Curriculum Council

Tertiary Entrance Examination, 2004

Question/Answer Booklet

PHYSICS

Please place your student identification label in this box

Student Number: In figures | | | | | | | | |

In words _____

_____

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Physics: Formulae and Constants Sheet (inside front cover of this Question/Answer Booklet)

To be provided by the candidate

Standard items: Pens, pencils, eraser or correction fluid, ruler, highlighter

Special items: MATHOMAT and/or Mathaid, drawing compass, protractor, set square and calculators satisfying the conditions set by the Curriculum Council for this subject.

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	No. of questions	No. of questions to be attempted	No. of marks out of 200	Proportion of examination total
A Short Answers	15	All	60	30%
B Problem Solving	8	8*	100	50%
C Comprehension and Interpretation	2 passages	All	40	20%

* Note that in Section B there is internal choice in one part of a question. For this question only one alternative should be answered. Markers will be instructed to mark only the first attempt among the alternatives (unless clearly cancelled).

Instructions to candidates

1. The rules for the conduct of Tertiary Entrance Examinations are detailed in the booklet *TEE Handbook*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in the spaces provided in this Question/Answer Booklet.

3. You may remove the enclosed *Physics: Formulae and Constants Sheet* from the booklet and use as required. This sheet is not to be handed in at the end of the examination.

4. Your answers to questions involving calculations should be evaluated and given in decimal form. It is suggested that you quote all answers to three significant figures, with the exception of questions for which estimates are required. Despite an incorrect final result, you may obtain marks for method and working, provided these are clearly and legibly set out.

5. Questions containing the specific instruction "**show working**" should be answered with a complete, logical, clear sequence of reasoning showing how your final answer was arrived at. For these questions, correct answers which do not show working will not be awarded full marks.

6. Questions containing the instruction "**estimate**" may give insufficient numerical data for their solution. You should provide appropriate figures to enable an approximate solution to be obtained.

7. When descriptive answers are required, you should display your understanding of the context of a question. An answer which does not display an understanding of Physics principles will not attract marks.

SEE NEXT PAGE

SECTION A: Short Answers **(60 Marks)**

Attempt **ALL** 15 questions in this section. Each question is worth 4 marks. Answers are to be written in the space provided.

---

1. A ship has a sonar system with frequency of 5×10^4 Hz that is being used to measure the depth of the ocean. Sound reflected from the ocean floor is detected 4.0 seconds after it is emitted by the ship's sonar device.

   How deep is the ocean?

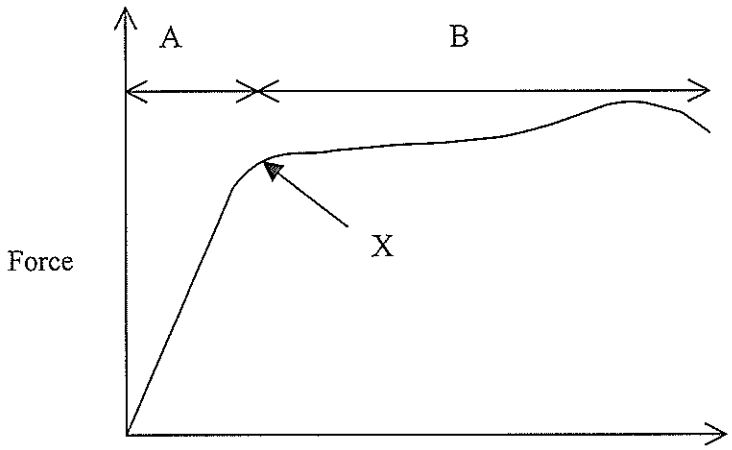
2. Using the following diagram, draw field lines to show the following features of the Earth's magnetic field. Clearly label your diagrams to show

   (i) the direction of the field;

   (ii) the shape of the field; and

   (iii) what is meant by the angle of dip.

3. The following is a graph showing how a piece of steel changes in length as increasing force is applied.



A = elastic region

B = plastic region

(a) What is the point X called? Answer: _____

(b) What is the physical difference between the behaviour of the wire in the elastic region and the plastic region?

_____

_____

_____

_____

_____

4. The frequency of sound does not change when it passes from air into water. Explain why.

_____

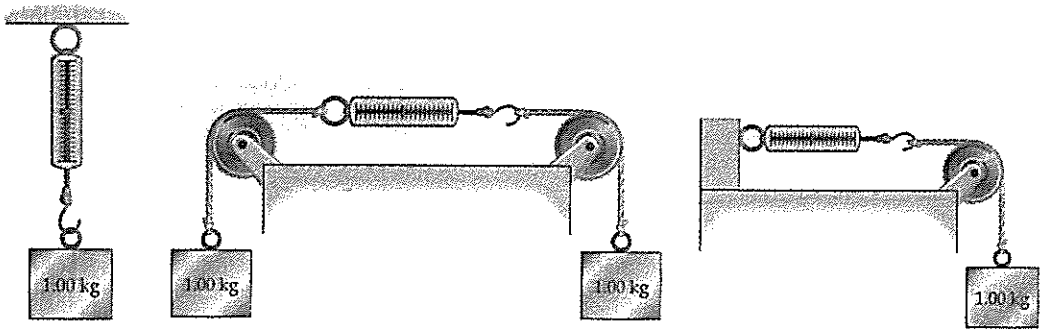
_____

_____

_____

_____

5. The spring balance in diagram A below reads 9.8 N. In diagrams A, B and C, assume that the cord has no mass and that the pulleys are frictionless.



(a) The spring balance in diagram B should read **more than**, **equal to**, or **less than** 9.8 N?

Answer: _____

(b) The spring balance in diagram C should read **more than**, **equal to**, or **less than** 9.8 N?

Answer: _____

6. Using the context you have studied, either *Bridges and Buildings* or *Human and Animal Frames*, describe a situation or example where the compressive strength of a material gives a whole structure its strength or durability. Include a diagram to illustrate the situation or example.

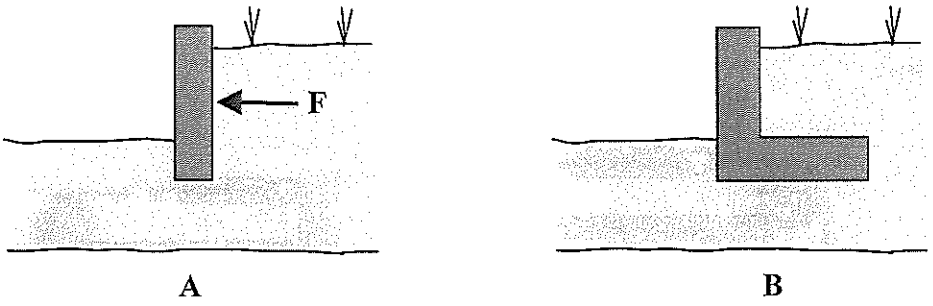
_____

_____

_____

_____

7. The diagrams below show two ways of building a garden retaining wall. When wet, the earth behind the wall can exert a large force on the wall, shown by F in diagram A.



(a) Show on diagram A, a force that produces the torque to keep the wall vertical.

(b) Explain why the wall in diagram B is much less likely to fall over than the one in diagram A. Use diagram B to illustrate your answer.

_____

_____

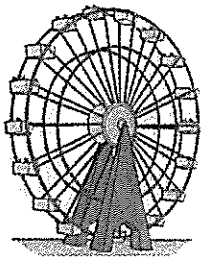
_____

_____

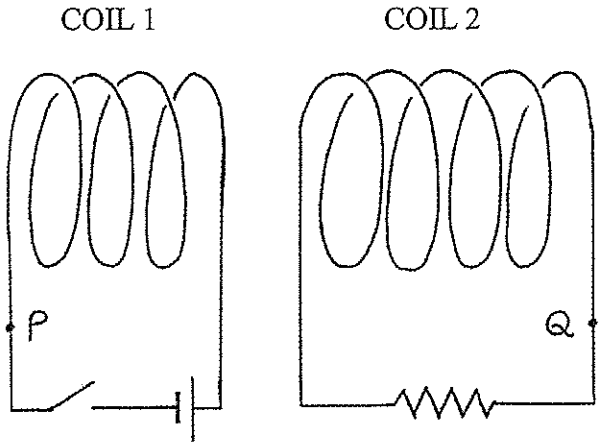
8. Two organ pipes with effective lengths of 57 cm and 61 cm, each open at one end only, are sounded together and produce audible beats. If both pipes are sounding their fundamental frequency, how many beats are heard per second?

9. Two students, with masses of 58 kg and 66 kg, sit in a cabin of a ferris wheel which rotates once every 10.5 seconds. The radius of the ferris wheel is 14 m.

Assuming that this speed is constant, clearly show that both students will be able to remain seated without having to hold on as their cabin passes through its highest point.



10. The diagram below shows two insulated wire coils.



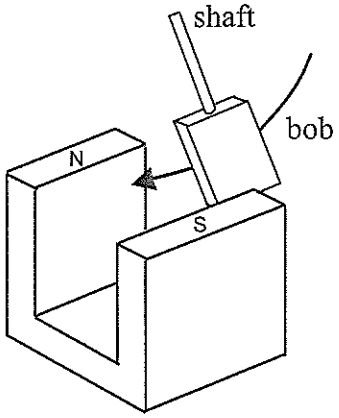
(a) At the instant the switch is closed, a (conventional) current begins to flow in Coil 1. At the points P and Q draw arrows to show the direction of the (conventional) current I_1 in the circuit for Coil 1 and the direction of the induced (conventional) current I_2 in the circuit for Coil 2.

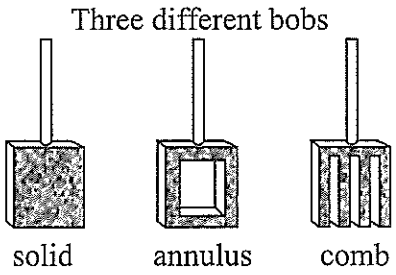
(b) If the switch remains closed, what happens to the current in Coil 2? Circle your choice of the options given below.

It reverses It decreases to zero It remains unchanged

SEE NEXT PAGE

11. The diagram below is from a book of physics demonstrations. The pendulum shaft is made from wood, and the bobs that swing through the magnetic field are made from flat pieces of aluminium.





(a) The pendulum slows down at different rates depending on which shaped bob is on the end. Of the three bobs shown, which one slows down most rapidly? Circle your choice of the options given below.

solid annulus comb

(b) Explain your choice of answer to part (a).

_____

_____

_____

_____

_____

12. The efficiency of a 100 W globe is about 3% (only 3% of electrical energy is converted to visible light). ESTIMATE the number of photons of visible electromagnetic radiation the globe emits in 1 second.

13. When a charged particle enters a magnetic field in a cloud chamber, the trail of droplets of condensed gas indicates that it has moved in a circular pathway. Explain why it moves this way rather than in a straight line.

_____

_____

_____

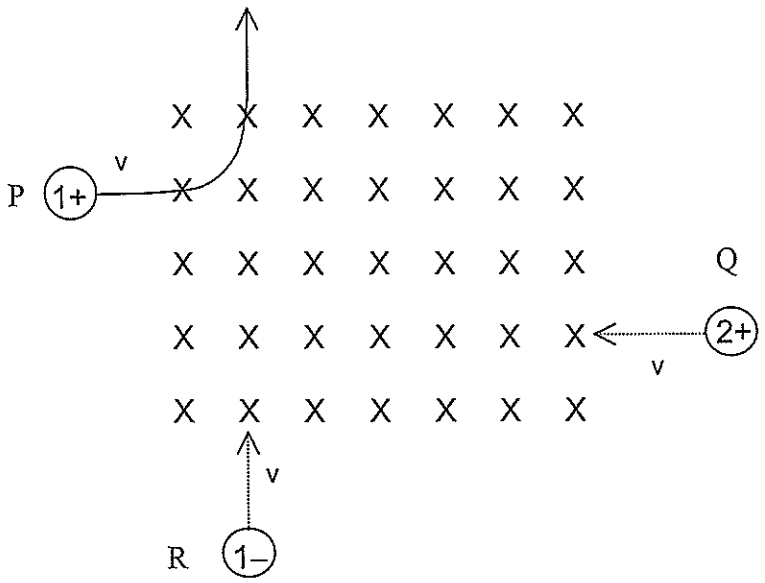
_____

_____

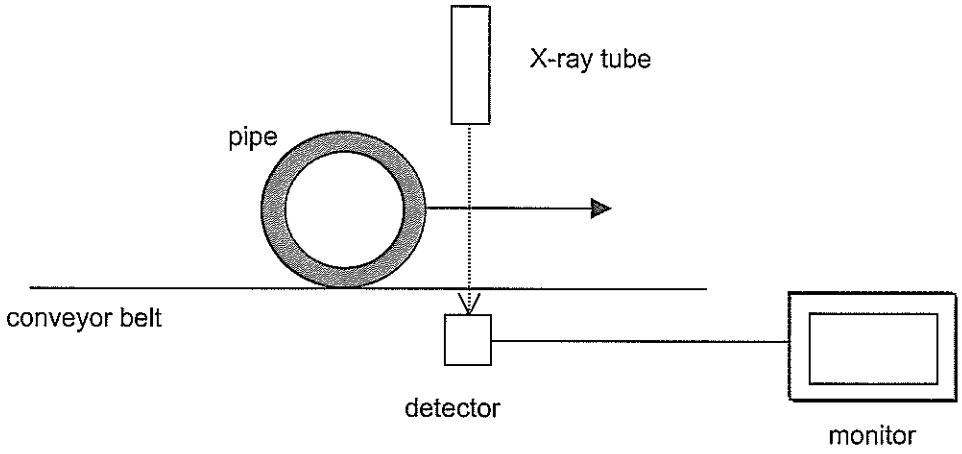
_____

14. The diagram below shows a uniform magnetic field directed into the page. Three particles P, Q and R have masses and charges as shown in the table below. They each enter the magnetic field with the same velocity, v, as shown. Complete the diagram to show the paths of particles Q and R. The path of particle P has been already been drawn.

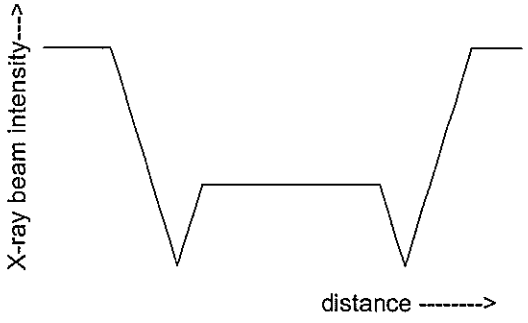
Particle	Relative charge	Relative mass
P	1 +	m
Q	2 +	2 m
R	1 –	2 m



15. X-rays can be used to monitor the thickness or shape of objects such as pipes during their manufacture. The diagram below shows a conveyor belt on which concrete pipes are carried through an X-ray beam. The monitor produces a graph showing the intensity of the X-ray beam at the detector as the pipes pass through.

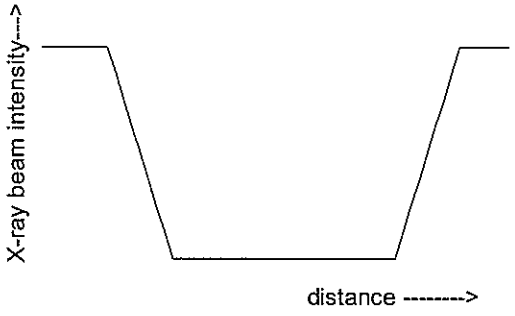


Which of the graphs A, B, C and D below would you expect to see as the pipe above passes over the detector? Give your answer in the space below.

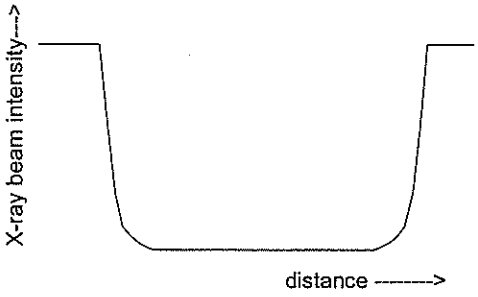


A

B



C



D

Answer: _____

SECTION B: Problem Solving **(100 Marks)**

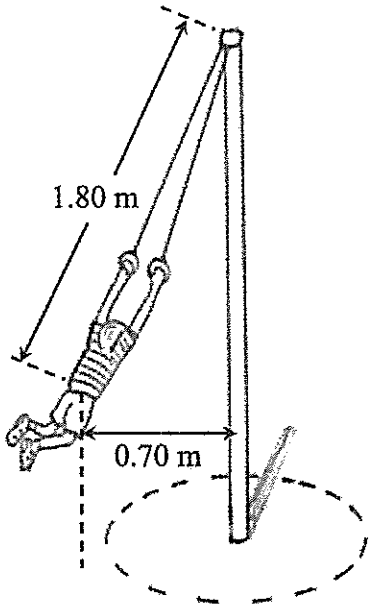
Attempt **ALL** 8 questions in this section.

Question 6, Part (c) has alternatives. Follow the directions in this question with care.

---

1. [10 marks]

A 20.0 kg child is shown swinging freely around a playground maypole such that his centre of mass is always located 1.80 m from the top of the pole and 0.70 m horizontally away from the pole.



(a) On the diagram above, clearly show and label any forces acting on the child. [2 marks]

(b) Calculate the tension in each supporting wire. [4 marks]

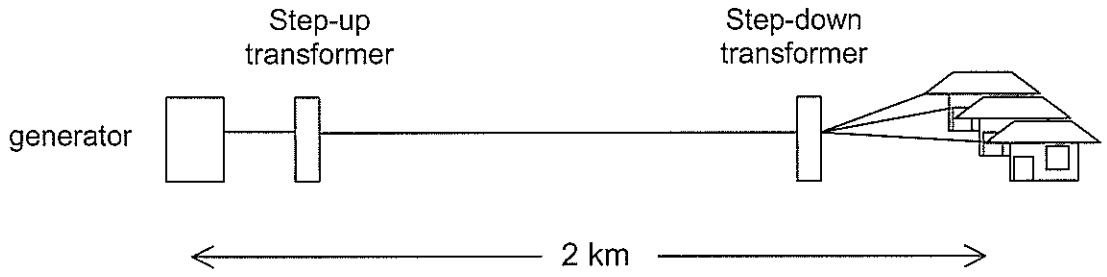
(c) Calculate the magnitude of the net force on the child, and state (or show on a diagram) its direction.

[4 marks]

2. [14 marks]

In a remote community, the electrical supply is from a 20 kW, 500 V diesel-powered generator. The noise from the generator is so loud that it is situated 2 km from the group of houses that it supplies. The generator is connected to a step-up transformer that changes the voltage from 500 V to 6 kV. The line between the step-up and the step-down transformer (near the houses) has a resistance of 10 Ω. The step-down transformer changes the voltage to 240 V.

The following is a *schematic* diagram only (not drawn to scale) of the electrical supply to the community.



(a) If the primary coil of the step-up transformer has 1000 turns, how many turns does the secondary coil have?

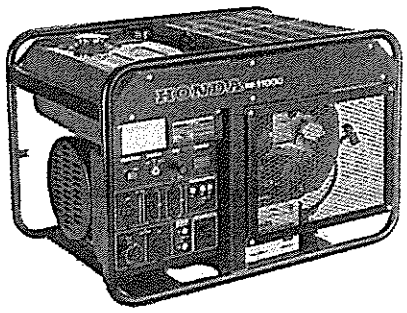
[3 marks]

(b) What voltage is delivered to the primary coil of the step-down transformer?

[4 marks]

(c) Modern generators, such as the one shown here, are reasonably efficient. Nevertheless, they can affect the environment. Briefly state three such effects.

[3 marks]



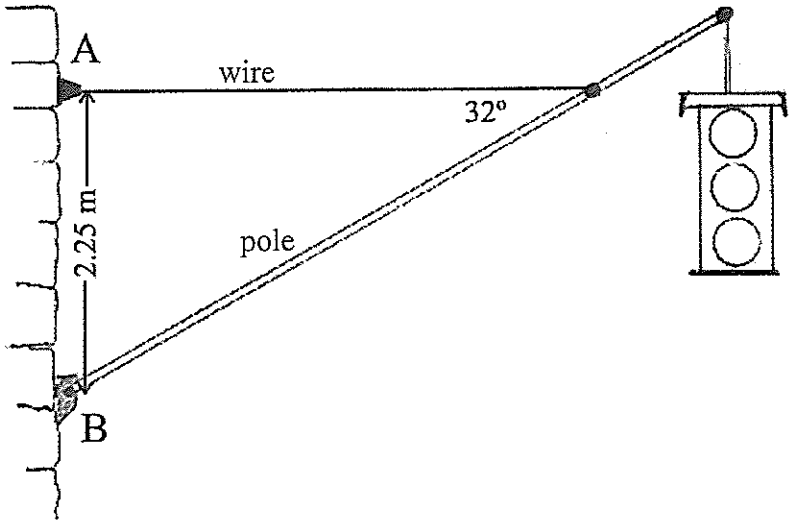
(d) The sound level 1.0 m from the generator is 120 dB. Can the sound from the generator be heard 2 km away if the threshold of human hearing is approximately 20 dB for the frequencies emitted?
To earn marks, you must justify the answer that you give.

[4 marks]

3. [12 marks]

The diagram below shows how a set of traffic lights can be suspended from a building at the side of the road. Copper wire holds the 5.00 m long uniform rigid pole in place. The wire is attached to the wall at bracket A. The pole is attached to the wall at bracket B. The pole weighs 54.0 N and the traffic lights weigh 200.0 N.

Other dimensions are shown on the diagram.



(a) State whether the brackets are under tension or compression.

Bracket at A: _____

Bracket at B: _____

[2 marks]

(b) Find the magnitude of the force that the copper wire exerts on the pole (assuming that the wire meets the wall at right angles).

[5 marks]

(c) If you could not answer part (b) of this question, assume the tension is 400 N for this part of the question.

For safety reasons, the engineer designing this arrangement must choose copper wire with a large enough diameter to ensure that it won't break. She decides to use wire that can withstand ten times the normal tension.
Calculate the diameter of the wire that she should select. Assume that the wire has a circular cross-section.

[5 marks]

4. [12 marks]

The following table shows data on a number of planets orbiting the Sun.

Planet	Average distance from the Sun (R) in metres	Period of orbit (T) in seconds
Mercury	5.79×10^{10}	7.60×10^{6}
Venus	1.08×10^{11}	1.94×10^{7}
Earth	1.50×10^{11}	3.16×10^{7}

(a) Make the necessary calculations to show that $\frac{T^2}{R^3}$ = constant for planets orbiting the Sun.

[3 marks]

(b) Use the relationship given in part (a) of this question to determine the average distance of Jupiter from the Sun, given that Jupiter's orbital period is 11.8 Earth years.

[4 marks]

(c) Scientists claim to have discovered a tenth planet which they have called Sedna. It is about three-quarters of the size of Pluto and is currently about 5.9×10^9 kilometres from the Sun. Its average distance from the Sun, however, is 7.1×10^{10} kilometres because its orbit is very elliptical. It is spinning relatively slowly, prompting scientists to think that it may have a moon orbiting it. The best estimate of Sedna's orbital period is 10 500 Earth years.

[5 marks]

(i) Determine the average gravitational acceleration of Sedna toward the Sun.

(ii) What two measurements about the motion of Sedna's moon would scientists have to make in order to ESTIMATE the mass of Sedna?

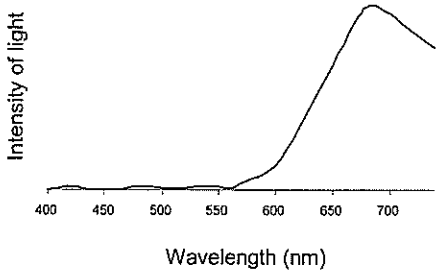
_____

_____

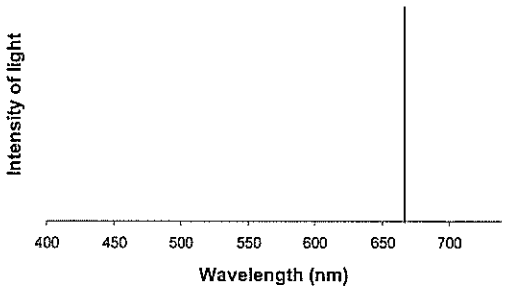
5. [15 marks]

(a) Consider the two spectra A and B below. One of them is the spectrum of red laser light and the other the spectrum of torchlight after it has passed through transparent red plastic.

[3 marks]



A



B

Indicate which spectrum is associated with which light source, and give a reason for each one.

(i) A is the spectrum of _____

Reason:

(ii) B is the spectrum of _____

Reason:

(b) The energy levels of a hydrogen atom can be calculated using the following equation.

$$E_n = \frac{-13.6}{n^2} \text{eV} \quad \text{where } n = 1 \text{ for level 1, } n = 2 \text{ for level 2, etc.}$$

[9 marks]

(i) Complete the energy level diagram for atomic hydrogen below, labelling all five levels with their numbers (on the left) and their energies in eV (on the right). Note that the diagram scale is only approximate.

(ii) What is the value of the ionisation energy of a hydrogen atom?

_____

_____

(iii) For a Hydrogen atom, a transition from the n = 2 to the n = 1 level produces radiation. In what part of the spectrum is the radiation? Support your answer with calculations.

Answer: Part of the electromagnetic spectrum _____

(c) The coloured emission lines of hydrogen are for transitions to level n = 2. The blue/green line results from a transition from n = 4 to n = 2.

[3 marks]

(i) On the energy level diagram in part (b), clearly show the transition resulting in the emission of the **red** line.

(ii) State briefly how you worked out your answer to part c(i) above. You do not need to show any working.

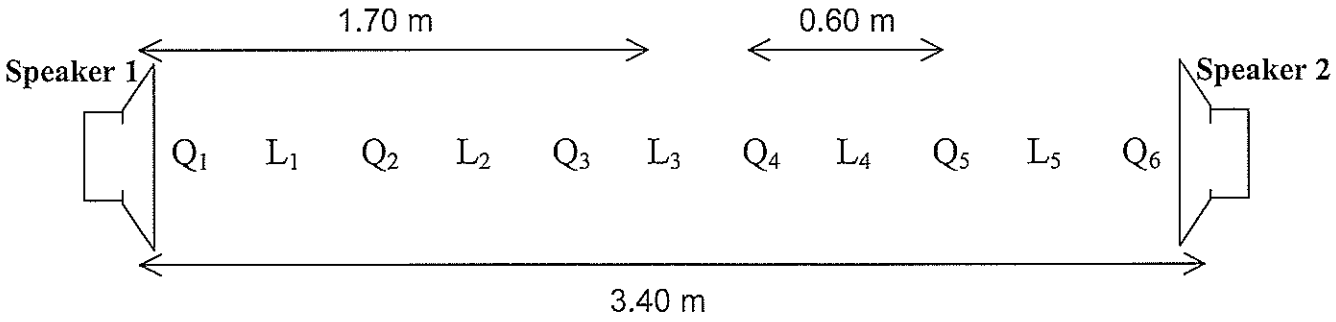
_____

_____

_____

6. [13 marks]

The two speakers shown in the diagram below each emit the same single note. The speakers are in phase with each other. A standing wave is created between the two speakers.



A student walking from Speaker 1 to Speaker 2 notices that at the points labelled L_1, L_2, L_3, L_4 and L_5 the sound from the speakers is loud. At the points labelled Q_1, Q_2, Q_3, Q_4, Q_5 and Q_6, however, the sound from the speakers is quiet (but not silent).
The speakers are 3.40 m apart. Point L_3 is half way between the speakers. The distance between Q_4 and Q_5 is 0.60 m.

(a) Assuming that the speed of sound in air is 346 ms^{-1}, calculate the frequency of the sound emitted from the speakers.

[3 marks]

(b) With the aid of a diagram or a graph, explain why the sound is quiet at the point marked Q_2.

[4 marks]

(c) NOTE: There is a CHOICE in the following part of this question.
Answer EITHER Part c (i) OR Part c (ii). Do not attempt both parts.

[3 marks]

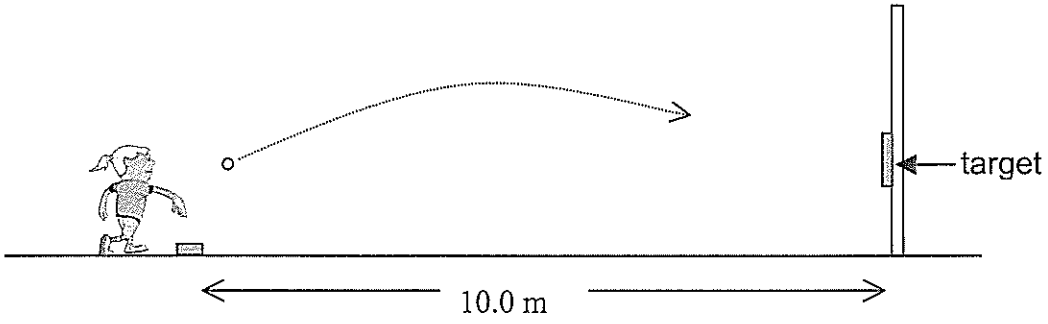
Part c (i):	Part c (ii):
Explain what is happening to the air pressure at point L_3.	Explain what is happening to the displacement of the air particles at point L_3.

(d) While the student is standing completely still between the two speakers, a teacher reduces the frequency emitted by Speaker 1 by 5 hertz.
How will this affect the sound that the student is hearing?

[3 marks]

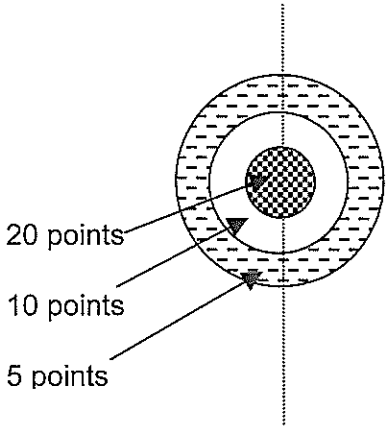
7. [12 marks]

A girl throws a golf ball at a target marked on a wall 10.0 m in front of the throwing line. As she releases the ball, her hand is level with the centre of the target.



The ball leaves her hand with a velocity of 11.9 ms^{-1} at an angle of 20.0 degrees above the horizontal.

The target, as shown here, consists of concentric circles with diameters of 20 cm, 40 cm and 60 cm. The arrows show the scoring.



(a) Calculate how many points the girl should score. Assume that the golf ball lands on the vertical dotted line.

[5 marks]

Answer: The girl should score _____ points

(b) A second throw lands just below the target. State and explain two small changes she could make so that her next throw will get a better score.

[4 marks]

Change 1: _____

Explanation 1:

_____

_____

_____

Change 2: _____

Explanation 2:

_____

_____

_____

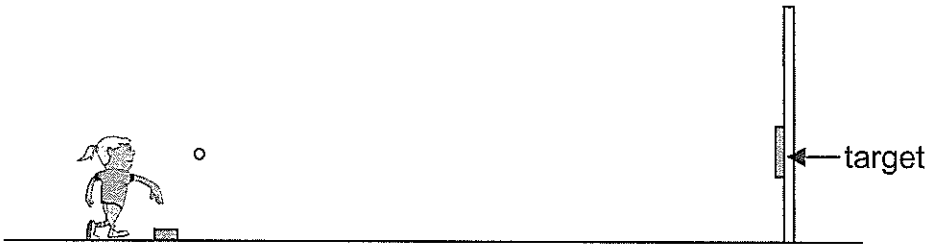
(c) The girl is then given a table tennis (ping-pong) ball to throw from the same position, and she manages to hit the target. However, it follows a different path from the golf balls.

[3 marks]

On the diagram below,

(i) sketch and label the approximate trajectories of the golf ball and table tennis ball, and

(ii) briefly explain why the table tennis ball follows a different path.



Explanation:

_____

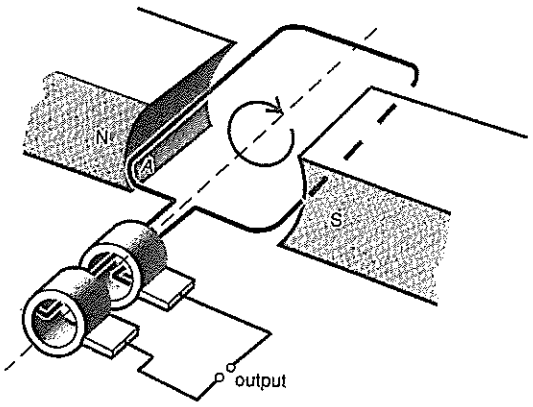
_____

_____

8. [12 marks]

A simple single-phase generator has a coil of 200 turns. The coil is 14 cm long and 9 cm wide. The magnetic field in the generator is 0.15 T. The generator coil is turned at a rate of 3 000 revolutions per minute.

(a) With the aid of the diagram, briefly explain the purpose of the slip rings on a generator. [3 marks]



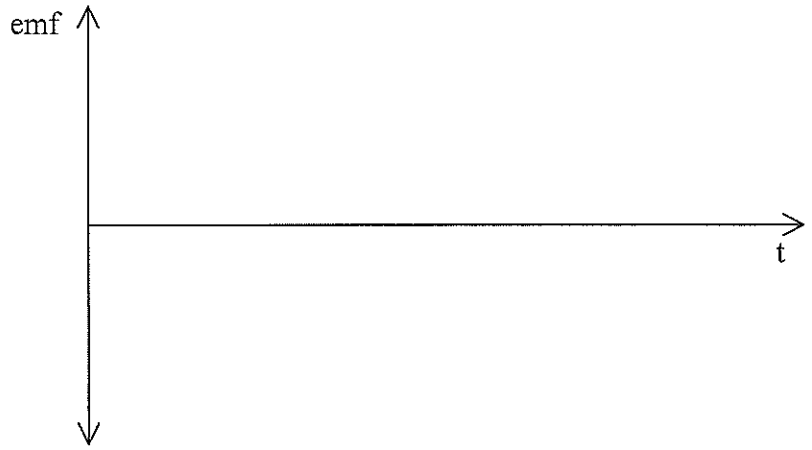
(b) [5 marks]

(i) Calculate the emf produced by this generator.

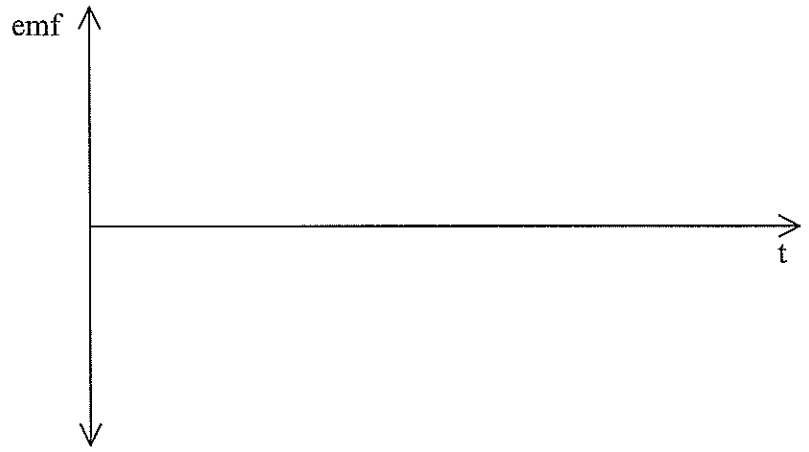
(ii) Is the emf you calculated the maximum emf produced or the average emf produced?

(c) [4 marks]

(i) On the following axes, draw a graph of the emf generated by this device. Mark a scale on each of the axes.



(ii) On the following axes, draw a graph of the emf produced if the generator was turned at 6 000 revolutions per minute instead of 3 000 revolutions per minute.



SECTION C: Comprehension and Interpretation **(40 Marks)**

BOTH questions should be attempted.

Read the following passages and answer the questions at the end of each. Candidates are reminded of the need for clear and concise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included as appropriate.

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1 WIRING ELECTRIC MOTORS [20 marks]

Motors, generators and transformers all contain coils of wire. When designing these devices, engineers must take into account the electrical properties of the wires, which need to be manufactured from appropriate materials and with the correct dimensions.

One property to take into account is the 'conductivity' of the metal from which the wires are made. The conductivity of a material is a measure of how well it conducts electric current. A higher value of conductivity means that the material is a better conductor. Each metal generally has a constant conductivity, provided the temperature does not change.

The resistance of a piece of conducting material is related to the conductivity, length and cross-sectional area of the material by the equation

$$R = \frac{\ell}{kA} \quad \text{.....(1)}$$

where: R is the resistance of the conductor (Ω)
ℓ is the length of the conductor (m)
A is the area of cross section of the conductor (m^2)
k is the conductivity of the material from which the conductor is made.

Some Year 12 students were given the task of designing and building a simple motor for their Physics project. They were given a roll of wire with a circular cross-section and made from an unidentified metal alloy. They then did a preliminary experiment to find the approximate conductivity of the alloy. They cut a piece of the wire and placed it in a circuit so that they could measure the current through it and the potential difference across it. They also used a micrometer gauge to measure the diameter (d) of the wire, which they measured as 0.40 mm. They obtained the following data:

Length of the wire, ℓ = 50 cm
Potential difference across the wire, 2.0 V
Current through the wire, 0.33 A

(a) [6 marks]

(i) Draw a diagram of the circuit that shows how they would have obtained the above measurements.

(ii) Since $V = I R$, you can replace R in equation (1) with $\frac{V}{I}$. The area of cross section, A, can be replaced with πr^2.

Perform these substitutions and then calculate the students' value for the conductivity of the wire. Include the units for conductivity.

In order to obtain a better experimental value for *k*, the students decided to collect more data and use graphical techniques to find *k*. They used different lengths of the same wire, and with a potential difference of 2.0 V across them each time, measured the current through each. They obtained the following data:

Diameter of the wire, d = 0.20 mm.
Potential difference across the wire, V = 2.0 V

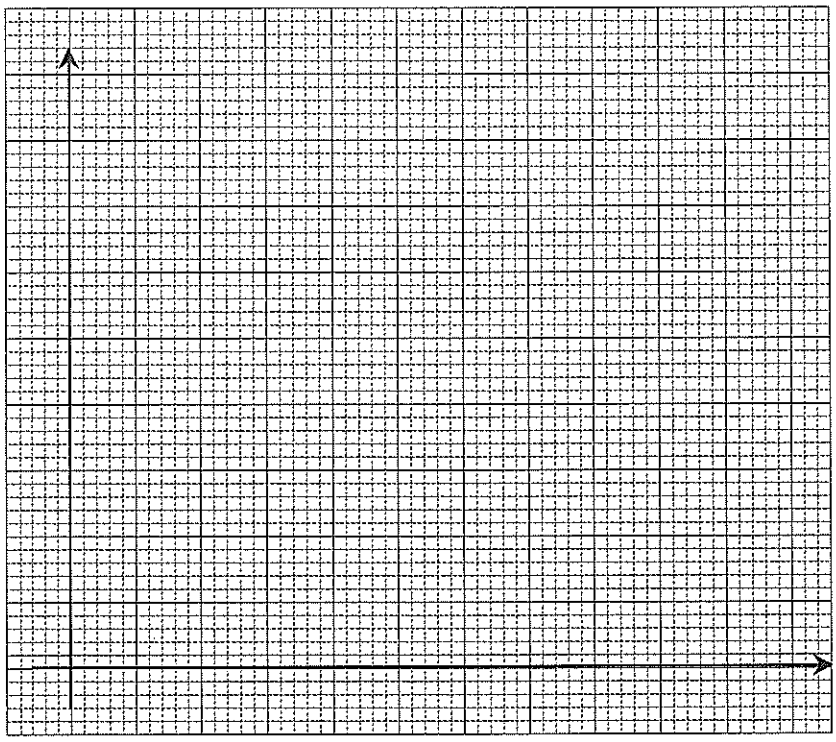
Current, I (A)	Wire length, ℓ (m)		
1.63	0.1		
0.82	0.2		
0.55	0.3		
0.40	0.4		
0.33	0.5		

(b) [10 marks]

(i) Rearrange the formula you created in part (a) to make current, I, the subject of the equation (i.e. put the equation into the form: I = ...).

(ii) If you graph current, I, on the vertical axis, what would you graph on the horizontal axis in order to get a straight line from the data shown in the table above?

(iii) Process your data as required in order to obtain a straight-line graph. Use either your graphics calculator or the graph paper supplied to draw the graph and obtain the slope of the line of best fit ('regression line').
If you use your graphics calculator to obtain the graph and linear fit, then write the equation of the line here.



(iv) Use the gradient (slope) of the line of best fit to find the experimental value of k.

(c) The usual metal used for the coils of electric motors is copper. Copper has a much higher conductivity than the alloy in this investigation, so copper wires of the same dimensions (length and cross-sectional area) would have much less resistance.

[4 marks]

(i) How would using this alloy wire instead of copper affect the operation of the students' motor?

(ii) Will the students' alloy-wired motor be more or less efficient than a motor wound with an equal amount of copper wire? Explain briefly.

2 ROLLOVER OF RECREATIONAL VEHICLES [20 marks]

In the period 1990 to 2000, more than 12 000 people in the United States of America are reported to have died in rollovers of four-wheel drive recreational vehicles (RVs). Such figures have led to the need to assess the stability of RVs.

In the United States, RVs and other cars will be given a 'rollover resistance rating' based on their Static Stability Factor (SSF). Vehicles with low stability (low SSF) will be given one star and vehicles with high stability (high SSF) will be given five stars.

There are two types of rollovers: tripped and untripped. A tripped rollover occurs when the vehicle hits an obstacle such as a kerb or a pothole. In this question, we refer only to untripped rollovers, which result solely from friction forces acting on the wheels. This is sometimes called a 'friction rollover'.

Figure 1 is a diagram of a car rounding a horizontal curve. The view is from the back and the car is turning to the left. If it is just on the point of rollover, the wheels on the left of the car are just losing contact with the ground and so the force on these wheels will be zero. The frictional force still acting on the right side wheels is given by F, and the radius of the curve is given by r.

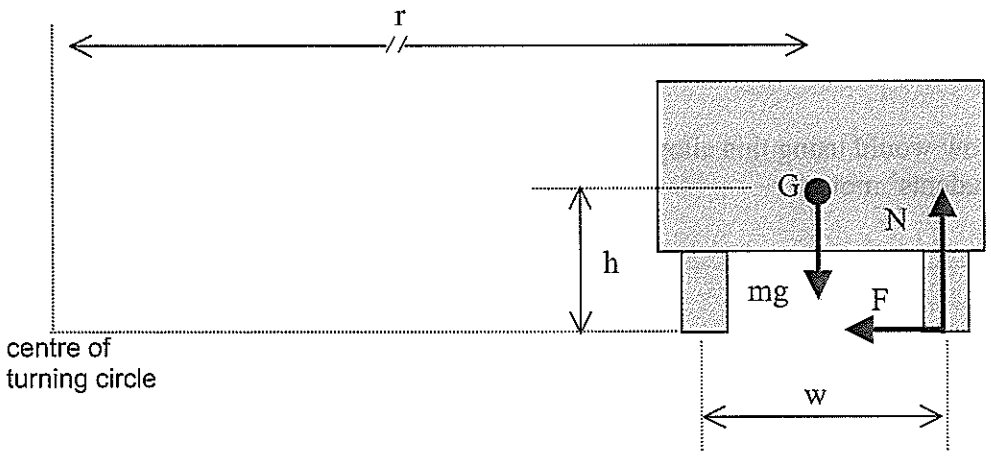


Figure 1: Shows the back view of a car rounding a curve to the left. The car is just at the point of rolling over (to the right).

If we apply Newton's second law to the car, the centripetal force, F, will be given by:

$$F = \frac{mv^2}{r} \quad \text{.....(1)}$$

In addition, because there is no resultant vertical force on the car:

$$N = mg \quad \text{.....(2)}$$

Since the car is just on the point of rotating, the sum of the moments about any point will be zero. This means that if we equate clockwise and anticlockwise moments about G, we get:

$$F \times h = N \times \frac{w}{2} \quad \text{.....(3)}$$

If we then combine equations 1, 2 and 3 we get what is called the 'rollover condition', i.e. the vehicle is just about to rollover when:

$$\frac{w}{2h} = \frac{v^2}{rg} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The term $\frac{w}{2h}$ is called the Static Stability Factor (SSF) or the rollover threshold. This term is totally determined by the size, shape and load of the vehicle. The larger the distance, w, between the tyres, the larger is the SSF, and the more stable is the vehicle. Heavily loaded vehicles generally have a large value of h and this lowers the SSF making them less stable and more likely to roll over. Once the SSF for the vehicle is known, its unsafe cornering speeds can be calculated using equation 4. In addition, the effect of overloading the vehicle can also be predicted.

Rollover accident data

Statistics collected on single-vehicle rollover accidents and the SSFs of the vehicles involved have resulted in the following chart (Figure 2). It shows that vehicles with SSFs about 1.2 and over have a low frequency of involvement in friction rollover accidents. The frequency is essentially constant as SSF increases. For vehicles with an SSF below 1.2, there is a rapidly increasing frequency of friction rollover accidents.

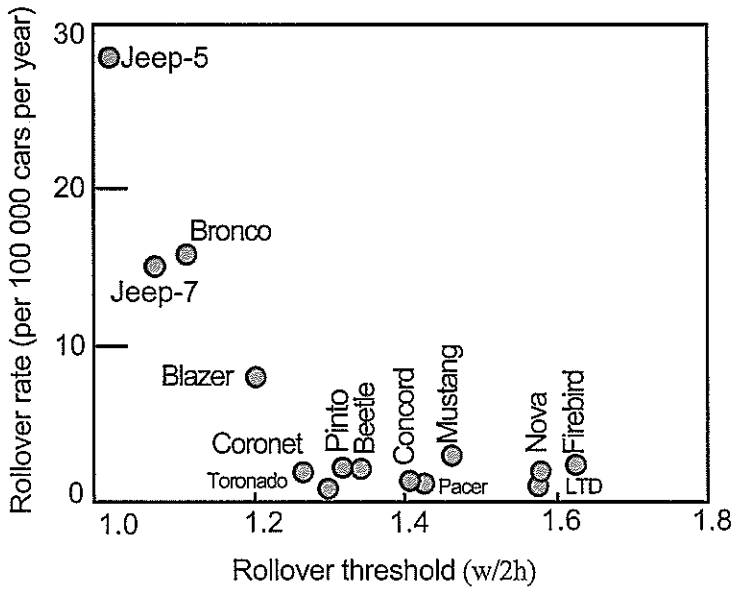


Figure 2: Chart showing the relationship between rollover rates and rollover thresholds (SSFs) for different makes of RV.

(a) In Figure 1, what do the following symbols represent?

[2 marks]

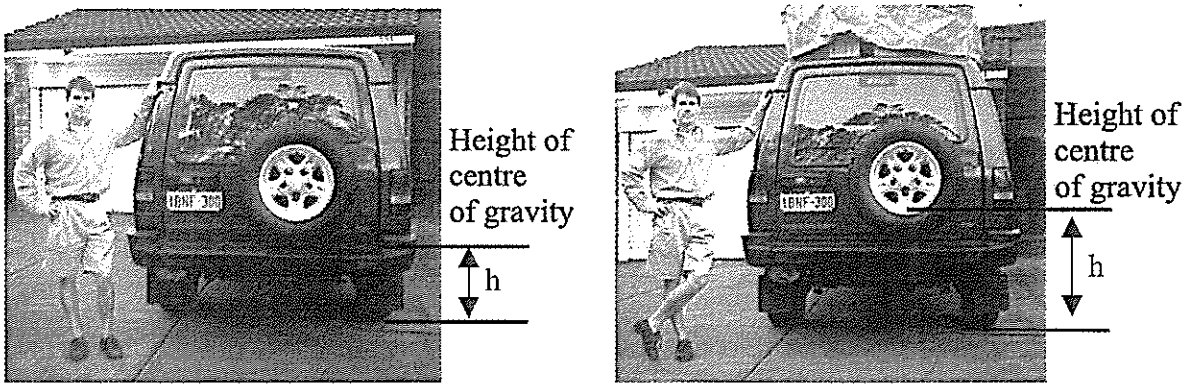
(i) G

(ii) N

(b) Explain how a friction rollover occurs. [4 marks]

(c) The centre of gravity of the unloaded RV (picture on the left) is lower than the centre of gravity of the heavily loaded RV (picture on the right). The man in the pictures below is 180 cm tall.

[9 marks]



(i) Using the information above, ESTIMATE the dimensions h and w for the unloaded and the loaded RV and hence calculate its approximate SSF for the unloaded and loaded conditions.

(ii) ESTIMATE the maximum safe speed of the ***loaded*** RV around a bend with a radius of 10.0 m.

(d) Following a review of single-vehicle rollover accident rates, there has been a suggestion that some models of RV should be withdrawn from sale. After considering the chart in Figure 2, answer the following questions.

[5 marks]

(i) Which models or vehicles are the ones most likely to be recommended for withdrawal from sale?

(ii) Comment on the safety of the RV in the pictures in part (c) in relation to the possibility of a friction rollover accident.

END OF PAPER

Check that you have written your Student Number on the front cover of this booklet.

ACKNOWLEDGEMENTS

SECTION A

Question 5: Diagram from: Walker, J.S. (2004). *Physics* (2nd ed.). New Jersey: Pearson Education.

Question 7: Adapted from: Giancoli, D.C. (2000). *Physics for scientists and engineers* (3rd ed.). US: Prentice Hall, p. 321.

SECTION C

Question 2: Adapted from: Penny, D.N. (2004). Rollover of sport utility vehicles. *The Physics Teacher*, *42*, 86–91.

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