Semester Two Examination, 2011

Question/Answer Booklet

3AB PHYSICS

Please place your student identification label in this box

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
Formulae and Constants Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

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.

	A	B	C	Total
Score				
Out of	54	90	36	180
%				

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short response	15	15	50	54	30
Section Two: Problem-solving	8	8	90	90	50
Section Three: Comprehension	2	2	40	36	20
					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2011.* Sitting this examination implies that you agree to abide by these rules.

2. Write answers in this Question/Answer Booklet.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Working or reasoning should be clearly shown when calculating or estimating answers.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
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Section One: Short response 30% (54 Marks)

This section has **15** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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Suggested working time for this section is 50 minutes.

Question 1

(4 marks)

Romeo (the student physicist) is throwing small pebbles at Juliet's window. He is trying to wake her up so she will come out and talk to him. He is throwing the pebbles with an initial velocity of 8.00 m s^{-1} at an angle of 70.0 ^{0} above the horizontal.

a) If the pebbles strike the centre of Juliet's window with purely horizontal motion, what is the height of the centre of the window above the throwing point?

(3 marks)

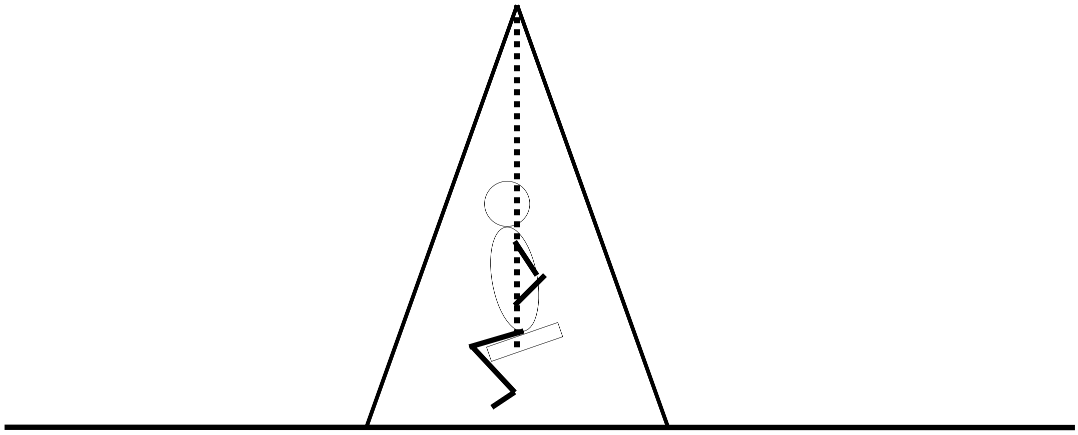
b) The window will break if the pebble has a kinetic energy of 4.70 J or greater. What minimum mass rock will cause the window to break?

(1 mark)

Question 2

(2 marks)

A child is sitting on a swing that is not moving.



a) Circle all option(s) that correctly describe the type of equilibrium that the swing is in. (1 mark)

Static equilibrium Mechanical Equilibrium

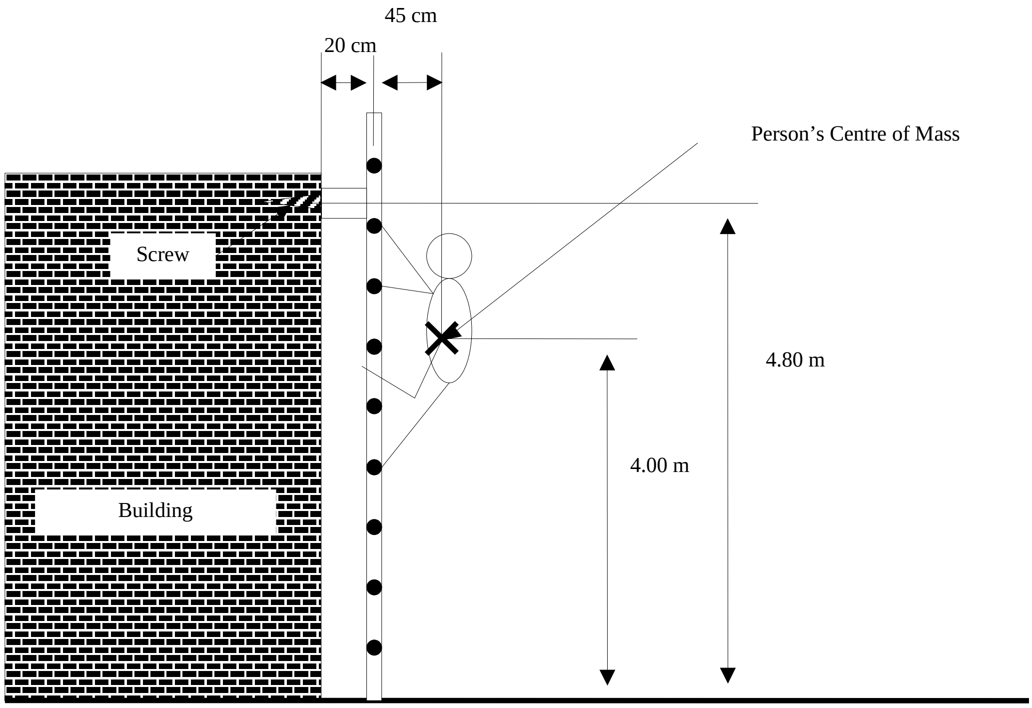
Stable Equilibrium Unstable Equilibrium Neutral Equilibrium.

b) Explain the reasons for your answer(s) to part a). (1 mark)

Question 3

(3 marks)

A fire escape ladder is attached to the side of a building by one large screw. The screw is shown in the diagram below. The base of the ladder touches the ground.

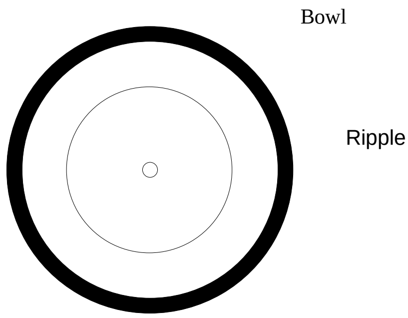


If the ladder has a mass of 20.0 kg, the person a mass of 90.0 kg and all of the attachments that join it to the wall are weightless, what is the force exerted by the screw on the ladder?

Question 4

(4 marks)

The roof is leaking. A round bowl is placed below the leak to catch the drips. When a drip drops into the bowl it creates a wave which travels outwards, strikes the side of the bowl and travels back inwards.



a) The bowl has a diameter of 44.0 cm and the ripples travel with a velocity of 0.110 m s^{-1}. At what frequency should the drips from the roof enter the bowl so the ripple returning to the centre coincides with the next drop from the roof entering the water.

(2 marks)

b) If this synchronised dripping continues, a standing wave will be set up causing the water in the bowl to slop over the edge. Explain what the home owner can do to prevent this from occurring and why it will work, if they cannot alter the timing of the drip?

(2 marks)

Question 5

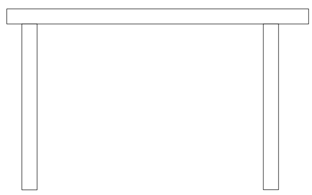
(3 marks)

Give three reasons why astronomers have decided to put telescopes in space instead of using ground based telescopes.

Question 6

(4 marks)

One day in church, the organist was practising (very loudly) and the flower lady was filling the vases with flowers. The flower lady noticed that a vase near her vibrated particularly strongly when the organist played particular notes.



a)   What are the frequencies of the 2 lowest pitch notes what will cause the vase to vibrate particularly strongly if the vase is 34.5 cm long?

(3 marks)

b)   Explain what will happen to the vase when each of these two notes are played if the flower lady now fills the vase 2/3rds full of water?

(1 mark)

Question 7

(3 marks)

a) A compact fluorescent light bulb is stamped 23.0 W and is 10.6 % efficient. How much power is output as light?

(1 mark)

b) If the best intensity of light for reading by is 0.8 W m^{-2}, how far should the reader stand from the light source?

(2 marks)

Question 8

(4 marks)

As the result of a collision between two protons in a hadron collider (atom smasher) a π^+ particle consisting of a u quark and an $\bar{d}$ quark is created. Classify the particle by ticking the correct boxes in the table below.

(2 marks)

Classification	Yes	No
Boson		
Lepton		
Hadron		
Baryon		
Meson		

Is this particle likely to be stable? Give reason**s** why or why not.

(1 mark)

Name two exchange particles that could mediate a force on this particle.

(1 mark)

________________________ ____________________________

Question 9 - Rel

(3 marks)

According to Einstein's special theory of relativity, the dimensions of objects moving at speeds approaching the speed of light become distorted. The formula that governs this distortion is…

$$l' = l \sqrt{(1 - (v^2 / c^2))}$$

Where
v = the velocity of the object, c = the speed of light, l = the length as observed by a person moving with the object and l' = the length as measured by a stationary person.

How fast would the object have to be moving if its distorted length is ½ of its undistorted length?

Question 10

(5 marks)

A research scientist is trying to make a solar cell out of calcium metal. Calcium has a work function of 2.90 eV.

a) If the scientist needs the electron to leave the surface of the calcium with a velocity equal to 1% the speed of light, what frequency of light should be shone on the surface?

(4 marks)

b) Which part of the electromagnetic spectrum does this light belong to?

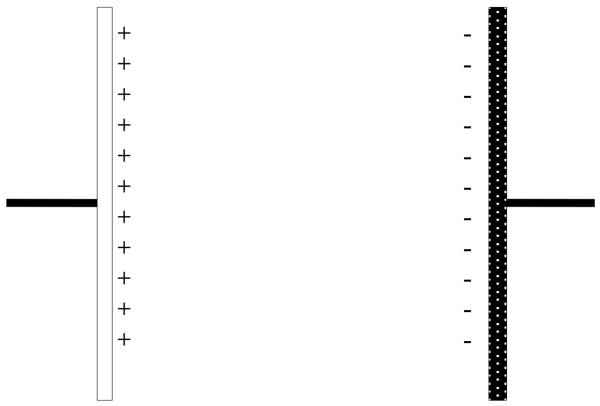
(1 mark)

Question 11

(4 marks)

a) Draw the Electric Field on the following diagram.

(1 mark)

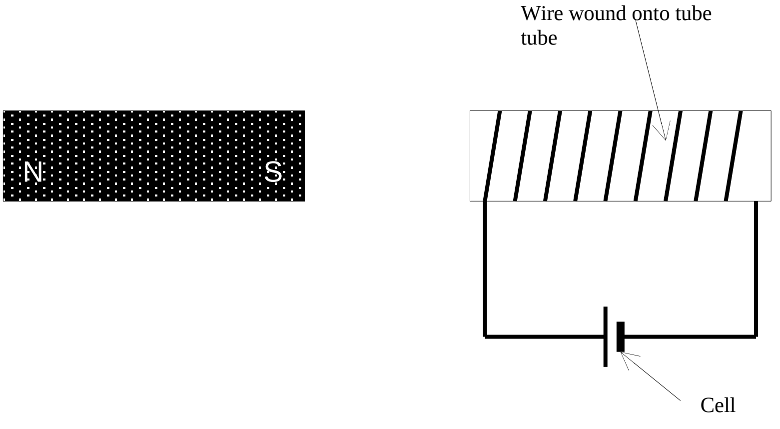


b) Draw onto the diagram the direction of the force on the <u>shaded object</u> as a single thick arrow in pencil.

(1 mark)

c) Draw the resultant magnetic field on the following diagram.

(1 mark)



d) Draw onto the diagram the direction of the force on the <u>shaded object</u> as a single thick arrow in pencil.

(1 mark)

Question 12

(3 marks)

An arrow from a magnetic compass is shot through a hollow horizontal aluminium tube at 100 m/s. Assume air resistance is negligible and that there is no gravity. What will happen to the arrow as it passes through the tube and why?

Side View Diagram

Hollow Aluminium Pipe

S N

100 m s-1

Question 13

(4 marks)

a) Explain why most of the electrical transmission networks of the world have elected to use AC instead of DC electricity?

(3 marks)

b) State one disadvantage of AC electricity?

(1 mark)

Question 14

(4 marks)

Tina goes to Kalgoorlie on holiday and discovers an old mine shaft (hole in the ground), with a sign saying "CAUTION -105.0 m drop". She decides to drop a stone from the edge of the hole. Assume the stone does not the touch the sides on the way down.

a) Calculate the time taken for the rock to reach the bottom of the hole.

(1 mark)

b) Calculate the relative error in this time. State any assumptions about the error associated with gravity.

(2 marks)

c) If the speed of sound in air is 346 m/s, how much time will elapse between the dropping of the stone and the sound of the collision returning to Tina's ear?

(1 mark)

Question 15

(4 marks)

A student is performing an experiment to determine the height to which a bowling ball will bounce after hitting the surface of a trampoline when dropped from different heights.

a) State one thing that you would do in the experiment to ensure the experiment is valid.

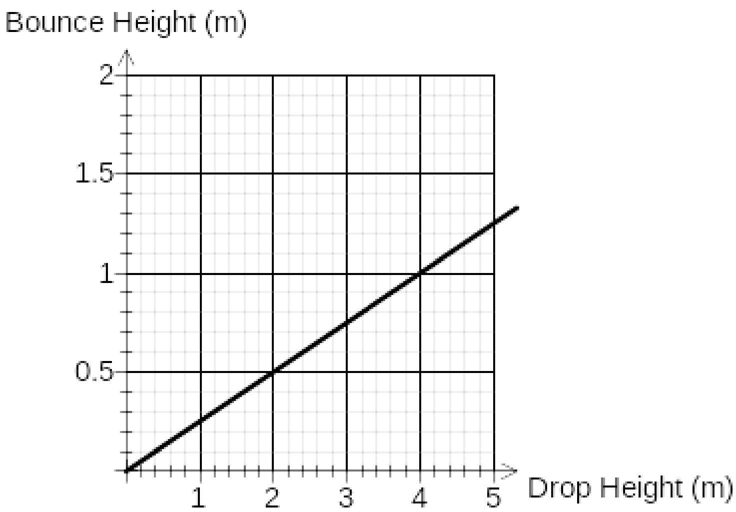
(1 mark)

b) State one thing you would do to ensure that the experiment is reliable.

(1 mark)

c) The student hypothesizes that the ball will bounce to 1/3rd of its drop height each time.

Graph of Bounce Height as Function of Drop Height



Based on the graph of the data collected in the experiment, is this hypothesis supported by the data? Explain

(2 marks)

End of Section One

Section Two: Problem-Solving 50% (90 Marks)

This section has **eight (8)** questions. You must answer **all** questions. Write your answers in the space provided.

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Suggested working time for this section is 90 minutes.

Question 16

(11 marks)

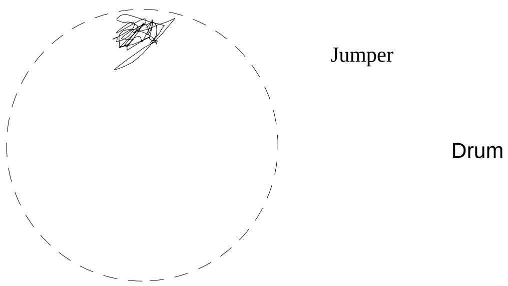
In a front loading washing machine clothes are spun at high speed to remove the water from them. The drum of the washing machine that contains the clothes is 53.0 cm in diameter and spins at 1200 RPM.

a) What is the speed of the side of the drum?

(2 marks)

b) If a 100 g jumper is put into the washing machine and it is spun at 1200 RPM. Draw a free body diagram showing the forces on the jumper at the top of the drum (circle).

(2 marks)



c) Calculate the size and direction of the force of the drum on the 100 g jumper when it is at the top of the drum?

(3 marks)

d) Calculate the centripetal acceleration on the jumper when it is at the bottom of the drum.

(2 marks)

e) The now slightly damp jumper is put in a dryer containing an identical rotating drum of 53.0 cm diameter. For clothes to dry effectively in a clothes dryer they must be tumbled. This means they must <u>not</u> be spun so fast that they stick to the side of the drum at the top. At what speed must the jumper be spun such that it <u>just</u> falls away from the top of the drum as it turns?

(2 marks)

Question 17

(12 marks)

The galaxy Triangulum (M33) is one of the furthest objects that can be seen with the naked eye from earth. It is the third largest galaxy in our local group. It is 2.64 Mly (mega light years) from earth.

a) What is the distance of Triangulum (M33) from earth in …

i) metres?

(1 mark)

ii) astronomical units?

(1 mark)

b) Derive 1 pc (parsec) from 1 AU (astronomical unit) with the assistance of a diagram. Show all working.

(3 marks)

According to the Hubble Law the distance of an object from our solar system is proportional to the velocity at which an object moves away from earth.

$$v_{object} = H_0\ d$$

Where v is the velocity of the object in km/s, H_o is the Hubble constant (= 71km s^{-1} / Mpc) and d is the distance of the object from our solar system in Mpc (megaparces).

c) From the numbers provided determine the recessional velocity of Triangulum (M33).

(3 marks)

d) Will the light from Triangulum (M33) appear to be red shifted of blue shifted?

(1 mark)

Blue Shifted Red Shifted please circle one only

e) If Triangulum (M33) is releasing a light of frequency 5.50 x 10^{14} Hz, what will be the frequency of the light after red shift / blue shift according to the S.I. formula below?

$$f_L = \left(\sqrt{\frac{c-v}{c+v}} \right) f_S$$

Where f_L is the frequency of the observer and f_S is the frequency of the source.

(1 mark)

Please state your answer accurate to 5 sig. fig.

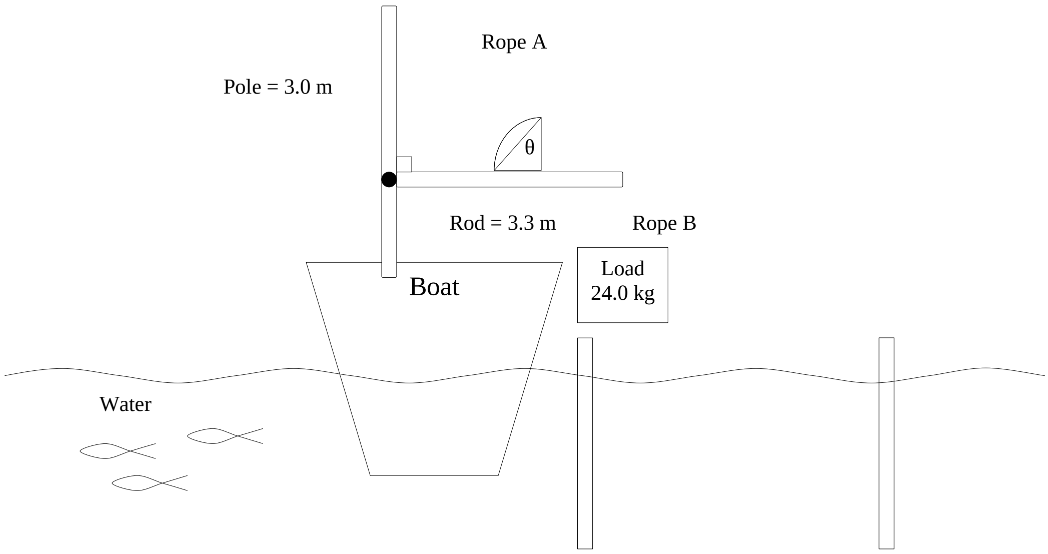
f) Does the Hubble Law support or refute the Big Bang Theory? Explain how.

(2 marks)

Question 18

(12 marks)

A ship's crane on an old sailing ship is lifting cargo off the pier (jetty) and loading it onto its deck. The pieces of the crane (rope, pole and rod) are **weightless.**



a) What is the tension in rope B?

(1 mark)

b) Calculate the angle θ.

(2 marks)

c) What is the tension in rope A?

(3 marks)

d) What is the force on the rod where it joins to the pole?

(2 marks)

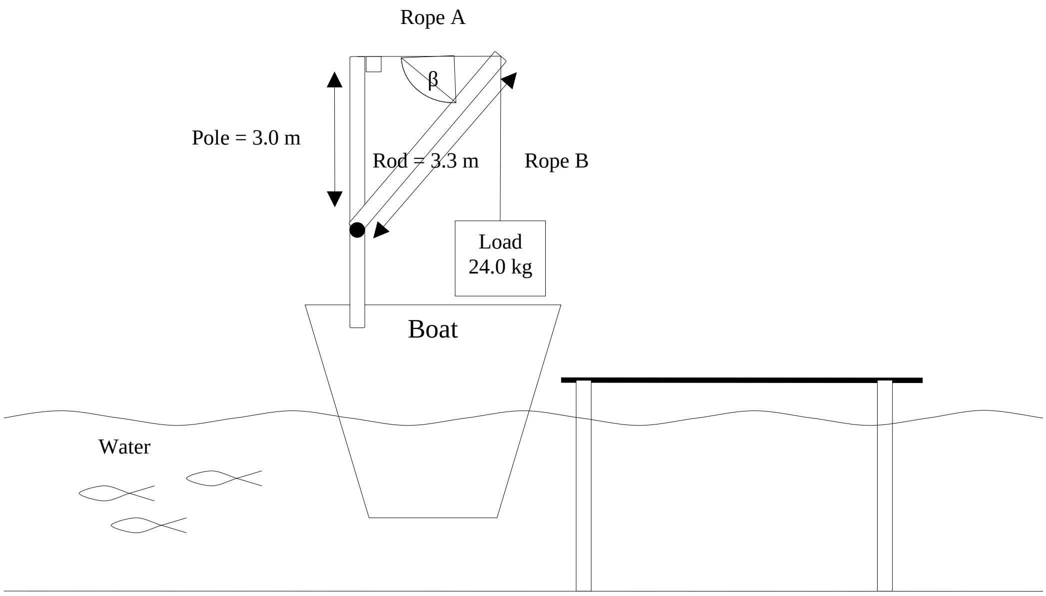
e) State whether the forces are pure Tension, pure Compression or Bending forces in each of the following pieces of the crane.

(1 mark)

Part	Tension / Compression / Bending
Rope A	
Rod	
Pole	

f) Rope A is now pulled to lift the load on board the boat. Rope A is now horizontal. What is the new tension in rope A?

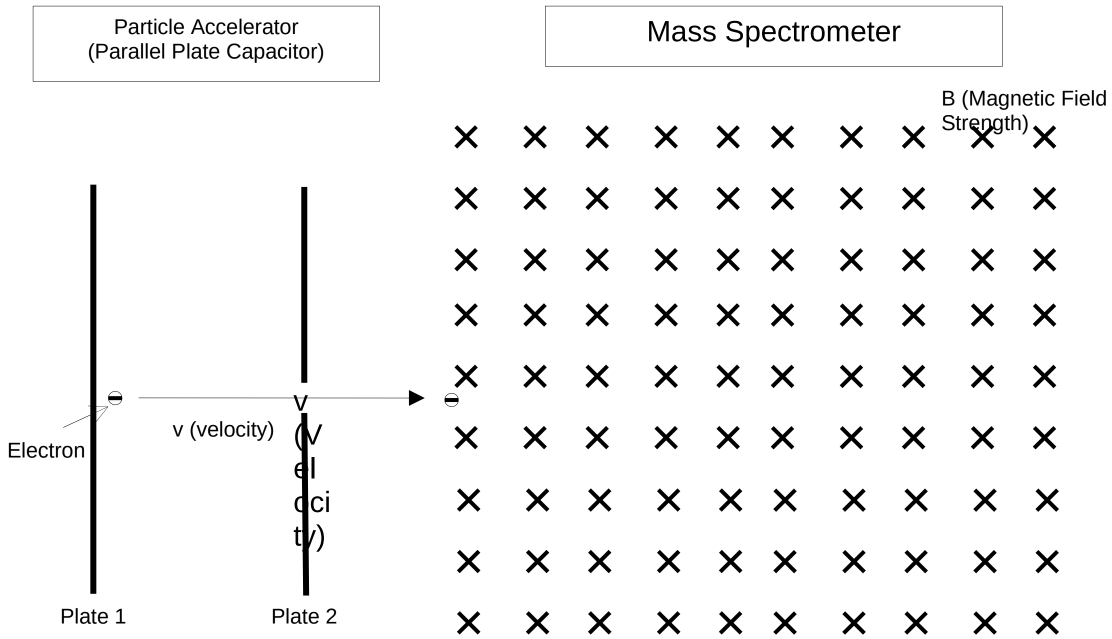
(3 marks)



Question 19

(9 marks)

A physicist has left his watch at home and decides to use his mass spectrometer at work as a clock. He wishes to set up the mass spectrometer so that an electron is fired into the magnetic field at 1/100th the speed of light causing it to complete 1000 000 revolutions each second.



a) Decide the charge on plate 1 and plate 2 by circling the correct words in the sentences below.

(1 mark)

Plate 1 should be charged positively / negatively. (Choose one only)

Plate 2 should be charged positively / negatively. (Choose one only)

b) What should be the voltage difference between plates 1 and 2 in order to accelerate the electron to 1/100th of the speed of light?

(2 marks)

c) On entering the magnetic field shown in the diagram, in which way will electron turn?

(1 mark)

Left right out of page into page top of page bottom of page

(Choose one only)

d) What is the circumference of the circle required if the electron is to revolve 1000 000 times in 1 second?

(1 mark)

e) What is the strength of the magnetic field required?

(3 marks)

f) Will the electron execute complete circles in the diagram above? Explain why or why not with the assistance of the diagram on page 21.

(1 mark)

Question 20

(10 marks)

Anna receives a new watch from her brother before going on camp. The watch face has numbers on it that glow a yellowy green for a while after you shine a torch or light on them.

a) Are the numbers fluorescent or phosphorescent? Explain the reason why.

(2 marks)

b) What is the approximate range of wavelengths emitted by the numbers on the clock face?

(1 mark)

c) Compare and contrast the light produced by the torch with the light produced by the numbers on the clock face.

(2 marks)

Anna goes to school after camp. The school has some lithium gas is a gas discharge tube which produces a line emission spectrum.

Energy Level Diagram
Lithium Atom (in eV)

d) If an electron is in the n = 4, how many possible lines can be produced when this electron transitions downwards?

(1 mark)

e) Is the n = 4 to n = 2 transition going to produce a photon in the Ultra-Violet, Visible or Infra-Red range? Support your answer with calculations.

(2 marks)

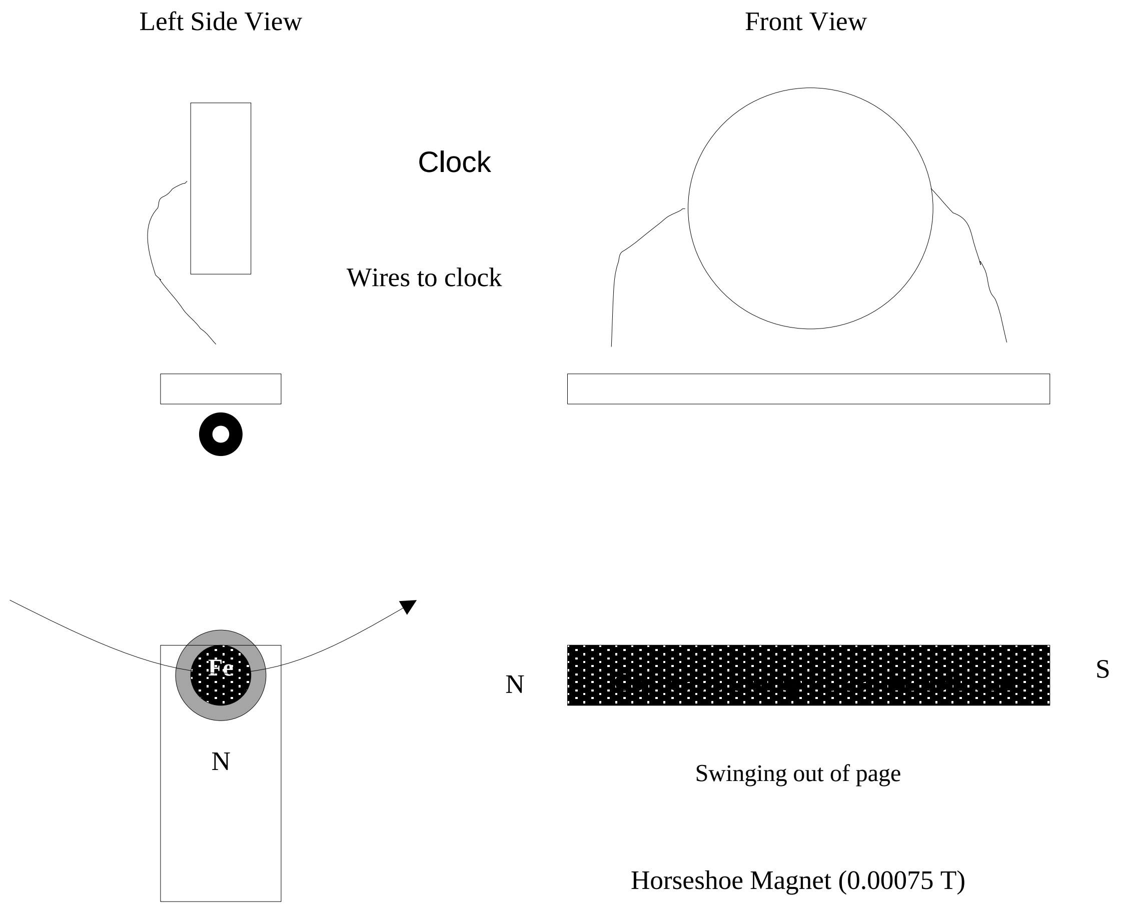
f) Would the visible glow from Anna's watch be theoretically able to cause any energy level transitions in the lithium gas? Explain why or why not with the support of calculations.

(2 marks)

Question 21

(11 marks)

A copper wire swing containing a soft iron rod of cross sectional area 3 x 10^{-4} m^2 is swung between the poles of a horse shoe magnet. The electricity generated is sent to an electrical clock in an attempt to drive it.



a) As the swing approaches the horseshoe magnet in the direction shown on the diagram, in what direction is the electrical current induced? Draw this onto the grey wires in the front view diagram.

(1 mark)

b) As the swing leaves the horseshoe magnet will the direction of the current induced in the wire reverse or stay the same?

(1 mark)

Current direction Reverses   Current direction Stays the Same

(Circle one only)

c) If on approaching the horseshoe magnet the magnetic field passing through the soft iron increases from zero to its maximum value in 0.004 s, What is the magnitude of the average voltage induced as the swing approaches over this time? Collect any additional information required for this calculation from the diagram.

(3 marks)

d) State 3 ways in which the voltage supplied by the swing could be increased.

(3 marks)

e) For one swing from left to right sketch on the graph paper below the current output for the swing as it approaches the magnet, is briefly in-line with the magnet and as it leaves the magnet.

(2 marks)

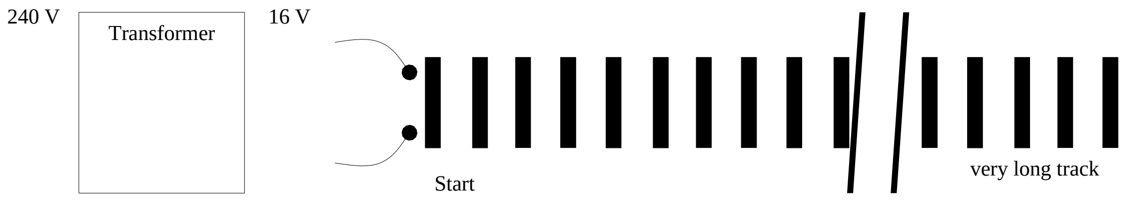
f) If there is no friction in the swing pivot, will the swing “swing” forever? Explain why or why not.

(1 mark)

Question 22

(12 marks)

A physics student buys an electrical train set. The train collects electrical current from the train rails to run its motor. The electricity put on the rails is drawn from a transformer that connects to the mains supply in Australia. The train is put at the start of the track. The student sets up the train track to create a long straight line as shown in the diagram below.



a) The train draws a current of 0.600 A and the track voltage is set at 16.0 V. What is the resistance of the motor in the train?

(2 marks)

b) What is the power supplied to the track / train by the transformer?

(2 marks)

c) The transformer is 82.0 % efficient. What is the power supplied to the transformer from the mains?

(2 marks)

d) What is the current supplied to the transformer from the mains?

(2 marks)

As the train travels along the tracks further from the transformer, the voltage available to the train is reduced due to the electrical resistance of the tracks. The train will continue to move until the voltage drops to just below 12.0 V at which point it will grind to a halt.

e) What is the power consumed by the train just before it grinds to a halt?

(2 marks)

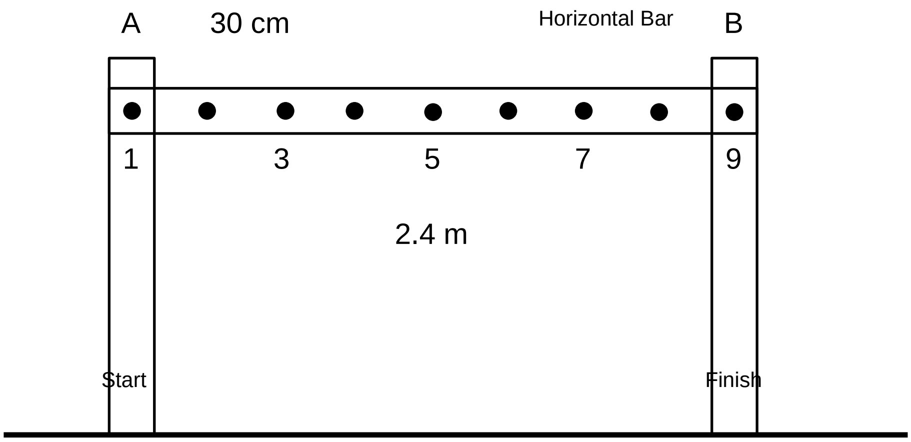
f) One rail of the track has a resistance of 0.2 $\Omega\ m^{-1}$. How far will the train get from the start along the straight track?

(2 marks)

Question 23

(13 marks)

A set of monkey bars are standing in a playground.



The horizontal ladder is 2.40 m long and has a mass of 20.0 kg. The rungs are spaced 30.0 cm apart.

a) If nobody is hanging from the horizontal ladder, show all of the forces acting on the ladder on the diagram above.

(1 mark)

b) What is the force of pole B on the horizontal ladder when nobody is swinging on the rungs?

(2 marks)

c) A 35.0 kg child now hangs from the hand rung 1 at the start of the monkey bars. What is the force of Pole B on the horizontal ladder now?

(1 mark)

d) What is the force of Pole A on the horizontal ladder if the child is now hanging from rung number 4?

(2 marks)

e) The child now moves from rung number 1 to rung number 9 by swinging one rung at a time. If we ignore the swinging forces of the child on the monkey bars draw a graph of the force exerted by Pole B on the horizontal ladder as a function of the distance the child is from rung number 1.

(4 marks)

f) Write out the mathematical function (formula) for the graph you have created.

(3 marks)

End of Section Two

Section Three: Comprehension 20% (36 Marks)

Question 24

Resonance in Rooms

(18 marks)

Paragraph 1

Room modes are the collection of resonances that exist in a room when the room is excited by an acoustic source such as a loudspeaker. Most rooms have their fundamental resonances in the 20 Hz to 200 Hz region, each frequency being related to one or more of the room's dimensions or a division thereof.

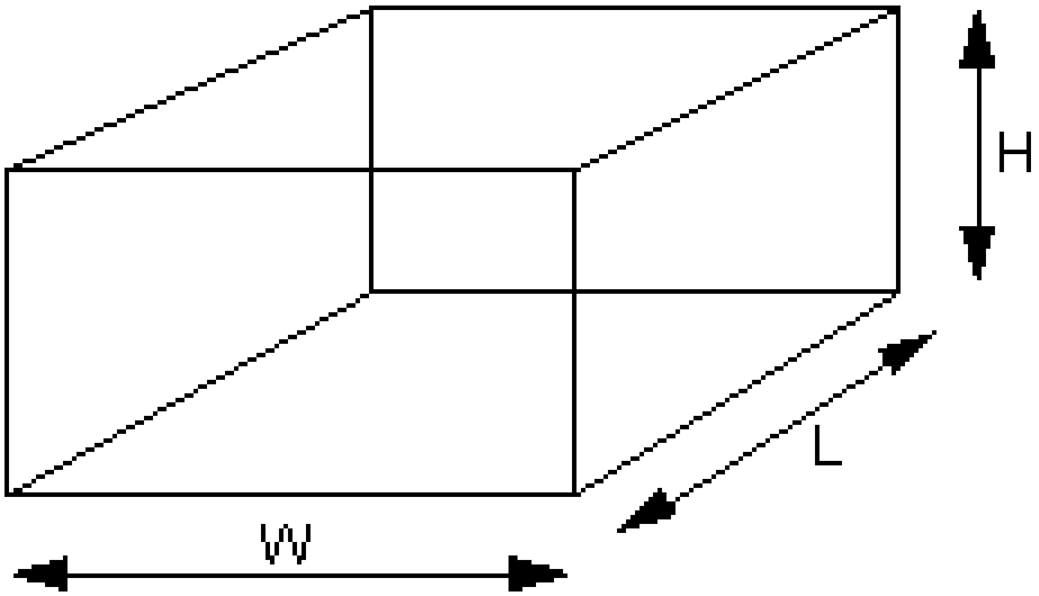


Figure 1 – Dimensions of a Room

These resonances affect the low-frequency to low-mid-frequency response of a sound system in the room and are one of the biggest obstacles to accurate sound reproduction.

Paragraph 2

1. The mechanism of the room's resonances

The input of acoustic energy to the room at the modal frequencies and multiples thereof causes standing waves. The nodes and antinodes of these standing waves result in the loudness of the particular resonant frequency being different at different locations of the room. These standing waves can be considered a temporary storage of acoustic energy as they take a finite time to build up and a finite time to dissipate once the sound energy source has been removed.

Paragraph 3

2. Minimizing the effect of room resonances

A room with generally hard surfaces will reverberate for a long time after the resonant frequency is switched off. Absorbent material can be added to the room to damp such resonances which work by more quickly dissipating the stored acoustic energy. In addition absorbent material will broaden the resonant frequencies to which the room will resonate and reduces the intensity of the resonance.

Intensity

Hard Walls

Frequency (Hz)

Intensity

Soft Walls

Frequency (Hz)

Figure 2 – Response of 2 identically shaped rooms covered in hard and soft surfaces as a function of frequency.

Paragraph 4

In order to be effective, a layer of absorbent material has to be of the order of a quarter-wavelength thick, which at low frequencies with their long wavelengths requires very thick absorbers. Absorption occurs through friction of the air motion against individual fibres, with kinetic energy converted to heat, and so the material must be of just the right 'density' in terms of fibre packing. Too loose, and sound will pass through, but too firm and reflection will occur. Technically it is a matter of air resistance matching between air motion and the individual fibres. Glass fibre, as used for thermal insulation, is very effective, but needs to be very thick (perhaps four to six inches) if the result is not to be a room that sounds unnaturally 'dead' at high frequencies but remains 'boomy' at lower frequencies, so that it provides absorption across a broad range of frequencies. Curtains and carpets are only effective at high frequencies (say 5 kHz and above).

Paragraph 5

As a rule of thumb, sound travels at one foot per millisecond (344 m/s), so the wavelength of notes at 1 kHz is about a foot (344mm), and at 10 kHz about an inch (34mm). Even six inches of glass fibre has little effect at 100 Hz, where a quarter wavelength is over 2 feet (860mm), and so adding absorbent material has virtually no effect in the lower bass region in the 20–50 Hz region, though it can bring about great improvement in the upper bass region above 100 Hz.

Paragraph 6
Open apertures, dispersion cylinders (large diameter and usually wall height), carefully sized and placed panels, and irregular room shapes are another way of either absorbing energy or breaking up resonant modes. For absorption, as with large foam wedges seen in anechoic chambers, the loss occurs ultimately through turbulence, as colliding air molecules convert some of their kinetic energy into heat. Damped panels, typically consisting of sheets of hardboard between glass fibre battens, have been used to absorb bass, by allowing movement of the surface panel and energy absorption by friction with the fibre batten.

Figure 2 - Anechoic Chamber

Paragraph 7
If a room is being constructed, it is possible to choose room dimensions for which it's resonances are less audible. This is done by ensuring that multiple room resonances are not at similar frequencies. For example a cubic room would exhibit three resonances at the same frequency.

Paragraph 8
3. Concert halls

Very large rooms like concert halls or large television studios have fundamental resonances which are much lower in frequency than small rooms. This means the closely spaced harmonic resonances are likely to lie in the low frequency region and thus the response tends to be more uniform.

End of Comprehension Article

References
http://en.wikipedia.org/wiki/Room_modes 5/7/2011

Questions

a) When the sound resonates in a hard walled room, do the walls represent rigid or non rigid barriers? Explain.

(2 marks)

Rigid Non Rigid

Explanation

b) Given your answer to Question a, does the resonance of the sound most closely approximate that of resonance in a string, open pipe or closed pipe (pipe closed at one end). Explain.

(2 marks)

String Open Pipe Closed Pipe

Explanation

c) Calculate the fundamental frequencies of a hard walled room that has a height = 2.4 m, width and length = 4.8 m?

(4 marks)

d) Will this room be good to play music in? Explain why or why not?

(2 marks)

e) State 2 ways in which a room can be designed to reduce resonance.

(2 marks)

f) Why is the response of the soft walled room more even than the hard walled room? Refer to Figure 2

(2 marks)

g) Explain why do large rooms have lower resonant frequencies?

(2 marks)

h) To what form of energy is the sound energy in a room converted as the sound dies away. Is this new form of energy easily measureable?

(2 marks)

Question 25

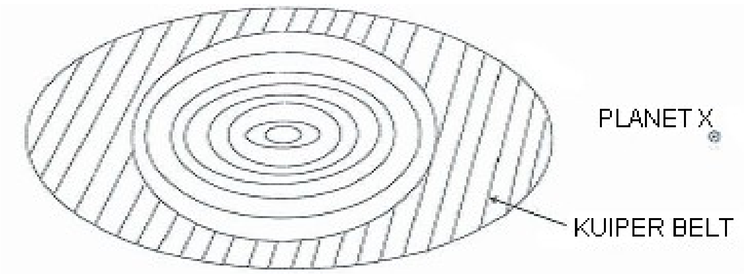
Looking for Planet X

(18 marks)

Paragraph 1
Marc Buie, an eminent astronomer, has been studying the solar system beyond Pluto, among the swarm of small worlds called the Kuiper Belt. He has been looking at the very edge, about 50 times further out from the Sun than the Earth's orbit. Here, at the 'Kuiper Cliff', the number of astronomical objects drops off dramatically. He speaks of the possibility that some 'massive object' has swept the zone clean of debris.

Paragraph 2
Other astronomers agree that there could be another large planet out there. Just how large has become clearer when computer models of the orbits of nearby objects predicted the kind of celestial object that could carve out the Kuiper Cliff and concluded that a planet about the mass of Mars or Earth would provide "a remarkable match" with the observations.

Paragraph 3
The last time the idea of a tenth planet created a stir was in 1983, when planetary scientists began to realise that some comets were coming from a region not far beyond Neptune and Pluto. Since 2001, astronomers have discovered four KBOs (Kuiper Belt Objects) bigger than 1000 kilometres across. Caltech astronomers announced the latest one, fully half the size of Pluto, in October 2001. They have provisionally called it Quaoar, after a native god of the indigenous dwellers of the Los Angeles region. Quaoar is over 1200 kilometres across and orbits the Sun every 288 years.



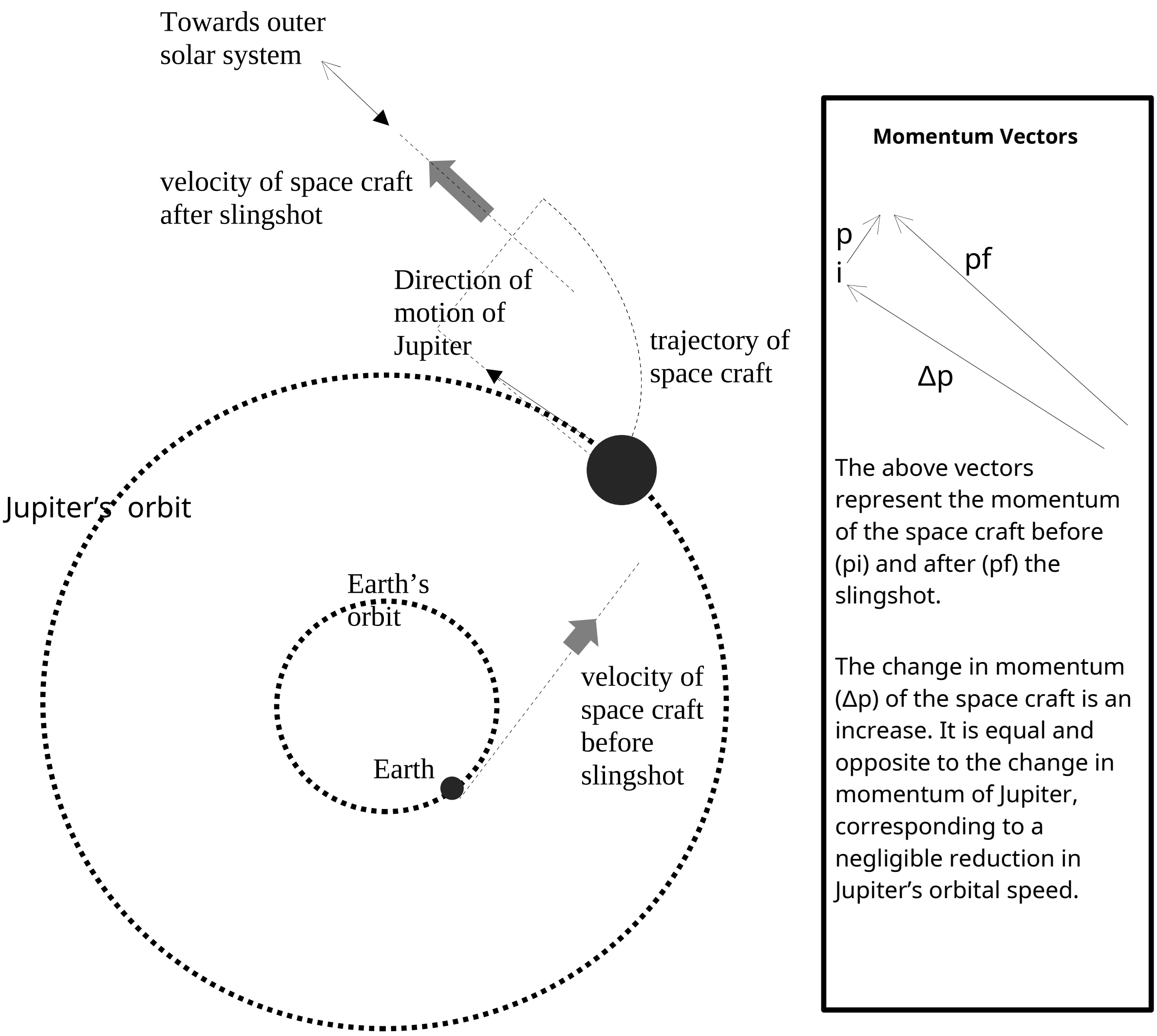
Paragraph 4
As well as containing the key to the origin of life, the Kuiper Belt, and Pluto in particular, may hold the key to how planets form. Studying the craters on both Pluto and its moon Charon, for example, will reveal how KBOs have collided over billions of years and provide clues to the way all the planets formed from smaller objects.

Paragraph 5
Pluto is only 2320 kilometres across, one-fifth the size of Earth. And the 1978 discovery that it is circled by a moon, Charon, whose diameter is 1270 kilometres, makes it even more distinct from the other planets we know about. Pluto and Charon make up a 'twin planet' – the only example in the Solar System.

Paragraph 6
In 2000, NASA scrapped its own Pluto-Kuiper Express mission on the grounds of expense. Under intense public pressure, it held a competition for universities and industry to design a cheaper, better mission. From this was born the New Horizons space probe, due for launch in December 2006. The mission's lead scientist calculates that New Horizons will return 10 times more data than the cancelled Pluto-Kuiper Express, and at little more than half the cost.

Paragraph 7
Just over a year after the New Horizons' launch, it will swing past Jupiter and pick up enough velocity, via the so called "slingshot effect", to reach Pluto, possibly as early as July 2015. Indeed, by the time New Horizons reaches the Kuiper Belt, we may have confirmed that a new planet exists. Because of its vast distances from Earth, the only way we'll find out for sure is to visit this new frontier of the Solar System and get a closer look.

Paragraph 8
The "slingshot effect" is commonly mentioned but rarely explained. In terms of momentum and energy it is similar to the interaction between a table tennis ball and a heavy wooden bat. If the bat and ball are moving towards each other and collide, after the collision, the speed of the ball relative to the ground would be increased. Obviously, trying to bounce a space craft off a moving planet would result in its destruction but if the space craft were to just miss the planet its trajectory could be changed by the mutual attraction between it and the planet, resulting in momentum being transferred from the planet to the space craft, increasing its velocity and changing its direction. This is shown in the diagram below:



Questions

a) How is it possible that some 'massive object' can sweep the zone clean of debris?

(3 marks)

b) Calculate the radius of the orbit of Quaoar about the Sun.

(4 marks)

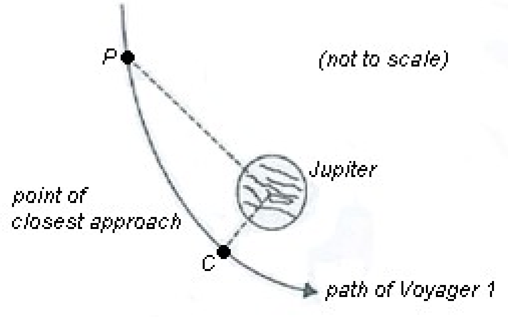
c) If it is assumed that Quaoar is rocky and has the same density as the Earth, compare the mass of Quaoar with that of the Earth (density = mass/volume and $vol_{sphere} = 4/3\ \pi r^3$)

(4 marks)

d) What property of Jupiter makes it ideal to use in the sling-shot effect?

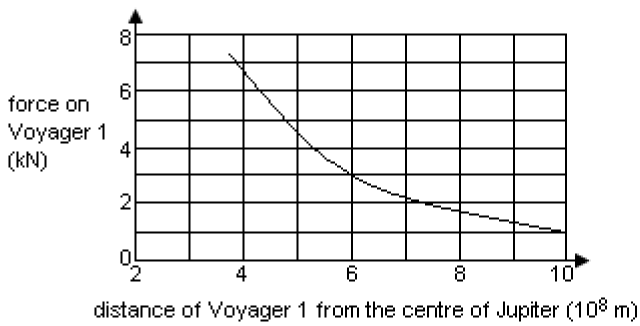
(1 mark)

e) The Voyager 1 spacecraft also used the sling-shot effect in 1979, when it travelled past Jupiter with its engines off, is shown in the following diagram.



As Voyager 1 moved from Point P to point C, the kinetic energy changed by 4.0×10^{11} J. At point C, the point of closest approach, the force attracting the spacecraft to Jupiter was 6.4×10^{3} N.

The graph following shows how the force that attracted Voyager 1 depended on the distance from the centre of Jupiter.



(i) Explain **how** you would use the information above to determine the distance of **point P** from the centre of Jupiter. (A numerical answer is ***not*** required).

(3 marks)

(ii) Briefly explain why the answer to (i) above cannot be obtained using the relationship from your constant sheet W = F s

(1 mark)

f) Do you believe that the New Horizons space probe mission should go ahead? Explain briefly.

(2 marks)

End of Exam

Additional working space

Additional working space

Additional working space

Semester Two Examination, 2011

Question/Answer Booklet

3AB PHYSICS

Answers

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
Formulae and Constants Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

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.

	A	B	C	Total
Score				
Out of	54	90	36	180
%				

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short response	15	15	50	54	30
Section Two: Problem-solving	8	8	90	90	50
Section Three: Comprehension	2	2	40	36	20
					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2011.* Sitting this examination implies that you agree to abide by these rules.

2. Write answers in this Question/Answer Booklet.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Working or reasoning should be clearly shown when calculating or estimating answers.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response 30% (54 Marks)

This section has **15** questions. Answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 50 minutes.

Question 1

(4 marks)

Romeo (the student physicist) is throwing small pebbles at Juliet's window. He is trying to wake her up so she will come out and talk to him. He is throwing the pebbles with an initial velocity of 8.00 m s^{-1} at an angle of 70.0 ^{0} above the horizontal.

a) If the pebbles strike the centre of Juliet's window with purely horizontal motion, what is the height of the centre of the window above the throwing point?

(3 marks)

V	**H**
$v^2 = u^2 + 2as$ $0 = 8 \text{ Sin } 70^{\,2} + 2 \times -9.8 \times s$ $0 = 7.52^{\,2} + 2 \times -9.8 \times s$ $-56.51 / (2 \times -9.8) = s$ **s = 2.89 m above hand height.**	

b) The window will break if the pebble has a kinetic energy of 4.70 J or greater. What minimum mass rock will cause the window to break?

(1 mark)

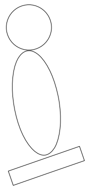
$v_h = 8 \text{ Cos } 70$
$v_h = 2.74$ m/s

$E_k = ½\, m\, v^2$
$4.70 = ½ \times m \times 2.74^2$
$4.70 = ½ \times m \times 7.49$
m = 1.26 kg

Question 2

(2 marks)

A child is sitting on a swing that is not moving.



a) Circle all option(s) that correctly describe the type of equilibrium that the swing is in.

(1 mark)

Static equilibrium   Mechanical Equilibrium

Stable Equilibrium   Unstable Equilibrium   Neutral Equilibrium.

b) Explain the reasons for your answer(s) to part a).

(1 mark)

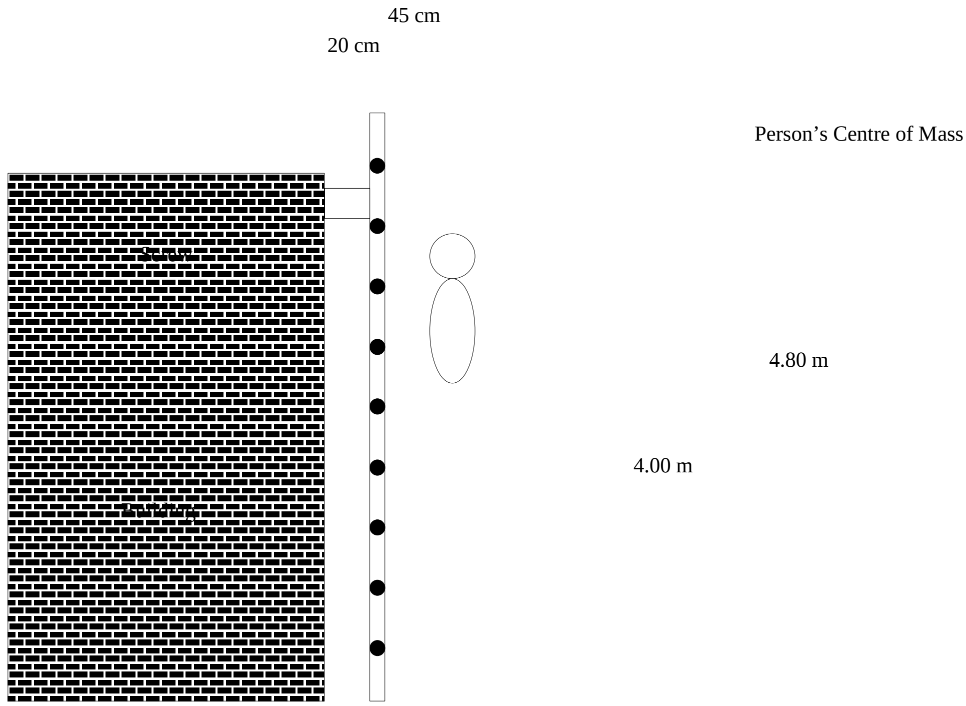
The child on the swing in in static equilibrium because all of the forces add to zero and the child is not moving

The child is in stable equilibrium because the torques / forces on the child cause the child to be moved back (restored) to their original position.

Question 3

(3 marks)

A fire escape ladder is attached to the side of a building by one large screw. The screw is shown in the diagram below. The base of the ladder touches the ground.



If the ladder has a mass of 20.0 kg, the person a mass of 90.0 kg and all of the attachments that join it to the wall are weightless, what is the force exerted by the screw on the ladder?

$\Sigma M_c = \Sigma M_A$

$0.45 \times 90 \times 9.8 = 4.8 \times F$ (2 marks) (one for each side of the equation)

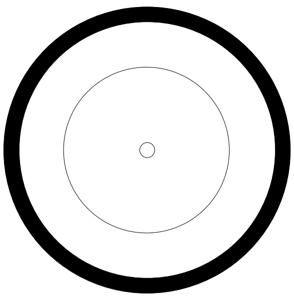
$0.45 \times 90 \times 9.8 / 4.8 = F$

F = 82.7 N towards the wall **(1 mark)**

Question 4

(4 marks)

The roof is leaking. A round bowl is placed below the leak to catch the drips. When a drip drops into the bowl it creates a wave which travels outwards, strikes the side of the bowl and travels back inwards.



a) The bowl has a diameter of 44.0 cm and the ripples travel with a velocity of 0.110 m s^{-1}. At what frequency should the drips from the roof enter the bowl so the ripple returning to the centre coincides with the next drop from the roof entering the water?

(2 marks)

v = s/t

$$0.11 = \frac{2 \times 0.22}{t}$$

$$t = \frac{0.44}{0.11}$$

t = 4 s

b) If this synchronised dripping continues, a standing wave will be set up causing the water in the bowl to slop over the edge. Explain what the home owner can do to prevent this from occurring and why it will work, if they cannot alter the timing of the drip?

(2 marks)

Shift the bowl so that the drip does not fall in the centre of the bowl.

This will cause energy to be put into the system that is not an antinode, causing the resonance pattern to break up.

Question 5

(3 marks)

Give three reasons why astronomers have decided to put telescopes in space instead of using ground based telescopes.

Bypass atmospheric interference.

Bypass electromagnetic interference from humans and there electronic devices.

A greater time to observe the object by reducing the horizon (objects can be viewed for more than 12 hours)

anything sensible.

Question 6

(4 marks)

One day in church, the organist was practising (very loudly) and the flower lady was filling the vases with flowers. The flower lady noticed that a vase near her vibrated particularly strongly when the organist played particular notes.

a) What are the frequencies of the 2 lowest pitch notes what will cause the vase to vibrate particularly strongly if the vase is 34.5 cm long?

(3 marks)

F1	F2
f = nv / 4L f = 1 x 346 / 4 x 0.345 f = 251 Hz	f = nv / 4L f = 3 x 346 / 4 x 0.345 f = 752 Hz

b) Explain what will happen to the vase when each of these two notes are played if the flower lady now fills the vase 2/3rds full of water?

(1 mark)

The vase will not resonate to the first frequency

The vase will resonate to the previous third harmonic. This is the new first harmonic of the shortened by water pipe.

Question 7

(3 marks)

a) A compact fluorescent light bulb is stamped 23.0 W and is 10.6 % efficient. How much power is output as light?

(1 mark)

$P_{out} = P_{in} \times 10.6 / 100$

$P_{out} = 23 \times 0.106$

$P_{out} = 2.44$ W

b) If the best intensity of light for reading by is 0.800 W m^{-2}, how far should the reader stand from the light source?

(2 marks)

$I = P / A$

$0.8 = 2.44 / 4\pi r^2$

$r^2 = 2.44 / (4\pi \times 0.8)$

$r^2 = 0.24267$

$r = 0.493$ m

Question 8

(4 marks)

As the result of a collision between two protons in a hadron collider (atom smasher) a π^+ particle consisting of a u quark and an $\bar{d}$ quark is created. Classify the particle by ticking the correct boxes in the table below.

(2 marks)

Classification	Yes	No
Boson		*
Lepton		*
Hadron	*	
Baryon		*
Meson	*	

Is this particle likely to be stable? Give reason**s** why or why not.

(1 mark)

No. The anti-quark next to the quark (antimatter and matter) make all mesons inherently unstable.

Name two exchange particles that could mediate a force on this particle.

(1 mark)

Photon – the particle is charged.
Graviton – the particle has mass
Gluon – mediates the force between the quarks but does not mediate between the meson and other particles.

Question 9 - Rel

(3 marks)

According to Einstein's special theory of relativity, the dimensions of objects moving at speeds approaching the speed of light become distorted. The formula that governs this distortion is…

$$l' = l \sqrt{(1 - (v^2 / c^2))}$$

Where
v = the velocity of the object, c = the speed of light, l = the length as observed by a person moving with the object and l' = the length as measured by a stationary person.

How fast would the object have to be moving if its distorted length is ½ of its undistorted length?

$l' = l \sqrt{(1 - (v^2 / c^2))}$
$0.5 = 1 \sqrt{(1 - (v^2 / c^2))}$
$0.5 = \sqrt{(1 - (v^2 / c^2))}$
$0.5^2 = (1 - (v^2 / c^2))$
$0.25 = (1 - (v^2 / c^2))$
$(v^2 / c^2)) = (1 - 0.25)$
$(v^2 / c^2)) = 0.75$
$(v / c)) = \sqrt{0.75}$
$(v / c)) = 0.866$
$v = 0.866 \times 3 \times 10^8$

$v = 2.60 \times 10^8$ m/s

Question 10

(5 marks)

A research scientist is trying to make a solar cell out of calcium metal. Calcium has a work function of 2.90 eV.

a) If the scientist needs the electron to leave the surface of the calcium with a velocity equal to 1% the speed of light, what frequency of light should be shone on the surface?

(4 marks)

$hf = \text{Work Function} + \frac{1}{2} mv^2$

$hf = (2.9 \times 1.6 \times 10^{-19}) + (\frac{1}{2} \times 9.11 \times 10^{-31} \times (3 \times 10^{6})^{2})$

$hf = 4.64 \times 10^{-19} + 4.09 \times 10^{-18}$

$hf = 4.5635 \times 10^{-18}$ J

$f = 4.5635 \times 10^{-18} / 6.63 \times 10^{-34}$

$f = 6.88 \times 10^{15}$ Hz

b) Which part of the electromagnetic spectrum does this light belong to?

(1 mark)

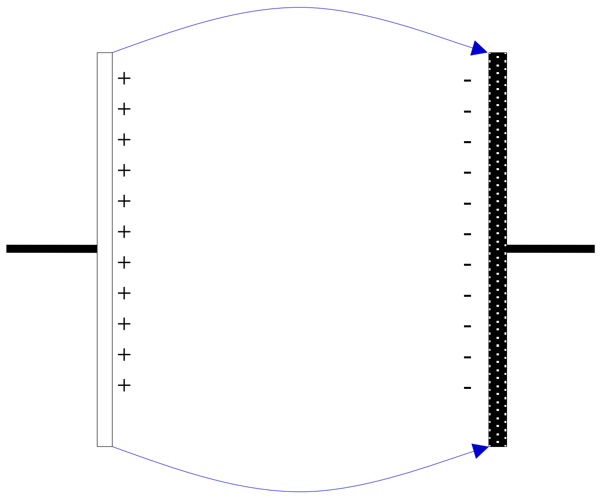
UV

Question 11

(4 marks)

a) Draw the Electric Field on the following diagram.

(1 mark)

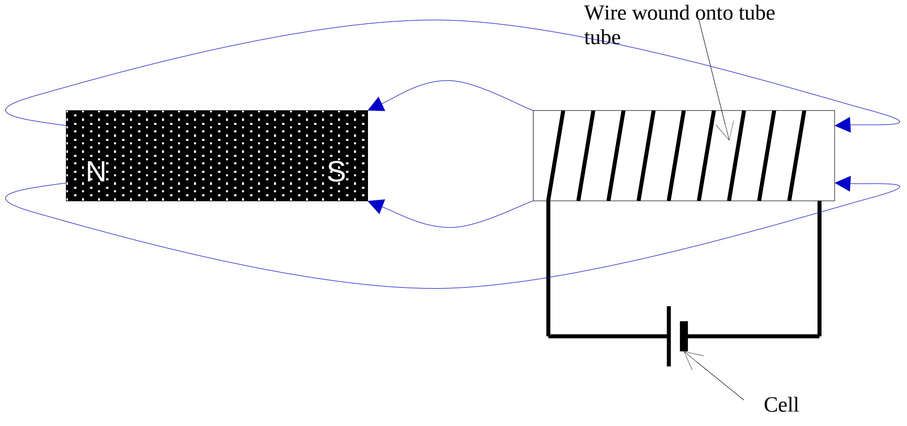


b) Draw onto the diagram the direction of the force on the <u>shaded object</u> as a single thick arrow in pencil.

(1 mark)

c) Draw the resultant magnetic field on the following diagram.

(1 mark)



d) Draw onto the diagram the direction of the force on the <u>shaded object</u> as a single thick arrow in pencil.

(1 mark)

Question 12

(3 marks)

An arrow from a magnetic compass is shot through a hollow horizontal aluminium tube at 100 m/s. Assume air resistance is negligible and that there is no gravity. What will happen to the arrow as it passes through the tube and why?

Side View Diagram

Hollow Aluminium Pipe

S N

100 m s-1

The arrow will be slowed due to Lenz's law.

As the magnetic arrow passes through the tube it induces a current (eddy current) in the tube ahead of the arrow (repulsion) and behind the arrow (attraction).

These eddy currents create magnetic fields that oppose the forwards motion of the arrow, slow its progress through the tube and emerge at a slower speed.

Question 13

(4 marks)

a) Explain why most of the electrical transmission networks of the world have elected to use AC instead of DC electricity?

(3 marks)

The AC allows alteration by transformers in the voltage and current characteristics of the electricity.

By increasing the voltage of the electricity before putting it on long distance power lines (high tension).the amount of power loss due to the resistance of the power lines is reduced.

This improves the efficiency of the electricity transmission process.

b) State one disadvantage of AC electricity?

(1 mark)

The changing magnetic fields around the wires induce electric currents in surrounding objects resulting in power losses.

Pay other sensible answers

Question 14

(4 marks)

Tina goes to Kalgoorlie on holiday and discovers an old mine shaft (hole in the ground), with a sign saying "CAUTION -105.0 m drop". She decides to drop a stone from the edge of the hole. Assume the stone does not the touch the sides on the way down.

a) Calculate the time taken for the rock to reach the bottom of the hole.

(1 mark)

Method 1	Method 2
$v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times -9.8 \times -105$ **v = 45.4 m/s down** $v = u + at$ $-45.4 = 0 + (-9.8) \times t$ $45.4 / 9.8 = t$ **t = 4.63 s**	$s = ut + ½ at^2$ $-105.0 = 0 + ½ \times -9.8 \times t^2$ **t = 4.63 s**

b) Calculate the **relative error** in this time. State any assumptions about the error associated with gravity.

(2 marks)

105.0 m implies 105.0m ± 0.05 m

9.80 m/s^2 from constants sheet implies 9.80 m/s^2 ± 0.005 m/s^2 but do pay anything sensible if they did not use 9.80 from constants sheet.

Assume no error in u

Convert absolute measurement error to % error

Symbol	Number	Abs error	Rel error
s	105.0 m	0.05 m	± 0.0476 % (1 mark)
g	9.80 m/s^2	0.005 $m\ s^{-2}$	± 0.0510 %

Error in v = (0.0510 % + 0.0476 %) x ½ (based on $v^2 = u^2 + 2as$)
Error in v = 0.0493 %
Error in t = (0.0493 % + 0.0510 %) (based on $v = u + at$)
Error in t = (0.1003 %) **(1 mark)**

Or

Error in t = (0.0510 % + 0.0476 %) x ½ (based on $s = ut + ½ at^2$)
Error in t = (0.0493 %) **(1 mark)**

c) If the speed of sound in air is 346 m/s, how much time will elapse between the dropping of the stone and the sound of the collision returning to Tina's ear?

(1 mark)

$v = s/t$
$346 = 105 / t$
$t = 105 / 346$
$t_{sound} = 0.303$ s

$t_{total} = 4.64 + 0.303$ $\mathbf{t_{total} = 4.943}$

Question 15

(4 marks)

A student is performing an experiment to determine the height to which a bowling ball will bounce after hitting the surface of a trampoline when dropped from different heights.

a) State one thing that you would do in the experiment to ensure the experiment is valid.

(1 mark)

Use the same bowling ball.
Use same trampoline.
A windless day.

Pay other controlled variables.

b) State one thing you would do to ensure that the experiment is reliable.

(1 mark)

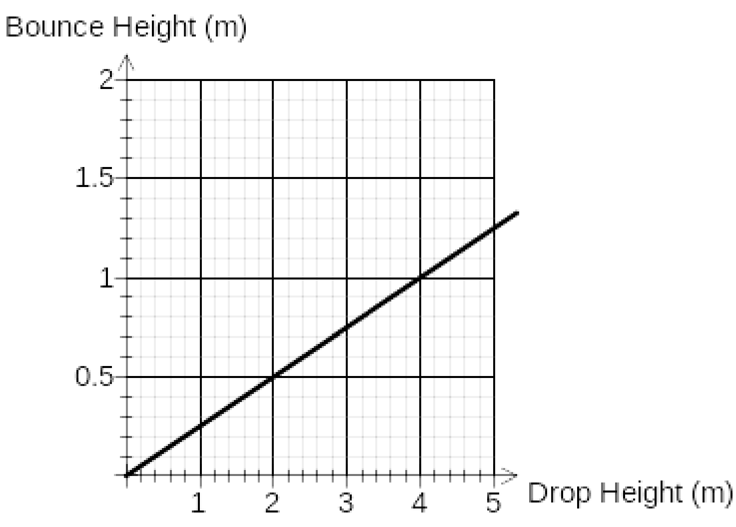
Average the results dropped from the same height to increase the reliability of the averaged data points.

Drop the ball from a large range of multiple heights to get multiple data points resulting in a clear trend.

Get others to do the same experiment under the same conditions to see if the trends / patterns produced are similar.

c) The student hypothesizes that the ball will bounce to 1/3rd of its drop height each time.

Graph of Bounce Height as Function of Drop Height



Based on the graph of the data collected in the experiment, is this hypothesis supported by the data ? Explain

(2 marks)

No. The bounce height is ¼ of the drop height. The hypothesis is not supported by the data.

(See Point 1, 4)

End of Section One

Section Two: Problem-Solving   50% (90 Marks)

This section has **eight (8)** questions. You must answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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Suggested working time for this section is 90 minutes.

Question 16

(11 marks)

In a front loading washing machine clothes are spun at high speed to remove the water from them. The drum of the washing machine that contains the clothes is 53.0 cm in diameter and spins at 1200 RPM.

a) What is the speed of the side of the drum?

(2 marks)

f = 1200 RPM
f = 20 Hz

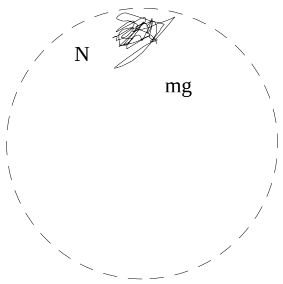
T = 1/ 20
T = 0.05

v = s / t
v = 2 π (0.53 / 2) / 0.05
v = 2 π (0.265/ 2) / 0.05

v = 33.3 m/s

b) If a 100 g jumper is put into the washing machine and it is spun at 1200 RPM. Draw a free body diagram showing the forces on the jumper at the top of the drum (circle).

(2 marks)



c) Calculate the size and direction of the force of the drum on the 100 g jumper when it is at the top of the drum?

(3 marks)

$(-N) + (-mg) = -mv^2 / r$ (1 mark)

$N = mv^2 / r - mg$

$N = (0.1 \times \mathbf{33.3^2 / 0.265) - (0.1 \times 9.8)}$ **(1 mark)**

$N = 418 - 0.98$

N = 417 N Down **(1 mark)**

d) Calculate the centripetal acceleration on the jumper when it is at the bottom of the drum.

(2 marks)

$a_c = v^2 / r$
$a_c = \mathbf{33.3^2} / 26.5 \times 10^{-2}$

$\mathbf{a_c = 4.18 \times 10^3\ m/s^2}$

e) The now slightly damp jumper is put in a dryer containing an identical rotating drum of 53.0 cm diameter. For clothes to dry effectively in a clothes dryer they must be tumbled. This means they must <u>not</u> be spun so fast that they stick to the side of the drum at the top. At what speed must the jumper be spun such that it <u>just</u> falls away from the top of the drum as it turns?

(2 marks)

$(-N) + (-mg) = -mv^2 / r$

Let $N = 0$

$(-mg) = -mv^2 / r$ (1 mark)
$(-g) = -v^2 / r$

v = square root of (rg)
$v = (0.265 \times 9.8)^{½}$
v = 1.61 m/s **(1 mark)**

Question 17

(12 marks)

The galaxy Triangulum (M33) is one of the furthest objects that can be seen with the naked eye from earth. It is the third largest galaxy in our local group. It is 2.64 Mly (mega light years) from earth.

a) What is the distance of Triangulum (M33) from earth in …

i) metres?

(1 mark)

1 ly = $3 \times 10^{8} \times 365.25 \times 24 \times 3600 = 9.467 \times 10^{15}$ m

$2.64 \times 10^{6} \times 9.467 \times 10^{15}$ m

s = 2.50×10^{22} m

ii) astronomical units?

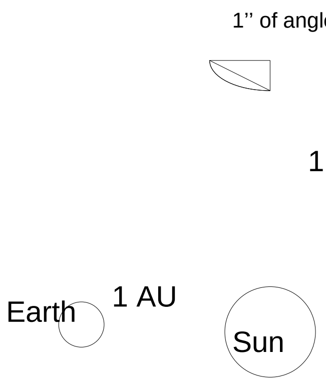
(1 mark)

1 AU = 1.50×10^{11}

s (AU) = $2.50 \times 10^{22} / 1.5 \times 10^{11}$
s (AU) = 1.66×10^{11} AU

b) Derive 1 pc (parsec) from 1 AU (astronomical unit) with the assistance of a diagram. Show all working.

(3 marks)



1 marks for diagram

Tan (1'') = 1 AU / 1pc
Tan (1'') = 1.5×10^{11} / 1 pc (1 mark)

1 pc = 3.09×10^{16} m (1 mark)

According to the Hubble Law the distance of an object from our solar system is proportional to the velocity at which an object moves away from earth.

$$v_{object} = H_0 \, d$$

Where v is the velocity of the object in km/s, H_o is the Hubble constant (= 71km s^{-1} / Mpc) and d is the distance of the object from our solar system in Mpc (megaparces).

c) From the numbers provided determine the recessional velocity of Triangulum (M33).

(3 marks)

$v_{object} = H_0\ d$

$v_{object} = 71_0\ d$

d(Mpc) = **2.50 x 10^{22} / (**3.09 x 10^{16} x 1 x 10^{6})

d(Mpc) = 8.09 x 10^{-1} Mpc

v_{object} = 71_0 x 8.09 x 10^{-1}

v_{object} = 5.74 x 10^{1} km / s

d) Will the light from Triangulum (M33) appear to be red shifted of blue shifted?

(1 mark)

Blue Shifted Red Shifted please circle one only

e) If Triangulum (M33) is releasing a light of frequency 5.50 x 10^{14} Hz, what will be the frequency of the light after red shift / blue shift according to the S.I. formula below?

$$f_L = \left(\sqrt{\frac{c-v}{c+v}}\right) f_S$$

Where f_L is the frequency of the observer and f_S is the frequency of the source.

(1 mark)

Please state your answer accurate to 5 sig. fig.

$$f_L = \left(\sqrt{\frac{c-v}{c+v}}\right) f_S$$

$f_L = ((3 \times 10^8 - 57400) / (3 \times 10^8 + 57400))^{1/2} \times 5.5 \times 10^{14}$

f_L =5.4989 x 10^{14} Hz

f) Does the Hubble Law support or refute the Big Bang Theory? Explain how.

(2 marks)

Support

The Hubble law explains that the universe is expanding due the increasing red shifts observed in increasingly distant galaxies.

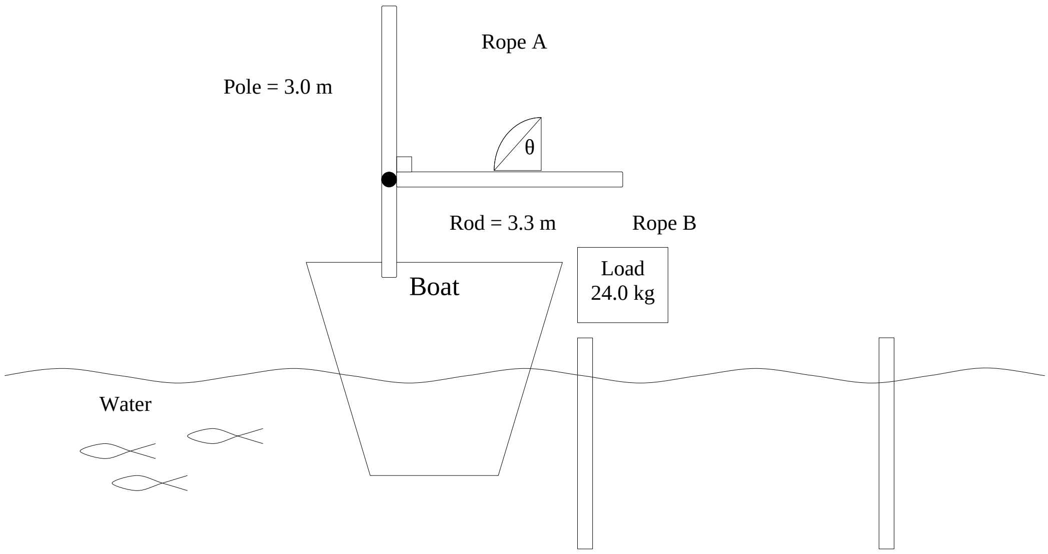
The universe is expanding (Hubble law) (1 mark)

The big bang explains the reason for the expansion. (1 mark)

Question 18

(12 marks)

A ship's crane on an old sailing ship is lifting cargo off the pier (jetty) and loading it onto its deck. The pieces of the crane (rope, pole and rod) are **weightless.**



a) What is the tension in rope B?

(1 mark)

T = mg
T = 24 x 9.8
T = 235.2 N

b) Calculate the angle θ.

(2 marks)

Tan θ = 3 / 3.3
θ = 42.3 ^{0}

c) What is the tension in rope A?

(3 marks)

$\Sigma M_c = \Sigma M_A$

3.3 x 234.2 = 3.3 x T Cos 47.7^{0}
234.2 = T Cos 47.7^{0}
T = 234.2 / Cos 47.7^{0}
T = 348 N

d) What is the force on the rod where it joins to the pole?

(2 marks)

$\Sigma F_{up} = \Sigma F_{down}$

P_{up} + 348 Cos 47.7^{0} = 24 x 9.8
P_{up} + 234.2 = 235.2
P_{up} = 235.2 – 234.2 = 1 N **This is only due to rounding error it should be zero**

$\Sigma F_{left} = \Sigma F_{right}$

P_{right} = 348 Sin 47.7^{0}
P_{right} = 258 N right Resultant = 258 N right

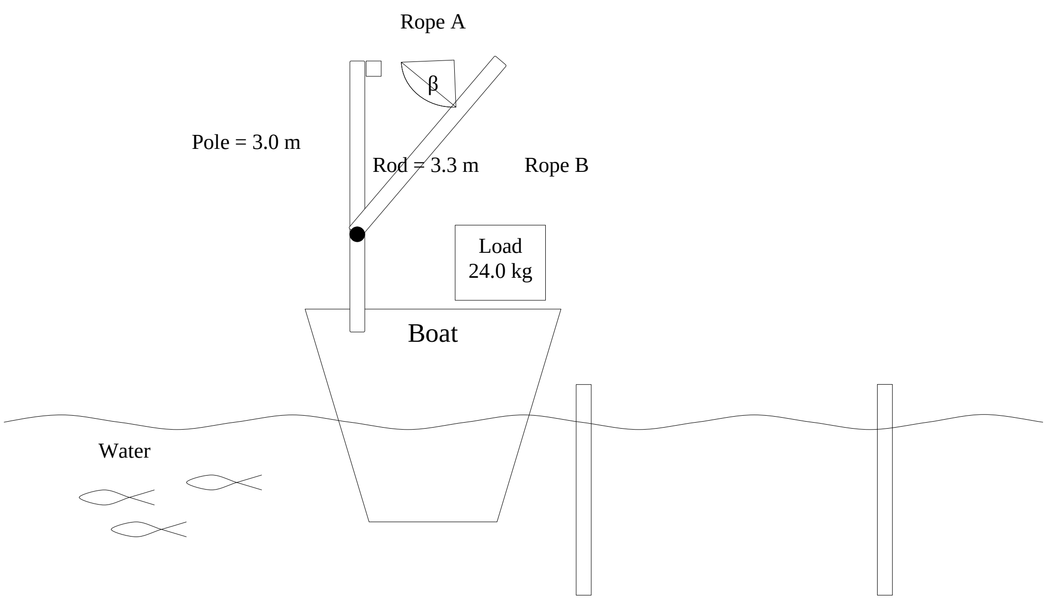
e) State whether the forces are pure Tension, pure Compression or Bending forces in each of the following pieces of the crane.

(1 mark)

Part	Tension / Compression / Bending
Rope A	Tension
Rod	Compression
Pole	Bending

f) Rope A is now pulled to lift the load on board the boat. Rope A is now horizontal. What is the new tension in rope A?

(3 marks)



Find angle

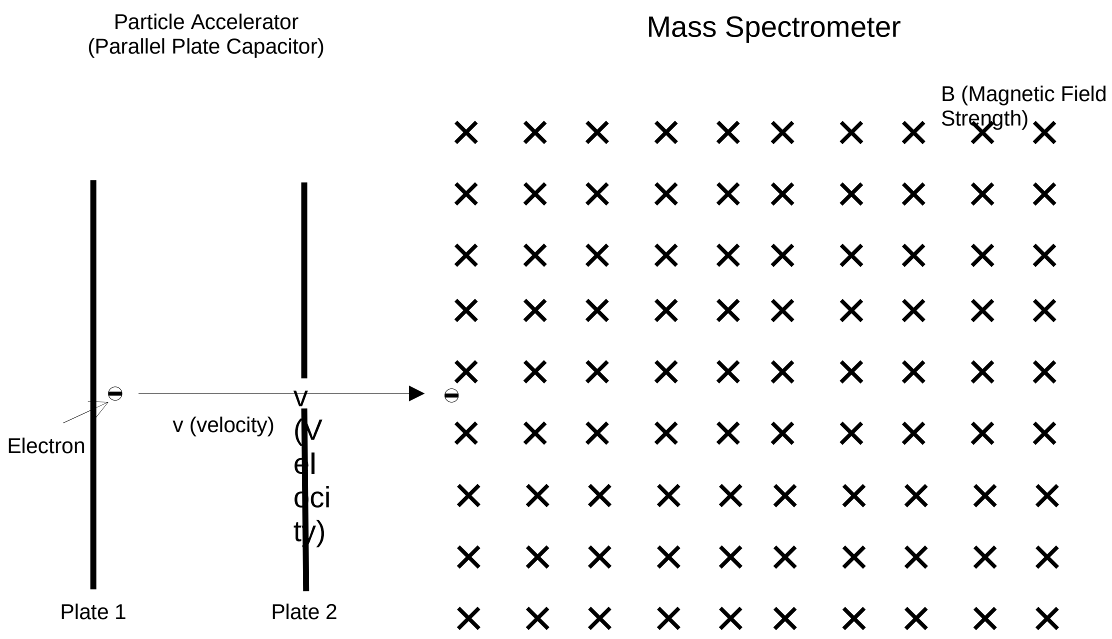
Sin β = 3 / 3.3
θ = 65.4 ^{0}

Method 1 – all dist, part force	Method 2 – All force, part dist.
$\Sigma M_c = \Sigma M_A$ 3.3 x 235.2 Cos 65.4^0 = 3.3 x T Cos 24.6^0 T = 3.3 x 235.2 Cos 65.4^0 / (3.3 Cos 24.6^0) T = 235.2 Cos 65.4^0 / (Cos 24.6^0) **T = 107.2 N**	$\Sigma M_c = \Sigma M_A$ 3.0 x T_A = 235.2 x 3.3 Cos 65.4^0 T_A = 235.2 x 3.3 Cos 65.4^0 / 3.0 **T_A = 107.2 N**

Question 19

(9 marks)

A physicist has left his watch at home and decides to use his mass spectrometer at work as a clock. He wishes to set up the mass spectrometer so that an electron is fired into the magnetic field at 1/100th the speed of light causing it to complete 1000 000 revolutions each second.



a) Decide the charge on plate 1 and plate 2 by circling the correct words in the sentences below.

(1 mark)

Plate 1 should be charged positively / negatively. (Choose one only)

Plate 2 should be charged positively / negatively. (Choose one only)

b) What should be the voltage difference between plates 1 and 2 in order to accelerate the electron to 1/100th of the speed of light?

(2 marks)

$qV = \frac{1}{2} mv^2$

$1.6 \times 10^{-19} \times V = 0.5 \times 9.11 \times 10^{-31} \times (3 \times 10^6)^2$

$V = 25.6$ V

c) On entering the magnetic field shown in the diagram, in which way will electron turn?

(1 mark)

Left right out of page into page top of page bottom of page

(Choose one only)

d) What is the circumference of the circle required if the electron is to revolve 1000 000 times in 1 second?

(1 mark)

$v = s / t$

$v = 2\pi r / t$

$3 \times 10^{6} = s / 1 \times 10^{-6}$

$s = 3.00$ m

e) What is the strength of the magnetic field required?

(3 marks)

Circ = $2\pi r$
$3.00 = 2\pi r$
$r = 0.4774$ m

$r = mv / qB$
$0.4774 = 9.11 \times 10^{-31} \times 3 \times 10^{6} / (1.6 \times 10^{-19} \times B)$
3.58×10^{-5} T

f) Will the electron execute complete circles in the diagram above? Explain why or why not with the assistance of the diagram on page 21.

(1 mark)

No

It will at best execute a half circle.

Question 20

(10 marks)

Anna receives a new watch from her brother before going on camp. The watch face has numbers on it that glow a yellowy green for a while after you shine a torch or light on them.

a) Are the numbers fluorescent or phosphorescent? Explain the reason why.

(2 marks)

Phosphorescent. The paint contains metastable states which absorb, store and then release at a later time.

b) What is the approximate range of wavelengths emitted by the numbers on the clock face?

(1 mark)

500 x 10^9 nm → 600 x 10^9 nm

c) Compare and contrast the light produced by the torch with the light produced by the numbers on the clock face.

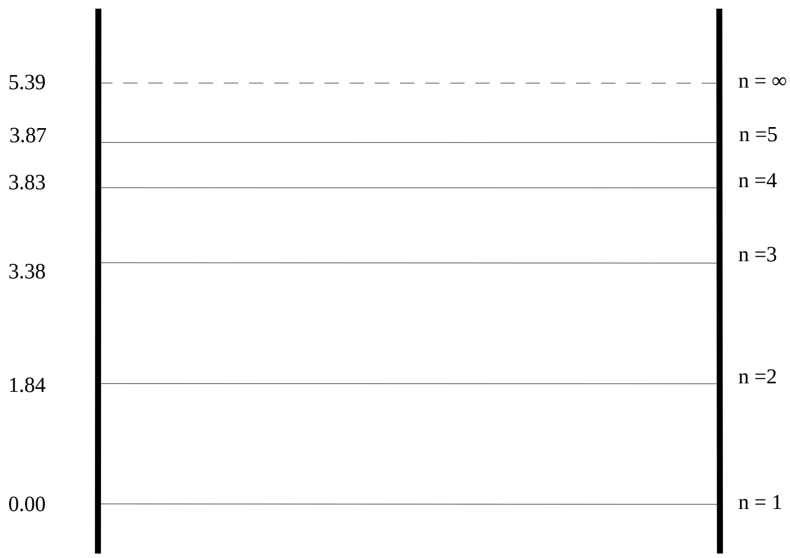
(2 marks)

The light from the torch is white and contains a mixture of photon energies. It is a continuous spectrum.

The light from the face is a line emission spectrum at best are a sub set of the line emission spectrum.

Anna goes to school after camp. The school has some lithium gas is a gas discharge tube which produces a line emission spectrum.

Energy Level Diagram
Lithium Atom (in eV)



d) If an electron is in the n = 4, how many possible lines can be produced when this electron transitions downwards?

(1 mark)

6 possible

e) Is the n = 4 to n = 2 transition going to produce a photon in the Ultra-Violet, Visible or Infra-Red range? Support your answer with calculations.

(2 marks)

Initial bet is visible because it belongs to the Balmer

Energy transition = 3.83 – 1.84
Energy transition = 1.99 eV

Energy transition = $1.99 \times 1.6 \times 10^{-19}$
Energy transition = 3.184×10^{-19}

E = hf
$3.184 \times 10^{-19} = 6.63 \times 10^{-34} \times f$
$f = 4.8 \times 10^{14}$ Hz → This is in the IR region. (Initial bet is wrong)

f) Would the visible glow from Anna's watch be theoretically able to cause any energy level transitions in the lithium gas? Explain why or why not with the support of calculations.

(2 marks)

Yellow	Green
Wavelength = 600×10^{-9} m $c = f \times \lambda$ $3 \times 10^{8} = f \times 600 \times 10^{-9}$ $f = 5 \times 10^{14}$ Hz E = hf $E = 6.63 \times 10^{-34} \times 5 \times 10^{14}$ $E = 3.315 \times 10^{-19}$ J E(eV) = 2.07 eV	Wavelength = 500×10^{-9} m $c = f \times \lambda$ $3 \times 10^{8} = f \times 500 \times 10^{-9}$ $f = 6 \times 10^{14}$ Hz E = hf $E = 6.63 \times 10^{-34} \times 6 \times 10^{14}$ $E = 3.978 \times 10^{-19}$ E(eV) = 2.48 eV

No.

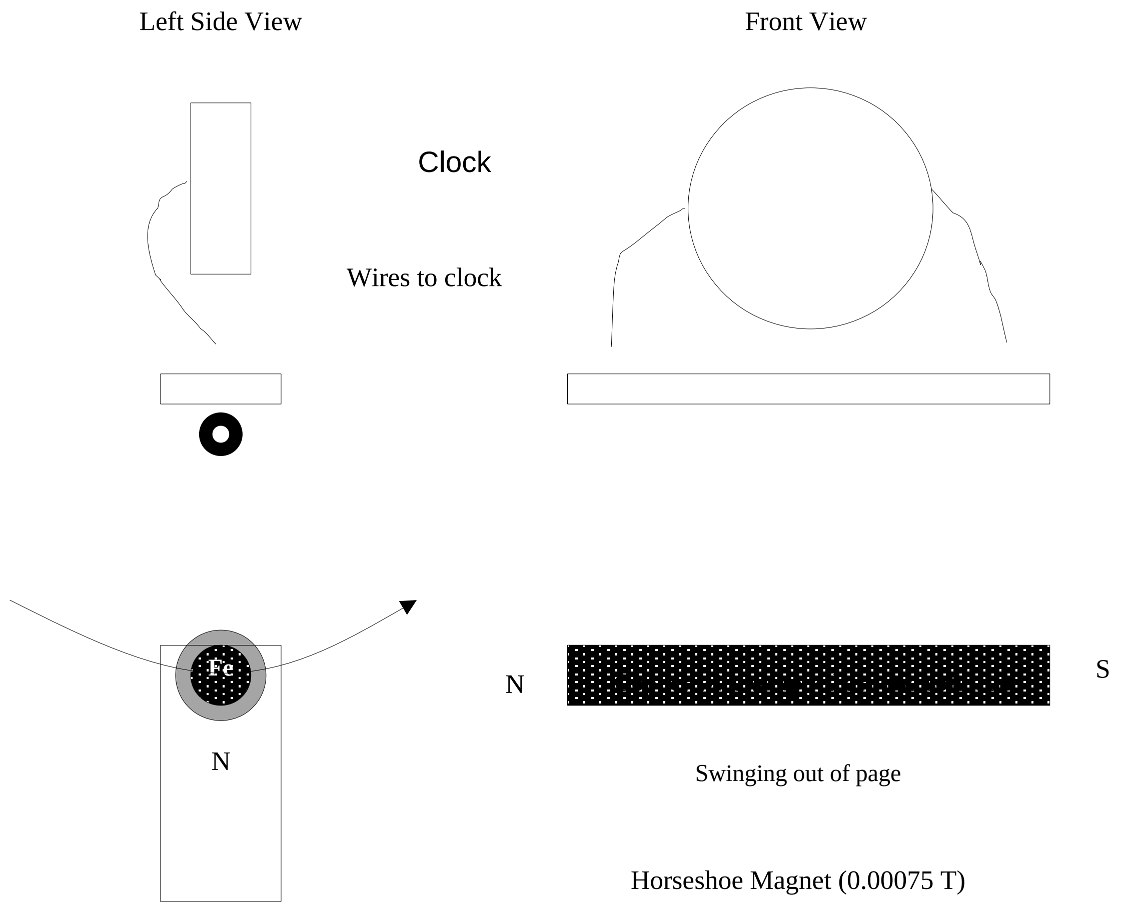
There are no energy levels in the 2.07 to 2.48 eV regions.

Photon energies cannot be split. This rules out the n = 2 state as an option.

Question 21

(11 marks)

A copper wire swing containing a soft iron rod of cross sectional area 3 x 10^{-4} m^2 is swung between the poles of a horse shoe magnet. The electricity generated is sent to an electrical clock in an attempt to drive it.



a) As the swing approaches the horseshoe magnet in the direction shown on the diagram, in what direction is the electrical current induced? Draw this onto the grey wires in the front view diagram.

(1 mark)

b) As the swing leaves the horseshoe magnet will the direction of the current induced in the wire reverse or stay the same?

(1 mark)

Current direction Reverses Current direction Stays the Same

(Circle one only)

c) If on approaching the horseshoe magnet the magnetic field passing through the soft iron increases from zero to its maximum value in 0.004 s, what is the magnitude of the average voltage induced as the swing approaches over this time? Collect any additional information required for this calculation from the diagram.

(3 marks)

Emf = -n A (B – B) / t

Emf = -14 x 3 x 10^{-4} (0.00075 – 0) / 0.004

Emf = 7.875 x 10^{-4} V

d) State 3 ways in which the voltage supplied by the swing could be increased.

(3 marks)

Increase B

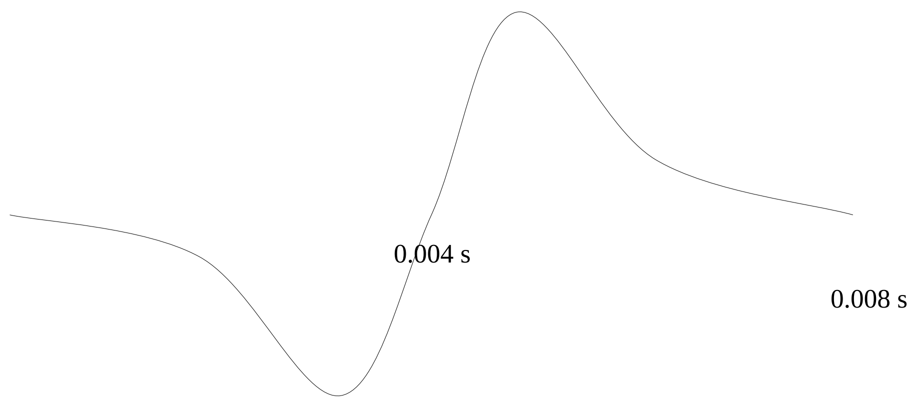
Increase N

Increase A

Decrease T

e) For one swing from left to right sketch on the graph paper below the current output for the swing as it approaches the magnet, is briefly in-line with the magnet and as it leaves the magnet.

(2 marks)



f) If there is no friction in the swing pivot, will the swing "swing" forever? Explain why or why not.

(1 mark)

No.

Lenz's Law.

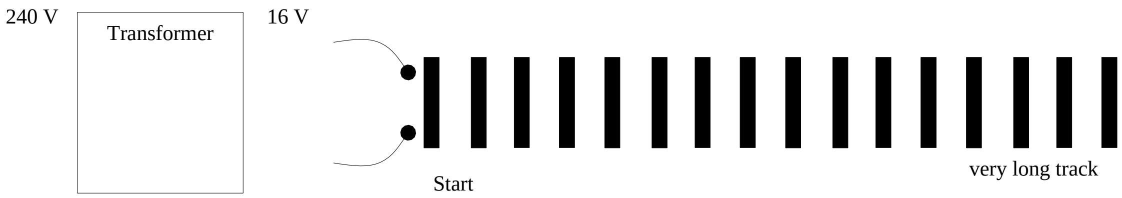
The kinetic energy will be converted to electrical energy and then heat.

The electricity generates a magnetic field that opposes the change in field an so opposes the motion of the pendulum

Question 22

(12 marks)

A physics student buys an electrical train set. The train collects electrical current from the train rails to run its motor. The electricity put on the rails is drawn from a transformer that connects to the mains supply in Australia. The train is put at the start of the track. The student sets up the train track to create a long straight line as shown in the diagram below.



a) The train draws a current of 0.600 A and the track voltage is set at 16.0 V. What is the resistance of the motor in the train?

(2 marks)

V = IR
16 = 0.6 x R
R = 26.666 Ω

b) What is the power supplied to the track / train by the transformer?

(2 marks)

P = VI
P = 16 x 0.6
P = 9.6 W

c) The transformer is 82.0 % efficient. What is the power supplied to the transformer from the mains?

(2 marks)

$P_{out} = P_{in}$ % eff / 100
9.6 = P_{in} 82 / 100
9.6 = P_{in} 0.82
P_{in} = 11.7 W

d) What is the current supplied to the transformer from the mains?

(2 marks)

$P = VI$
$11.7 = 240 \times I$
$I = 0.04875$ A

As the train travels along the tracks further from the transformer, the voltage available to the train is reduced due to the electrical resistance of the tracks. The train will continue to move until the voltage drops to just below 12.0 V at which point it will grind to a halt.

e) What is the power consumed by the train just before it grinds to a halt?

(2 marks)

$P = V^2 / R$
$P = 12^2 \times 26.7$
$P = 5.413$ W

f) One rail of the track has a resistance of 0.2 Ω m^{-1}. How far will the train get from the start along the straight track?

(2 marks)

$P\ loss = P_T - P_{train}$
$P\ loss = 9.6 – 5.431$
$P\ loss = 4.187$ W

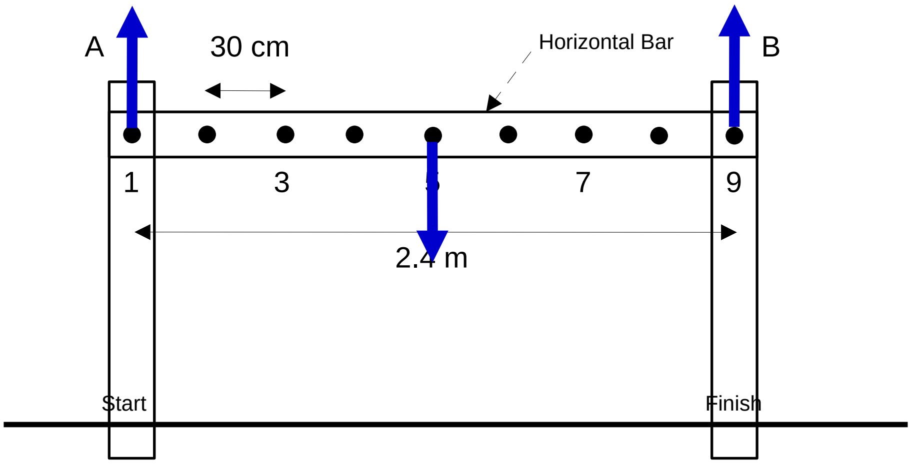
$P\ loss = V_{loss}^2 / R_{tracks}$
$4.187 = 4^2 / R_{tracks}$
$R_{tracks} = 3.82135\ \Omega$

$3.82135\ \Omega = X \times (2 \times 0.2)$
$X = 95.53$ m

Question 23

(13 marks)

A set of monkey bars are standing in a playground.



The horizontal ladder is 2.40 m long and has a mass of 20.0 kg. The rungs are spaced 30.0 cm apart.

a) If nobody is hanging from the horizontal ladder, show all of the forces acting on the ladder on the diagram above.

(1 mark)

b) What is the force of pole B on the horizontal ladder when nobody is swinging on the rungs?

(2 marks)

$M_c = M_A$
$20 \times 9.8 \times 1.2 = N_B \times 2.4$
$N_B = 98$ N

c) A 35.0 kg child now hangs from the hand rung 1 at the start of the monkey bars. What is the force of Pole B on the horizontal ladder now?

(2 marks)

Same as before.

Taking the moments about A negates the weight of the child because it is acting at the pivot.

d) What is the force of Pole A on the horizontal ladder if the child is now hanging from rung number 4?

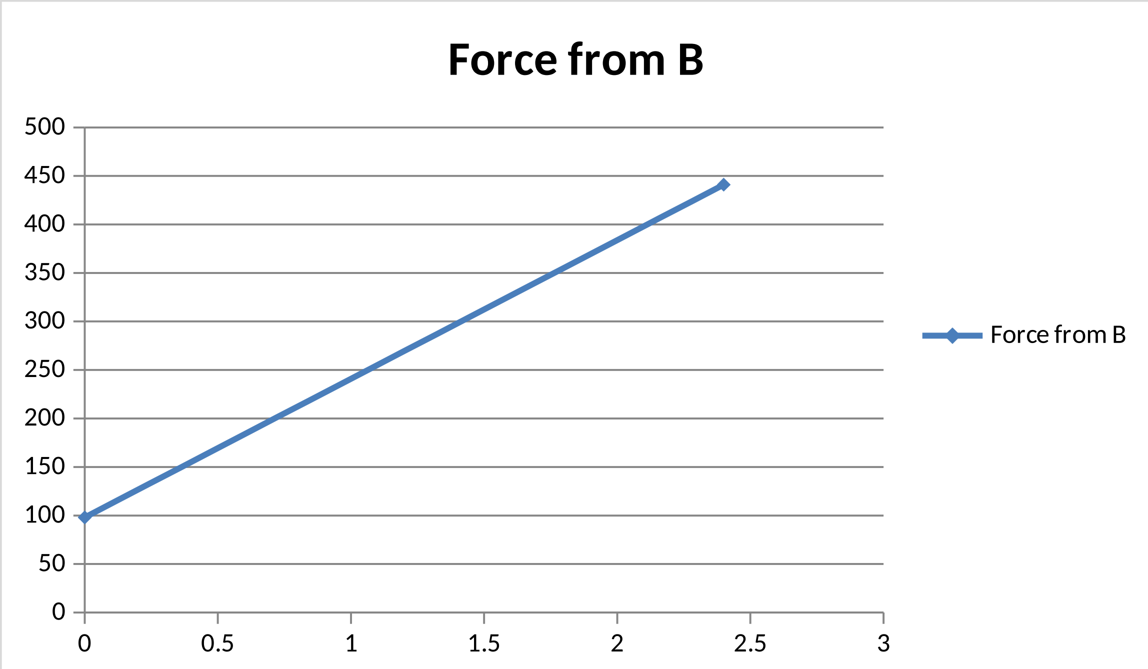
(2 marks)

Take moments about B

$M_c = M_A$
$(N_A \times 2.4) + = (1.5 \times 35 \times 9.8) + (20 \times 9.8 \times 1.2)$
$N_A = ((514.5) + (235.2)) / 2.4$
$\mathbf{N_A = 312\ N}$

e) The child now moves from rung number 1 to rung number 9 by swinging one rung at a time. If we ignore the swinging forces of the child on the monkey bars draw a graph of the force exerted by Pole B on the horizontal ladder as a function of the distance the child is from rung number 1.

(4 marks)



f) Write out the mathematical function (formula) for the graph you have created.

(3 marks)

$N_B \times 2.4 = (20 \times 9.8 \times 1.2) + (35 \times 9.8 \times r)$

$N_B = (20 \times 9.8 \times 1.2)/2.4 + (35 \times 9.8 \times r)/2.4$

$\mathbf{N_B = (143 \times r) + 98}$

End of Section Two

Section Three: Comprehension 20% (36 Marks)

Question 24

Resonance in Rooms

(18 marks)

Paragraph 1
Room modes are the collection of resonances that exist in a room when the room is excited by an acoustic source such as a loudspeaker. Most rooms have their fundamental resonances in the 20 Hz to 200 Hz region, each frequency being related to one or more of the room's dimensions or a division there of.

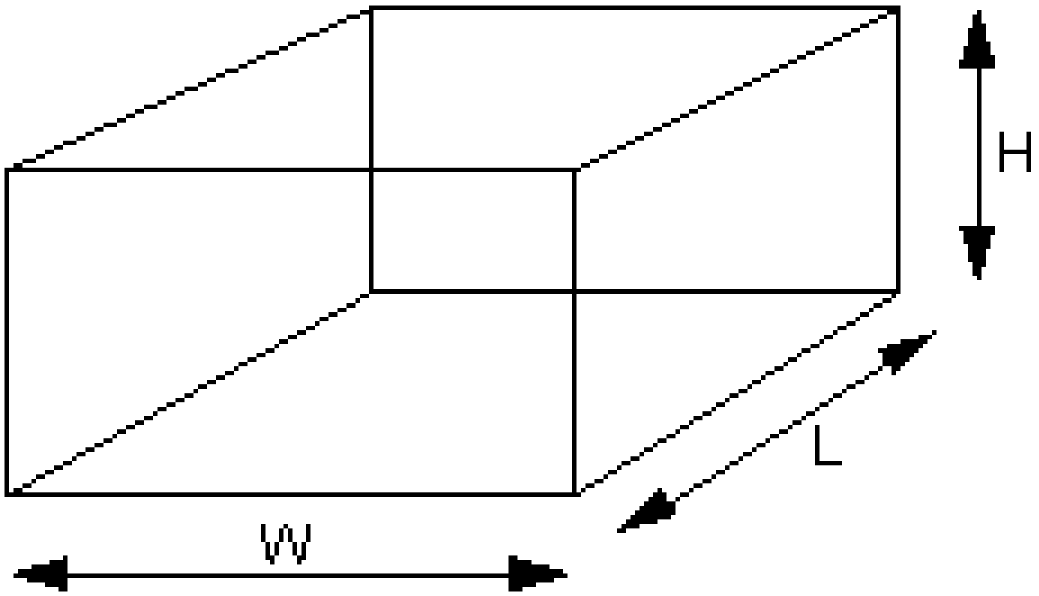


Figure 1 – Dimensions of a Room

These resonances affect the low-frequency to low-mid-frequency response of a sound system in the room and are one of the biggest obstacles to accurate sound reproduction.

Paragraph 2
4. The mechanism of the room's resonances

The input of acoustic energy to the room at the modal frequencies and multiples thereof causes standing waves. The nodes and antinodes of these standing waves result in the loudness of the particular resonant frequency being different at different locations of the room. These standing waves can be considered a temporary storage of acoustic energy as they take a finite time to build up and a finite time to dissipate once the sound energy source has been removed.

Paragraph 3

5. Minimizing the effect of room resonances

A room with generally hard surfaces will reverberate for a long time after the resonant frequency is switched off. Absorbent material can be added to the room to damp such resonances which work by more quickly dissipating the stored acoustic energy. In addition absorbent material will broaden the resonant frequencies to which the room will resonate and reduces the intensity of the resonance.

Intensity

Hard Walls

Frequency (Hz)

Intensity

Soft Walls

Frequency (Hz)

Figure 2 – Response of 2 identically shaped rooms covered in hard and soft surfaces as a function of frequency.

Paragraph 4

In order to be effective, a layer of absorbent material has to be of the order of a quarter-wavelength thick, which at low frequencies with their long wavelengths requires very thick absorbers. Absorption occurs through friction of the air motion against individual fibres, with kinetic energy converted to heat, and so the material must be of just the right 'density' in terms of fibre packing. Too loose, and sound will pass through, but too firm and reflection will occur. Technically it is a matter of air resistance matching between air motion and the individual fibres. Glass fibre, as used for thermal insulation, is very effective, but needs to be very thick (perhaps four to six inches) if the result is not to be a room that sounds unnaturally 'dead' at high frequencies but remains 'boomy' at lower frequencies, so that it provides absorption across a broad range of frequencies. Curtains and carpets are only effective at high frequencies (say 5 kHz and above).

Paragraph 5

As a rule of thumb, sound travels at one foot per millisecond (344 m/s), so the wavelength of notes at 1 kHz is about a foot (344mm), and at 10 kHz about an inch (34mm). Even six inches of glass fibre has little effect at 100 Hz, where a quarter wavelength is over 2 feet (860mm), and so adding absorbent material has virtually no effect in the lower bass region in the 20–50 Hz region, though it can bring about great improvement in the upper bass region above 100 Hz.

Paragraph 6
Open apertures, dispersion cylinders (large diameter and usually wall height), carefully sized and placed panels, and irregular room shapes are another way of either absorbing energy or breaking up resonant modes. For absorption, as with large foam wedges seen in anechoic chambers, the loss occurs ultimately through turbulence, as colliding air molecules convert some of their kinetic energy into heat. Damped panels, typically consisting of sheets of hardboard between glass fibre battens, have been used to absorb bass, by allowing movement of the surface panel and energy absorption by friction with the fibre batten.

Figure 2 - Anechoic Chamber

Paragraph 7
If a room is being constructed, it is possible to choose room dimensions for which it's resonances are less audible. This is done by ensuring that multiple room resonances are not at similar frequencies. For example a cubic room would exhibit three resonances at the same frequency.

Paragraph 8
6. Concert halls

Very large rooms like concert halls or large television studios have fundamental resonances which are much lower in frequency than small rooms. This means the closely spaced harmonic resonances are likely to lie in the low frequency region and thus the response tends to be more uniform.

End of Comprehension Article

References
http://en.wikipedia.org/wiki/Room_modes 5/7/2011

Questions

a) When the sound resonates in a hard walled room, do the walls represent rigid or non rigid barriers? Explain.

(2 marks)

Rigid Non Rigid

Explanation
The air particles on the surface of the walls are restricted in their longitudinal movement at right angles to the wall. (1 mark for circle) (1 mark for explanation)

b) Given your answer to Question a, does the resonance of the sound most closely approximate that of resonance in a string, open pipe or closed pipe (pipe closed at one end). Explain.

(2 marks)

String Open Pipe Closed Pipe

Explanation

The walls represent displacement notes (same as a string).
(1 mark for circle) (1 mark for explanation)

c) Calculate the fundamental frequencies of a hard walled room that has a height = 2.4 m, width and length = 4.8 m?

(4 marks)

H = 2.4 m	L or W = 4.8 m
f = nv/2L f = 1 x 346 / (2 x 2.4) **f = 72.1 Hz**	f = nv/2L f = 1 x 346 / (2 x 4.8) **f = 36.0 Hz**

d) Will this room be good to play music in? Explain why or why not?

(2 marks)

No. (1 mark)
The frequency response of the room will not be even. The room will resonate to some frequencies and not to others. This will alter the balance (relative strength or intensity) of the frequencies in the room. (1 mark)

e) State 2 ways in which a room can be designed to reduce resonance.

(2 marks)

(paragraph 3)
Soft walls (padding).

(paragraph 6)
Irregular room shapes.
Open apertures.
Dispersion cylinders.
Angled panels ("carefully sized and placed panels")

Pay others if sensible.

f) Why is the response of the soft walled room more even than the hard walled room? Refer to Figure 2

(2 marks)

1. Soft walls absorb some of the sound energy reducing the amplitude of the sound.

2. Soft walls distort / alter the dimensions of the room, broadening out the frequencies ot which the room will resonate, evening out the response of the room

g) Explain why do large rooms have lower resonant frequencies?

(2 marks)

The longer the dimension, the lower fundamental and overtone the resonant frequencies according to the formula.

f = n v / 2 L As L increases, f decreases

h) To what form of energy is the sound energy in a room converted as the sound dies away. Is this new form of energy easily measureable?

(2 marks)

Heat as random vibration in the particles (1 mark)

Eventually this becomes EMR (1 mark)

Question 25

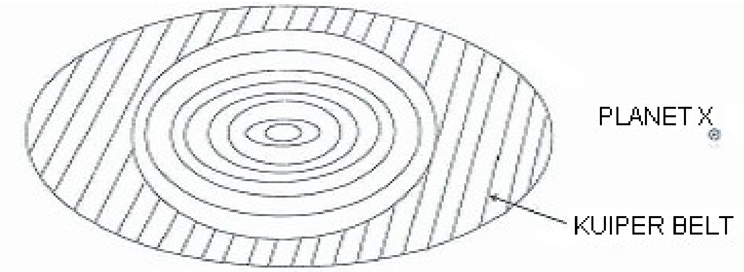
Looking for Planet X

(18 marks)

Paragraph 1
Marc Buie, an eminent astronomer, has been studying the solar system beyond Pluto, among the swarm of small worlds called the Kuiper Belt. He has been looking at the very edge, about 50 times further out from the Sun than the Earth's orbit. Here, at the 'Kuiper Cliff', the number of astronomical objects drops off dramatically. He speaks of the possibility that some 'massive object' has swept the zone clean of debris.

Paragraph 2
Other astronomers agree that there could be another large planet out there. Just how large has become clearer when computer models of the orbits of nearby objects predicted the kind of celestial object that could carve out the Kuiper Cliff and concluded that a planet about the mass of Mars or Earth would provide "a remarkable match" with the observations.

Paragraph 3
The last time the idea of a tenth planet created a stir was in 1983, when planetary scientists began to realise that some comets were coming from a region not far beyond Neptune and Pluto. Since 2001, astronomers have discovered four KBOs (Kuiper Belt Objects) bigger than 1000 kilometres across. Caltech astronomers announced the latest one, fully half the size of Pluto, in October 2001. They have provisionally called it Quaoar, after a native god of the indigenous dwellers of the Los Angeles region. Quaoar is over 1200 kilometres across and orbits the Sun every 288 years.



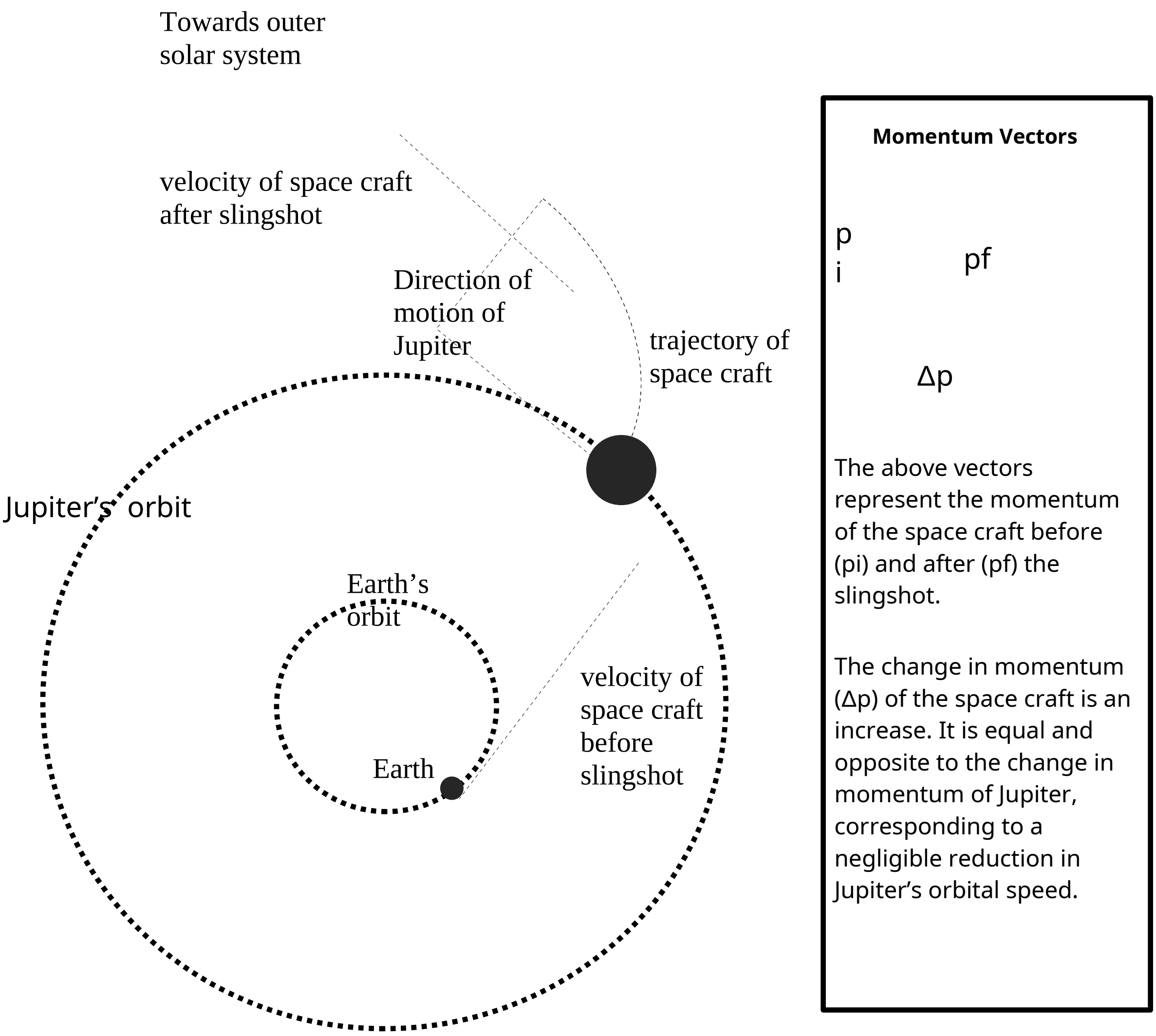
Paragraph 4
As well as containing the key to the origin of life, the Kuiper Belt, and Pluto in particular, may hold the key to how planets form. Studying the craters on both Pluto and its moon Charon, for example, will reveal how KBOs have collided over billions of years and provide clues to the way all the planets formed from smaller objects.

Paragraph 5
Pluto is only 2320 kilometres across, one-fifth the size of Earth. And the 1978 discovery that it is circled by a moon, Charon, whose diameter is 1270 kilometres, makes it even more distinct from the other planets we know about. Pluto and Charon make up a 'twin planet' – the only example in the Solar System.

Paragraph 6
In 2000, NASA scrapped its own Pluto-Kuiper Express mission on the grounds of expense. Under intense public pressure, it held a competition for universities and industry to design a cheaper, better mission. From this was born the New Horizons space probe, due for launch in December 2006. The mission's lead scientist calculates that New Horizons will return 10 times more data than the cancelled Pluto-Kuiper Express, and at little more than half the cost.

Paragraph 7
Just over a year after the New Horizons' launch, it will swing past Jupiter and pick up enough velocity, via the so called "slingshot effect", to reach Pluto, possibly as early as July 2015. Indeed, by the time New Horizons reaches the Kuiper Belt, we may have confirmed that a new planet exists. Because of its vast distances from Earth, the only way we'll find out for sure is to visit this new frontier of the Solar System and get a closer look.

Paragraph 8
The "slingshot effect" is commonly mentioned but rarely explained. In terms of momentum and energy it is similar to the interaction between a table tennis ball and a heavy wooden bat. If the bat and ball are moving towards each other and collide, after the collision, the speed of the ball relative to the ground would be increased. Obviously, trying to bounce a space craft off a moving planet would result in its destruction but if the space craft were to just miss the planet its trajectory could be changed by the mutual attraction between it and the planet, resulting in momentum being transferred from the planet to the space craft, increasing its velocity and changing its direction. This is shown in the diagram below:



QUESTIONS:

a). How is it possible that some 'massive object' can sweep the zone clean of debris?

(3 marks)

$F = G\ m_1\ m_2\ /\ d^2$

If m_2 is large then it can exert a large force of attraction on the other objects due to gravitational pull. Once it 'absorbs' the mass of these objects it will increase its mass and attract even more objects over a greater distance.

b) Calculate the radius of the orbit of Quaoar about the Sun.

(4 marks)

$4\pi^2\ r^3\ /\ T^2 = G\ M_{sun}$

$r^3 = G\ M_{sun}\ T^2\ /\ 4\pi^2$

$r^3 = (6.67 \times 10^{-11}) \times (1.99 \times 10^{30}) \times (288 \times 365 \times 24 \times 3600)^2\ /\ 4\pi^2$

$r = (2.77 \times 10^{38})^{1/3}$

$r = 6.52 \times 10^{12}$m

c) If it is assumed that Quaoar is rocky and has the same density as the Earth, compare the mass of Quaoar with that of the Earth (density = mass/volume and $vol_{sphere} = 4/3\ \pi r^3$)

(4 marks)

Density of earth (E) = density of Quaoar (Q)

Radius of earth is 6.37×10^6 m

Radius of Quaoar = 6×10^5 m

Density = mass/volume

$$\frac{Mass\ of\ Q}{Mass\ of\ E} = \frac{desnity\ of\ Q\ x\ volume\ of\ Q}{desnity\ of\ E\ x\ volume\ of\ E}$$

$$\frac{Mass\ of\ Q}{Mass\ of\ E} = \frac{(\frac{4}{3}\pi r_Q{}^3)}{(\frac{4}{3}\pi r_E{}^3)}$$

$$\frac{Mass\ of\ Q}{Mass\ of\ E} = \frac{600\ x\ 10^3}{6.37\ x\ 10^6}$$

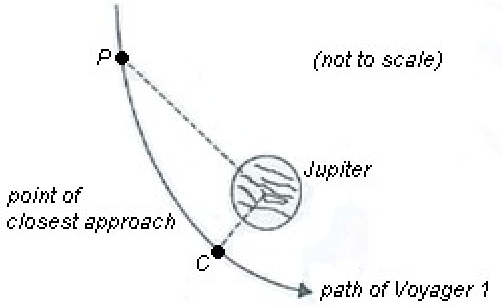
Ratio of Q to E is 8.36×10^{-4}

d) What property of Jupiter makes it ideal to use in the sling-shot effect?

(1 mark)

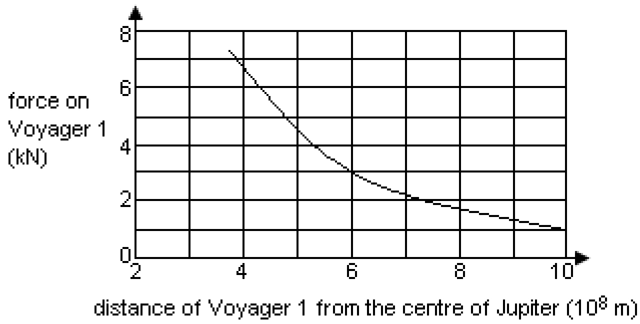
Jupiter has a very large mass and hence a very large gravitational attraction.

e) The Voyager 1 spacecraft also used the sling-shot effect in 1979, when it travelled past Jupiter with its engines off, is shown in the following diagram.



As Voyager 1 moved from Point P to point C, the kinetic energy changed by 4.0×10^{11} J. At point C, the point of closest approach, the force attracting the spacecraft to Jupiter was 6.4×10^{3} N.

The graph following shows how the force that attracted Voyager 1 depended on the distance from the centre of Jupiter.



(i) Explain **how** you would use the information above to determine the distance of **point P** from the centre of Jupiter. (A numerical answer is ***not*** required).

(3 marks)

The graph could be used by finding the area under the curve starting at 6.4×10^{3} on the y axis and calculating the distance that would equate to 4.0×10^{11} J of energy on the x axis. (see diagram)

(ii) Briefly explain why the answer to (i) above cannot be obtained using the relationship from your constant sheet W = F s

(1 mark)

The standard formula of work = force x distance requires a constant (or average) force but the graph indicates that the force is not constant.

f) Do you believe that the New Horizons space probe mission should go ahead? Explain briefly.

(2 marks)

Various answers acceptable depending on how the student has interpreted the passage.

Additional working space

Additional working space

Additional working space