YEAR 12 PHYSICS
Semester 2 Exam 2009

Name of Student: _____

Name of Teacher: _____

TIME ALLOWED FOR THIS PAPER:

Reading time: Ten minutes
Working time: Three hours

MATERIALS REQUIRED FOR THIS EXAMINATION:

To be provided by the supervisor:

- Question/answer booklet comprising 38 pages
- Physics Data Sheet

To be provided by the candidate:

- Standard items: pens, pencils, ruler, eraser or correction fluid
- Special items: a calculator satisfying conditions set by the Curriculum Council of Western Australia

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 items in the examination room. Please check carefully and hand any unauthorised items to the supervisor BEFORE continuing.

Section A	*Short Answer* 60 marks	Attempt all questions	
Section B	*Problem Solving* 100 marks	Attempt all questions	
Section C	*Comprehension* 40 marks	Attempt all questions	
	TOTAL 200 marks		

STRUCTURE OF THE PAPER

Section	No. of Questions	No. of questions be attempted	No of marks out of 200	Proportion of Examination total
A: Short Answers	15	ALL	60	30%
B: Problem Solving	8	ALL	100	50%
C: Comprehension and Interpretation	2	ALL	40	20%

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question. The value of each question (out of 200) is shown following each question. You should note that the space made available for an answer is not necessarily an indication of the length of the answer.

The enclosed Physics: Formulae and Constants Sheet may be removed from the booklet and used as required.

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.

Questions containing specific instructions to **show working** should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at. Correct answers which do not show working will not be awarded full marks

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

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.

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Section A: Short Answers
Marks allocated: 60 marks out of a total of 200 (30%)

Attempt ALL 15 questions in this section. Each question is worth 4 marks.

Answers are to be written in the space below or next to each question.

1. A loudspeaker produces sound waves of wavelength 0.68 m and the speed of sound is 340 m s^{-1}.

   (a) Calculate the frequency of the sound waves.

   (b) How many vibrations will the speaker cone make in 200 ms?

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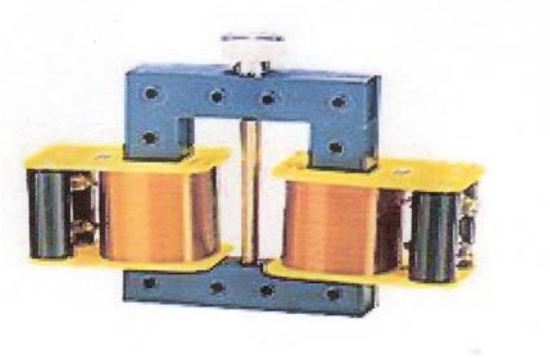
2. Below is a photo of an electrical transformer, an enclosed, larger version often seen in local parks and a smaller version is used in the cable that you use to charge your mobile phone.



(a) Is this type of transformer used to produce

Alternating current OR Direct current?

Cross out the INCORRECT answer

(b) Explain why you chose this answer.

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3 The State's electricity grid covers a huge area of WA. It is estimated that 25% of energy is lost in transmission of this electrical energy.

(a) Why is energy transmission in this case an inefficient process?

(b) Why, if high voltage is used, is the energy loss reduced significantly?

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4. Below is a familiar diagram of a crane on a building site

Below is an enlargement of part of the jib.

(a) Explain why the jib, the horizontal beam, has the structure shown.

(b) What is the purpose of the concrete block shown in the top diagram?

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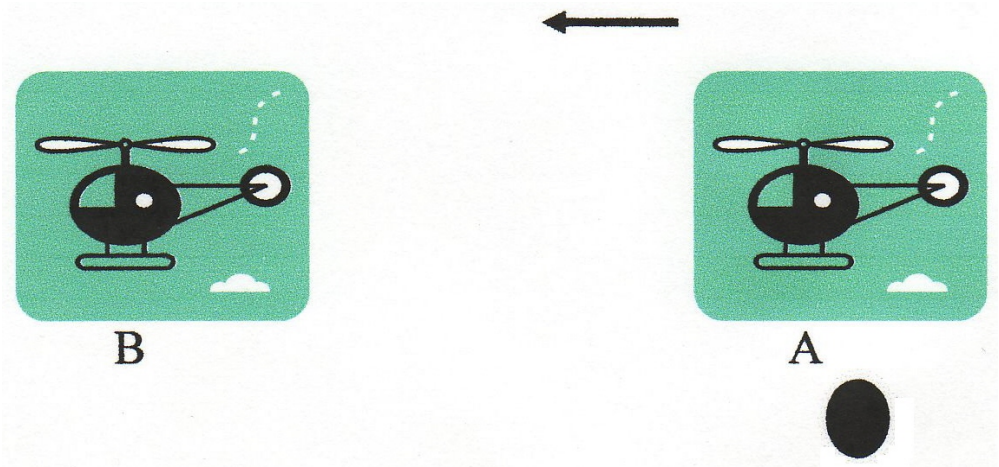
5. A pilot drops a package from a helicopter when at position A when flying horizontally at constant speed in the direction shown by the arrow.

(a) On the diagram below show the position of the package relative to the helicopter when the helicopter has moved to position B (ignore air resistance).



(b) Give reason for your answer to (a).

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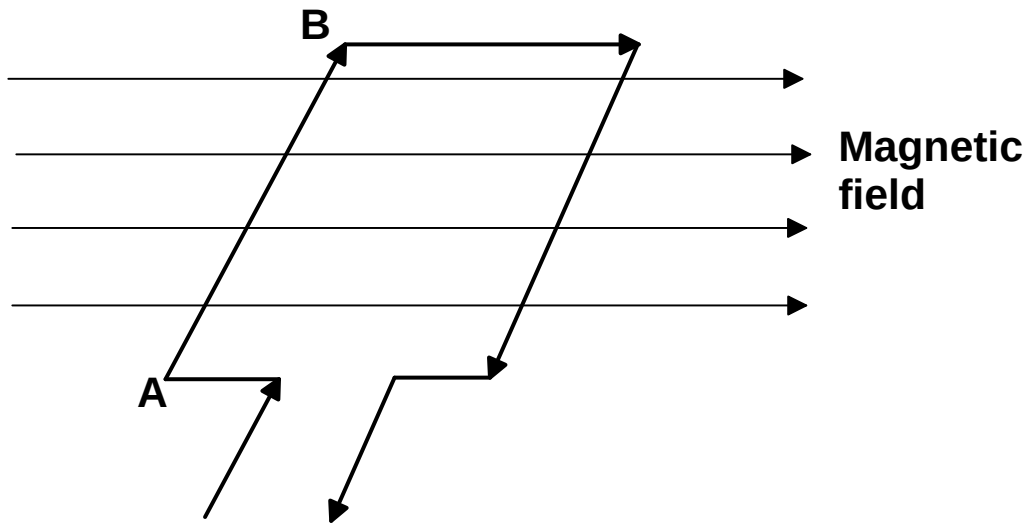
6. Solar panels are becoming familiar on the roofs of some houses and schools. They convert solar radiation into electrical energy.

   (a) Calculate the energy of one photon of infra red radiation if it is incident on a solar panel.

   (b) How many photons would be necessary to transmit 5 joule of energy assuming the process to be 100% efficient?

7. The following diagram represents a single coil associated with an electric motor in a magnetic field. The arrows on the coil represent the direction of the conventional current flow in the coil.



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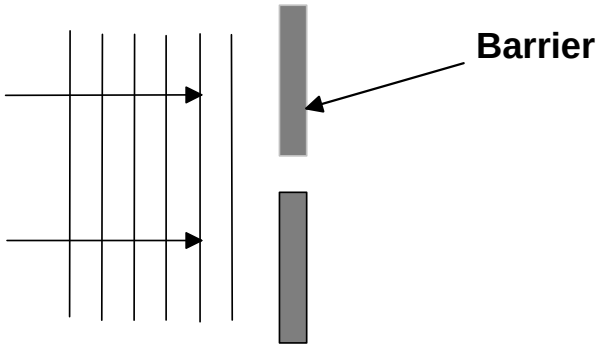
(a) What is the direction of the force on AB? Indicate the directions on the diagram.

(b) If the magnetic field has strength of 0.55 T and AB is 0.40 m in length and 2.0 A flows in the circuit then what is the force on the side AB?

8. The following diagram shows wavefronts approaching a gap in a barrier.



(a) Complete the diagram showing the wavefronts after passing through the gap.

(b) What is the name for this behaviour of waves?

(c) Are the waves:

(i) sound waves (ii) light waves (iii) could be either?

Circle the correct answer.

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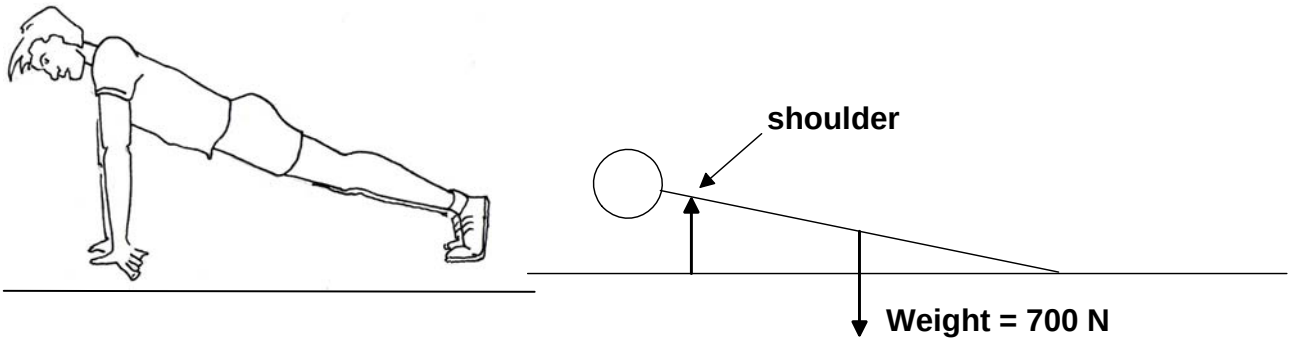
9. At a concert in the Botanical gardens in Kings Park the Ten Tenors were performing. From where I sat, when one tenor sang, the sound level was 55 dB. Later in the concert all 10 tenors sang simultaneously (assume sound level for each tenor is 55 dB).
   (a) What was the new sound level in dB when all Ten Tenors sang?

   (b) When I moved to double the distance from the stage and there were still all Ten Tenors singing then what was the sound level?

10. At a local park a fitness enthusiast has ended his exercise with a few push ups. Below is a picture of this exercise and a diagram of the forces involved. His weight is 700 N and his height is 1.90 m.



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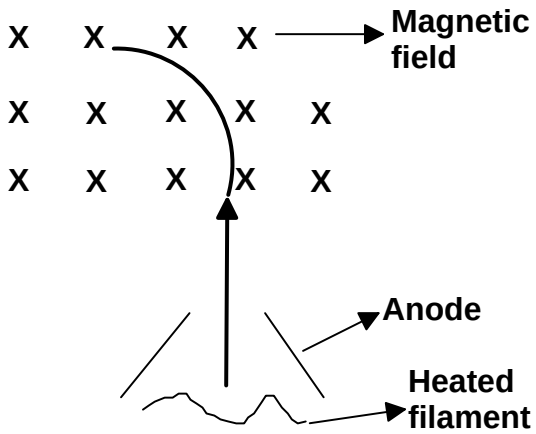
ESTIMATE the compression in his arms? Show all your working and include the estimates you have made

11. You may have seen a fine beam tube demonstrated to you at school. Electrons are produced by heating a metal filament and are accelerated away from this filament by a conical anode. The resulting fine beam is persuaded to follow a circular path by entering a uniform magnetic field at right angles. This is illustrated below.



(a) What polarity of voltage will be on the anode? Explain your answer.

(b) What will be radius of the circular orbit if the field is 0.2 T and the speed is 3×10^7 m s^{-1}?

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12. If the apparatus in Q 11 is in a sealed sphere containing an inert gas, often neon, why would the beam leave a pink trail in the case of neon?

13. A child is swinging on a tyre in a vertical semi circular, to and fro, motion as shown below. ESTIMATE the reaction force exerted by the tyre and label its direction on the diagram. The boy has a mass of 55 kg and the tyre 5 kg.

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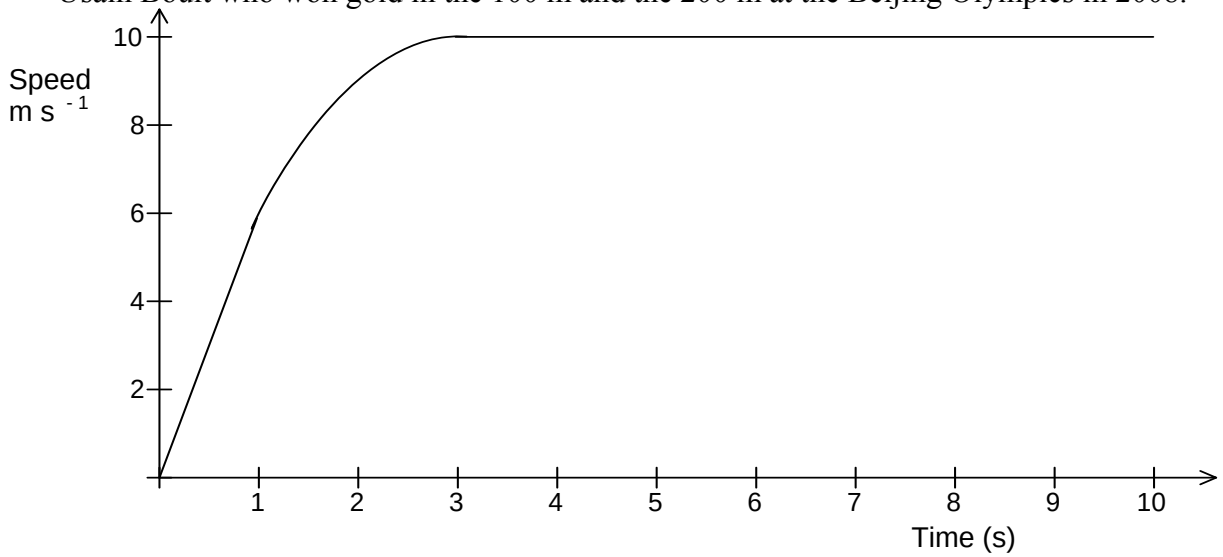
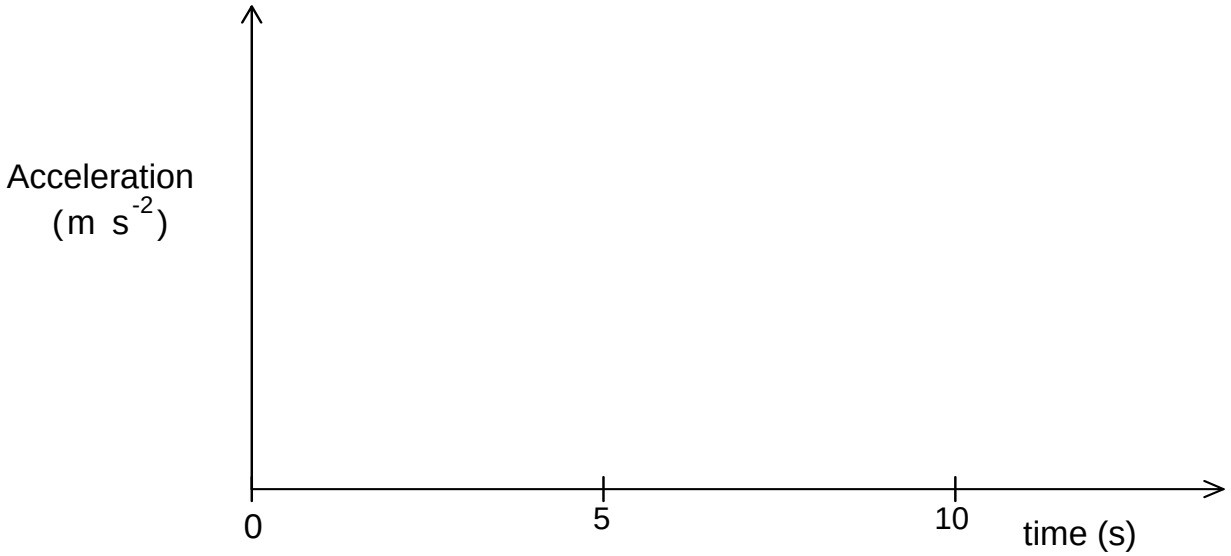
14. The following graph represents the approximate velocity (v) / time (t) profile for Usain Boult who won gold in the 100 m and the 200 m at the Beijing Olympics in 2008.



(a) Sketch the acceleration v time graph over the same time interval. No calculations are required



(b) Calculate the approximate distance covered in the first 2 seconds of the race.

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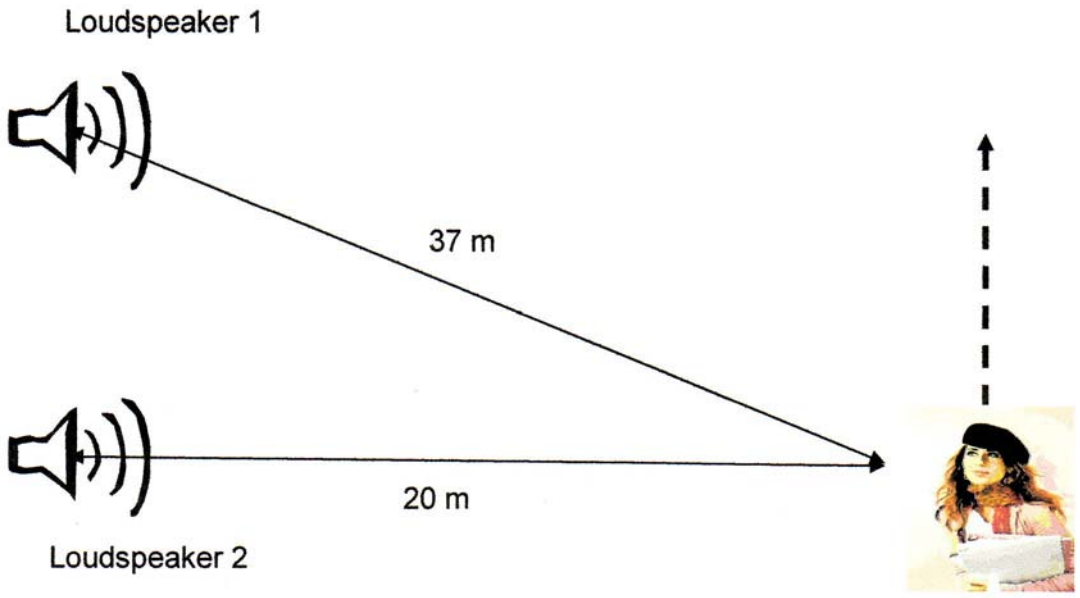
15. A student hears a announcement from the school principal from 2 different speakers as shown in the diagram below. Assume speed of sound in this question is 340 m s^{-1}. Relevant distances in metres are shown.



(a) If the principal started his speech by ringing a bell at a frequency of 680 Hz, would she hear a loud clear sound. Explain your answer.

(b) If she moved in the direction of the arrow, what changes would she notice?

END OF SECTION A

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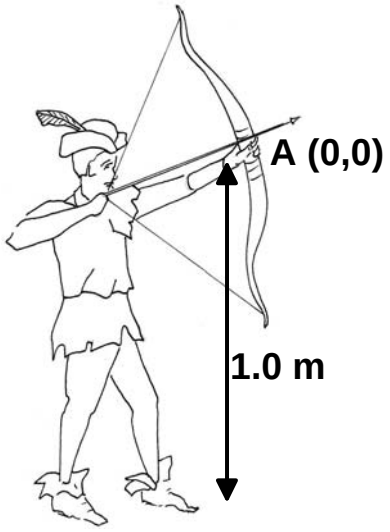
Section B Problem Solving
Marks allotted: 100 marks out of a total of 200 (50%).

This section contains 8 questions.

You should answer: ALL of the questions. Answer the questions in the spaces provided

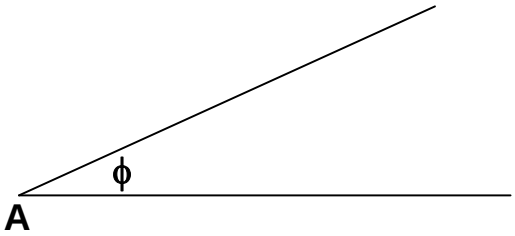
1. (16 marks)

You are familiar, I hope, with the amazing skill that Robin Hood displayed with the bow and arrow!



Imagine the arrow is projected at speed u m s^{-1} at an angle ϕ to the horizontal as in the diagram below.

Note for parts (a) and (b) take all measurements using the archers hand to be the base line i.e A is (0,0) in the diagram above.



(a) Resolve the arrow speed into horizontal and vertical components and show these on the diagram above. (2)

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(b) Now starting with the fact that at maximum height, the vertical component of the speed is zero, derive the following formula for the time (t) to reach maximum height. (3)

$$t = \frac{u \sin \phi}{g}$$

(c) Using the equation for horizontal displacement show that

Distance travelled [horizontally] $= \frac{u^2 \sin \phi \cos \phi}{g}$ (2)

(d) Robin now shoots the arrow at angle where $\phi = 25^0$ towards a target at a speed of 50 m s^{-1}. The point A is 1.0 m from the ground. If the arrow hits the target at 1.0 m from the ground how far away is the target? (3)

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(e) For how long is the arrow in the air? (3)

(f) His second arrow misses the target and lands on the ground.
How much longer is it in the air? (3)

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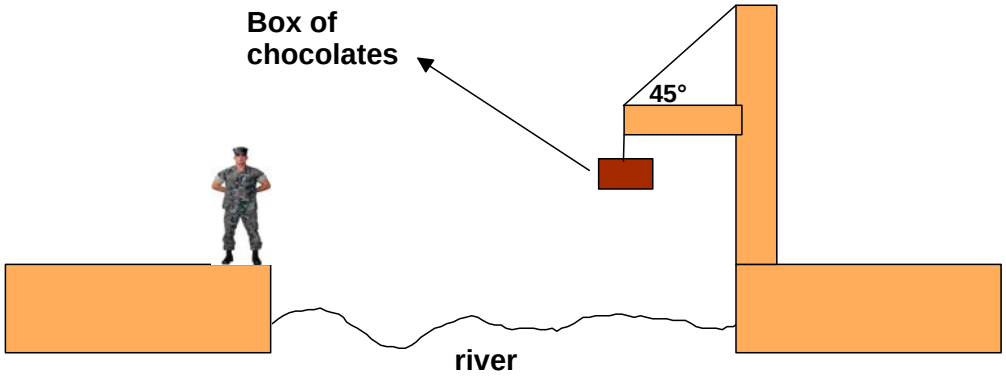
2. (11 marks)

A survival course requires soldiers to get a prize (2 kg box of chocolates) suspended above a river as shown in the diagram below,



(a) What is the net force on the prize? (1)

(b) On the diagram draw vectors to represent all the forces acting on the prize and its support system. Include directions on the vectors. (3)

(c) Calculate the tension in the rope supporting the prize at 45^0. (3)

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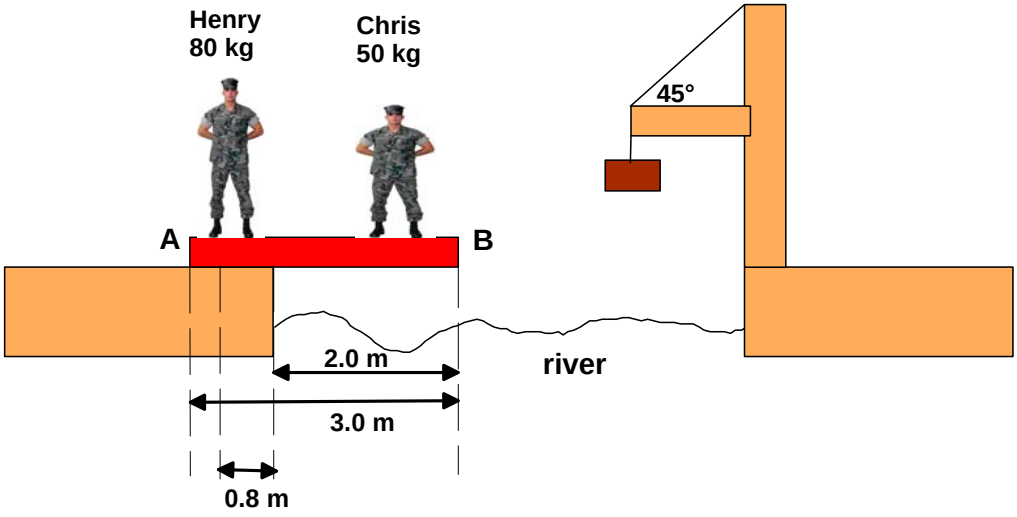
(d) Henry, the soldier, is unable to reach the prize so suggests to a friend that they use a plank of mass 40 kg as shown below. His friend, Chris has a mass of 50 kg and Henry's mass is 80 kg. The plank is 3.0 m long and extends over the bank by 2.0 m. Henry's centre of mass is 0.2 m from end A of the plank.



(e) Calculate how far Chris's centre of mass can be from the point A before the plank would fall. (4)

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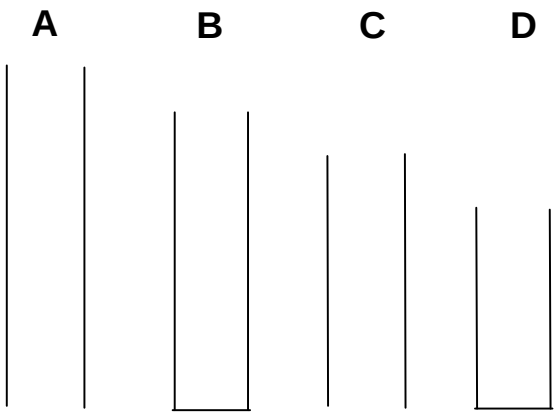
3. (12 marks)

A local church has commissioned an organ maker to produce a new organ. Unfortunately he has made a slight error and every second tube is a closed pipe and not an open pipe as shown in the diagram below. Air, at 25^0C, is blown through the pipes.



(a) On the diagram draw the displacement v distance graph for the fundamental in tubes A and B. (2)

(b) If pipe A is 5.09 m long and resonates at its fundamental frequency calculate that frequency. (3)

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(c) If tube C is 4.22 m long what is its fundamental frequency? (2)

(d) Now if both tubes A and C are played simultaneously what would a listener hear? (2)

(e) Now tube B is played so as to allow resonance at its fundamental frequency. What will be tube's fundamental frequency? Tube B has a length of 4.8 m. (3)

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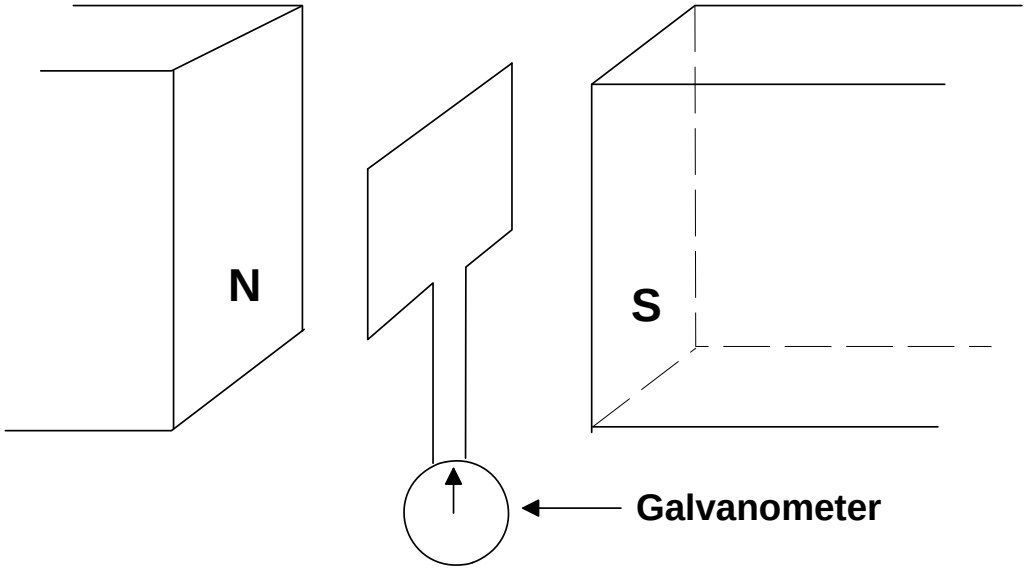
4. (15 marks)

A rectangular loop of nonmagnetic wire is placed between the poles of a permanent magnet parallel to the faces as shown in the diagram below.



It was noticed that as the loop was moved a current flowed momentarily in the loop detected by the sensitive, centre zero galvanometer.

(a) Explain this observation using your understanding of the physics involved. (3)

(b) What factors affect the magnitude and direction of the current flow in this case? (2)

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(c) What current would flow in the coil whose resistance is 4 ohms if the field strength is 0.2 tesla, and the area of the coil 0.05 m^2? The coil is completely withdraw from the field in 0.5 s. (4)

(d) Describe, in point form, the operating principle of a AC generator. Include a diagram with the essential features labelled clearly. Also include an explanation for the shape of the output voltage generated. (3 +3)

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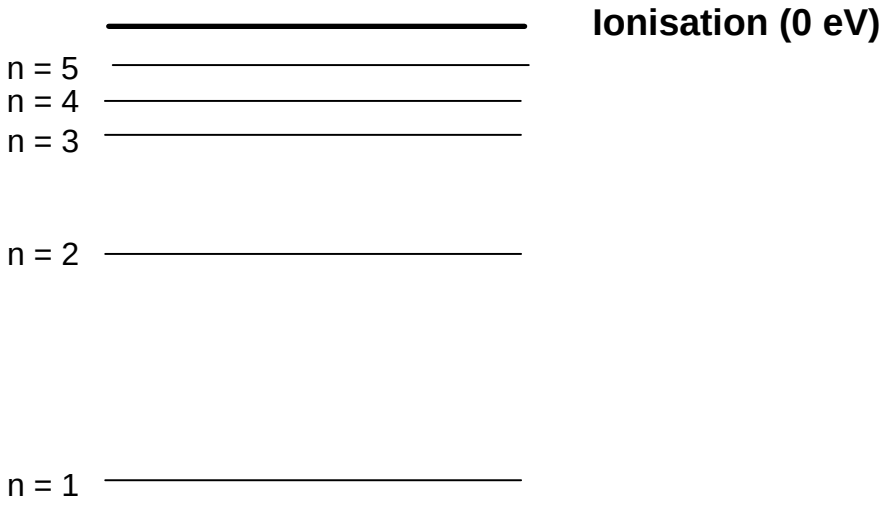
5. (10 marks)

The diagram below shows some of the possible electron energy levels in a hydrogen atom. The ionisation energy is 13.6 eV.



(a) Explain what is meant by ionisation energy? Indicate on the diagram where the electron would be if it were in "the ground state". (3)

(b) Light from a hydrogen discharge tube consists of a *line emission spectra.* Explain how line emission spectra are produced. (3)

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(c) The only emission spectra which occur in the visible region are those involved with transitions to level 2.
Draw an arrow on your diagram to indicate this transition and calculate the energy difference in joules. (The longest wavelength of these in the visible region has a wavelength of 655 nm) (1 +3)

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6. (10 marks)

In your lifetime it is expected that there will be a manned mission to the planet Mars. One strategy is to launch the rocket from a base on the moon and that rocket will have a capsule that will be ejected and land on the surface of Mars. This is similar to the lunar missions 40 years ago. The capsule launches itself from the surface of Mars and reunites with the rocket. That is the plan.

(a) Why would they even consider a launch from the moon rather than Cape Canaveral in the USA? (1)

(b) Calculate the radius of Mars given the gravitational field strength on Mars is 3.73 m s^{-2} and it's mass is 6.42 x 10^{23} kg. (3)

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(c) If the orbiting space craft will be at an altitude of 150 km, what will be the time for one orbit around Mars? If you were unable to do part (b) assume a value of 4×10^6 m as the radius of Mars. (4)

(d) How many orbits will occur in one "earth day" of 24 hours. (1)

(e) Do you think sending men to Mars (or the moon) is worthwhile and why? (1)

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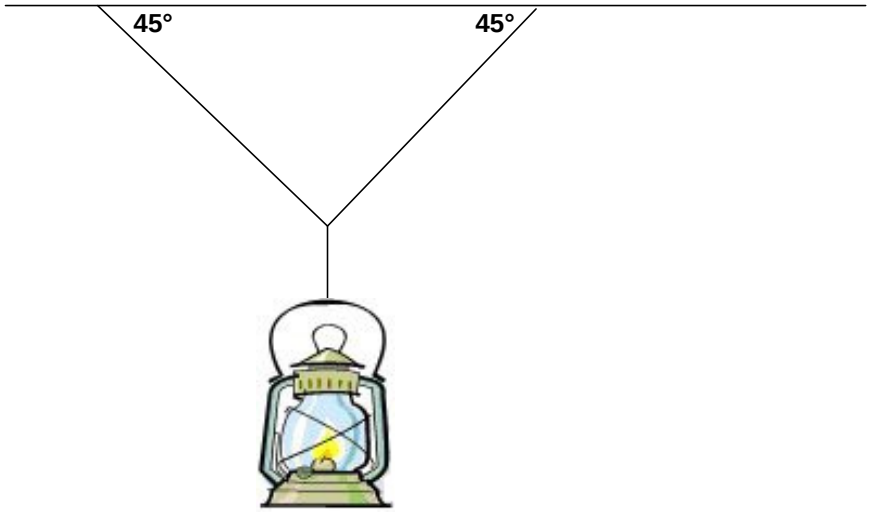
7. (13 marks)

A lamp is suspended from the roof by a pair of cables as shown in the diagram below. The mass of the lamp is 5.0 kg. The cables each make an angle of 45 ^{o} to the horizontal as shown in the diagram.



(a) What is the tension in each of the cables? (3)

(b) If the cables are made of copper and of length 2 m and diameter 3 mm, what will be the extension? (4)

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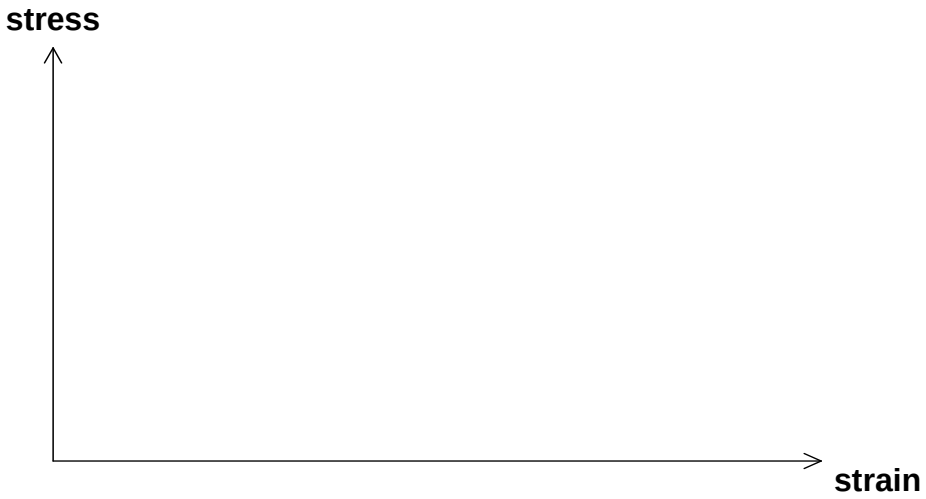
(c) The lamp is replaced by a heavier object. What is the maximum mass the copper wire could support before breaking? (4)

(d) On the axes below sketch the stress v strain graph for this copper wire, no numerical working is required but indicate where the breaking of the wire occurs. (2)



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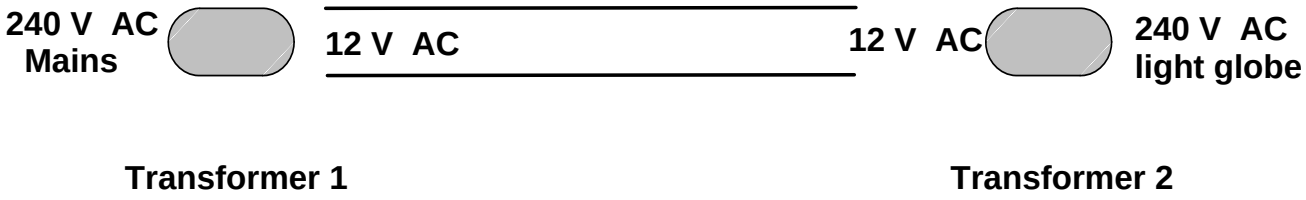
8. (13 marks)

It is common practice for the wires associated with garden lamps to carry only low voltages, normally 12 volts. However it is more efficient to use 240 volt globes and to achieve this a circuit like the one shown below is often used.
At the 240 mains the AC voltage is stepped down to 12 V AC via a transformer and the light is stepped up using a 12 V to 240 V transformer. The wire connecting these transformers are often many metres long. Assume in this question that the transformers are 100% efficient.



(a) The light globe is rated at 120 W when connected to a 240 VAC supply. What current does it use under these circumstances? (2)

(b) When the system was tested it was clear that the globe was not operating at 120 W. Explain a reason for this. (2)

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(c) What is the "turn ratio" at transformer 2. Turn ratio compares the number of turns on the primary coil with the number of turns on the secondary coil. (1)

(d) When the garden light is operating, the voltage across the input of transformer 2 is 10 V AC. What is the voltage across the light globe? (2)

(e) Under these conditions the current in the long wire is 8.3 A. What current flows through the globe's filament? (2)

(f) What is the total resistance of the wires remembering the transformers in this example are 100% efficient? (2)

(g) Which one or more of the following would increase the voltage across the globe? (2)

A Use wires of higher resistance.

B Use wires of lower resistance.

C Use transformer with ratios 240 : 24 and 24 : 240.

D Use transformers with ratios 240 : 1 and 6 : 240.

END OF SECTION B

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Section C: Comprehension and Interpretation

Marks allotted: 40 marks out of 200 (20%)

SECTION C: Comprehension & Interpretation

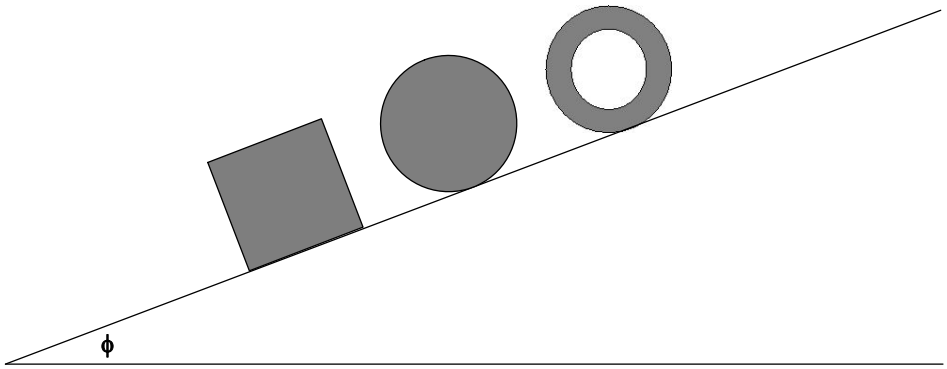
Marks allotted: 40 marks out of 200 marks total (20%)
BOTH questions should be attempted.

Read both passages carefully and answer all of the questions at the end of each passage. Candidates are reminded of the need for correct English and clear and concise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included where appropriate.

Question 1 (22 marks)

Rolling Down Hill – Moment of Inertia

Imagine the following situation a solid cylinder, a hollow cylinder and a block of wood all slide/roll down a smooth slope as shown in the diagram below



Assuming all the shapes have equal mass and started at the same place, have you ever wondered which would arrive at the bottom of the slope in the shortest time?
To answer this you need to understand about conservation of energy and moment of inertia, The loss of potential energy is translated into kinetic energy as the shapes travel down the incline, however the two cylinders rotate as well as move down the slope. This is expressed mathematically.

Loss of Potential Energy = Gain of translational kinetic Energy + Gain of rotational kinetic energy

$$mgh = \frac{mv^2}{2} + \frac{Iv^2}{2r^2}$$

Where I is known as the Moment of Inertia of the object, r is the radius of the cylinder, m is the objects mass and v its speed. The Moment of Inertia changes with the distribution of mass so a hollow cylinder has a different Moment of Inertia to that of a solid cylinder. This is the reason an ice skater (especially if holding masses in their extended arms) can change their rate of spinning just by drawing their hands together.

(a) Show on the diagram the direction of rotation of each of the cylinders. (2)

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(b) What assumptions are made in the formula where v, the speed is the same for translational speed as it is for rotational speed? (2)

The following data was obtained by rolling a cylinder down a slope of length 2 metres. This distance travelled is kept constant and the angle of the slope is increased.

Time of journey (s)	Acceleration ($m\ s^{-2}$)	Angle of slope (ϕ)	
		0	
1.88		10	
1.33		20	
1.09		30	
0.96		40	
0.89		50	
0.67		60	

(c) Fill in the acceleration column using the formula, assuming the object started from rest. (2)

$$s = u\,t + \frac{a\,t^{2}}{2}$$

(d) Consider the block of wood and resolve the weight of the block into a component parallel to the slope and show this as a vector on the diagram. Label it **V.** (2 +1)

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(e) Use the above equations and any other motion equation on the constants and data sheet to derive this formula. Remember the object starts from rest. (5)

$$\text{acceleration} = a = \frac{m g \sin\phi}{\left(m + \frac{I}{r^2}\right)}$$

Hint : (i) $mgh = mg2\sin\phi$, since vertical height change $h = 2\sin\phi$

(ii) $v^2 = u^2 + 2as$ and since $u = 0$ $s = 2$ m then $v^2 = 4a$

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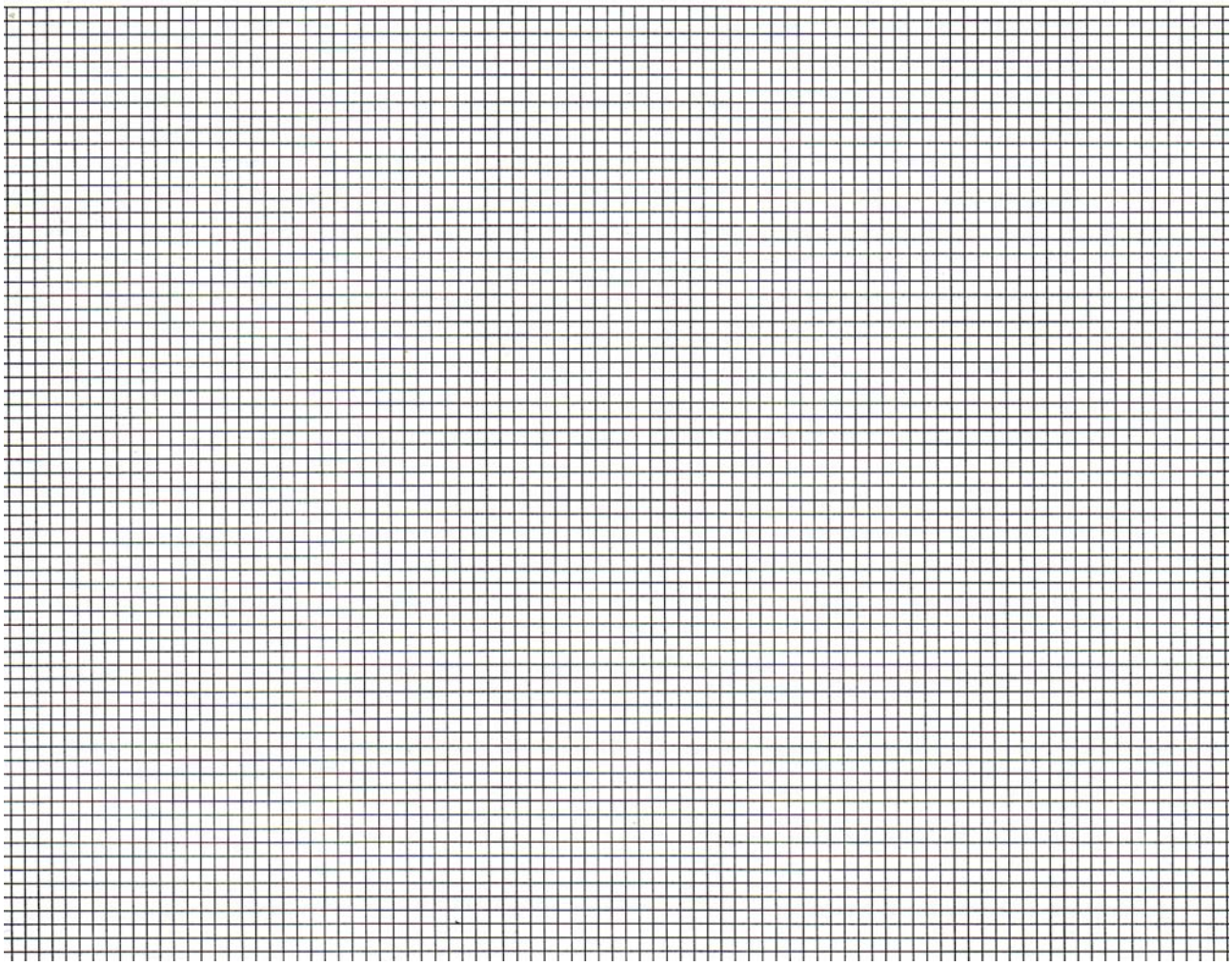
(f) Plot, using suitable axes, the above data for the cylindrical shape so as to obtain a linear graph and from the graph predict a value for I, the Moment of Inertia of the shape. Assume the mass of the cylinder is 2 kg and its radius is 0.50 m. (3+3)



(g) Which of the shapes in the diagram would reach the end of the slope in the shortest time if they all started at the same point? Explain. (2)

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2. **(18 marks)**

Electric Cars - have they a future?

Petrol cars have long been known to pollute, be expensive to run and guilty of consuming a precious resource, oil. Why then after all these years are they still "king of the freeway"? Innovations have come and gone yet some scientists in San Francisco believe electric cars have a use other than on golf courses.

They tested a Tesla Roadster which can accelerate 0 – 100 km hr^{-1} in 5 seconds and has a top speed of 180 km hr^{-1} and a range of 350 km. They are impressive credentials but the down side is the cost it is over $100 000 and this is because it is powered by a Lithium ion battery of mass 450 kg and costs about $35 000. The roadster has a CO_2 emission less than a quarter of that of a typical American car even including the energy and associated pollution used to recharge the battery. The company involved reports it costs less than 2 cents per kilometre compared to a conventional car that cost 9 cents per kilometre.

So what is the future of electric cars? There are doubters that the Tesla Roadster can be downsized to make a affordable family car. A compromise is the Toyota Prius which is very popular in the USA. It is a hybrid which means it uses a battery and small petrol driven motor to both charge the battery and run the car at high speeds or where increased acceleration is needed. The small electric motor is much more efficient that a petrol engine. (Just think how hot even your small lawn mower engine becomes.) Lastly both cars mentioned uses regenerative braking where the wheels power a dynamo on slowing down that produces electricity to charge the battery. That is a bonus.

The key breakthrough that the scientists in San Francisco have made is with the battery. Lithium-Ion is a well tested technology used in both mobile phones and portable radios. They can store a lot of energy per kilogram and the materials are recyclable. Recent advances have enabled these small batteries to be able to deliver the tens of kilojoules of energy that is needed to drive a small car. A Li-ion battery can deliver 150 kJ / kg. They are also about half the mass of an equivalent lead acid battery.

You may ask how does this help if extra coal fired power stations are needed to produce the electricity to recharge the Lithium-ion batteries. Well, the key is that the batteries can be recharged at night when there is spare generating capacity. A study by the Electric Power Research Institute [EPRI] has found that the existing system has the capacity to generate 70 % of the required power. The shortfall can be made up by using renewable energy sources.

Questions (18 marks)

(a) What does the phrase petrol cars are still "king of the freeway" mean? (1)

(b) What is the acceleration of the Tesla Roadster in m s^{-2}? (1)

(c) What are the likely problems with "downsizing" the Teslar Roadster? (2)

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(d) Explain how regenerative braking produces electricity and why it is a bonus. (2)

(e) Why in the calculations do we have to include the pollution the power stations make? (1)

(f) Why would an electric motor be more efficient that a petrol engine and how would you detect the increase in efficiency? (2)

(g) How much energy would it require to accelerate a car of mass 1 500 kg from rest to 72 km hr^{-1}? Ignore any friction between the tyres and the road. (2)

(h) Why is energy / kg so important? (1)

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(i) ESTIMATE the energy required to travel 100 km of which 20 km is in city traffic, 80 km is on country roads and regenerative braking provides 50% return to the battery system. Show your assumptions in your calculations to attract marks. Assume travelling at constant speed on the country roads requires 80 kJ per km. (4)

(j) How can the cost of the cars be made cheaper and what constraints will that put on the driver? (2)

END OF EXAM