The speed of these waves is 300 ms^{-1}.



(a) Determine the frequency of Y. **1**

....

(b) Calculate the wavelength of Y **1**

....

....

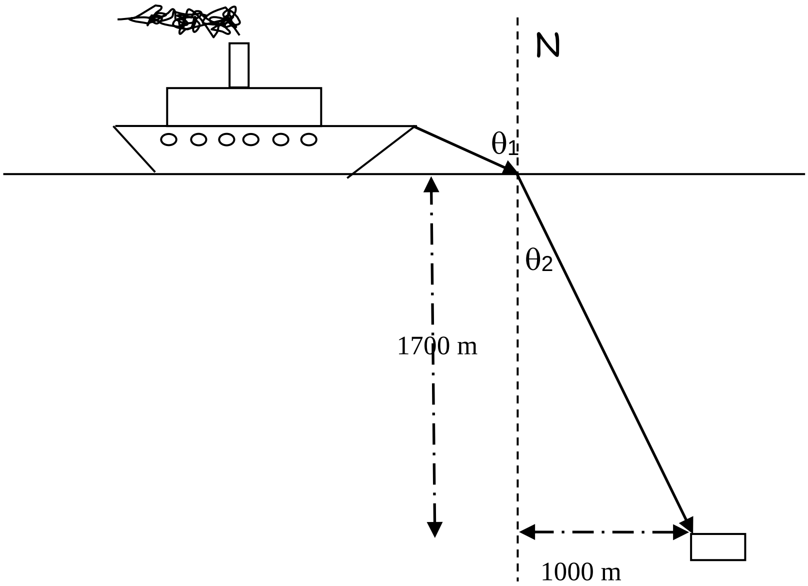
(c) Describe the difference you would hear between X and Z if these are sound waves. **1**

....

....

Question 14: (7 marks)

A ship searching for a sunken treasure chest was making use of a powerful beam of blue light which could penetrate to great depths of the ocean. The diagram below shows the arrangement.



The refractive index for blue light in sea water is 1.33 and for air is 1.00.

(a) Given the above information how would you expect the speed of light in air to compare with the speed of light in the sea water? **1**

....

....

(b) Calculate the angle θ_1, at which the light must shine on the water so that it hits the sunken chest as shown in the diagram. **2**

....

....

....

....

....

....

(c) State how the refractive index for red light in sea water would differ compared to the blue light used. Give a reason for your answer. **2**

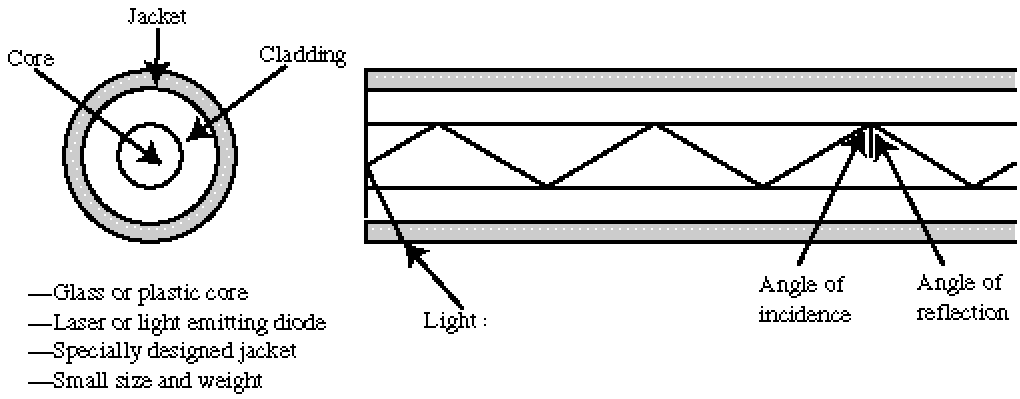
....

....

....

....

(d) The searchers aboard the ship used a camera attached to optical fibre to investigate the sunken chest. Using the diagrams below, outline how total internal reflection is used in optical fibres. **2**



Optical Fiber

....

....

....

....

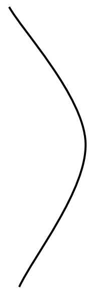
....

....

Question 15: (4 marks)

Radio telescopes, like the one pictured gather electromagnetic radiation (EMR) from space and provide a means for the exploration of the universe.

(a) Draw a ray diagram to show the path of the EMR as it is gathered by the radio telescope and hence explain why the radio telescope has such a distinctive shape. **2**



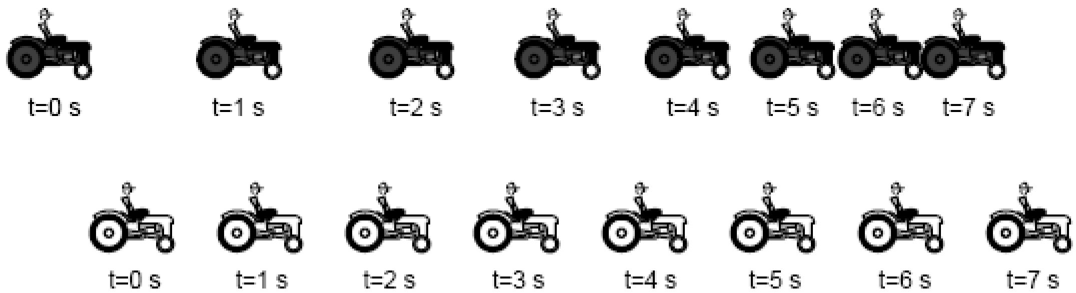
(b) The intensity of the radiation collected is very low. Explain, using an appropriate example and equation, why this is so. **2**

Question 16: (6 marks)

(a) "She moves at a constant speed in a constant direction."
Write a sentence which gives the same information in fewer words. **1**

....

The figure shows a sequence of positions for two racing tractors.



(b) Examine the motion of the tractors as the race progresses.
The drawing is scaled at 1:100 **2**
Complete the following table to calculate the average velocity of each tractor per second for each interval shown in the diagram.

Time								
Black Tractor								
White Tractor								

(c) Draw a velocity time graph on the grid below for both the black tractor and the white tractor. Use the same set of axes for both graphs. **3**

Question 17: (8 marks)

A high-speed bus and an innocent bug have a head-on collision. The force of impact splatters the poor bug over the windshield.

(a) Is the force that the bug exerts against the windshield greater, less, or the same as the force the bus exerts on the bug? **1**

....

(b) Is the resulting deceleration of the bus greater than, less than, or the same as that of the bug? Use appropriate formula(s) to explain your answer. **1**

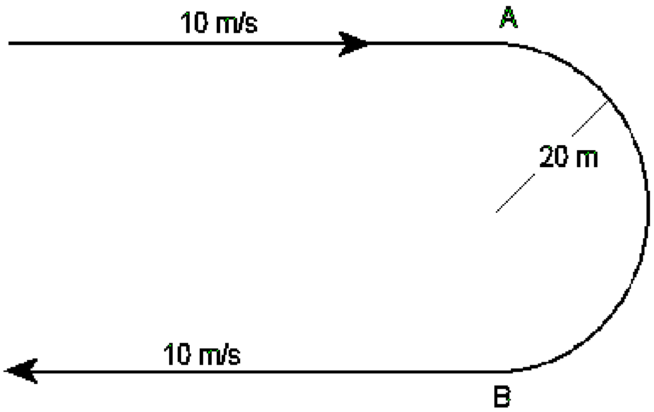
....

....

....

....

The bus has a mass 500 kg. It is travelling at 10 ms^{-1} east when it comes to a roundabout of radius 20 m. After turning as shown, it was travelling at 10 ms^{-1} to the west.



(c) Determine the size and direction of the centripetal force acting on the bus as it is going around the roundabout. **2**

....

....

....

....

(d) Calculate the change in momentum the bus experiences from just before it enters the roundabout to leaving the roundabout. **2**

....

....

....

(e) Modern buses are fitted with safety belts. Use Newton's Laws to explain the function of a safety belt. **2**

Question 18: (4 marks)

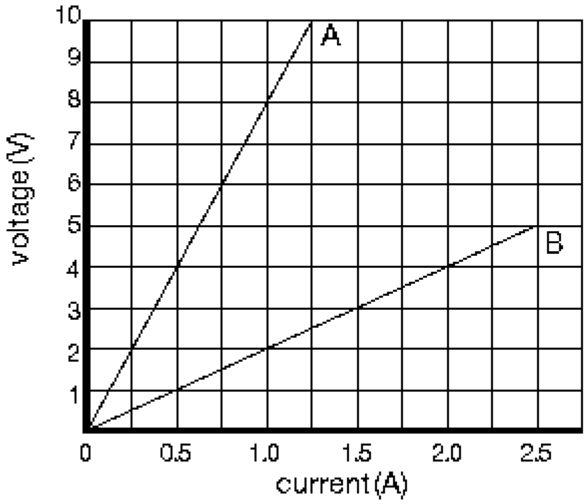
Below is a diagram of a positive point charge, **Q** and a nearby point **P** which is uncharged. **2**

a) Draw the electric field lines surrounding the point charge, **Q**.

b) An electron is now placed at point **P**.
The electric field strength at **P** due to the point charge at **Q** is 8×10^{-20} $NC^{-1.}$
Calculate the magnitude and direction of the force on the electron. **2**

Question 19: (5 marks)

The following graph shows how the potential difference varies with current for two resistors A and B.



(a) Which resistor has the highest resistance value? **1**

....

(b) Calculate the value of the resistance of the resistor you identified in part (a). **2**

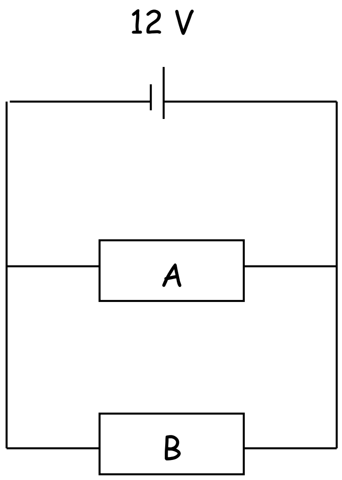
....

....

....

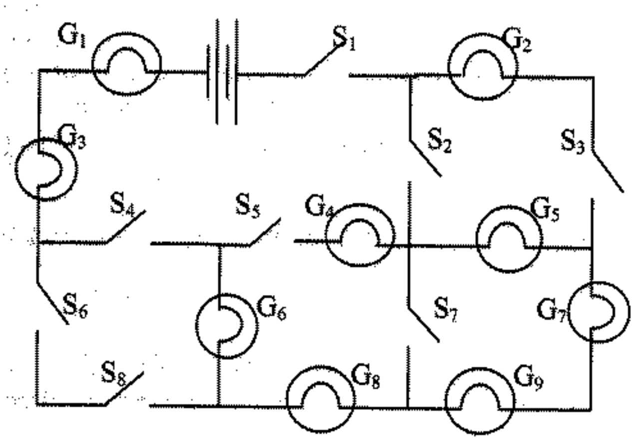
....

(c) These resistors were connected in parallel, as shown below. On the diagram show where you would connect an ammeter to measure the current in B. **1**



Question 20: (5 marks)

Look at the circuit diagram to answer part (a).



(a) Identify the globes that will be on if **only** switches S_1, S_3, S_4, and S_7 are closed. **1**

....

(b) Explain why it is essential for voltmeters to have a very high resistance. **2**

....

....

....

....

(c) Explain why there are different circuits for heating, lighting and other appliances in a house. **2**

....

....

....

....

....

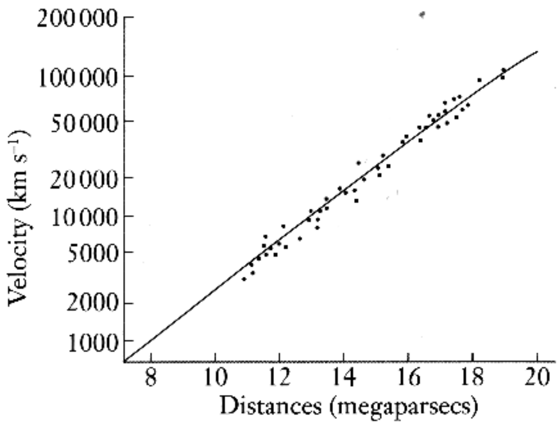
....

....

....

Question 21 (6 marks)

Early in the 20th century Edwin Hubble studied the light coming from stars in galaxies outside the Milky Way. He found that their velocities relative to the Milky Way followed a pattern as shown in the graph below.



(a) Outline how Hubble applied the Doppler Effect to determine the velocities of the galaxies. **3**

....

....

....

....

....

....

....

....

(b) Explain why this graph is evidence for the Big Bang theory of the origin of the Universe. **2**

....

....

....

....

....

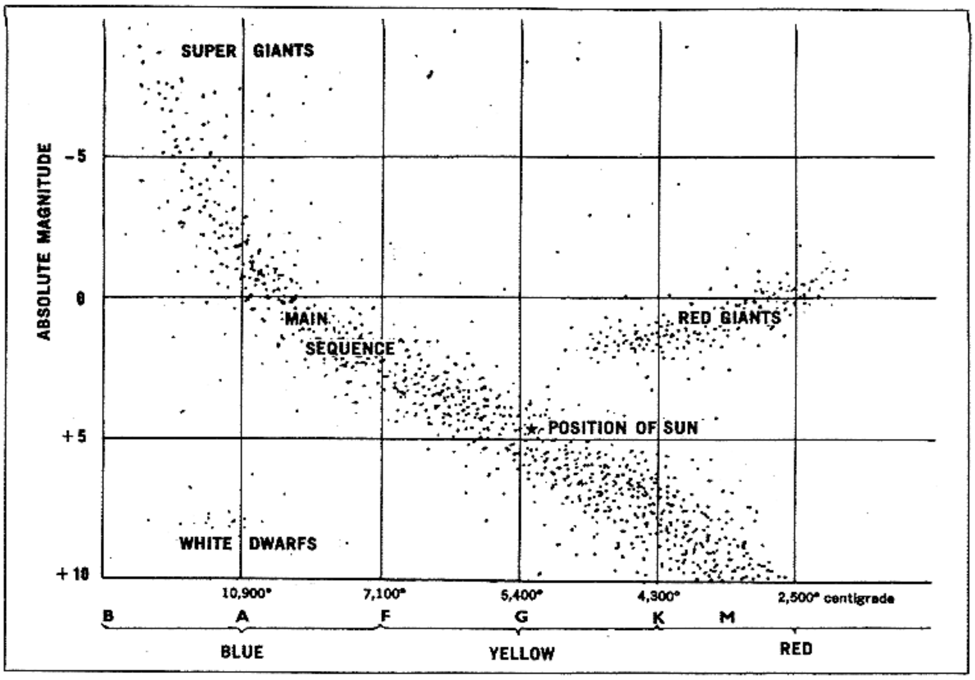
(c) Identify one other piece of evidence which supports the Big Bang theory. **1**

....

....

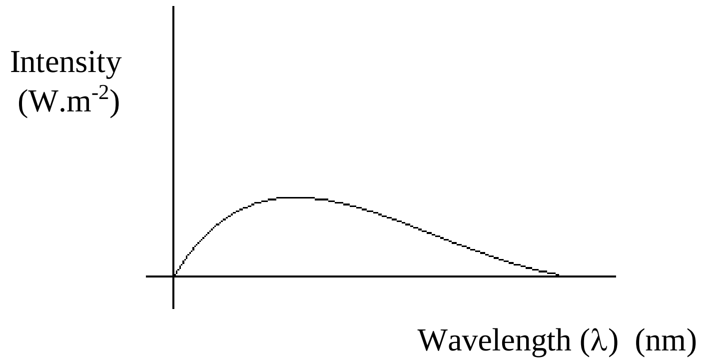
Question 22 (8 marks)

The graph below is a Hertzsprung-Russell diagram with the position of the Sun indicated in the Main Sequence.



(a) On the H-R diagram above, draw the expected path of the evolution of the Sun after it leaves the Main Sequence. **1**

(b) The diagram below represents a graph of Intensity of radiation emitted from the Sun as a function of Wavelength.



On the same diagram, sketch the Intensity vs Wavelength graph for a typical blue Super Giant. **1**

(c) The Sun produces energy by the nuclear fusion of hydrogen into helium. A simplified equation for one kind of nuclear fusion is as follows:

$$4H^{+} \rightarrow He^{2+} + 2e^{+} + 2\nu + \text{energy}$$

During this process mass is converted into energy. If the luminosity (rate of energy output) of the Sun is 3.9×10^{26} J/s, calculate the rate at which mass is being 'lost' from the Sun. **2**

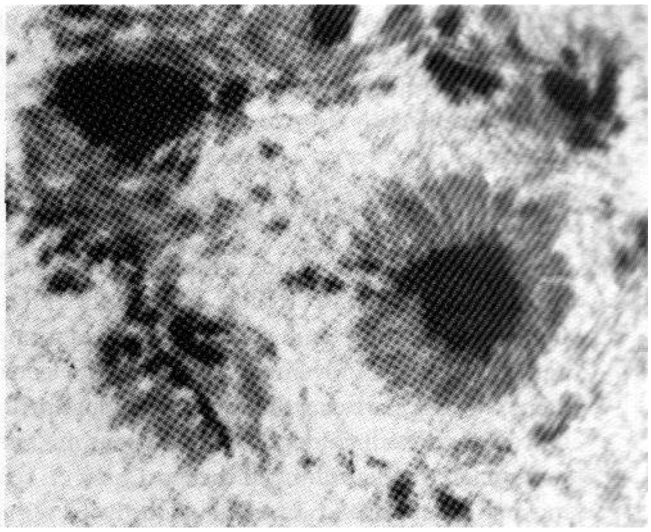
....

....

....

....

(d) The photograph below shows a group of sunspots on the surface of the Sun.



(i) Describe the nature of sunspots. **1**

....

....

....

....

(ii) Explain how increased sunspot activity could cause problems on Earth. **3**

....

....

....

....

END OF PAPER

NO. OF COPIES: **45**

Dr. M. Jeffreys
Mr. P. Krautil

PYMBLE LADIES' COLLEGE

SEMESTER 2, 2005

YEAR 11 ~ PHYSICS

TIME ALLOWED: 2 HOURS

DIRECTIONS TO CANDIDATES:

ALL Questions are compulsory

PART A: 12 Multiple Choice questions, each worth one mark.
Indicate all answers on the grid on the Multiple Choice Answer Sheet provided.
(12 marks)

PART B: Questions 13 – 22
Written response questions.
Marks for each question are clearly indicated.
All answers are to be written in the spaces provided with each question.
(56 marks)

Please write your name on the Multiple Choice Answer Sheet and on page 7.

Formulae and Data Sheets are provided at the back of this paper.

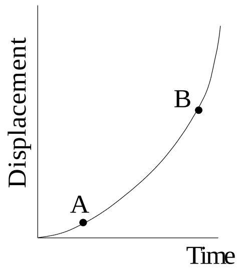
Part A

Total marks **(12)**

• Attempt **Questions 1–12**
• Allow about **20 minutes** for this part

Question 1:

The following diagram is the displacement-time graph for a moving object



Which of the following statements is true?

(A) The average speed of the object over the interval from A to B less than the instantaneous speed of the object at point A?

(B) The average speed of the object over the interval from A to B equal to than the instantaneous speed of the object at point A?

(C) The average speed of the object over the interval from A to B greater than the instantaneous speed of the object at point A?

(D) The speed of the object over the interval from A to B is changing so we cannot find an average.

Question 2:

A sled of mass m is coasting on the icy surface of a frozen river. While it is passing under a bridge, a large person of equal mass m drops straight down and lands on the sled (without causing any damage). The sled plus the added load then continue along the original line of motion.
How does the kinetic energy of the sled + load compare with the original kinetic energy of the sled?

(A) It is 1/4 the original kinetic energy of the sled.

(B) It is 1/2 the original kinetic energy of the sled.

(C) It is the same as the original kinetic energy of the sled.

(D) It is twice the original kinetic energy of the sled.

Question 3:

A stunt person jumps from the roof of a tall building, but no injury occurs because the person lands on a large, air-filled bag. Which one of the following best describes why no injury occurs?

(A) The bag provides the necessary force to stop the person.

(B) The bag reduces the impulse to the person.

(C) The bag increases the amount of time the force acts on the person and reduces the change in kinetic energy.

(D) The bag increases the amount of time during which the kinetic energy is changing and reduces the average force on the person.

Question 4:

A standing wave with a 36 centimetre wavelength is established along a horizontal string. If point P on this string is a trough or crest (antinode), what is the horizontal distance between point P and the closest node (equilibrium point)?

(A) 36 cm

(B) 18 cm

(C) 27 cm

(D) 9 cm

Question 5:

The following table gives the values for some wave variables

type of wave	frequency (Hz)	wavelength (m)	speed (ms^{-1})
sound in air (bass guitar)	220	1.5	**X**
sound in air (whistle)	**Y**	0.1	330
sound in water (whale)	50	**Z**	1500

The value for X, Y and Z respectively are:

(A) 330, 3300, 30

(B) 30, 330, 3300

(C) 3300, 30, 330

(D) 330, 30, 3300

Question 6:

All of the following statements are true of light waves, sound waves, and radio waves EXCEPT:

(A) Their wavelengths depend upon the medium in which they are travelling.

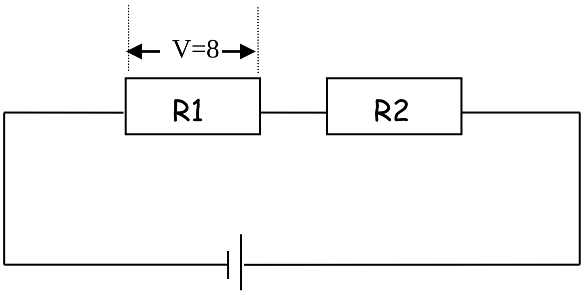
(B) They belong to the electromagnetic spectrum.

(C) They undergo refraction in accordance with Snell's law.

(D) For point sources, they obey the inverse-square law of intensity.

Question 7:

A circuit is set up with two resistors of equal value in series, as shown below. The voltage across R1 is 8V. What is the voltage provided by the power supply?



(A) 4 V

(B) 8 V

(C) 12 V

(D) 16 V

Question 8:

Which of the following would decrease the resistance of a piece of wire?

(A) changing its material from gold to iron

(B) increasing its cross sectional area

(C) increasing its length

(D) increasing its temperature

Question 9:

A circuit contains two 100 Ω globes connected in series with a battery. What is the total circuit resistance?

(A) 50 Ω

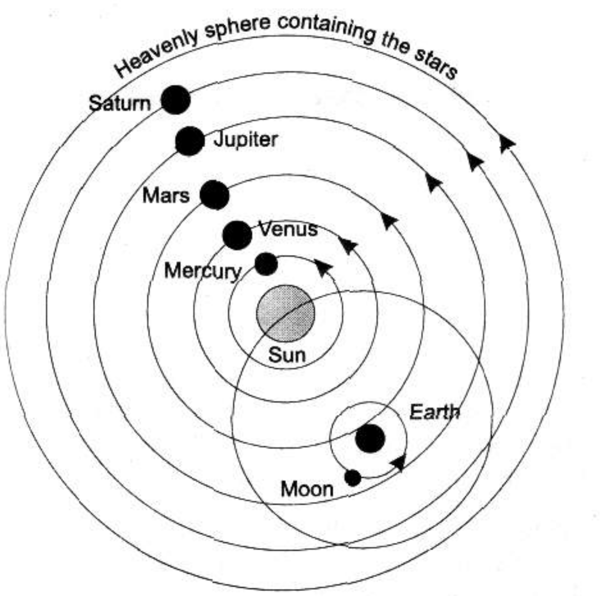
(B) 100 Ω

(C) 200 Ω

(D) 250 Ω

Question 10:

The diagram below shows a model of the Universe as developed by Tycho Brahe.



What is its main problem, when judged from a modern perspective?

(A) It shows the planets going around the Sun

(B) It shows the stars outside the planets

(C) It shows the Sun going around the Earth

(D) It shows the planets travelling in circular paths

Question 11:

How can we explain the formation of the heaviest elements observed in the Universe with our current understanding of matter and energy?

(A) The conversion of radiant energy into mass soon after the Big Bang

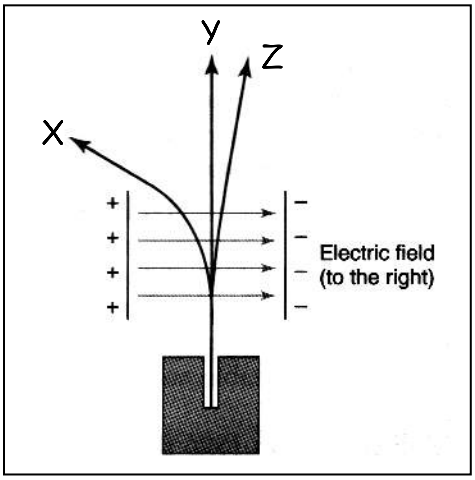
(B) Nuclear fusion during a supernova explosion

(C) Nuclear fusion inside Main Sequence stars

(D) Nuclear fusion inside Supergiant stars

Question 12:

The diagram below shows three kinds of nuclear radiation X, Y and Z, passing through an electric field.



Which kinds of nuclear radiation are X, Y and Z?

(A) alpha, beta, gamma

(B) alpha, gamma, beta

(C) beta, alpha, gamma

(D) beta, gamma, alpha

Name ....

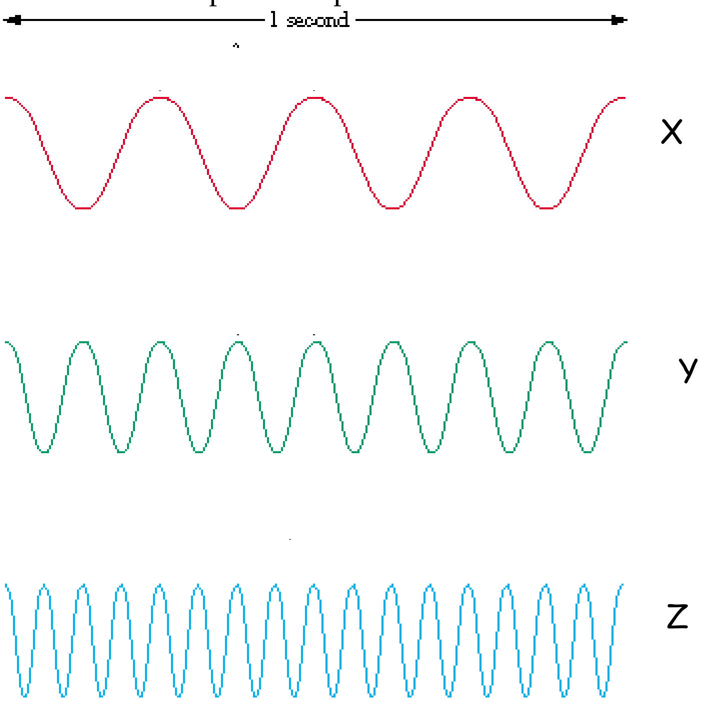
Part B

Total marks **(56)**

• Attempt **Questions 13 – 22**
• Allow about **1 hour and 40 minutes** for this part

Question 13: (3 marks)

The following diagram depicts three waves X, Y and Z over a period of one second as seen on an oscilloscope. The speed of these waves is 300 ms^{-1}.



(a) Determine the frequency of Y. **1**

8 Hz.

(b) Calculate the wavelength of Y **1**

$v = f\lambda$ 300 = 8 × λ

λ = 37.5 m

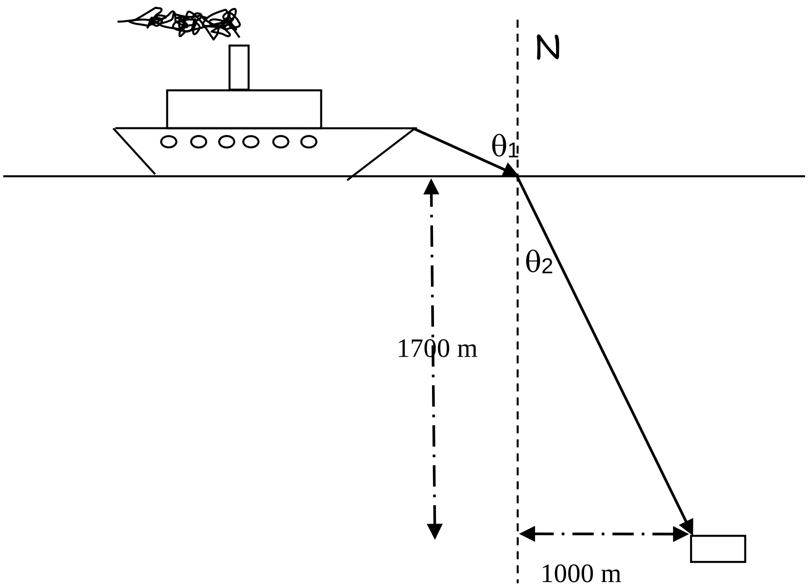
(c) Describe the difference you would hear between X and Z if these are sound waves. **1**

X would have a lower pitch than Z. (they would have the same loudness)

....

Question 14: (7 marks)

A ship searching for a sunken treasure chest was making use of a powerful beam of blue light which could penetrate to great depths of the ocean. The diagram below shows the arrangement.



The refractive index for blue light in sea water is 1.33 and for air is 1.00.

(a) Given the above information how would you expect the speed of light in air to compare with the speed of light in the sea water? **1**

The speed of light would be slower in water.

(b) Calculate the angle θ_1, that the light must shine on the water so that it hits the sunken chest as shown in the diagram. **2**

$$\frac{\sin i}{\sin r} = n$$

$$\sin r = \frac{1000}{\sqrt{1000^2 + 1700^2}} \qquad (r = 30.46^\circ)$$

$$\sin r = 0.507$$

$$\sin i = 1.33 \times 0.507$$

$$i = \sin^{-1} 0.659$$

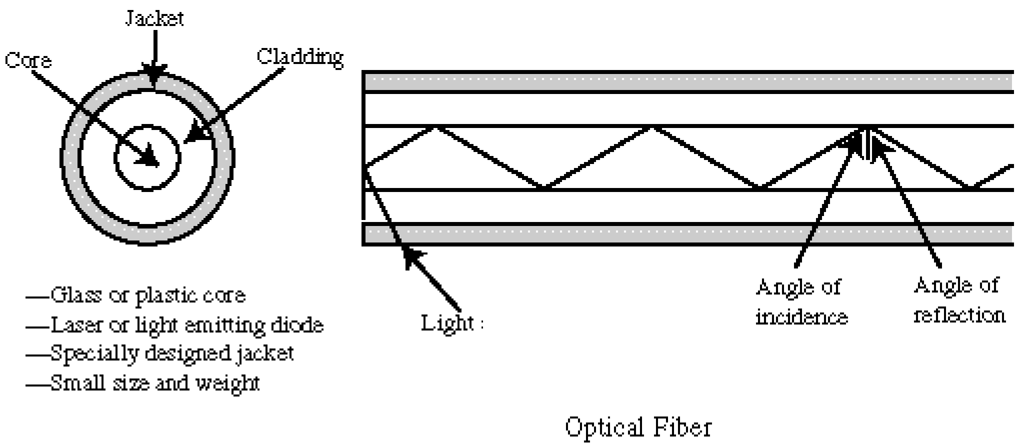
$$i = 42.4^\circ$$

(½ eqn, ½ sin r, ½ correct subst, ½ answer)....................................

(c) State how the refractive index for red light in sea water would differ compared to the blue light used. Give a reason for your answer. **2**

The refractive index for red light would be less than that for blue light. (1) This can be seen in a rainbow in which white light is split into the colours. The blue turns to a greater extent than the red (1)

(d) The searchers aboard the ship used a camera attached to optical fibre to investigate the sunken chest. Using the diagrams below, outline how total internal reflection is used in optical fibres. **2**

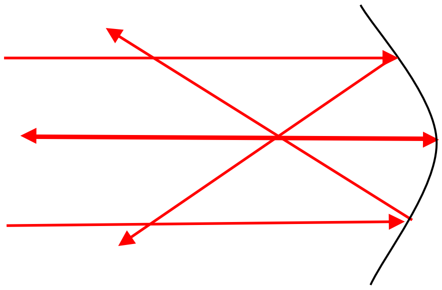


Optical fibre has a high density core with a lower density cladding. (½) If light enters the fibre at greater than the critical angle (½) then it will not be able to refract but instead is reflected at the interface. (½) This means the light will "bounce" along the length of the fibre. (½)

Question 15: (4 marks)

Radio telescopes, like the one pictured gather electromagnetic radiation (EMR) from space and provide a means for the exploration of the universe.

(a) Draw a ray diagram to show the path of the EMR as it is gathered by the radio telescope and hence explain why the radio telescope has such a distinctive shape. **2**



(1)

The dish focuses the rays to a single point for collection. (1)

(b) The intensity of the radiation collected is very low. Explain, using an appropriate example and equation, why this is so. **2**

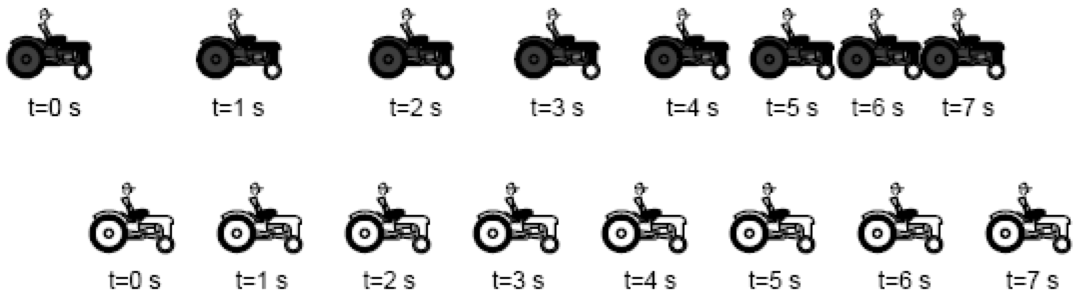
The EMR is taken as if it emanates from a point source. The intensity will be subject to the inverse square law (½). $I = \frac{k}{d^2}$ **. (½) The EMR comes from stars that are a great distance away. (1)**

Question 16: (6 marks)

(a) "She moves at a constant speed in a constant direction."
Write a sentence which gives the same information in fewer words. **1**

She is moving with constant velocity.

The figure shows a sequence of positions for two racing tractors.



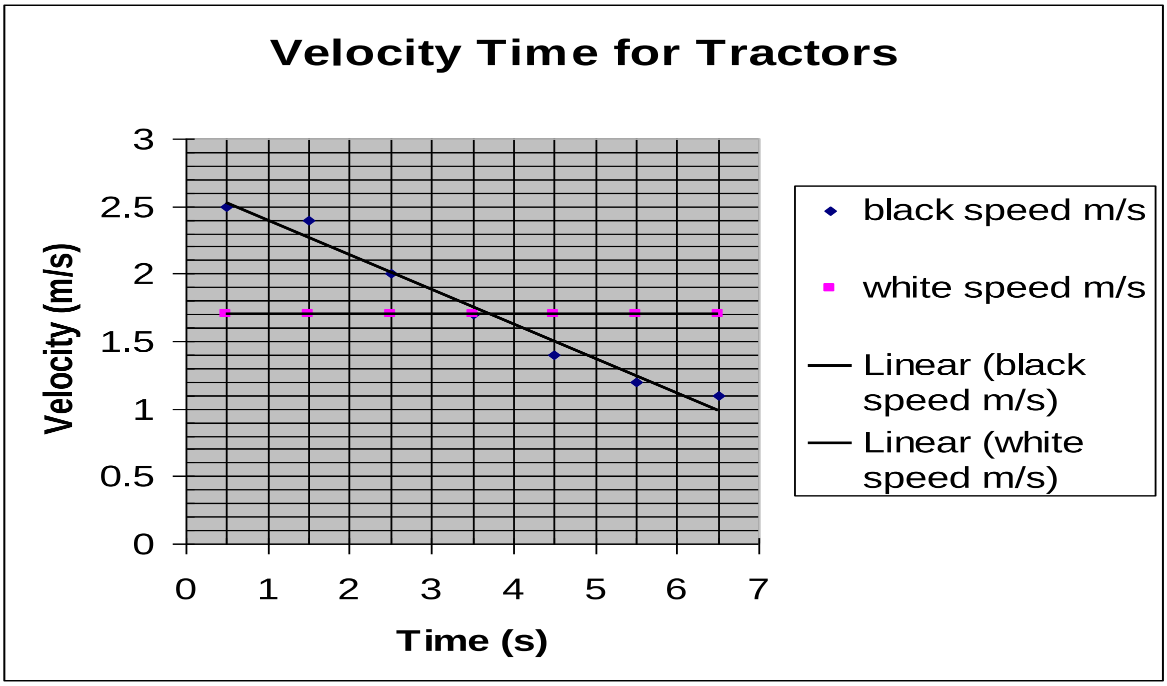
(b) Examine the motion of the tractors as the race progresses.
The drawing is scaled at 1:100 **2**
Complete the following table to calculate the average velocity of each tractor per second for each interval shown in the diagram.

(½ times, ½ speed and time units, ½ Black [allow .1 tolerance], ½ white)

Time (s)	**0.5**	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	
Black Tractor (ms^{-1})	**2.5**	**2.4**	**2**	**1.7**	**1.4**	**1.2**	**1.1**	
White Tractor (ms^{-1})	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	

Draw a velocity time graph on the grid below with plotting both the black tractor and the white tractor. **3**

(1 ½ axes labels heading, ½ mark LOBF black, 1 mark correct plotting)



Question 17: (8 marks)

A high-speed bus and an innocent bug have a head-on collision. The force of impact splatters the poor bug over the windshield.

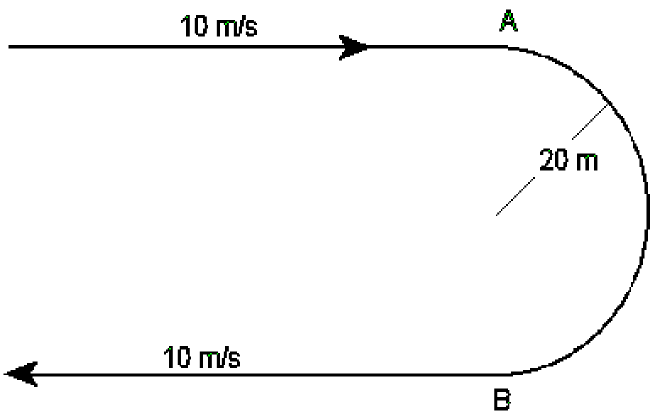
(a) Is the force that the bug exerts against the windshield greater, less, or the same as the force the bus exerts on the bug? **1**

Same.

(b) Is the resulting deceleration of the bus greater than, less than, or the same as that of the bug? Use appropriate formula(s) to explain your answer. **1**

The bus deceleration is much less than that of the bug. According to F=ma since the mass of the bus is significantly more than the mass of the bug, and the applied force to each is the same, the bus will have the smaller acceleration.

The bus has a mass 500 kg. It is travelling at 10 ms^{-1} east when it comes to a roundabout of radius 20 m. After turning as shown, it was travelling at 10 ms^{-1} to the west.



(c) Determine the size and direction of the centripetal force acting on the bus as it is going around the roundabout. **2**

$$F_c = \frac{mv^2}{r} = \frac{500x10^2}{20} = 2500N$$ **towards the centre of the circle.**

(½ eqn ½ correct subst, ½ answer, ½ unit)

(d) Calculate the change in momentum the bus experiences from just before it enters the roundabout to leaving the roundabout. **2**

$\Delta p = mv_2 - mv_1$ (½) Take West as positive direction (½)

$\Delta p = m(v_2 - v_1)$

$\Delta p = 500(10 - (- 10))$ (½)

$\Delta p = 10000$ Nm (½ units)

(e) Modern buses are fitted with safety belts. Use Newton's Laws to explain the function of a safety belt. **2**

1st Law – a moving body will continue in its motion until acted on by an external force.

(½) So in a head-on crash an unrestrained person will continue to move forward. (½)

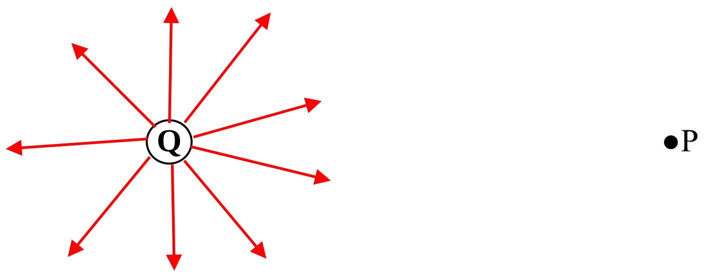
The seat belt supplies the force to stop the forward movement of the person. (1)

Question 18: (4 marks)

Below is a diagram of a positive point charge, **Q** and a nearby point P which is uncharged.

2

a) Draw the electric field lines surrounding the point charge, **Q**.
(1 for arrangement of field, 1 direction)



b) An electron is now placed at point **P**.
The electric field strength at **P** due to the point charge at **Q** is 8×10^{-20} NC^{-1}.
Calculate the magnitude and direction of the force on the electron. **2**

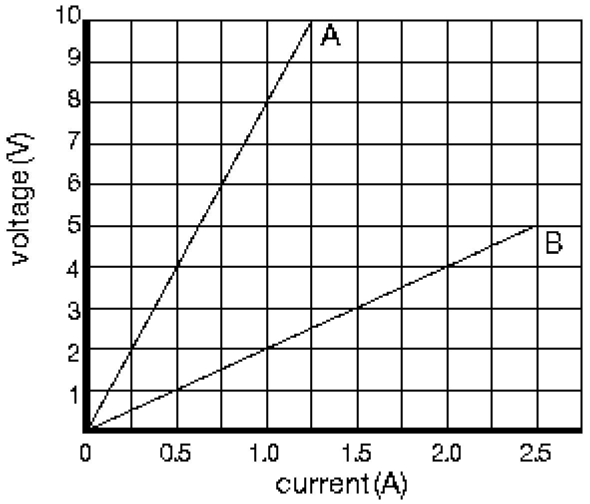
$F = Eq$

$F = 8 \times 10^{-20} \times 1.6 \times 10^{-19}$ **(½ dir + ½ electron charge + ½ answer + ½ unit)**

$F = 1.28 \times 10^{-38} N \qquad Towrds Q$

Question 19: (5 marks)

The following graph shows how the potential difference varies with current for two resistors A and B.



(a) Which resistor has the highest resistance value? **1**

Resistor A.

(b) Calculate the value of the resistance of the resistor you identified in part (a). **2**

V = IR

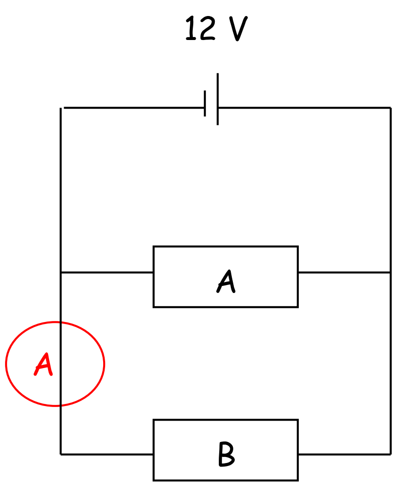
R = V/I (this is the gradient) (½)

$$gradient = \frac{\Delta V}{\Delta I}$$

$$= \frac{8-0}{1.0-0}$$ **(1 correct substitution) + (½ units)**

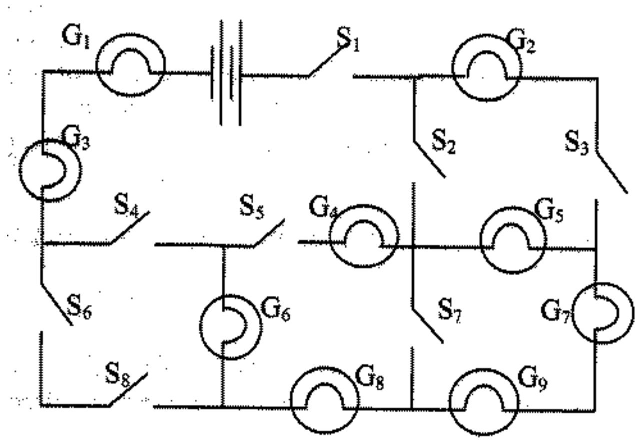
$$= 8\Omega$$

(c) These resistors were connected in parallel, as shown below. On the diagram show where you would connect an ammeter to measure the current in B. **1**



Question 20: (5 marks)

Look at the circuit diagram to answer part (a).



(a) Identify the globes that will be on if **only** switches S_1, S_3, S_4, and S_7 are closed. **1**

Globes 1,2,3,5,6,7,8,9

(b) Explain why it is essential for voltmeters to have a very high resistance. **2**

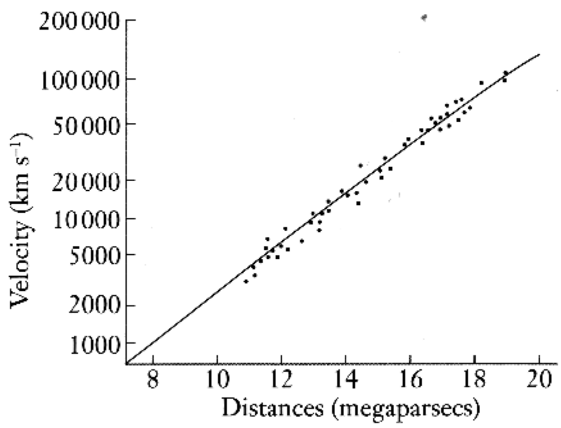
Voltmeters have a high resistance as they are to measure the potential difference (½) across a circuit element. They are connected in parallel (½) to the element and the high resistance ensures the voltmeter does not draw any current away (½) from the circuit element and change the voltage drop through that element (½).

(c) Explain why there are different circuits for heating, lighting and other appliances in a house. **2**

Different appliances require different amounts of energy (½), which results in different amounts of current necessary to power one appliance compared to another. Heaters and ovens are high current devices whereas lights need relatively small currents (½). If all appliances were on the same circuit then some would get much greater current (½) than necessary which could damage them or result in fire. (½)

Question 21 (6 marks)

Early in the 20th century Edwin Hubble studied the light coming from stars in galaxies outside the Milky Way. He found that their velocities relative to the Milky Way followed a pattern as shown in the graph below.



(a) Outline how Hubble applied the Doppler Effect to determine the velocities of the galaxies. **3**

- **Used the spectral lines of the elements. (1 mark)**
- **Observed how the wavelengths of the same spectral lines of the elements had changed in the stars of other galaxies relative to those observed on Earth. (1 mark)**
- **Used the change in wavelength / frequency and the Doppler equations to calculate the speed of the galaxies relative to the Earth. (1 mark)**
- **The bigger the Doppler shift, the greater the velocity. (1 mark)**
- **Showed that most galaxies are moving away from Earth, due to the 'red' shift i.e. the shift to longer wavelengths. (1/2 mark)**

(Max. 3 marks)

(b) Explain why this graph is evidence for the Big Bang theory of the origin of the Universe. **2**

- **The graph shows that most galaxies are moving away from Earth, and the further away they are, the faster they are moving. (1 mark)**
- **This is what would be expected if the Universe were expanding (everything moving away from everything else) i.e. at one point in the past they were much closer, as predicted by the Big Bang theory. (1 mark)**

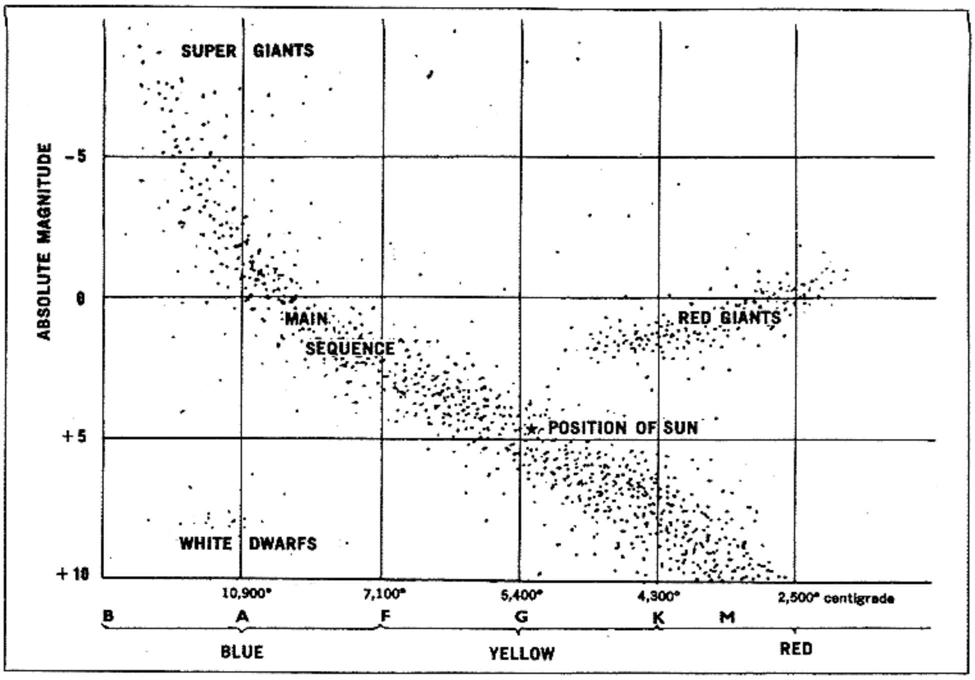
(c) Identify one other piece of evidence which supports the Big Bang theory. **1**

- **Background microwave radiation.**
- **Proportions of the elements H, He and Li present in the Universe.**

(1 mark for 1 point)

Question 22 (8 marks)

The graph below is a Hertzsprung-Russell diagram with the position of the Sun indicated in the Main Sequence.

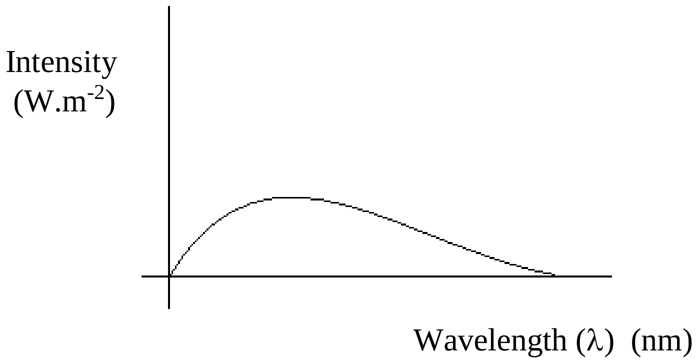


(a) On the H-R diagram above, draw the expected path of the evolution of the Sun after it leaves the Main Sequence. **1**

- **The path should star at the present position of the Sun,**
- **go to the Red Giant section (1/2 mark),**
- **and end up at the White Dwarf section (1/2 mark).**

Don't worry about any other complications in the path.

(b) The diagram below represents a graph of Intensity of radiation emitted from the Sun as a function of Wavelength.



On the same diagram, sketch the Intensity vs Wavelength graph for a typical blue Super Giant. **1**

- **Curve must be entirely above the given curve at all points (1/2 mark)**
- **and the peak wavelength must be at a shorter wavelength than the given curve. (1/2 mark)**

(c) The Sun produces it energy by the nuclear fusion of hydrogen into helium. A simplified equation for one kind of nuclear fusion is as follows:

$$4H^+ \rightarrow He^{2+} + 2e^+ + 2\nu + \text{energy}$$

During this process mass is converted into energy. If the luminosity (rate of energy output) of the Sun is 3.9 x 10^{26} J/s, calculate the rate at which mass is being 'lost' from the Sun. **2**

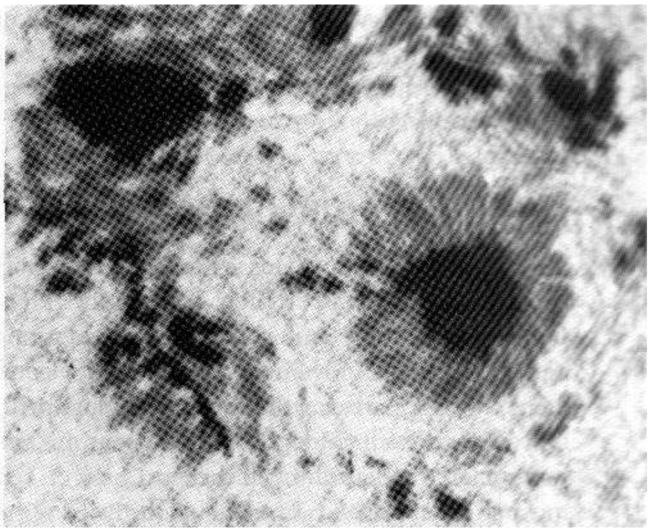
- **The rate of energy production and rate of mass loss are related by Einstein's equation: $E = mc^2$.**
- **The mass equivalent of 3.9 x 10^{26} J is given by:**

$m = E / c^2 = (3.9 \times 10^{26}) / (3 \times 10^8)^2 = 4.3 \times 10^9$ kg

So the rate of mass loss is 4.3 x 10^9 kg/s

(1/2 mark for correct equation to find m; 1 mark for correct substitution; ½ mark for correct answer; ½ mark for unit)

(d) The photograph below shows a group of sunspots on the surface of the Sun.



(i) Describe the nature of sunspots. **1**

- **Regions of strong magnetic activity. (1/2 mark)**
- **Regions of lower temperature relative to the rest of the photosphere. (1/2 mark)**
- **Peak in number occurs about every 11 years. (1/2 mark)**
- **Associated with increased solar wind. (1/2)**

(Max. 1 mark)

(ii) Explain how increased sunspot activity could cause problems on Earth. **3**

- **Increased sunspot activity may be associated with increased solar wind from the Sun reaching the Earth. (1 mark)**
- **The solar wind is composed of high speed charged particles (mainly protons & electrons). (1 mark)**
- **The particles may be deflected by the Earth's magnetic field and trapped in the van Allen belts, but some reach the Earth's surface, increasing at times of high solar wind. (1 mark)**
- **The particles of the solar wind can affect power grids on Earth (1 mark) and the operation of communication satellites. (1 mark)**

(Max. 3 marks)

END OF PAPER