PHYSICS

YEAR 12

STAGE 3

Name: ____

Teacher: Holyoake Shashikumar Grasl Patterson

TIME ALLOWED FOR THIS PAPER

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

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

- This Question/Answer Booklet; Formula and Constants sheet

To be provided by the candidate:

- Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.
- Special items: Calculators satisfying the conditions set by the Curriculum Council for this subject.

IMPORTANT NOTE TO CANDIDATES

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

All calculations are to be set out in detail. Marks may be awarded for correct equations and clear setting out, even if you cannot complete the calculation. Express **numerical answers** to three (3) significant figures unless you are required to estimate and include units where appropriate. Express **estimates** to one (1) or two (2) significant figures, and state any assumptions clearly.

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 answer	13	13	50	54	30
Section Two: Extended answer	8	8	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
			Total	180	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2013.* 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 follow any instructions that are specific to a particular question.

4. Working or reasoning should be clearly shown when calculating or estimating answers. It is suggested that answers to calculations are given to 3 significant figures except when you are required to estimate. For estimation questions an appropriate number of significant figures must be stated.

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.
   - 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. Refer to the question(s) where you are continuing your work.

Section One: Short response **30% (54 Marks)**

This section has **13** questions. Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 50 minutes.

Question 1

Classify the following spectra by circling two (2) of the options beneath each description:

a. The flame of a burning candle

Emission Absorption Line Broadband Continuous

b. Light shining from a mercury vapour lamp

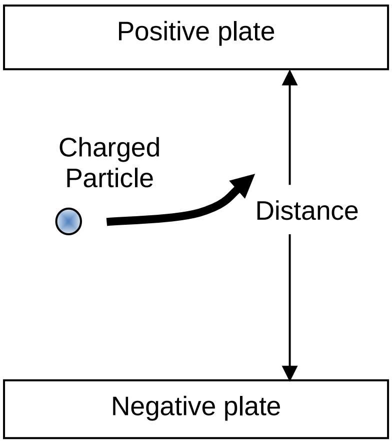
Emission Absorption Line Broadband Continuous

c. Light after white light was passed through a solution of Potassium Permanganate

Emission Absorption Line Broadband Continuous

(3)

Question 2



A charged particle enters a region between 2 parallel charged plates. The potential difference between the plates is 455 V. The electric field strength in the region between the charged plates is 6.50×10^4 V m^{-1}.

a. Calculate the distance between the plates.

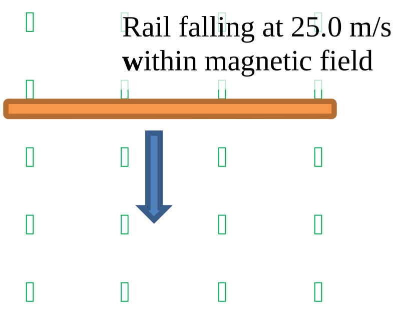
(2)

b. The charged particle experiences a force of magnitude 3.12×10^{-14} N that causes it to deflect towards the positive plate. Determine the charge of the particle.

(3)

Question 3

An iron rail of mass 150 kg and length 4.22 m is falling at 25.0 m s^{-1} next to a magnetic pole of a large electro-magnet. The magnetic flux density of the electro-magnet is 840 mT and its direction is indicated in the diagram.



a. Calculate the potential difference across the length of the rail.

(2)

b. Explain, referring to charge location, how a potential difference is established in this situation.

(2)

Question 4

For particles travelling at near light speeds in a particle accelerator, more force is required to maintain a constant acceleration as the speed of the particle increases.

a. Explain why this is the case.

(2)

b. If the particle is radioactive, explain what happens to the value of its half-life when viewed from a stationary frame of reference as it accelerates.

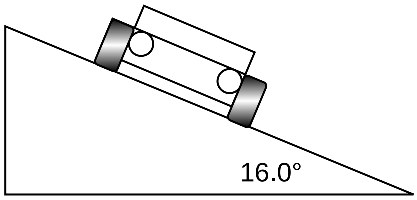
(2)

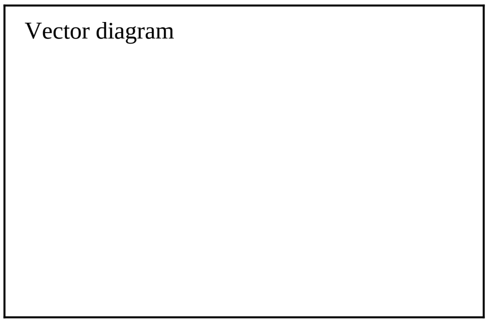
c. If the particle is radioactive, explain what happens to the value of its half-life when viewed from its own frame of reference.

(1)

Question 5

By banking the curves of racetracks it is possible for vehicles to turn in a horizontal circle without relying on friction. For a car of mass 2100 kg the angle of banking is set at 16.0° above the horizontal. The car drives at a speed 24.0 m s^{-1} to maintain its height on the bank.





a) Draw a vector diagram in the space above showing the forces acting on the car and the sum of those forces.

(1)

b) Calculate the horizontal radius of the car's path.

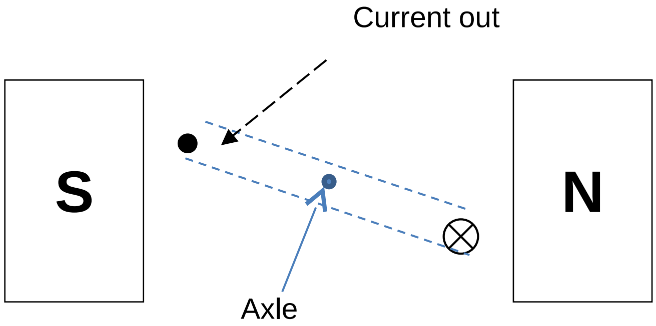
(3)

c) The speed of the car increases to greater than 24.0 m s^{-1}. Explain what other change must occur if the magnitude of forces on your vector diagram remain the same on this frictionless track.

(2)

Question 6

The diagram shows a DC electric motor. A **square coil** of one turn is rotating about an axle. The current is 0.40 A. The direction of current in the lengths of the coil next to each magnetic pole is indicated on the diagram. The scale of the diagram is the **actual size** of the motor. A uniform magnetic field of 86 mT exists between the magnetic poles.



a. Place arrows on the diagram to indicate the direction of magnetic force on each length of wire shown carrying current.

(1)

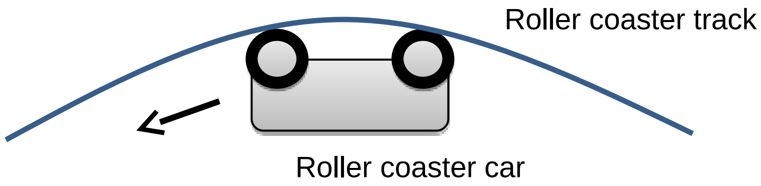
b. **Estimate** the magnitude and direction of torque due to the length of wire next to the South magnetic pole at the instant shown.

(3)

Question 7

A roller coaster car of mass 700 kg is upside down whilst doing a 'loop the loop'. The radius of the loop is 12.0 m. Calculate the speed required at the top of the loop for the car to experience a normal reaction force of 5000 N from the track. You must refer to a vector diagram in your answer.

Vector diagram



(4)

Question 8

The following table of data applies to a transformer that is ideal in terms of voltage but only 90.0 % efficient due to current losses. Fill in the data for the blank cells. There is space below the table to show your working.

(4)

	Primary Winding	Secondary Winding
Number of turns	480 turns	288 turns
Voltage	240 V	
Current		450 mA
Power		

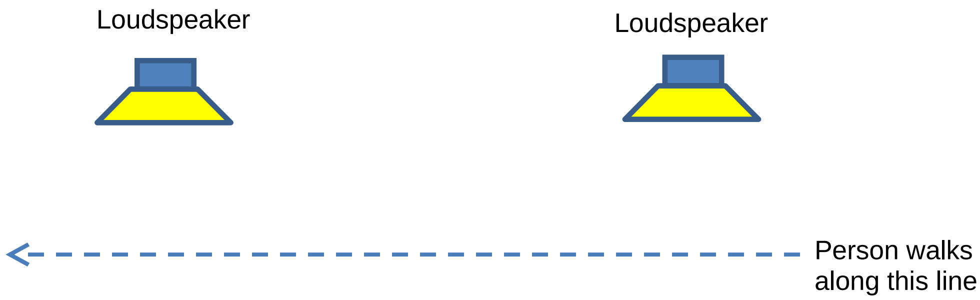
Question 9

Galaxy NGC 3351 is in the constellation of Leo. It is a distance of 11.7 megaparsecs from Earth. One parsec equals 3.26 light-years. A light-year is the distance travelled by light in one year. Calculate the distance to NGC 3351 in kilometres.

(4)

Question 10

Two loudspeakers are set up outside and both emit a single frequency sound in phase. A person walking along a line parallel to the loudspeakers notices that the intensity of sound varies between loud and quiet.



Use physics principles to explain why there are loud regions and quiet regions in this situation.

(4)

Question 11

The line emission spectra observed from elements in distant stars can be compared to line emission spectra from the same elements in a laboratory. Explain what differences between the two spectra are likely to be seen and from this, what information can be deduced about the stars that can be applied to Hubble's Law.

(4)

Question 12

a. There are six flavours of quarks (normal matter version). These are detailed in the table. **Determine the charge** of the following particles that are made from quarks:

Xi-plus (dss) __________ (1)

Kaon- minus ($\bar{u}$s) __________ (1)

Note: $\bar{u}$ refers to an anti up quark

Quark	Charge
Up (u)	$+\frac{2}{3}e$
Down (d)	$-\frac{1}{3}e$
Charmed (c)	$+\frac{2}{3}e$
Strange (s)	$-\frac{1}{3}e$
Top (t)	$+\frac{2}{3}e$
Bottom (b)	$-\frac{1}{3}e$

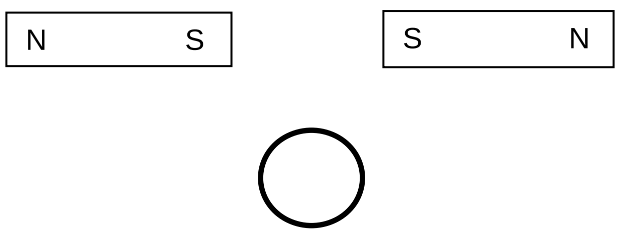
b. Neutrinos we believe travel at the speed of light and have negligible mass. Experiments suggest the mass is very small and is usually stated in terms of its energy equivalent in electron volts. Most experiments conclude that the mass equivalent of the neutrino is less than 50 eV. Determine the mass of neutrios in kg. (Hint $E=mc^2$) (2)

Question 13

Two identical magnets are fixed in position on a flat bench. A compass is placed near the magnets.

a. Sketch the magnetic field in the region around the magnets. Draw at least 4 field lines for each magnet. (2)

b. Indicate the direction that the compass needle will point by placing an arrow in the circle. (1)



Compass

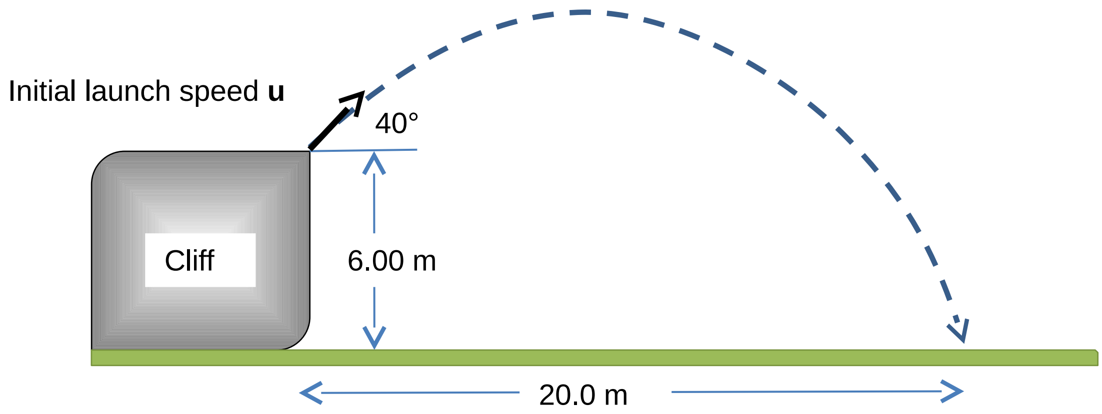
End of Section One

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. Suggested working time for this section is 90 minutes.

Question 14 (13 marks)

A physics student observes a stone of mass 450 g being catapulted from the top of a cliff. The launch position at the top of the cliff is 6.00 m above ground level. The stone lands 20.0 m in front of the launch position. The initial launch speed u is at an angle of 40.0° to the horizontal. You may ignore air resistance for the calculations.



a. Calculate the initial launch speed **u** of the stone. You must show clear algebraic steps in your solution.

Hint: consider the flight time for both the horizontal and vertical components of motion.

(5)

b. Calculate the flight time of the stone. (If you were not able to solve part a), use a numerical value of 12.1 m s^{-1} for the initial launch speed **u**).

(3)

c. Calculate the minimum value of kinetic energy of the stone whilst in flight. (If you were not able to solve part a), use a numerical value of 12.1 m s^{-1} for the initial launch speed **u**).

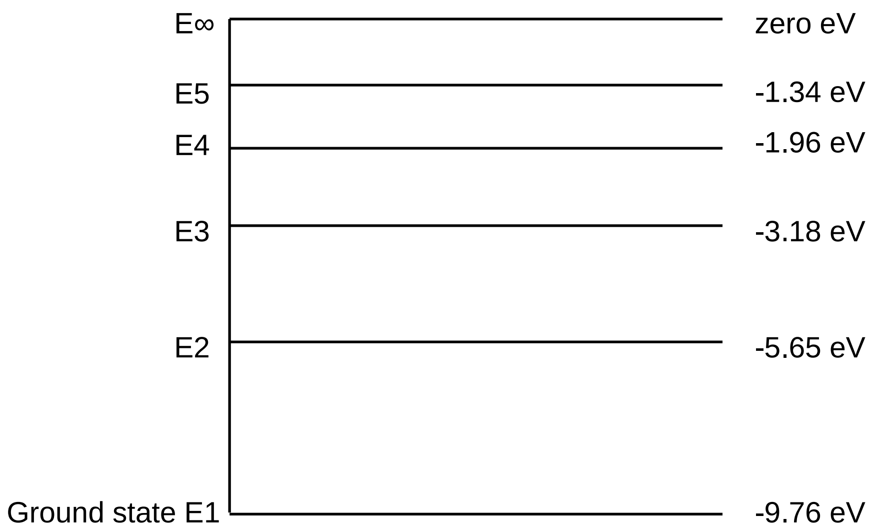
(2)

d. Calculate the maximum height above ground level that the stone reaches on its flight path. (If you were not able to solve part a), use a numerical value of 12.1 m s^{-1} for the initial launch speed **u**).

(3)

Question 15 (13 marks)

The diagram below details some of the energy levels for a fictitious atom, Michellium.



a. Calculate the minimum photon energy in joules that could ionise the atom in its ground state. (2)

b. Calculate the longest wavelength (nm) possible in the emission spectrum of Michellium as the ionised atom returns to its ground state. (3)

c. For the wavelength you calculated in part b. state which area of the electromagnetic spectrum this belongs to.

(1)

d. Is it possible for a Michellium atom to absorb a 4.21 eV photon? Explain briefly.

(2)

e. An atomic electron is at E5. How many lines in the emission spectrum would be possible for the energy levels considered above if it returns to the ground state?

(1)

Number of lines =

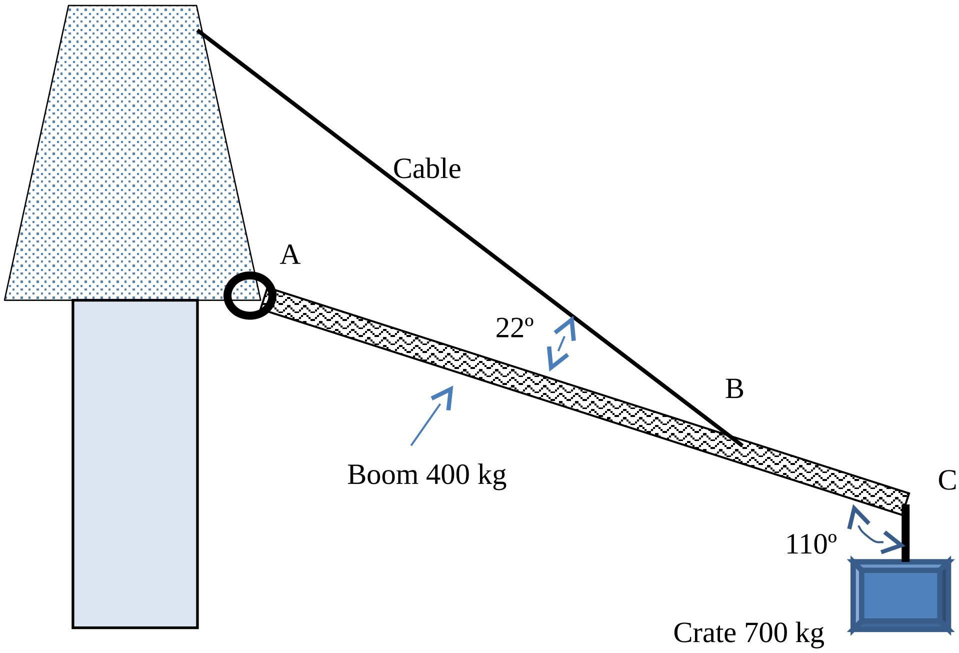
f. A **single** Michellium atom in the ground state is bombarded by **one** electron with a kinetic energy of 6.78 eV. Detail in the table below the possible photon energies observable on de-excitation and the possible bombarding electron energies after passing through the Michellium atom.

(4)

Possible photon energies on de-excitation (eV)	Possible bombarding electron energies after passing through the Michellium atom (eV)

Question 16 (10 marks)

The 400 kg boom of a crane is pivoted at point A. The length of the uniform boom AC is 8.00 m. A crate of mass 700 kg is lifted by a rope attached at C. A flexible cable is attached at point B where the length AB is 6.00 m. The cable makes an angle of 22º with the boom. The rope lifting the crate makes an angle of 110º with the boom.



a. Demonstrate by calculation that the tension in the cable is 2.95×10^4 N

(4)

b. Construct a **vector diagram (approximately to scale)** to show that $\Sigma F = 0$ when considering the weight of the boom, the weight of the crate, tension in the cable and reaction force from the pivot.

(1)

c. Calculate the **magnitude** of the reaction force from the pivot.

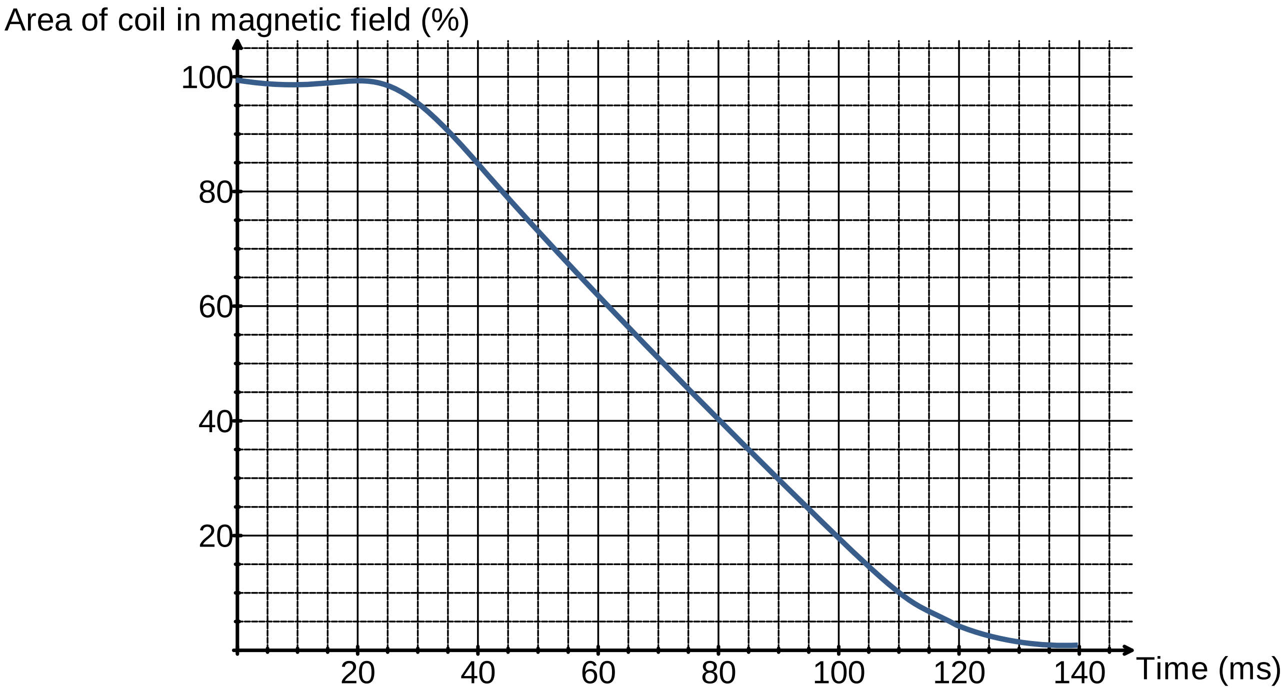
(3)

d. Calculate the direction of the reaction force relative to the vertical and show this angle on your vector diagram. (note that the reaction force acts below the horizontal)

(2)

Question 17 (12 marks)

A rectangular coil is placed in the uniform magnetic field between 2 magnetic poles such that the plane of the coil is always perpendicular to the field lines. The coil has dimensions of 16.0 cm by 10.0 cm and is made from 75 turns of wire. The magnetic field has a flux density of 75.0 mT. The coil is quickly removed from the magnetic field. The graph shows the area of the coil in the field **(expressed as a percentage)** versus time, whilst the coil is removed.



a. Calculate the magnetic flux enclosed by the coil when it is fully within the magnetic field.

(2)

b. Calculate the average value of induced emf between the times of 40 milliseconds and 100 milliseconds.

(4)

c. How does the magnitude of induced emf from 120 ms to 140 ms compare with your previous answer? Explain briefly, no calculation is required.

(2)

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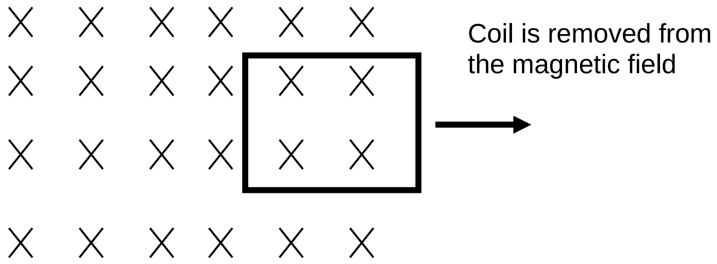
The diagram below shows the rectangular coil being removed from the magnetic field.

d. Show the direction of induced current as the coil is moved to the right. Draw an arrow on the coil to indicate current direction and label it ‘current’. Briefly explain your answer.

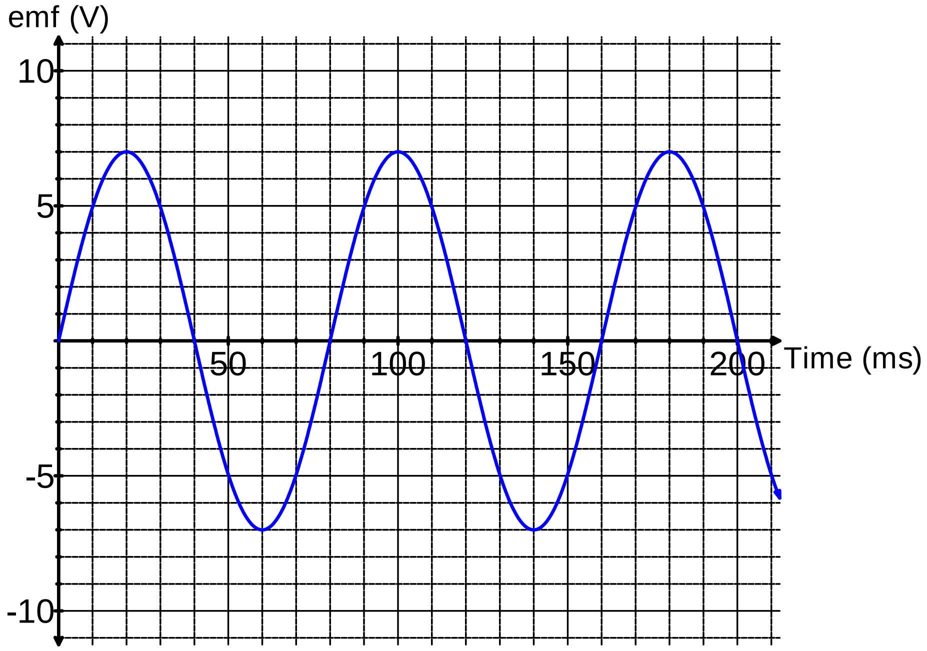
(2)



The rectangular coil is then fixed on an axle, placed back in the uniform field and rotated at a uniform rate of 750 rpm. A graph showing emf voltage versus time is shown.

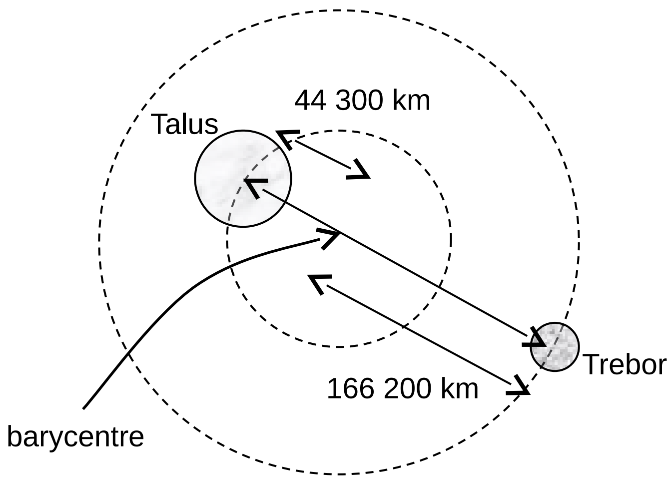
e. Using the same axes, sketch the approximate shape of an emf graph if the rate of rotation is changed to 375 rpm.

(2)



Question 18 (13 marks)

A **binary** planet system consists of two planets orbiting around their common centre of mass. This location is known as the *barycentre.* A binary planet system is shown below. Planet Talus has a mass of 2.04 x 10^{25} kg, Planet Trebor has a mass of 5.44 x 10^{24} Kg. The total separation between the 2 planets is **always** 210 500 km and the *barycentre* **always** lies on a straight line between Talus and Trebor, The distance between each planet and the barycentre is detailed in the diagram below (not to scale).



a) Calculate the gravitational force of attraction between Talus and Trebor.

(3)

b) Calculate the speed of Talus around the *barycentre.*

(3)

c) Calculate how many Earth hours it takes for Talus to orbit the *barycentre.*

(2)

d) Estimate the position of the planets after 32 hours of time from the initial position shown. Sketch them on the diagram and label them. Talus orbits in a clockwise direction about the *barycentre*. (If you could not determine the previous answer use 128 hours)

(2)

e) Show by algebraic proof that the following relationship must be true for any binary planet system that rotates around a *barycentre* in the pattern described in this question.

$$m_1 = \frac{m_2 \times r_2}{r_1}$$

m_1 = mass of planet 1 (kg) m_2 = mass of planet 2 (kg)
r_1 = distance of planet 1 to *barycentre* (m)
r_2 = distance of planet 2 to *barycentre* (m)

(3)

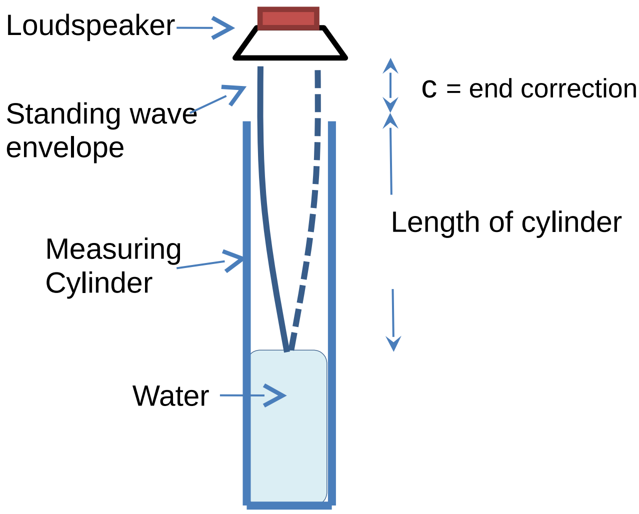
Question 19 (16 marks)

Some students are investigating resonance in an air column. They use a large measuring cylinder as a pipe closed at one end and fill it with different amounts of water to set the length of the pipe.

They perform an experiment to determine the speed of sound in air. A loudspeaker at the top of the cylinder is set at different frequencies by musical notes from a synthesiser and then the water level is varied until resonance occurs at the fundamental frequency.

The students found it difficult to set the length at the resonant frequency so decided to record this data with an **uncertainty of ±10%.**

One quarter of a standing wave forms in the tube at the fundamental frequency for a given length.



The effective length of tube is just beyond the actual length of the tube so the students derived the following expression:

$$\ell + c = \frac{\lambda}{4}$$

Where, ℓ = the length of the air column (m) and c = the end correction (m)

They manipulate this expression to get the following equation that shows the relationship between frequency and length in a **y = mx + c** format.

$$\ell = \left(\frac{v}{4}\right) \cdot \left(\frac{1}{f}\right) - c$$

Where, v = speed of sound (m s^{-1}) f = frequency of sound (Hz)

The results obtained were as follows:

Note	Frequency (Hz)	1/f (s)	Length (m)
D3	147	0.00680	0.508 ± 0.051
F3	175		0.415
A3	220		0.340
D4	294		0.210
G4	392		0.147
B4	494		0.102 ± 0.010

Answer the following questions:

a. Complete the third column of the table **(1/f)** so that you can plot a graph where the gradient of the line of best fit produced is equal to an average value of (v/4). One of the values has been done for you.

(2)

b. Complete the fourth column of the table **(Length)** including the uncertainty in the measurement. Two values have been done for you.

(1)

c. Plot a graph of length against 1/f using error bars to indicate uncertainty. You must allow your y-axis to have a range of values from -0.100 m to +0.600 m. You must allow your x-axis values to have a range from zero to +0.007.

If you need to make a second attempt, spare graph paper is at the end of this question.
Indicate clearly if you have used the second graph and cancel the working on the first graph.

(5)

d. Calculate the gradient of your line of best fit from your graph showing all working (including construction lines).

(3)

e. Determine the speed of sound from the value of the gradient that you obtained. (If you could not determine the gradient use the numerical value 80.0).

(3)

f. From your graph determine what the end correction (**c**) is for this air column. Show clearly on your graph how you obtained this value.

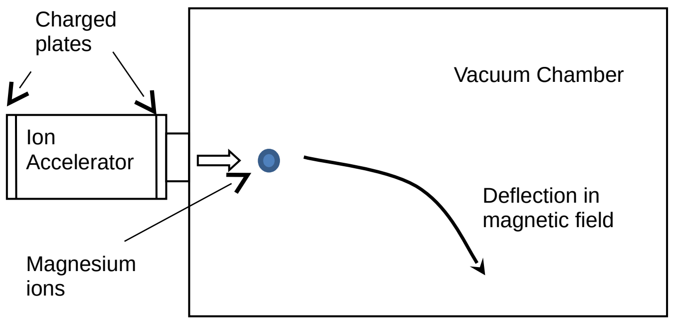
(2)

Spare graph paper

(5)

Question 20 (7 marks)

Ionised atoms of magnesium (Mg^{2+}) are doubly charged positive ions. They each have a mass of 3.98×10^{-26} kg. They are accelerated through an electric field between charged parallel plates before entering a vacuum chamber where they are deflected by a magnetic field.



a. Calculate the potential difference between the charged plates in the Ion Accelerator that will give the magnesium ions a maximum velocity of 1.33×10^5 m s^{-1}

(3)

b. Indicate on the diagram, the direction of the magnetic field within the vacuum chamber that will cause the deflection shown.

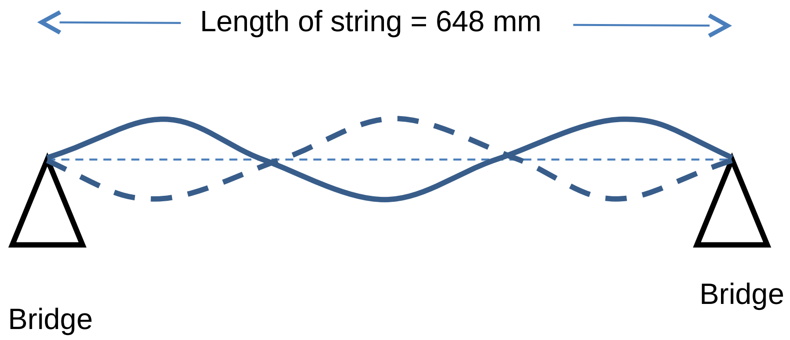
(1)

c. The magnetic flux density within the chamber is set to 98.0 mT. Calculate the radius of the circular path followed by a magnesium ion travelling at 1.33×10^5 m s^{-1}.

(3)

Question 21 (6 marks)

The diagram shows a guitar string that is plucked to form the standing wave envelope shown. The note heard has a frequency of 587.3 Hz. The string is in tension between the two fixed bridges and has a length of 648 mm.



a) Calculate the wave speed along the string that leads to the formation of this standing wave. (3)

b) Identify all the particle displacement antinodes by labelling them ‘AN’ on the diagram. (1)

c) Calculate the frequency produced by the string if it were vibrating in its fundamental mode. (2)

End of Section 2

Section Thre[illegible]rks)

This section c[illegible]st answer both questions. Write your answers in the space pro[illegible]his section is 40 minutes.

Question 22 [illegible] medical imaging (18 marks)

Ultrasound is high frequency sound waves above the upper limit for human hearing. Ultrasound in medical imaging is produced by a transducer that uses a piezoelectric crystal. An alternating voltage applied across the crystal causes it to vibrate and send out a pulse of sound waves. The applied voltage is removed to allow the crystal to detect any reflections. Reflected pulses received after a time delay vibrate the crystal and generate a current which can give information about the distance to the point of reflection. The transmit/receive cycle can be repeated thousands of times per second.

The reflection of ultrasound is used to observe structures within the human body. Imaging with an ‘Amplitude Modulated’ scan can be used to measure distances within the body (e.g. the diameter of the torso). A ‘Brightness Modulated’ scan can provide a two dimensional outline image of a feature within the body e.g. stones in a gall bladder.

Reflection occurs when an ultrasonic pulse passes across an interface between two media - for example soft tissue and bone. Some of the energy and intensity of the ultrasonic pulse is reflected as a result of the fact that the two media will have different ‘acoustic impedances’. This is shown in Figure 1.

Equation 1. The acoustic impedance Z of a medium is defined by: $\mathbf{Z = \rho \times v_{sound}}$

ρ = density of medium (kg m^{-3}), v_{sound} = speed of sound in the medium (m s^{-1})

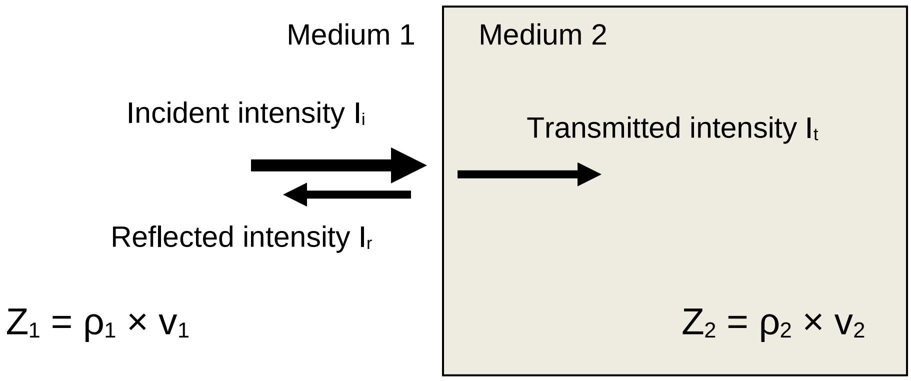


Figure 1: Reflection of ultrasound at an interface

Values of density and speed of ultrasound in different media are shown in the table.

Material	**Density (× 10^3 kg m^{-3})**	**Speed of ultrasound (m s^{-1})**
Air	0.0013	330
Bone	1.91	4080
Brain	1.03	1540
Fat	0.952	1450
Muscle	1.08	1580
Soft tissue	1.06	1540
Water	1.00	1500

Equation 2:

The fraction α_r of the intensity reflected is given by:

$$\alpha_r = \frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$

I_i = incident intensity within medium 1,
I_r = intensity reflected back into medium 1 at the boundary between medium 1 and medium 2

If $\alpha_r = 1$, then 100% of the incident energy is reflected. If $\alpha_r = 0$, then none of the incident energy is reflected. As long as α_r is greater than 40%, then a 'Brightness Modulated' scan should produce an excellent outline image of a feature within the body.

Answer the following questions

a) What type of ultrasound scan would be used to give an image of a developing foetus in a pregnant lady?

(1)

b) Calculate the **minimum time gap** that should be left between pulses emitted by the transducer if ultrasound is reflected from a depth of 7.00 cm and travels only in soft tissue.

(3)

c) Demonstrate by calculation that the acoustic impedance of 'air' = 429 kg m^{-2} s^{-1}

(2)

d) Demonstrate by calculation that the acoustic impedance of 'soft tissue' = 1.63×10^6 kg m^{-2} s^{-1}

(2)

e) A student attempts to perform an ultrasound scan directly onto the stomach of a pregnant lady. The ultrasound must travel through a small air gap before going into the soft tissue of the patient's stomach. Calculate the fraction $\boldsymbol{\alpha_r}$ of the intensity reflected at the air-soft tissue interface and explain why an image of the foetus cannot be formed.

(3)

f) The student tells her teacher that she cannot get an image. The teacher advises her to smear a "coupling gel" onto the patient's stomach to exclude all air between the transducer and the soft tissue of the patient. The "coupling gel" has the same acoustic impedance as soft tissue. Explain the reason for using a "coupling gel".

(3)

g) The acoustic impedance of bone is $Z_{bone} = 7.79 \times 10^6$ kg m^{-2} s^{-1}. Demonstrate by reference to a calculation that reflections at the soft tissue-bone interface will give a good image of the skeleton of a developing foetus.

(4)

Question 23 From Orbits to Energy Levels (18 marks)

The work of Michael Faraday led James Clark Maxwell to develop a theory about the origin of electromagnetic waves. In 1864 Maxwell predicted that any accelerated charged particle should generate an electromagnetic wave. In 1887 Heinrich Hertz verified Maxwell's theory. By causing electrons to accelerate back and forth in a wire loop he generated an electromagnetic wave. The radio waves coming from the loop were detected by a second wire loop on the other side of his laboratory. Worldwide radio communication was developed from this discovery.

Rutherford proposed his model of the atom in 1911 to supersede JJ Thomson's "plum pudding model", of 1904. Rutherford envisaged distant electrons following circular orbits around a central positively charged nucleus much like the planets in a solar system orbit a star. The problem with this planetary model is that according to classical Physics any mass that is undergoing circular motion is by definition experiencing a force to give it centripetal acceleration. If this were the case then the electrons would be sending out electromagnetic waves, which would reduce their energy and so send them spiralling into the nucleus. This is not the case and called for a further refinement to the atomic model.

In 1913 Niels Bohr proposed what is now called the Bohr model of the atom. He suggested that electrons could only have certain motions:

- The electrons travel in orbits that have discrete quantized speeds, and therefore quantized energies. That is, not every orbit is possible but only certain specific ones, at certain specific distances from the nucleus.
- The electrons do not continuously lose energy as they travel. They can only gain or lose energy by jumping from one allowed orbit to another.

What made Bohr's hypothesis brilliant was the derivation of formulae that predicted the radius of the energy levels and the values of the energy levels for the hydrogen atom. These predictions were later verified by experimental data.

Bohr derived the following formula using high school level algebra. The energy level value for electrons in the hydrogen atom is given by:

$$E = -\left(\frac{2\pi^2 K^2 m (q_e)^4}{n^2 h^2}\right)$$

E = energy level value (J)
K = Coulombs constant = 9.00×10^9 N m^2 C^{-2}
m = mass of electron (kg)
q_e = the charge on an electron (C)
n = the energy level number (1, 2, 3….)
h = Planck's constant

In 1900 Max Planck had introduced the idea that light is only delivered in quantum amounts. The 'photon' model fitted well with Bohr's energy level model where the energy of an emitted photon given by E = h.f, must match the difference in energy level values (joules) in a de-excitation between energy levels.

In 1924 the French aristocrat Louis de Broglie (pronounced 'broy') was able to solve the dilemma that electrons seemed to violate some of the basic principles of classical physics. In a doctoral thesis he introduced the idea that particles have wave characteristics in the same way that light waves have particle characteristics.

By linking the Einstein equation $E = mc^2$ and the Planck equation $E = h.f$, De Broglie derived an equation for the wavelength λ (m) of any particle of mass m (kg), travelling at a speed v ($m\ s^{-1}$) :

The De Broglie equation for wavelength of a particle: $$\lambda = \frac{h}{m.v}$$

Diffraction of electrons through a crystalline solid by GP Thomson demonstrated by experiment the wave nature of matter suggested by De Broglie. The principle that electrons also behave like waves is used in the tunnelling electron microscope to produce clear images of objects that are too small for conventional microscopes.

De Broglie showed that the circumferences of the Bohr energy levels are exactly whole integer multiples of the electron wavelengths. So an electron wavelength fits the circumference a whole number of times leading to an electron standing wave through reinforcement. The ground state is like the "fundamental frequency" and excited states are like the "harmonics" in mechanical standing waves.

The piecemeal quantisation of Physics by Planck, Bohr, Einstein and others was successful but disjointed.

Further work by Schrödinger, Born, Pauli and Dirac led to our current understanding of electron orbitals (regions around the nucleus in which there is a high probability of finding an electron at any given instant).

Questions

a) Rutherford's planetary model of the atom was considered flawed. Explain why.

(2)

b) What type of experimental data could have verified Bohr's energy level values for the hydrogen atom?

(2)

c) The formula $E = -\left(\frac{2\pi^2 K^2 m(q_e)^4}{n^2 h^2}\right)$ can be simplified to, $E = -\left(\frac{X}{n^2}\right)$

Calculate the numerical value of X, showing all working and stating your answer in scientific notation.

(3)

d) In terms of energy in electron volts the formula in part c) may also be written $E(eV) = -\left(\frac{13.6}{n^2}\right)$

Use this formula to calculate the energy level values for hydrogen for n = 1, 2, 3 and 4 (2)

Energy Level Number	Energy level value (eV)
4	
3	
2	
1	

e) How did the work of Louis de Broglie link back to the predictions of Niels Bohr?

(2)

f) Use the *De Broglie equation for wavelength of a particle* to calculate the wavelength of a cricket ball of mass 250 g bowled at 20 m s^{-1} and explain why it is hard to observe wave motion of a cricket ball along its projectile path.

(3)

g) How is a De Broglie electron orbit similar to a guitar string that has been plucked?

(2)

h) What is the fundamental difference between a conventional microscope and a tunnelling electron microscope?

(2)

End of questions

Additional working space

Additional working space

Additional working space

End of examination