Mercedes College

TRIAL WACE EXAMINATION 2011

PHYSICS
Stage 3

Write your name here

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. Graphics calculators may **not** be used.

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.

MARKS SUMMARY

Section One (60 marks)	Section Two (100 marks)	Section Three (40 marks)	Total Mark (200)	Final %

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 answers	14	14	50	60	30
Section Two: Extended Answer	7	7	90	100	50
Section Three: Comprehension and Data Analysis	2	2	40	40	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 your answers in this Question/Answer Booklet.

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

4. 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. The "Formula and Constants Sheet" may be used as required.

6. All final numerical answers should be expressed to **three** (3) significant figures and include the appropriate **units**.

Section One (Short Answer) **60 marks or 30% of total**

Answer all 14 questions in the spaces provided. Show all working.

Question 1

What is the speed of a satellite in a stable orbit 350 km above the surface of the Earth?

[2 marks]

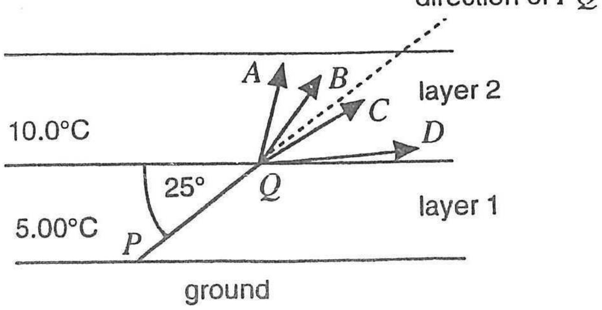
Justify the following statement:

"***The acceleration due to the Earth's gravity at the height of the orbit is only slightly less than at the surface of the Earth".***

[2 marks]

Question 2

Sound is travelling in the direction **PQ** in the diagram below. Which one of the paths (**A**, **B**, **C** or **D**) best represents the path taken by the sound wave as it passes from layer 1 into layer 2? Give a brief reason to support your answer.



Answer: ___________ **[3 marks]**

Reason: ____

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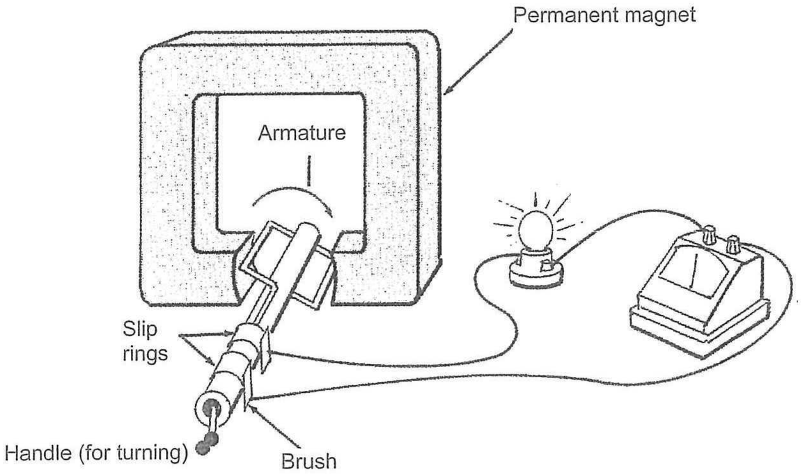
Question 3

The apparatus shown below represents a common classroom demonstration.



What particular device is being demonstrated? ______________________

Justify your answer in terms of **TWO** features of the apparatus.

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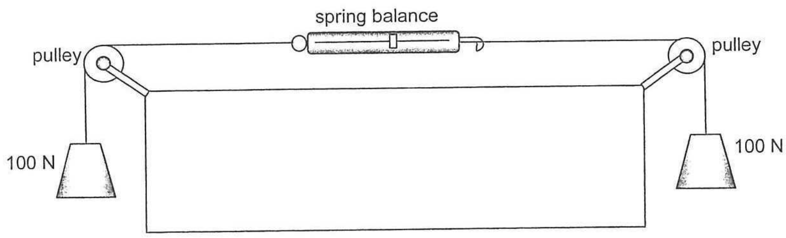
[3 marks]

Question 4

Look closely at the diagram below.



(a) What is the reading on the spring balance? Circle your answer.

100 N **200 N** **zero**

(b) Choose **one** of the answers that you **rejected** and give a reason why you rejected it.

Answer: ______________________ **[3 marks]**

Reason: ______________________

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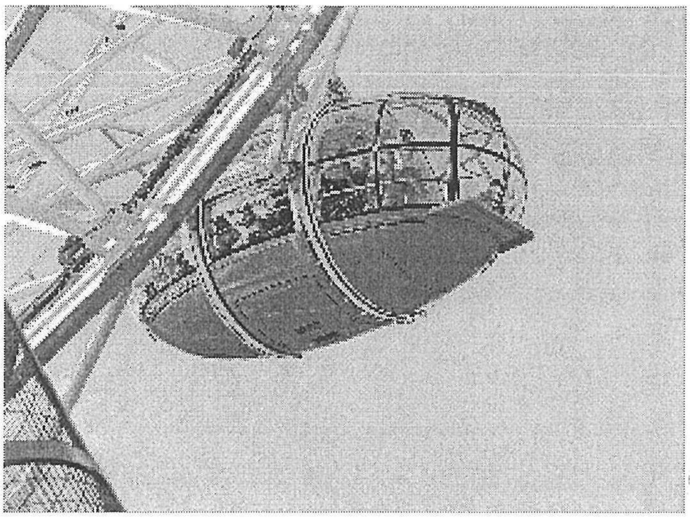
Question 5

The London Eye is a giant rotating wheel that has 32 capsules attached at evenly spaced intervals to its outer rim. Passengers riding in the capsules get spectacular views over London, especially at the top.



Capsule

The capsules each have a mass of 1.10×10^4 kg and are at a distance of 68 m from the centre of the wheel. They travel at a constant speed of 0.28 ms^{-1}.

(a) How long does it take the wheel to make one complete revolution?

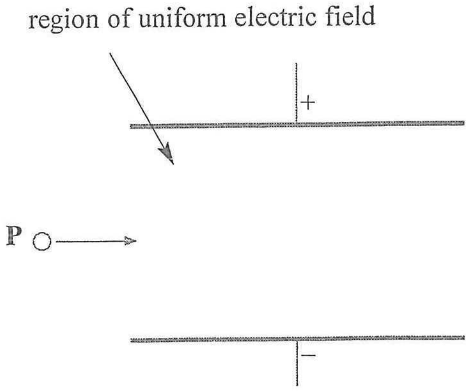
[2 marks]

(b) A passenger in one of the capsules has a mass of 67.3 kg. What reaction force does the passenger experience when the capsule is just passing through the **lowest** point of the ride?

[3 marks]

Question 6

A particle P with a charge of + 6.4 x 10^{-19} C enters a region where there is a uniform electric field of strength 2.0 x 10^4 NC^{-1} as shown below.



(a) Draw the flux lines associated with the electric field between the plates.

[1 mark]

(b) The separation of the plates is 45 mm. Calculate the potential difference between the plates.

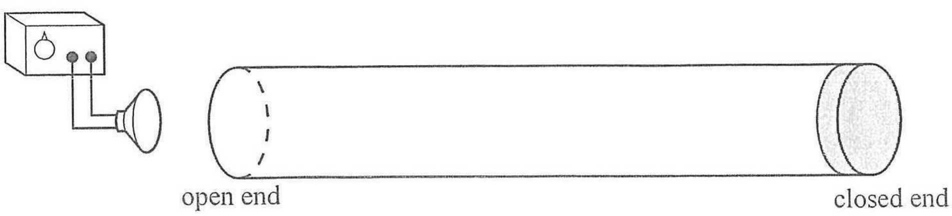
[2 marks]

(c) What is the **magnitude** and **direction** of the force experienced by particle P when it is in the field?

[2 marks]

Question 7

A student uses a narrow tube, open at one end and closed at the other, to construct one of the pipes for a pipe organ. She tests it by using a frequency generator and a loudspeaker as shown in the diagram below.



The speed of sound under the conditions of the test is 320 ms^{-1}. She finds that the fundamental frequency is 133 Hz.

(a) What is the length of the tube?

[2 marks]

(b) Which of the following best gives the next higher resonant frequency that she will hear?

A - 200 Hz
B - 267 Hz
C - 400 Hz
D - 532 Hz

[1 mark]

(c) The student now takes off the cover off the other end of the pipe, so it is open at **both** ends.

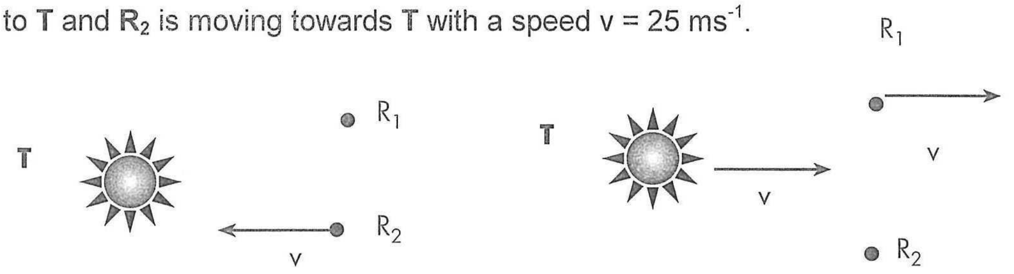
What frequency will she now hear at the fundamental resonance?

[2 marks]

Question 8

Consider a sound source **T** which emits sound waves travelling at 340 ms^{-1} and two observers $\mathbf{R_1}$ and $\mathbf{R_2}$.

$\mathbf{R_1}$ is at rest relative to **T** and $\mathbf{R_2}$ is moving towards **T** with a speed v = 25 ms^{-1}.



(a) What is the speed of the sound waves as measured by observer $\mathbf{R_1}$? ______________________

(b) What is the speed of the sound waves as measured by observer $\mathbf{R_2}$? ______________________

The source of sound is now replaced by a source of light. $\mathbf{R_1}$ measures the speed of light as 3.00×10^8 ms^{-1}

(c) What is the speed of light measured by $\mathbf{R_2}$? **Circle your answer.**

c + v c - v c

(d) Briefly justify your answer to (c) above.

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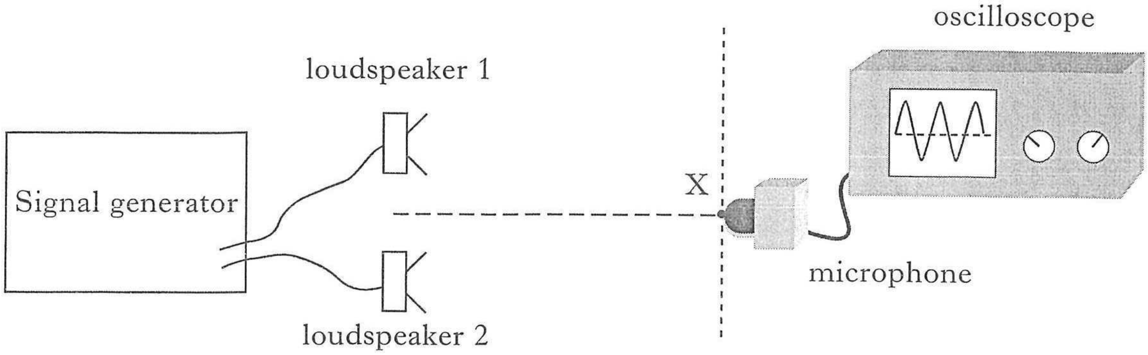
[4 marks]

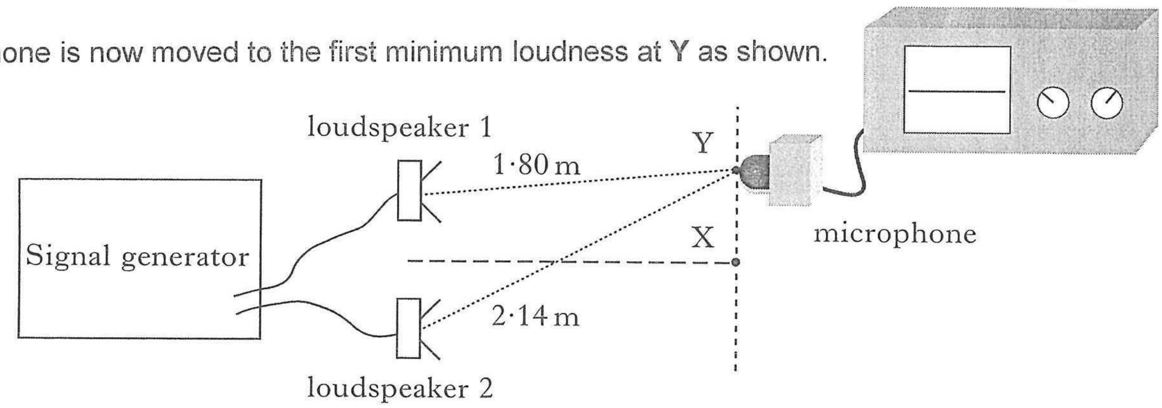
Question 9

A student sets up the following experiment to investigate the interference of sound waves.



The microphone is initially placed at point **X** which is the same distance from each loudspeaker. A maximum loudness is detected at **X**.

The microphone is now moved to the first minimum loudness at **Y** as shown.



(a) What is the frequency of the sound waves produced from the loudspeaker? Assume the speed of sound in the room is 340 ms^{-1}.

[3 marks]

(b) Loudspeaker 1 is now disconnected.

What happens to the amplitude of the sound detected by the microphone at **Y**? **Explain your answer**.

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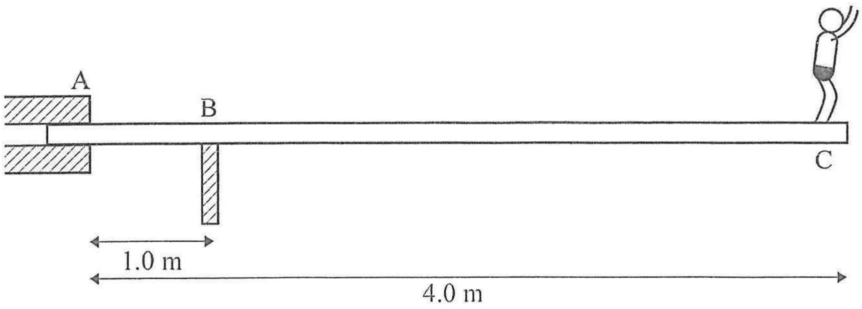
[2 marks]

Question 10

A diving board is constructed of reinforced concrete. It is mounted with two supports at **A** and **B**, as shown. The board has a mass of 80 kg and a length of 4.0 m. A diver of mass 100 kg is standing stationary on the very end of the board at **C**. Support **A** is at one end of the board. Support **B** is 1.0 m from **A**.



What is the magnitude and direction of the force exerted on the board by the support at **B**?

[4 marks]

Question 11

Nucleons are held together by a strong force called the "strong nuclear force". Protons and neutrons belong to a broad group of particles known as **hadrons**.

The quark model of matter suggests that hadrons are themselves made up of other fundamental particles called quarks. Mesons are composed of two quarks while baryons contain three quarks.

The table below gives some information about the properties of three types of quarks.
Each type of quark has an "anti-quark" with the same mass but exactly opposite properties.

Type of Quark	Symbol	Charge (in terms of e^-)
Up	u	+2/3
Down	d	-1/3
Strange	s	-1/3

(a) If the charge on a ρ-meson is +1, what combination of the above quarks could make up a ρ-meson?

[1 mark]

(b) What combination of the above quarks could make up an anti-proton? (a type of baryon with an overall charge of -1)

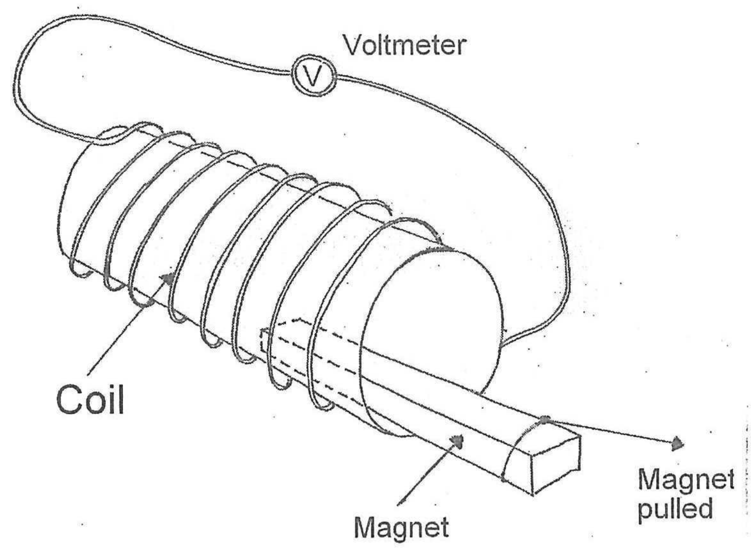
[2 marks]

Question 12

An EMF can be generated in a coil of insulated wire by inserting a magnet in the coil and then pulling the magnet quickly away from the coil. If the magnetic field strength near the end of the magnet is 0.15 T, **estimate** the time interval in which the magnet must be pulled away to generate an EMF of about 1.8 V in the coil.

A **full scale** diagram of the coil and magnet is drawn below.

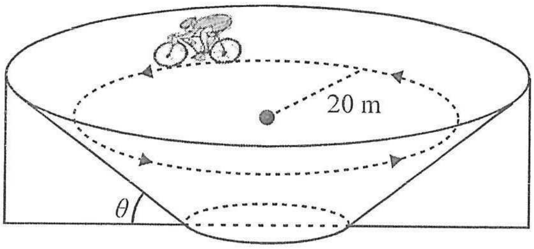
[4 marks]



Question 13

A demonstration at the Royal Show involves a bike being ridden around a circular banked track. The horizontal path the bike takes is a circle of radius 20 m, and the bike travels at a constant speed of 15 ms^{-1}. The bike and rider have a combined mass of 300 kg.

Ignore the effects of friction.

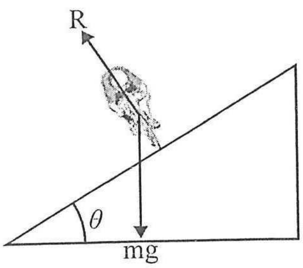


(a) What is the magnitude of the **net force** acting on the bike and rider?

[2 marks]

(b) Using the diagram below, clearly explain how the two forces acting on the bike and rider cause this net force.

[2 marks]



(c) What is the correct angle of the banked track, θ, to achieve this net force?

[2 marks]

Question 14

Two solenoids (coils) with hollow cores are suspended using string so that they are hanging in the positions shown below. The solenoids are free to move in a sideways motion, similar to that of a pendulum.

In the first investigation shown in figure 1, a strong magnet is moved towards the solenoid until the north end of the magnet is inside the end B of the coil. The motion of the magnet is then stopped.

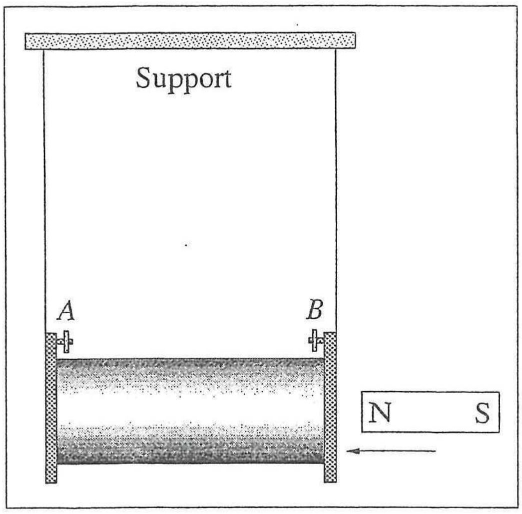


Figure 1 – First investigation

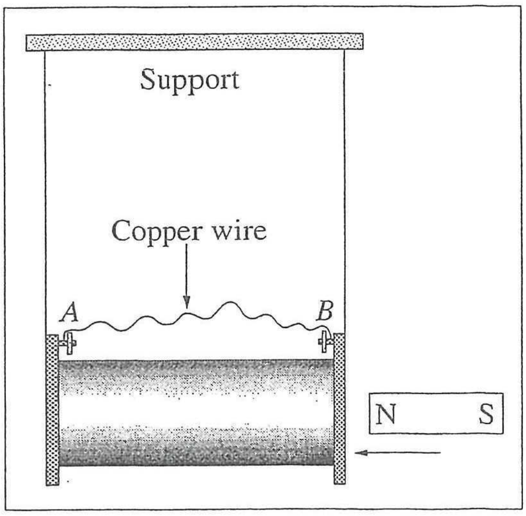


Figure 2 – Second investigation

In the second investigation, as shown in figure 2, a thick copper wire is connected between the two terminals, A and B, at the ends of the solenoid. The motion of the magnet is repeated exactly in this second investigation.

Which of the following **best** describes what happens in this experiment?

Choice	Investigation 1	Investigation 2
A	Coil moves to the right	Coil moves to the left
B	Coil moves to the left	Coil remains stationary
C	Coil moves to the left	Coil moves to the right
D	Coil remains stationary	Coil moves to the left
E	Coil remains stationary	Coil moves to the right

Answer: _______________

Briefly explain the reasons for your choice.

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[4 marks]

End of Section A

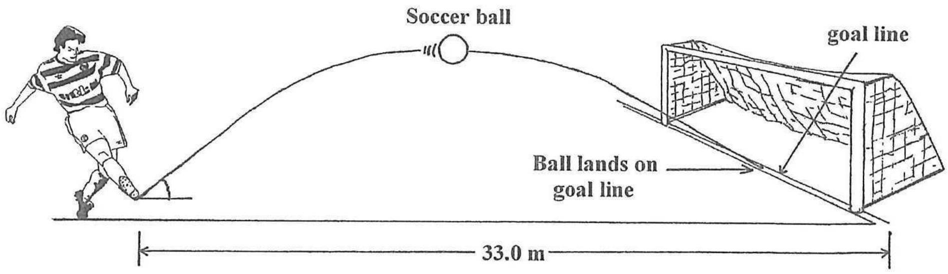
Section Two (Extended Answer) **100 marks or 50 % of total**

This section has **seven** (7) questions. You must answer **all** questions. Write your answers in the spaces provided.

Question 15

A soccer player kicks a ball from ground level at an angle to the horizontal in an attempt to score a goal. The goal is 33.0 m away. The ball lands on the goal line, and bounces into the goal.

This situation is shown in the diagram below.



The ball is kicked with a velocity of 18.1 ms^{-1} at an angle to the ground and reaches the goal line in exactly 2.38 seconds.

(a) At what angle (measured from the horizontal) does the ball leave the player's boot?

[3 marks]

(b) What is the highest distance above the ground that the ball reaches?

[3 marks]

(c) What is the acceleration of the ball when it is at its maximum height?

[1 mark]

See Next Page

(d) At what **horizontal distance** from the kick off point does the ball reach its maximum height?

[2 marks]

(e) In a separate attempt to score a goal the player kicks the ball with a velocity of 25.6 ms^{-1} at an angle of 28^{o} to the horizontal. Does this improve his chance of landing the ball on the goal line and scoring a goal? **Justify your answer with appropriate working**.

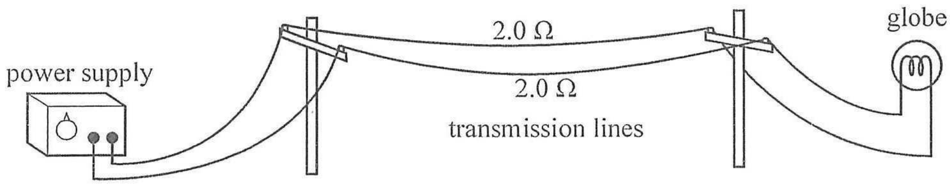
[4 marks]

Question 16

A group of students are using a model of a transmission line to study power and voltage loss in transmission lines.

The students' "transmission lines" consist of wires, **each** of resistance 2.0 ohm. As a load they use a 4.0 W light globe which operates at 4.0 W when there are 2.0 V across it.

The experimental arrangement is shown in the diagram below. The connecting wires from the power supply to the transmission lines and from the transmission lines to the globe have negligible resistance.



(a) Initially the students use the power supply set on a voltage of **2.0 V DC**. They find that the globe does not glow as brightly as they expected. **Explain why**.

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[2 marks]

(b) One of the students, Catherine, says that in the real situation which they are attempting to model, it is more likely that AC rather than DC would be used for long distance electric power transmission.

Explain why AC is often used for long distance electric power transmission.

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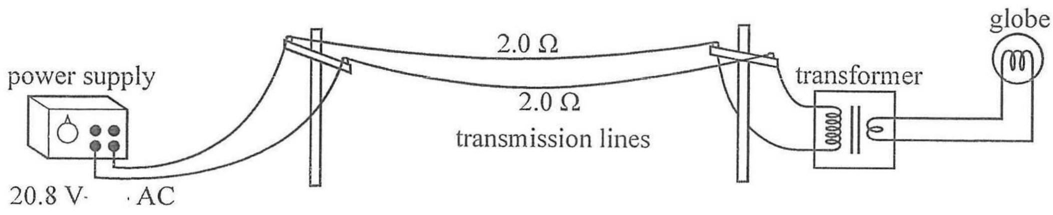
[2 marks]

To model this AC transmission system, they use a 20.8 V AC power supply attached to the transmission lines and use a step-down transformer at the other end. The output of the transformer is connected to the globe. The globe now operates at 2.0 V and 4.0 W.

This new arrangement is shown below.



(c) The transformer used is a 10:1 step down transformer. The primary coil has 1460 turns. How many turns does the secondary coil have?

[2 marks]

(d) What is the voltage supplied to the primary coil of the transformer? Assume the transformer is **ideal.**

[2 marks]

(e) Hence, what % of the electrical power is lost along the transmission lines?

[2 marks]

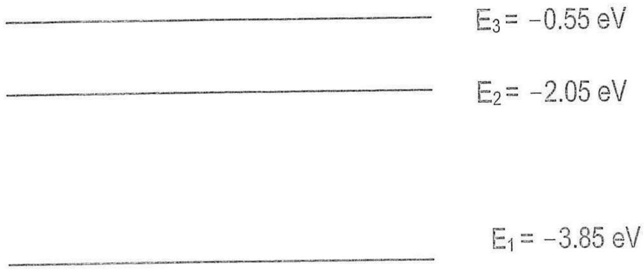
(f) The students notice that the transformer is quite warm after it has been operating for some time. Briefly describe **two** possible reasons for this.

[4 marks]

Question 17

The colour of many corals is due to fluorescent proteins. Stony coral contains the protein P-620, and when exposed to ultraviolet light, it glows with a particularly bright colour. People with aquariums that contain living coral use lamps that emit UV light to ensure that the coral is always coloured.

A partial energy level diagram for P-620 is shown below:



(a) Calculate the wavelength of the UV light needed to cause this effect.

[3 marks]

(b) Calculate the wavelength of the **emission line** with the **<u>shorter</u>** wavelength and hence determine the colour of stony coral under UV light.

[4 marks]

colour	*wavelength* (nm)
red	700
orange	620
yellow	560
green	515
blue	470
indigo	440
violet	410

(c) Many of the UV lamps sold to aquarium owners have acrylic-coated safety covers, designed to shield people from the more dangerous forms of UV radiation.

Why is UV radiation considered harmful to humans?

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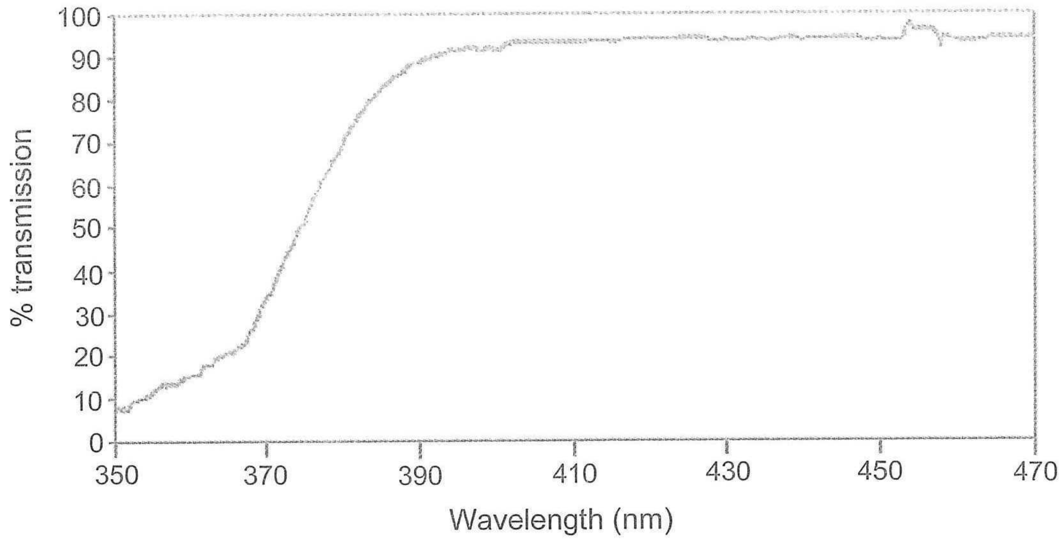
[2 marks]

The following graph shows the transmission properties of an acrylic-coated safety cover. At least 50% transmission is needed for enough UV light to illuminate coral in an aquarium.



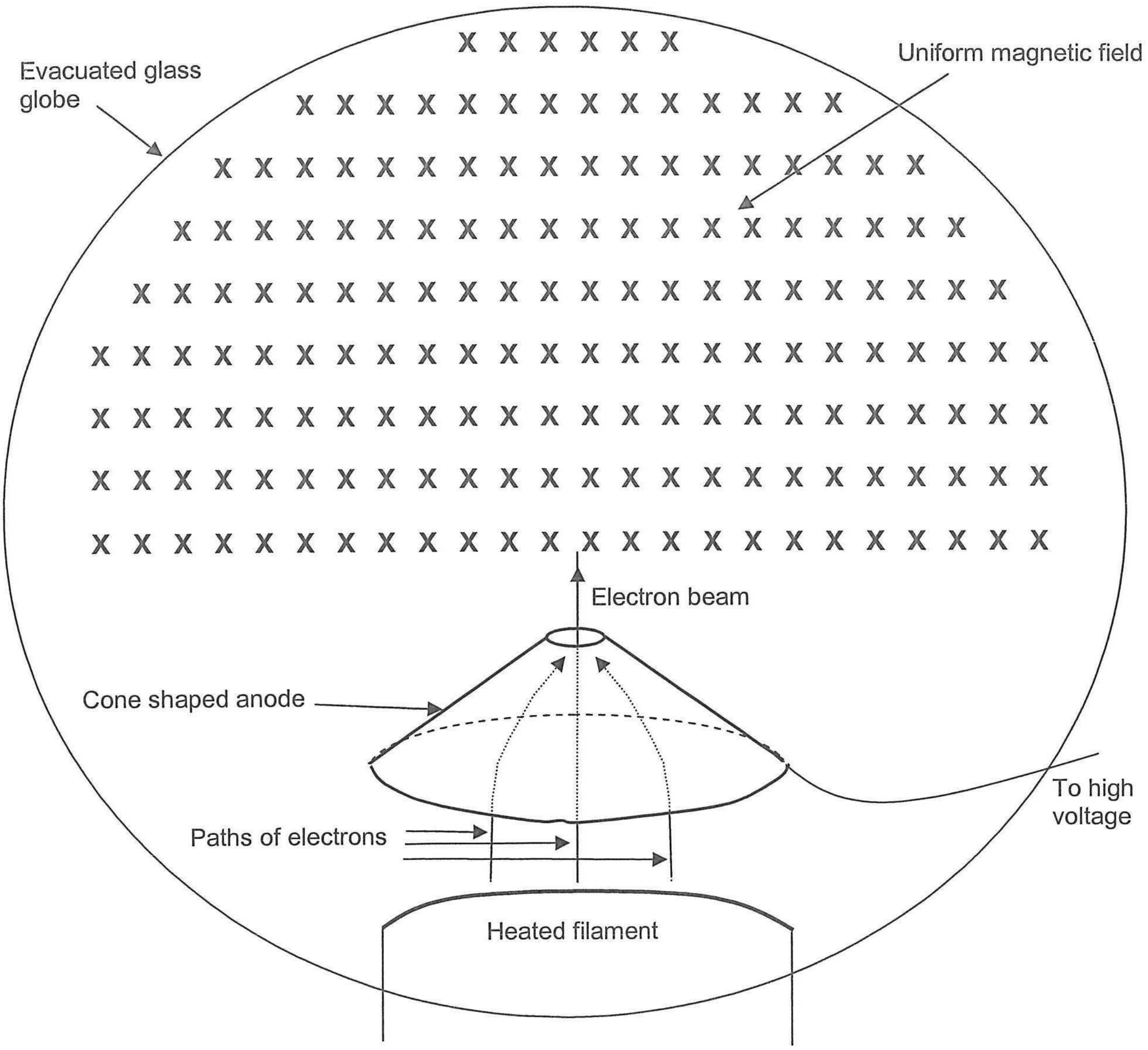
Determine the percentage transmission of the particular UV light that can cause stony coral to fluoresce (as determined in (a) above) and hence explain whether or not this material would be a suitable cover for an aquarium lamp if the owner wanted stony coral to fluoresce.

[3 marks]

Question 18

The diagram below shows a glass globe containing a heated filament that emits electrons by thermionic emission. Initially, the space inside the globe is a vacuum. The electrons are attracted to, and then pass through, a hollow conical anode. This forms a narrow beam of electrons.

The electrons then enter a region of a uniform magnetic field. The magnitude of this field can change. This device can be used for a range of experiments.



(a) Is the anode positively or negatively charged? Explain your answer.

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[2 marks]

(b) Show clearly on the diagram the trajectory (path) of the electron beam whilst in the uniform magnetic field.

[2 marks]

(c) If the kinetic energy of an electron in the beam is 1.14×10^3 eV and the strength of the magnetic field is 1.2 mT, calculate the radius of the electron's circular path.

[3 marks]

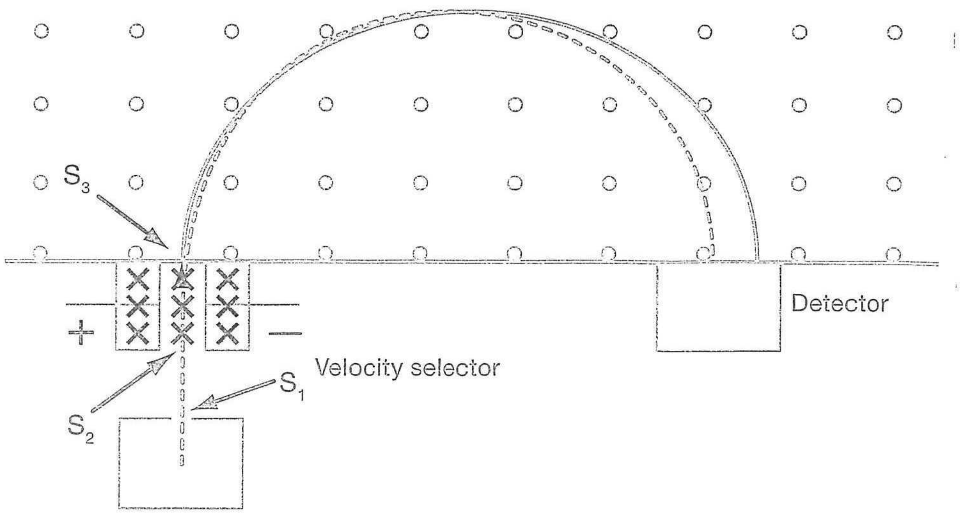
(d) If the glass bulb is filled with neon gas, a glowing pink ring appears within the globe when the electron beam is turned on. Explain why this glowing ring appears.

[3 marks]

(e) Suggest how the colour of the glowing ring could be changed.

[1 mark]

Another application of a similar principle is the **mass spectrometer** which may be used to analyse a mixture of charged particles.



The beam consisting of two types of charged particles enter the mass spectrometer with the <u>same</u> velocity of 1.24×10^4 ms^{-1}. Both types of charged particles carry a charge of <u>magnitude</u> 1.6×10^{-19} C.

(f) If the magnetic field is directed out of the page, do the charged particles carry a positive or a negative charge? **Explain.**

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[2 marks]

(g) Which of the paths (solid or dotted) represents the path taken by the heavier of the two types of particles? **Justify your answer.**

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[3 marks]

(h) The heavier particle has a mass of 3.35×10^{-27} kg and follows a path with a radius of curvature of 200 mm.

What was the strength of the magnetic field used in the mass spectrometer?

[4 marks]

Question 19

Assume that somewhere in space there is a small spherical planet with a radius of 30 km. By some chance a person living on this planet visits Earth. She finds that she weighs the same on Earth as she did on her home planet, even though the Earth is much larger.

(a) What is the gravitational field strength on the surface of the visitor's home planet?

[1 mark]

(b) What is the mass of the visitor's planet?

[3 marks]

(c) What would be the period of the orbit of the visitor's planet around this star?

[4 marks]

The star is part of a very large galaxy. The light from the star is analysed using a spectroscope and it is found that the absorption line for a given element appears at 490 nm whereas the same absorption line occurs at 475 nm when examined on the Earth's surface.

(d) Does this evidence confirm the belief that galaxies are moving away from the Earth? **Explain.**

[2 marks]

(e) What is the recessional velocity of this galaxy? [You may use $\mathbf{v_{galaxy} = (\Delta\lambda/\lambda)\ c}$]

[3 marks]

(f) Use Hubble's Law to estimate the distance (in light years) from the Earth to this galaxy.

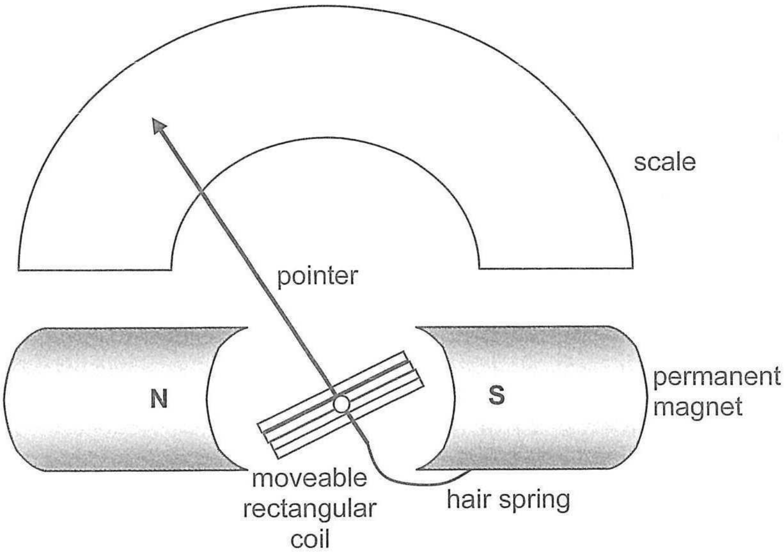
[Take Hubble's constant H_o = 22 kms^{-1} light $year^{-1}$]

[3 marks]

Question 20

Question 20

Galvanometers are instruments used to detect and measure electric currents. They work on a principle similar to that of an electric motor. The interaction between the current flowing in a coil of wire and a permanent magnet creates a torque. When the coil is attached to a pointer (as shown below), the rotation of the coil causes the position of the pointer to change on the scale.



(a) What happens to the position of the pointer when a **larger** current enters the coil? Why?

[2 marks]

The coil has a length of 0.120 m and a width of 0.090 m and has 80 turns. There is a current of 3.50 A in the coil and it is in a uniform magnetic field of 0.010 T.

(b) Calculate the **total force** acting on one of the long sides of the coil.

[4 marks]

(c) Hence determine the torque acting on the coil.

[3 marks]

(d) Why will the coil rotate?

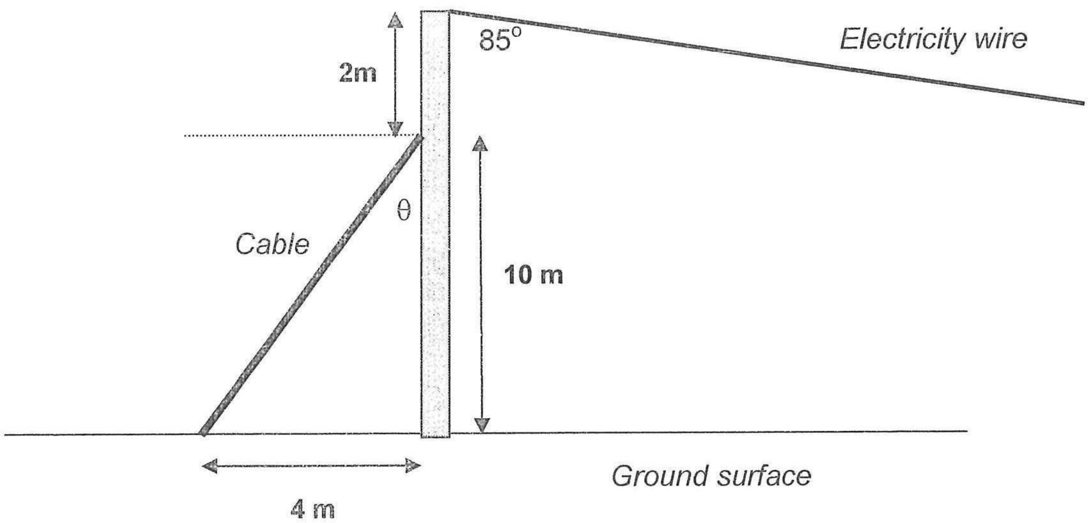
[2 marks]

(e) A loosely coiled spring provides a torque that opposes the coil's rotation. When the coil is stationary, with a current flowing in it, state the relationship between the torque acting on the coil because of the magnetic field, and the torque provided by the spring.

[1 mark]

Question 21

Poles that support electricity wires often have a cable running at an angle down to a support buried in the ground. The purpose of these cables is to stop the electricity wires from pulling the poles over. The diagram below shows one such pole.



The electricity wires make an angle of 85° to the wooden pole as shown in the diagram. The supporting cable is attached to the pole at a position 10 m above the ground.

(a) Calculate the angle (θ) between the supporting cable and the wooden pole.

[2 marks]

(b) With the aid of a diagram, explain how the cable helps prevent the pole from being pulled over by the electricity wire.

[3 marks]

(c) Suppose that the force exerted by the electricity wires on the pole shown in the above diagram is 1.65×10^3 N. Calculate the tension force in the support cable so that the pole is not moved in any direction.

[4 marks]

(d) The wooden pole has a weight. Why is it possible to ignore the effect of the weight of the pole in the calculation of the tension in the support cable?

[2 marks]

(e) What happens to the tension in the support cable if the cable is attached to the wooden pole at a point nearer the ground? **Explain.**

[2 marks]

End of Section Two

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Section Three (Comprehension and Data Analysis) **40 marks or 20 % of total**

This section has **TWO** questions. Answer **all** parts from **both** questions. Write your answers in the space provided.

Question 22

Standing Waves in Stretched Strings

The properties of standing waves on stretched strings are of special significance to musical instruments. In all stringed instruments, for example guitar or violin, a string is plucked or bowed which generates a note.

For all waves the speed of a wave is given by the equation $v = f\lambda$

The speed of a wave on a stretched string can also be expressed as $v = \sqrt{\frac{T}{\mu}}$

where v = wave speed (m s^{-1})
f = frequency (Hz)
T = tension in string (N)
μ = mass per unit length of string (kg m^{-1})

When a stretched string is vibrating at its fundamental frequency, the wavelength $\lambda = 2L$

where L = length of the string.

Substituting for wavelength and equating the equations for speed leads to the equation

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

On a guitar the different notes are supplied by strings with different mass per unit length. The mass per unit length is the only variable in the equation that can be easily changed on a guitar; the length is determined by the length of the guitar and it would place strain on the guitar if the strings were under significantly different tensions.

For a particular manufacturer of guitar strings, the values of mass per unit length (μ), for the different notes are shown below.

String (note)	Mass per unit length, μ (kg m^{-1} x 10^{-3})
E	0.401
B	0.708
G	1.140
D	2.333
A	4.466

Experiment

A group of students were asked to determine the mass per unit length of an unknown guitar string. The students changed the length of the string, maintained the same tension throughout the experiment and measured the resonant frequency each time.

The results of the experiment are tabulated below.

Length (m)	Tension (N)	Resonant Frequency (Hz)	1/2L
0.8	7.6	86 +/- 4	
1.0	7.6	69 +/- 4	
1.2	7.6	57 +/- 4	
1.4	7.6	49 +/- 2	
1.6	7.6	43 +/- 2	
1.8	7.6	38 +/- 2	

(a) What was the **dependent variable** in this experiment?

____

____

[1 mark]

(b) What were **two** variables which were **controlled** in this experiment?

1. ____

2. ____

[2 marks]

(c) Make the necessary calculations and enter the results into the students table of results in the column headed **1/2L**.

[2 marks]

(d) Plot a graph of frequency (y-axis) against 1/2L (x-axis) using the graph grid on the next page.

Include the error bars in your graph.

Draw a line of best fit.

[6 marks]

Graph grid for question (d)

(e) Determine the gradient of the graph. Include the appropriate units.

[4 marks]

(f) Use the **gradient** to determine an estimate for the mass per unit length (μ) for the guitar string used in this experiment.

[4 marks]

Working:

(g) Hence, identify the guitar string used in this experiment.

[2 marks]

(h) Predict the effect on the frequency of the note produced by a guitar string when each of the following changes are made.

The tension in the string is loosened	
The length of the string being played is increased	

[2 marks]

Question 23

Tides on Jupiter's Moon, IO

The planet Jupiter and its moons are like a miniature solar system. The moons orbit Jupiter, bound by gravitational attraction, in the same way that the planets orbit the Sun. The four largest moons were discovered and named by Galileo in 1609. The table below gives the details of the three Galilean moons that are closest to Jupiter: Io, Europa and Ganymede. Each of the three moons lie on the plane of Jupiter's equator and rotates so that the same side always faces the planet.

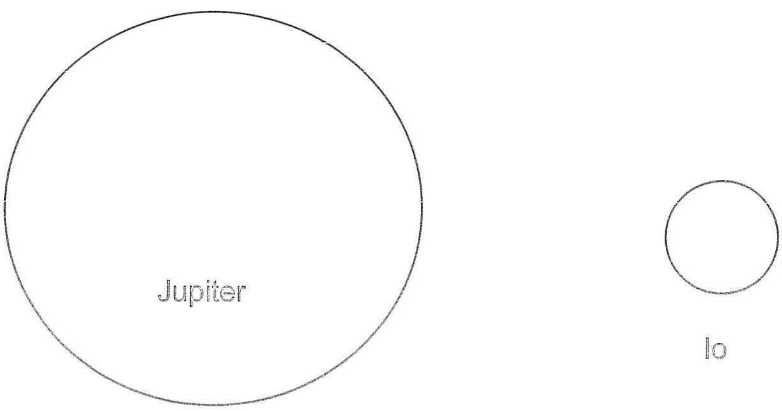
Name	Orbital radius (m)	Orbital period (days)	Radius of moon (m)	Mass of moon (kg)
Io	4.22×10^8	1.769	1.82×10^6	8.94×10^{22}
Europa	6.71×10^8	3.551	1.52×10^6	4.87×10^{22}
Ganymede	10.70×10^8	7.155	2.61×10^6	14.9×10^{22}

Io is best known for its active volcanoes that eject sulfurous fumes that constantly re-form into the yellow brown surface and hide any meteoric craters. What force is responsible for powering the volcanoes on Io? It is too small to have heat left over from its formation, and radioactive decay in its interior could not generate the tremendous energy required to power all of its volcanic activity. The answer is tidal heating. Tidal heating is the heating of the interior of one planetary body caused by varying stresses resulting from the gravitational pull of other planetary bodies.

Jupiter is an enormous planet with a mass of 1.90×10^{27} kg and a radius of 7.14×10^7 m. As a result, Jupiter exerts a tremendous gravitational force. Io, on the other hand, is a tiny moon orbiting very close to the giant planet. Io is therefore affected very strongly by the pull of Jupiter's gravity.

If Io was Jupiter's only moon, it would not be subject to varying internal stresses. The other moons orbiting nearby exert a gravitational pull of their own. Io's volcanic activity is thus caused by the powerful force of Jupiter's gravity, coupled with the gravitational pull of the two moons closet to Io: Europa and Ganymede. Jupiter pulls Io inward toward itself, while the gravity of the outer moons pulls it in other directions. As a result, Io is subjected to tremendous tidal forces that alternately squeeze and stretch its interior. This causes Io's surface to rise and fall by about 100 metres. This perpetual friction generates enormous amounts of heat and pressure within Io, causing molten material and gases to rise through fractures in the crust and erupt onto the surface.

For the following questions, assume that Jupiter's moons follow circular orbits. Use this diagram of Jupiter and Io if you need it.



(a) Calculate the gravitational acceleration on the surface of Io due to its own mass.

[4 marks]

(b) At the surface of Io that is facing toward Jupiter, calculate the gravitational acceleration due to the mass of Jupiter.

[4 marks]

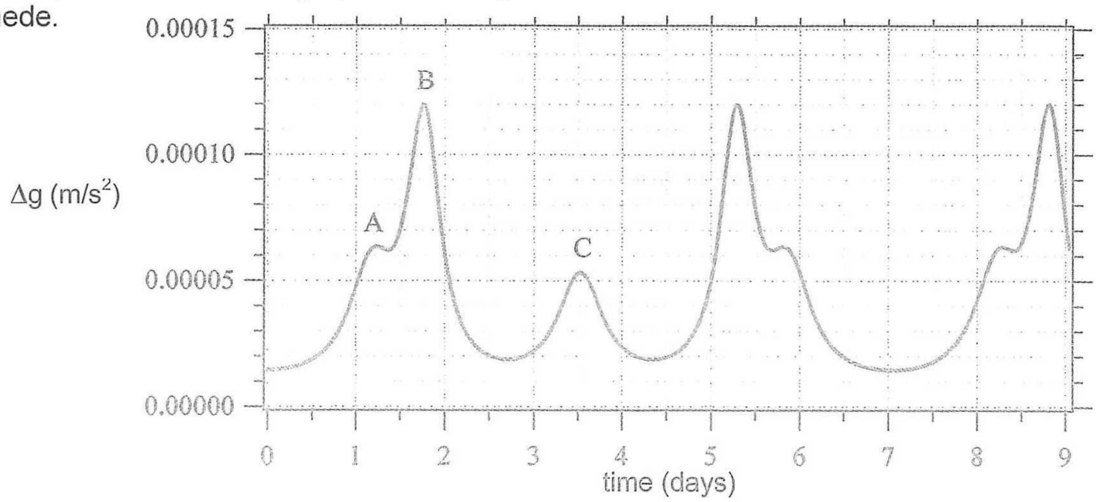
(c) From your answers to (a) and (b), find the **net** gravitational acceleration at the surface of Io facing toward Jupiter.

[3 marks]

If you could not calculate an answer to (c), use the value of 1.10 ms^{-2} for the following questions.

In a similar manner to parts (a) and (c), the net gravitational acceleration on the surface of Io **facing away from Jupiter** can be shown to be **2.51** ms^{-2}. Thus there is a different gravitational acceleration on opposite sides of Io.

When further calculations are made to include the gravitational effects of Europa and Ganymede, the differences in the gravitational acceleration at the inner and outer surfaces of Io are found to vary as a function of time, as shown in the graph below. Δg is the amount of extra tidal acceleration due to Europa and Ganymede.



(d) The consequence of the extra tidal stresses on Io can be calculated using the following formula:

$$\frac{h}{R_{Io}} = \frac{\Delta g}{g_o}$$

Where h = increase in surface height of Io

R_{Io} = Io's mean radius

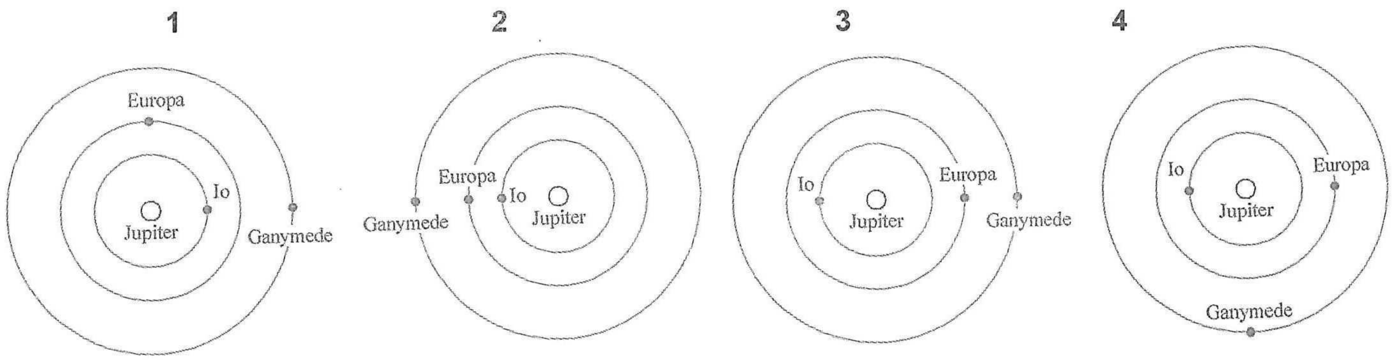
Δg = the extra tidal stress plotted in the graph above

g_o = the surface gravitational acceleration on Io

Using this formula, the values from the graph above and data from the article, calculate the **maximum height h** that would be expected to result from the tidal effects of Europa and Ganymede on the surface of Io.

[4 marks]

(e) The diagrams below show five different orbital positions of Io, Europa and Ganymede as they orbit around Jupiter.



Which diagram shows the orbital positions when the tidal stress on the surface of Io is a **maximum**?

☐

Which diagram shows the orbital positions when the tidal stress on the surface of Io is a **minimum**?

☐

[2 marks]

End of Examination