Government of **Western Australia**
School Curriculum and Standards Authority

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education Examination, 2013

Question/Answer Booklet

PHYSICS

Stage 3

Please place your student identification label in this box

Student Number: In figures

In words

Number of additional answer booklets used (if applicable):

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 Data Booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor

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.

Ref: 13-124

PHY3

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	12	12	50	54	30
Section Two: Problem-solving	6	6	90	90	50
Section Three: Comprehension	2	2	40	36	20
				Total	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 your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

   When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

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. 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 that you are continuing to answer at the top of the page.

6. The Formulae and Data booklet is **not** handed in with your Question/Answer Booklet.

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

This section has **12** questions. Answer **all** questions.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

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Suggested working time: 50 minutes.

Question 1 **(5 marks)**

Mindy flicks a coin across a desk. The coin leaves the edge of the desk and lands at a point 0.455 m below the desk top and 1.45 m from the edge of the desk. Calculate the velocity in m s^{-1} of the coin as it leaves the desktop.

Question 2 **(3 marks)**

A distant star is seen by an astronomer using a powerful telescope to be travelling toward the Earth with a velocity of 0.1c.

(a) At what velocity does the light reach the telescope? (1 mark)

(b) What is it about the starlight's spectrum that tells the astronomer that the star is approaching? Explain your answer. (2 marks)

Question 3 **(3 marks)**

Explain, using an appropriate formula, why high-voltage power lines are used when transporting electrical power over large distances.

Question 4 **(3 marks)**

Table of quarks

Name	Symbol	Electrostatic charge
Up	u	$+\frac{2}{3}$ e
Down	d	$-\frac{1}{3}$ e
Strange	s	$-\frac{1}{3}$ e
Charmed	c	$+\frac{2}{3}$ e
Bottom	b	$-\frac{1}{3}$ e
Top	t	$+\frac{2}{3}$ e

Table of baryons

Particle	Composition
p^+	u u d
n	u d d
Σ^+	u u s
Σ^0	u d s
Σ^-	d d s
Ω^-	s s s

(a) Use the information in the above tables to explain why the electrostatic charge on the Σ^0 particle is neutral. (2 marks)

(b) It is possible for another baryonic particle to exist in nature with a positive electrostatic charge equal to that of the proton. What would its quark composition be, given that this particle contains two up quarks and is **not** a proton? (1 mark)

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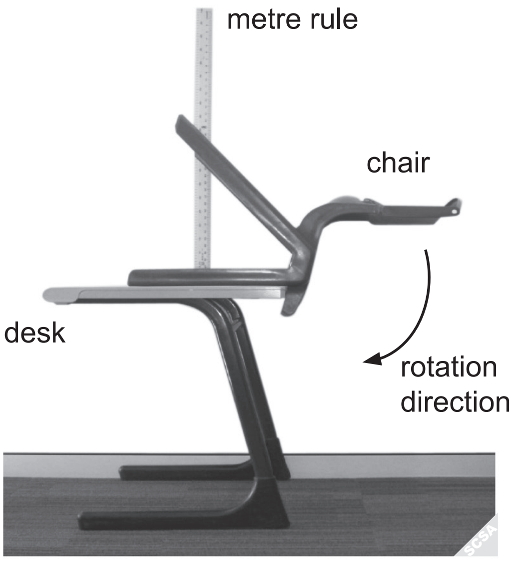
Question 5 **(8 marks)**



Photograph A

Photograph B

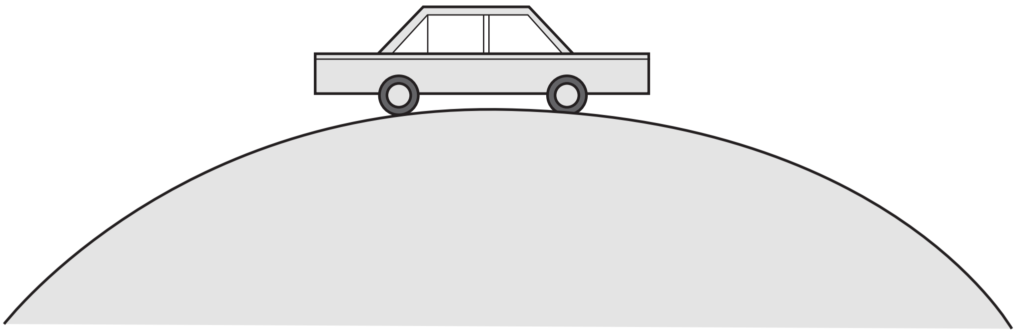
(a) The photographs above show the same chair in two different positions. A metre rule is included to provide scale. Photograph A shows the chair in the instant after the person holding it in place let go.

In Photograph A the chair will begin to rotate and fall to the floor as soon as the hand is removed, while in Photograph B the chair will stay in the position as shown. Explain why the chair will rotate in Photograph A but not in Photograph B. (3 marks)

(b) On the photograph below, indicate the direction of the force that you could apply at Point X in order to prevent the chair from rotating. Estimate the magnitude of this force, stating clearly any assumptions that you make. (5 marks)

Question 6 **(3 marks)**

A car is driving over a hill with a radius of 250 m at a speed of 30.0 m s^{-1}. Determine the magnitude of the net force experienced between a 65.0 kg passenger and their seat or seat belt.



Question 7 **(4 marks)**

The element helium gets its name from the Greek sun-god 'Helios'. This is because helium is the only element to have been discovered in the Sun before it was isolated on the Earth. Helium was identified from unknown lines in the solar spectrum.

With reference to the discovery of helium, explain the origin and significance of lines in the solar spectrum.

Question 8 **(4 marks)**

When a satellite is launched it is placed in an initial circular orbit around the Earth. Later some small jets on board the satellite will fire compressed gas for a set period of time to move it to the precise final circular orbit required. These gas jets point backward relative to the satellite's motion only and **not** toward or away from the Earth.

How can backward facing gas jets be used to raise the satellite to a higher final circular orbit?

Question 9 **(5 marks)**

Use a labelled free body diagram to help explain why a runner or a cyclist needs to lean when making a turn.

Question 10 **(3 marks)**

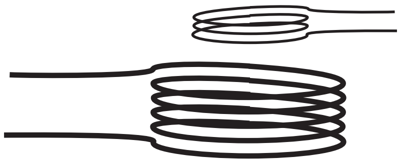
A geostationary satellite orbits the Earth at an altitude of 35 000 km. It travels at a speed of approximately 3000 m s^{-1}.

Relativistic effects may cause a clock on board the satellite to run a little slower or a little faster than the same clock on the surface of the Earth. Considering the factors that may lead to relativistic effects, complete the table below.

Factor leading to relativistic effect	Change in factor	Effect on time shown by clock
gravitational field	decreased	faster

Question 11 **(6 marks)**

Inductive charging is becoming more popular for mobile devices such as phones. A simplified diagram of the charging system is shown below.



(a) Assume that one such charging system runs directly from the mains power (240 V AC) to charge a device that requires an input of 4 V. Describe the transformer and the relationship between the two coils. (3 marks)

(b) Use appropriate formulae or relationships to explain how this inductive charging system works. (3 marks)

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Question 12 **(7 marks)**

A satellite orbits 4.22×10^7 m above the Earth's centre. At a certain point in its orbit around the Earth, the satellite and the Moon line up as shown in the diagram below. Show that in this position the influence of the Moon on the satellite is negligible, compared with the influence of the Earth.

End of Section One

Section Two: Problem-solving **50% (90 Marks)**

This section has **six (6)** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

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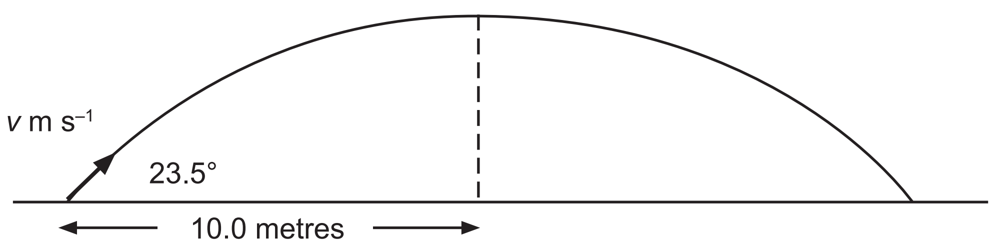
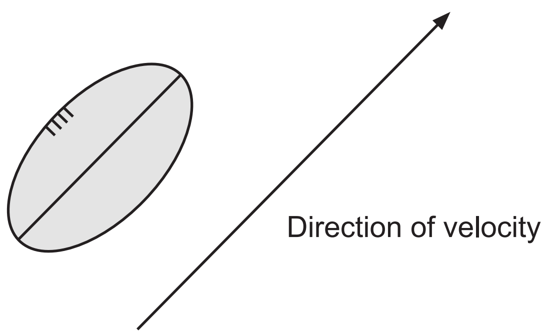
Suggested working time: 90 minutes.

Question 13 **(14 marks)**

Gary is playing in a park and decides to kick a ball over a branch of a large tree. He places the ball on the ground to kick it. The path of the ball is shown in the diagram. The tree is 10.0 m away. Gary kicks the ball with a velocity v at an angle of 23.5° to the horizontal. The ball will just clear the branch.



(a) Draw the force(s) acting on the ball just after it has been kicked. (2 marks)



(b) The ball is in the air for 1.33 s. Assuming no air resistance, determine:

(i) the initial velocity of the ball in m s^{-1} (4 marks)

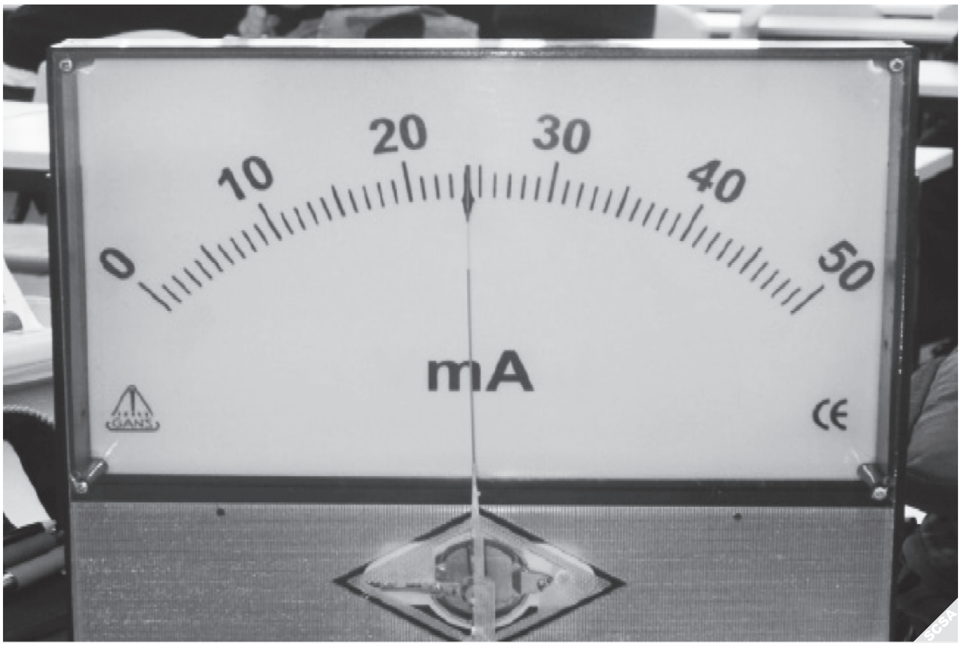
(ii) the height of the branch (3 marks)

(iii) the distance in metres on the opposite side of the tree that Gary should place his sister so she can catch the ball when it is 1.25 m above the ground. (5 marks)

Question 14 **(16 marks)**

An ammeter is a device that is used to determine the magnitude of an electric current. The unknown current is passed through a coil of wire in a magnetic field. The turning effect of the current-carrying coil is balanced by a spring and a corresponding value is read from the meter.

(a) Use the photograph below of an ammeter's scale to determine the magnitude of the current passing through it, as well as the absolute and relative uncertainty for this value. (3 marks)

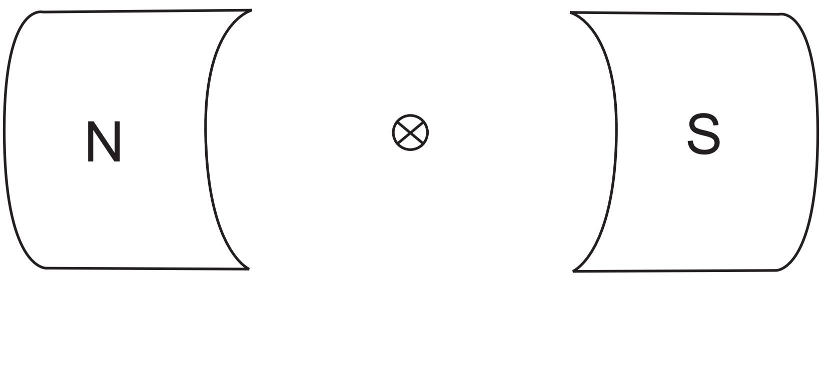


Current: ______________________mA

Absolute uncertainty: ______________________

Relative uncertainty: ______________________

(b) A simplified diagram representing one current-carrying wire of the ammeter's coil between two magnets, is shown below. Draw at least **five** field lines to show the resultant magnetic field between the magnets. (4 marks)



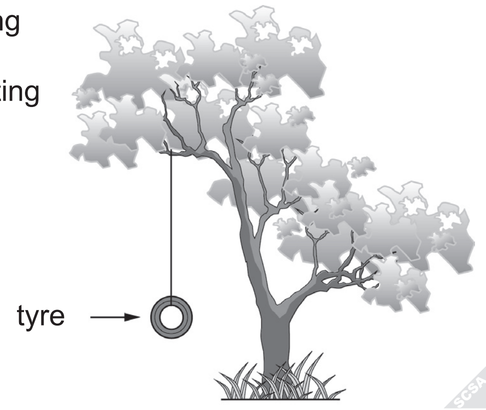
(c) Calculate the magnitude of the force, in newtons, acting on the wire carrying a current of 1.45 A in the simplified diagram on page 14, given that the magnetic field strength is 4.25×10^{-2} T and the length of the wire in the field is 2.50×10^{-2} m. (2 marks)

(d) The actual ammeter shown has 250 turns of wire that form a square coil with sides of 3.20×10^{-2} m. Determine the magnitude of the current in amperes, given that the spring provides a restoring torque of 2.65×10^{-2} N m in the magnetic field strength of 4.25×10^{-2} T. (4 marks)

(e) When the ammeter is disconnected, the spring rotates the coil so that the marker needle returns to zero. This causes a change in flux of 2.18×10^{-5} Wb to occur in the coil in 0.115 s. Determine the average potential difference induced in the coil during this change. Include the units in your answer. (3 marks)

Question 15 **(18 marks)**

Andrew and Sarah were at the park and noticed a tyre-swing hanging in a tree. They realised that it would behave as a pendulum and would complete one swing (return to its starting point for one complete cycle) with a period (T) in seconds. They had previously discussed pendulums in class and been given the equation:



$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

[Where ℓ = length in metres]

(a) The tyre swung with a period of 3.84 s. Determine the length of the rope in metres. (2 marks)

(b) Andrew and Sarah decided to conduct an investigation to determine the relationship between the length of a pendulum and its period.

An incomplete table of results for this investigation is shown below:

Length of pendulum ℓ (m)	Time for ten swings (s)	Time for one swing T (s)	Period squared T^2 (s^2)
0.10	5.5		
0.20	6.9		
0.30	10.9		
0.40	12.5		
0.50	15.0		
0.60	18.5		

(i) Complete the above table. (2 marks)

(ii) Use the data from the table to plot a straight line graph on the grid provided to demonstrate the relationship between the length of the pendulum and the square of the period (plot ℓ on the x-axis). (4 marks)

If you wish to make a second attempt at this item, the graph is repeated an the end of this Question/Answer Booklet. Indicate clearly on this page if you have used the second graph and cancel the working on the graph on this page.

Question 15 (continued)

(b) (iii) Use your graph to determine the pendulum length that gives a period of 1.0 s. (3 marks)

(iv) Determine the gradient of your graph using a line of best fit. (4 marks)

(v) Use your gradient to determine the experimental value of g. (3 marks)

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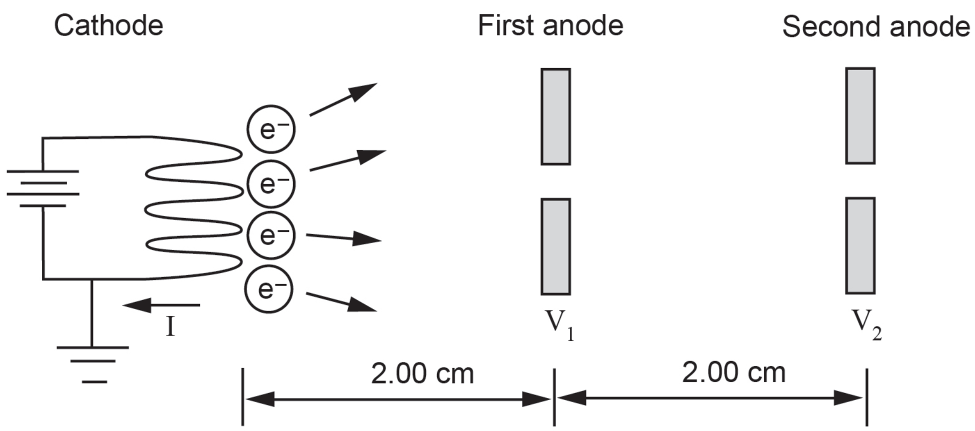
Question 16 **(16 marks)**

An electron gun is a very important component of many devices, including particle accelerators, electron microscopes and cathode-ray tubes. A schematic diagram of an electron gun is shown below.



Assume the average initial velocity of a thermal electron is zero. The anode voltages are V_1= 1500 V and V_2 = 4500 V and the distances between the cathode and anodes are as shown above.

(a) Calculate the velocity in m s^{-1} of the thermal electrons as they pass through the first anode. (4 marks)

(b) Calculate the average acceleration in m s^{-2} of an electron in the region between the cathode and the first anode. (3 marks)

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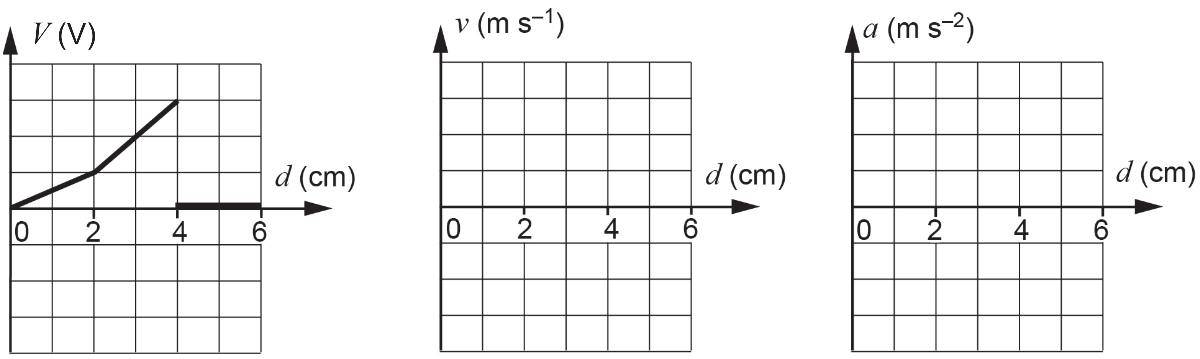
(c) Complete the sketches that qualitatively represent the situation on the axes below. The first graph, of distance versus potential difference, has been completed for you. (6 marks)



(d) Calculate the electrical work done by the electric field in moving one electron from the first anode to the second anode. Include units with your answer. (3 marks)

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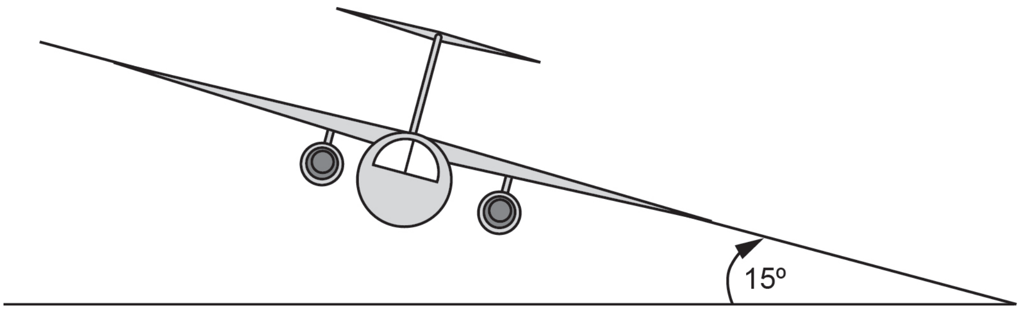
Question 17 **(12 marks)**

An aircraft is flying horizontally with a constant speed of 600 km h^{-1} at an altitude of 5000 m. The upward (lift) force provided by the wings that is necessary to keep the aircraft in level flight is 9.80×10^4 N.

(a) Show that the mass of the aircraft must be 1.00×10^4 kg. (3 marks)

(b) The pilot begins a turn by tilting the aircraft so that its wings are at 15.0° to the horizontal as shown. Assume that the airspeed does not change, and that the size and angle to the wing of the lift force remain constant.



Draw a free body diagram below labelling the forces acting on the aircraft. Ignore drag/friction and thrust forces directed into and out of the page. (2 marks)

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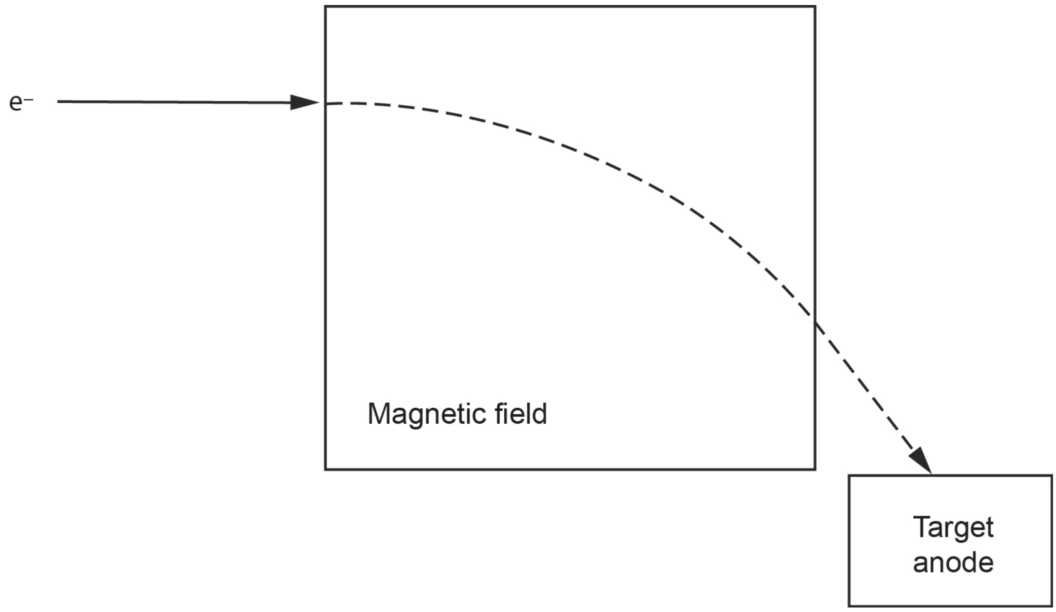
(c) Calculate the horizontal radius of the aircraft's turn, assuming the airspeed does not change. (5 marks)

(d) Describe any effects that this turn will have on the altitude of the aircraft. No calculations are required. (2 marks)

Question 18 **(14 marks)**

An electron moving at 0.9c enters a region of space and follows a path that has a constant radius of 0.348 m while in the magnetic field shown on the diagram, before striking a target anode.



(a) Draw the magnetic field enclosed in the indicated space. (2 marks)

(b) (i) Derive the formula $B = \frac{mv}{qr}$. (2 marks)

(ii) Use this formula to calculate the field strength needed to direct an electron along this path. Include units in your answer. (4 marks)

(iii) Describe how each of the changes below affect the charged particle's path in the magnetic field. (4 marks)

Property changed	Effect on radius of the path
Particle's charge is reversed	
Particle's charge is increased	
Particle's velocity is increased	
Magnetic field is increased	

(c) Relativistic effects were not considered when calculating the electron's path. Outline briefly the effects that special relativity predicts about the radius of the electron's motion. (2 marks)

End of Section Two

Section Three: Comprehension 20% (36 Marks)

This section has **two (2)** questions. You must answer **both** questions. Write your answers in the spaces provided.

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Suggested working time: 40 minutes.

Question 19 (20 marks)

The club-winged manakin

Manakins are birds that perform spectacular song-and-dance acts in the middle of a tropical forest. While all manakins produce vocal calls, about half of the 40 known species also make music at lower frequencies by moving their body parts.

Scientists knew that the wings were the source of the sound but did not know exactly how the process worked. The manakin's movements were recorded on a video camera operating at a thousand frames per second. Viewing the video in slow motion showed that the bird was knocking its wings together 107 times a second. Examining the manakin's feathers under a microscope showed that each wing has a specialised feather with seven separate ridges. An adjacent feather rubs against the ridged feather in a plectrum-like[1] action. A single note is produced when the wings come together and then move apart.

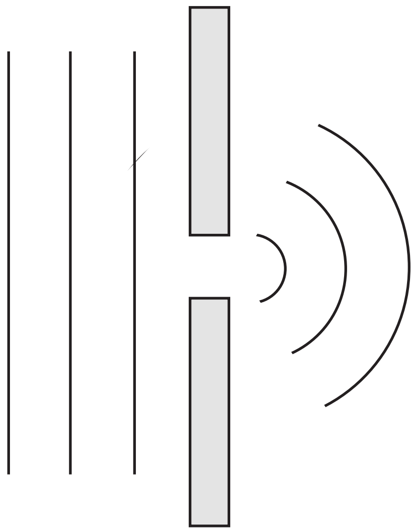
The club-winged manakin has nine hollow feathers with enlarged shafts that are closed at both ends and held adjacent by a ligament on each wing. Two of these are specialised feathers that produce a note as described above. The scientists found that when these two specialised feathers are excited at their resonant frequency, all nine hollow feathers resonate as a unit to create a violin-like fundamental note. The wing also produces a second harmonic at a similar volume.

Bone density appears to be critical in the production of this sound. Scientists who studied manakin wings discovered that the wing bones are solid. Most birds have hollow bones which make it easier for them to fly. The manakin's solid bones are likely to have evolved in order to support the knocking action of the specialised feathers.

[1] plectrum: in music, a plucking device such as a guitar pick

(a) Using the information contained in the passage, calculate the frequency of the sound (including units) the feathers produce. (4 marks)

(b) The sound produced by a manakin's wings is shown interacting with a gap below (left). Draw at least **five** wave fronts, showing the difference in the interaction as a manakin's vocal call passes through a similar gap, using the diagram on the right. (3 marks)



Wing sound

Vocal call

Question 19 (continued)

(c) The two specialised feathers produce standing waves when excited.

(i) Using the boxes provided, draw the two standing waves as described in the passage. Each box represents the resonant space inside a hollow specialised feather. (2 marks)

(ii) Determine the length of a specialised feather's air space. (4 marks)

(d) The average speed of sound in bone is 3000 m s^{-1}. The length of the manakin's longest solid bone is about 5 cm.

(i) Determine the lowest frequency of sound that would be present. (3 marks)

(ii) One scientist hypothesised that the bones are solid so that they can be resonant structures. Explain what 'resonance' means and explain whether this is a reasonable hypothesis in this context. (4 marks)

Question 20 **(16 marks)**

How plasma displays work

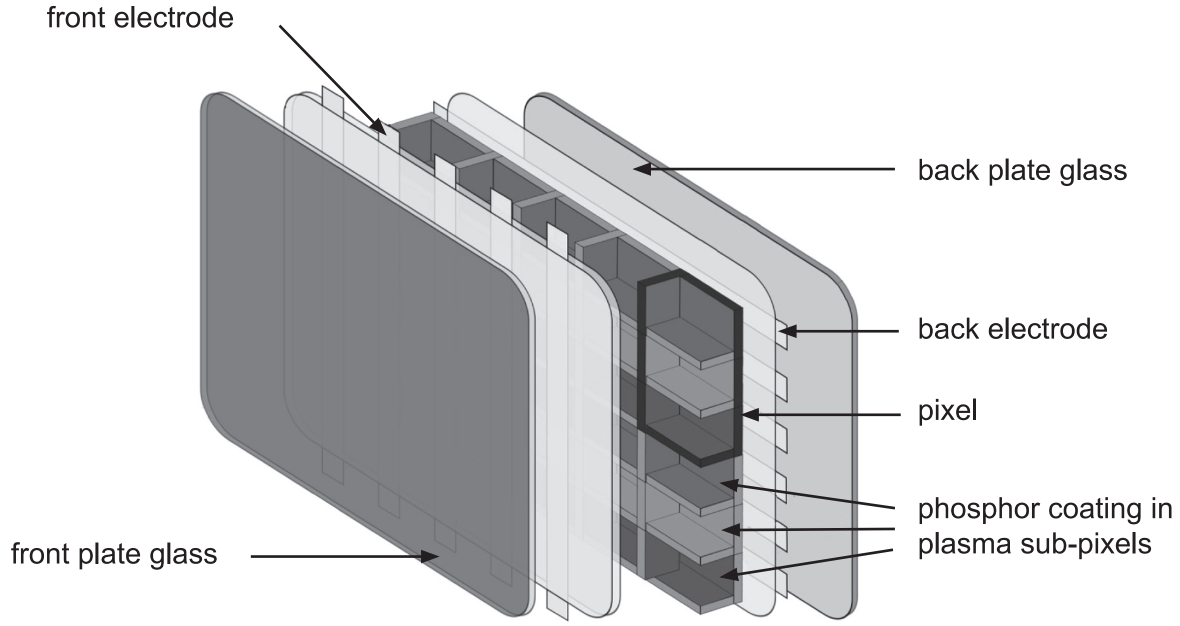
A plasma display panel typically comprises of millions of tiny compartments called 'sub-pixels' between two glass panels. Each sub-pixel contains a mixture of unreactive gases, mostly neon and xenon. These gases have electron energy levels suitable for the emission of ultraviolet (UV) photons when their atoms are excited. This occurs when a potential difference across a sub-pixel creates a current in the gas.

As electrons move through a sub-pixel, some strike gas atoms, causing the gas to emit UV photons. The UV photons then strike a phosphor layer that coats the inside of the sub-pixel, and the phosphor molecules fluoresce. An outer-orbit electron in a phosphor molecule momentarily moves from a stable lower-energy state to an unstable higher-energy state. The excited electron then returns to the stable state by a series of decays, emitting photons of lower energy than UV. These lower-energy photons are about 60% infrared and 40% visible.

Different phosphors produce different colours of visible light. A group of three sub-pixels, each of which produces one of the primary colours of visible light (red, green and blue), makes up a pixel in a plasma display.

The electrodes are strips of electrically-conducting material that also lie between the glass plates, in front of or behind the sub-pixels.

A plasma display panel



Control circuitry creates a voltage difference between the electrodes at the front and back of a sub-pixel. This sends a pulse of current through the sub-pixel. Some of the gas atoms in the sub-pixel become ionised, creating an electrically-conducting plasma consisting of atoms, free electrons and ions.

By varying the voltages across the sub-pixels, the control circuitry increases or decreases the intensity of each sub-pixel colour. The hundreds of different possible combinations of red, green and blue intensities allow the plasma screen to produce perceived colours across the entire visible spectrum.

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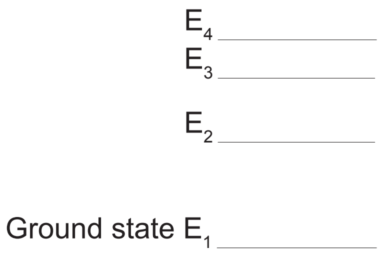
(a) Use the simplified sketch of an atom's energy levels below to explain how a phosphor produces visible light. (3 marks)



(b) Explain how plasma screens are able to create different colours of light by varying the potential difference across the individual cells. (3 marks)

Question 20 (continued)

(c) The first ionisation energy of xenon is 1.94×10^{-18} J. Determine the minimum speed in $m\ s^{-1}$ of an electron that can ionise the xenon atom through collision. (3 marks)

(d) Given that one ampere is equivalent to a charge transfer rate of one coulomb per second, determine the current flow needed in a plasma sub-pixel to generate 1.00 μW of red light at a frequency of 4.00×10^{14} Hz. (7 marks)

End of questions

Additional working space

Question number: ____________

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Question 15

ACKNOWLEDGEMENTS

Section Three

Question 19 Adapted from: Koeppel, D. (2012, May). Manakins. *National Geographic,* 221(5), pp. 62–69. Retrieved December 11, 2012, from http://ngm.nationalgeographic.com/2012/05/manakins/koeppel-text

Adapted from: Ramanujan, K. (2009, November 11). Resonating feathers produce courtship song in rare bird, researchers report. *Cornell Chronicle.* Retrieved January 1, 2013, from http://news.cornell.edu/stories/2009/11/south-american-bird-woos-mate-resonating-feathers

Adapted from Club-winged Manakin. (n.d.). *Wikipedia.* Retrieved December 25, 2012, from http://en.wikipedia.org/wiki/Club-winged_Manakin Used under the Creative Commons Attribution-ShareAlike License.

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