Government of South Australia

SACE Board of SA

External Examination 2013

2013 PHYSICS

FOR OFFICE USE ONLY

SUPERVISOR CHECK

RE-MARKED

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

27 pages, 17 questions

Tuesday 12 November: 1.30 p.m.

Time: 3 hours

Part 1 of Section A

Examination material: Question Booklet 1 (27 pages)
Question Booklet 2 (22 pages)
Question Booklet 3 (8 pages)
one SACE registration number label

Approved dictionaries and calculators may be used.

Instructions to Students

1. You will have 10 minutes to read the paper. You must not write in your question booklets or use a calculator during this reading time but you may make notes on the scribbling paper provided.

2. This paper is in two sections: Section A is divided between Question Booklet 1 and Question Booklet 2; Section B is in Question Booklet 3.

   Section A (Questions 1 to 29)
   This section consists of questions of different types (e.g. short-answer, graphical interpretation, and data and practical skills).
   Answer Part 1 of Section A (Questions 1 to 17) in the spaces provided in Question Booklet 1.
   Write on page 27 of Question Booklet 1 if you need more space to finish your answers.
   Answer Part 2 of Section A (Questions 18 to 29) in the spaces provided in Question Booklet 2.
   Write on page 22 of Question Booklet 2 if you need more space to finish your answers.

   Section B (Questions 30 and 31)
   This section consists of two extended-response questions.
   Answer Section B in the spaces provided in Question Booklet 3.
   Write on page 8 of Question Booklet 3 if you need more space to finish your answers.

3. The allocation of marks and the suggested allotment of time are:

Section A			
	Part 1	77 marks	75 minutes
	Part 2	73 marks	70 minutes
Section B			
		30 marks	35 minutes
Total		180 marks	180 minutes

4. The equation sheet is on pages 3 and 4, which you may remove from this booklet.

5. Vector quantities in this paper are indicated by arrows over the symbols.

6. Marks may be deducted if you do not clearly show all steps in the solution of problems, if you give answers with an inappropriate number of significant figures or with incorrect units, or if you do not define additional symbols. You should use diagrams where appropriate in your answers.

7. Use only black or blue pens for all work other than graphs and diagrams, for which you may use a sharp dark pencil.

8. Attach your SACE registration number label to the box at the top of this page. Copy the information from your SACE registration number label into the boxes on the front covers of Question Booklet 2 and Question Booklet 3.

9. At the end of the examination, place Question Booklet 2 and Question Booklet 3 inside the back cover of this question booklet.

STUDENT'S DECLARATION ON THE USE OF CALCULATORS

By signing the examination attendance roll I declare that:

- my calculators have been cleared of all memory
- no external storage media are in use on these calculators.

I understand that if I do not comply with the above conditions for the use of calculators I will:

- be in breach of the rules
- have my results for the examination cancelled or amended
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as the SACE Board of South Australia determines.

Remove this page from the booklet by tearing along the perforations and keep the information in front of you for reference.

EQUATION SHEET

The following tables show the symbols of common quantities and the magnitude of physical constants used in the equations. Other symbols used are shown next to the equations. Vectors are indicated by arrows. If only the magnitude of a vector quantity is used, the arrow is not used.

Symbols of Common Quantities

acceleration	$\vec{a}$	wavelength	λ	momentum	$\vec{p}$
time	t	force	$\vec{F}$	electric field	$\vec{E}$
displacement	$\vec{s}$	charge	q	kinetic energy	K
velocity	$\vec{v}$	mass	m	magnetic field	$\vec{B}$
period	T	potential difference	ΔV	electric current	I
frequency	f	work done	W		

Magnitude of Physical Constants

Acceleration due to gravity at the Earth's surface	$g = 9.8 \text{ m s}^{-2}$	Charge of the electron	$e = 1.60 \times 10^{-19} \text{ C}$
Constant of universal gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	Mass of the electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Speed of light in a vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	Mass of the proton	$m_p = 1.673 \times 10^{-27} \text{ kg}$
Coulomb's law constant	$\frac{1}{4\pi\varepsilon_0} = 9.00 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	Mass of the neutron	$m_n = 1.675 \times 10^{-27} \text{ kg}$
Planck's constant	$h = 6.63 \times 10^{-34} \text{ J s}$	Mass of the α particle	$m_\alpha = 6.645 \times 10^{-27} \text{ kg}$

Section 1: Motion in Two Dimensions

$\vec{v} = \vec{v}_0 + \vec{a}t$ — $\vec{v}$ = velocity at time t; $\vec{v}_0$ = velocity at time $t = 0$

$v^2 = v_0^2 + 2as$

$\vec{s} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$

$v_H = v\cos\theta$ — θ = angle to horizontal

$v_v = v\sin\theta$

$v = \frac{2\pi r}{T}$ — r = radius of circle

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i$ — $\vec{v}_f$ = final velocity; $\vec{v}_i$ = initial velocity

$\vec{a}_{ave} = \frac{\Delta\vec{v}}{\Delta t}$ — $\vec{a}_{ave}$ = average acceleration

$a = \frac{v^2}{r}$

$\tan\theta = \frac{v^2}{rg}$ — θ = banking angle

$F = G\frac{m_1 m_2}{r^2}$ — r = distance between masses m_1 and m_2

$v = \sqrt{\frac{GM}{r}}$ — M = mass of object orbited by satellite; r = radius of orbit

$\vec{F} = m\vec{a}$

$\vec{p} = m\vec{v}$

$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$

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

$W = Fs\cos\theta$ — θ = angle between force $\vec{F}$ and displacement $\vec{s}$

Section 2: Electricity and Magnetism

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ $r =$ distance between charges q_1 and q_2

$\vec{E} = \frac{\vec{F}}{q}$

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

$W = q\Delta V$

$E = \frac{\Delta V}{d}$ $d =$ distance between parallel plates

$F = I\Delta lB\sin\theta$ $\theta =$ angle between field $\vec{B}$ and current element $I\Delta\vec{l}$

$F = qvB\sin\theta$ $\theta =$ angle between field $\vec{B}$ and velocity $\vec{v}$

$r = \frac{mv}{qB}$ $r =$ radius of circle

$T = \frac{2\pi m}{qB}$

$K = \frac{q^2 B^2 r^2}{2m}$

Section 3: Light and Matter

$v = f\lambda$ $v =$ speed of light

$d\sin\theta = m\lambda$ $d =$ distance between slits
$\theta =$ angular position of mth maximum
$m =$ integer $(0, 1, 2, \ldots)$

$\Delta y = \frac{\lambda L}{d}$ $\Delta y =$ distance between adjacent minima or maxima
$L =$ slit-to-screen distance

$d = \frac{1}{N}$ $N =$ number of slits per metre of grating

$E = hf$ $E =$ energy of photon

$p = \frac{h}{\lambda}$

$K_{max} = hf - W$ $W =$ work function of the metal

$W = hf_0$ $f_0 =$ threshold frequency

$f_{max} = \frac{e\Delta V}{h}$ $\Delta V =$ potential difference across the tube

Section 4: Atoms and Nuclei

$E_n - E_m = hf$ $E_n - E_m =$ energy difference

$A = Z + N$ $A =$ mass number
$Z =$ atomic number
$N =$ number of neutrons

$E = mc^2$ $E =$ energy

TABLE OF PREFIXES

Refer to the following table when answering questions that involve the conversion of units:

Prefix	Symbol	Value
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

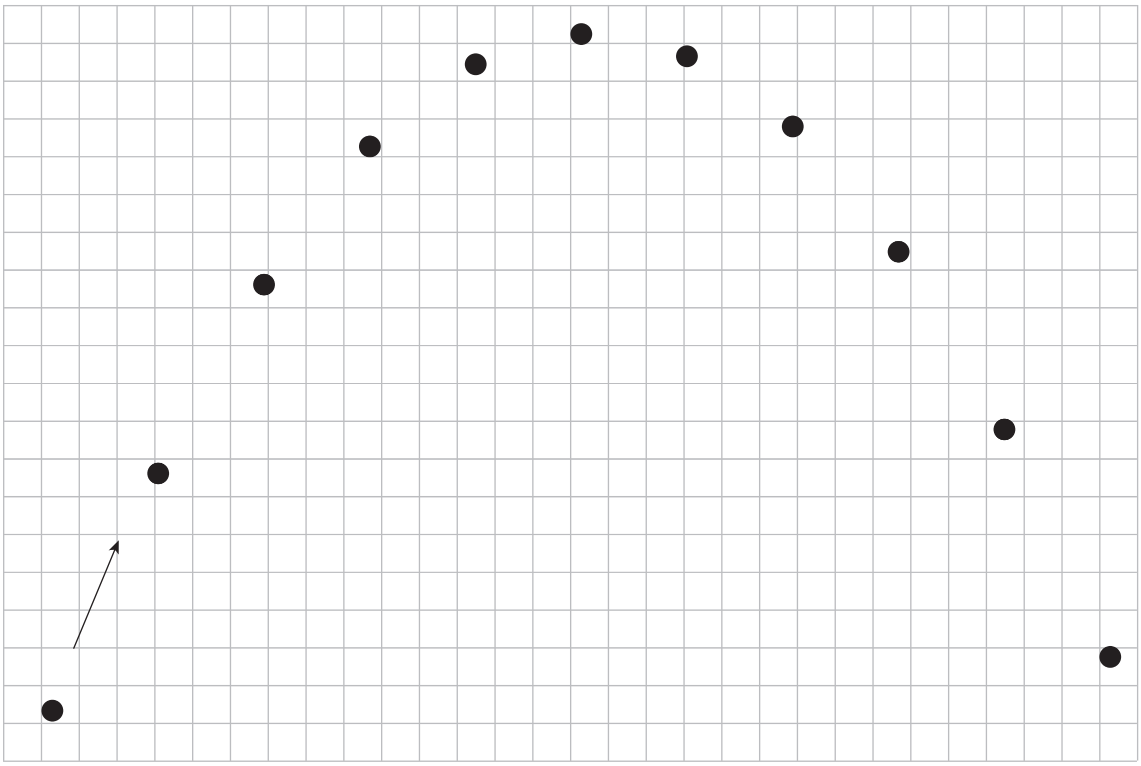
SECTION A

PART 1 (Questions 1 to 17)

(77 marks)

*Answer **all** questions in this part in the spaces provided.*

1. The multi-image diagram below shows the path of a projectile. The time between images was constant.



Using the multi-image diagram, show that the projectile did not undergo any horizontal acceleration.

____

____

____

____

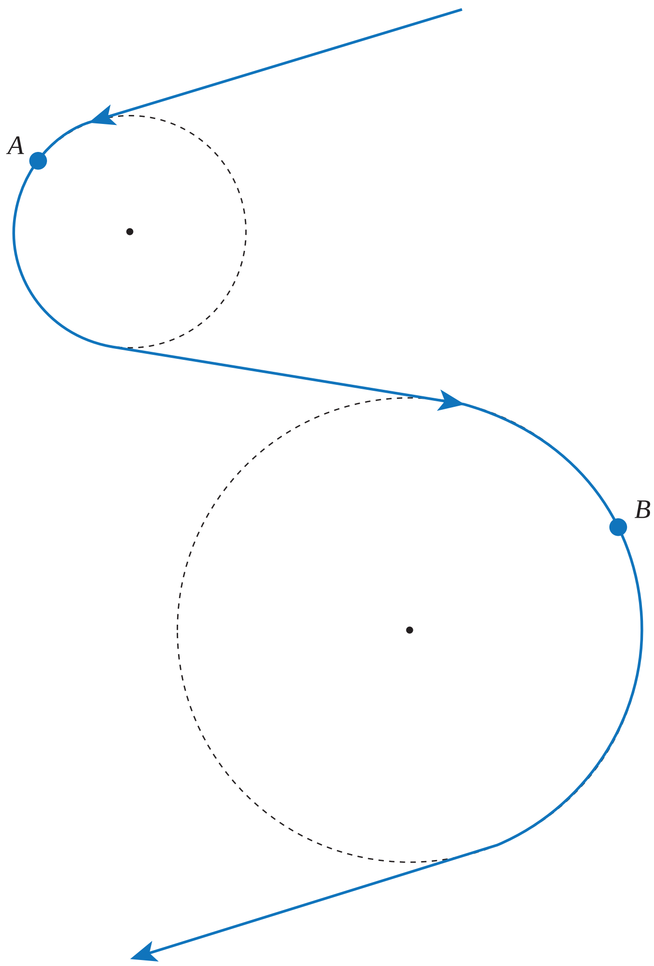
____

____ (3 marks)

2.

Source: © iStockphoto.com/amriphoto

The path taken by a skier (as in the photograph above) is shown in the diagram below. The path includes two sections where the skier moves with uniform circular motion.



Point A in the diagram on page 6 is on a circular section with a radius of $20\,\mathrm{m}$, and point B is on a circular section with a radius of $40\,\mathrm{m}$.

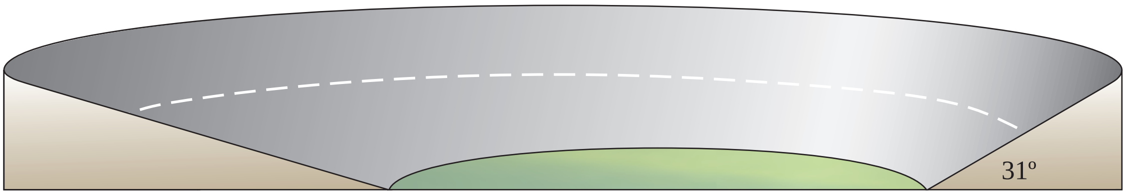
The skier travels on all sections of the path at a constant speed of $18\,\mathrm{m\,s^{-1}}$.

(a) Determine the magnitude of the ratio $\dfrac{\text{centripetal acceleration at } A}{\text{centripetal acceleration at } B}$.

(3 marks)

(b) *On the diagram on page 6*, draw vectors to show the *magnitude* and *direction* of the force causing the centripetal acceleration of the skier at points A and B. (2 marks)

3. The curves in a circular car-racing track are banked at different angles, as shown in the diagram below. The steepest curve is banked at $31°$. The track has a constant radius of $150\,m$.



(a) Determine the speed at which a car can travel around the curve banked at $31°$ without relying on friction.

____

____

____

____

____

____ (3 marks)

(b) State why the car should be able to travel at the same speed on the entire track, despite the lower banking angles of some curves.

____

____ (1 mark)

4. On 15 February 2013 the asteroid 2012 DA14 passed closer to the Earth than geostationary satellites. This was the closest an asteroid of this size had come to the Earth since regular sky surveys started. The asteroid had a mass of approximately 1.3×10^{8} kg.

This photograph cannot be reproduced here for copyright reasons.

Source: http://lupuvictor.blogspot.com.au

(a) Calculate the magnitude of the gravitational force that the Earth exerted on the asteroid when it was 2.8×10^{7} m from the centre of the Earth. The mass of the Earth is 6.0×10^{24} kg.

____

____

____

____

____

____ (2 marks)

(b) *On the diagram below*, draw vectors to show the *magnitude* and *direction* of the gravitational forces that the Earth and the asteroid exerted on each other.

Source: © Cloki/Dreamstime.com

(2 marks)

5. Some geostationary satellites are used for communications. A geostationary satellite cannot be in an orbit directly above Australia.

Source: © Cloki/Dreamstime.com

(a) Explain why a geostationary satellite cannot be in an orbit directly above Australia.

____

____

____

____

____

____

____

____ (3 marks)

(b) (i) Derive the formula for the speed of a satellite moving in a circular orbit of radius r around the Earth:

$$v = \sqrt{\frac{GM}{r}}.$$

____

____

____

____

____

____ (3 marks)

(ii) A satellite is in a geostationary orbit of radius 4.2×10^{7} m.

Calculate the speed of the satellite. The mass of the Earth is 6.0×10^{24} kg.

____

____

____

____

____ (2 marks)

(c) Many communication satellites remain in geostationary orbits after they have served their purpose, occupying positions that new satellites could hold. Scientists have proposed attaching solar sails to these satellites to accelerate them to move them out of their orbits.

Explain how the reflection of photons can be used to accelerate a satellite with a solar sail attached.

____

____

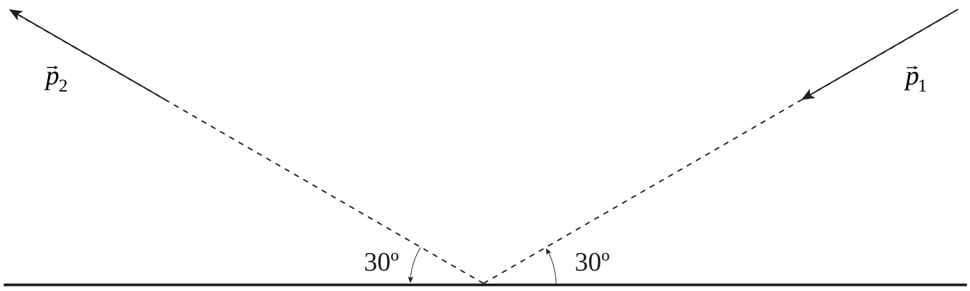
____

____

____

____ (3 marks)

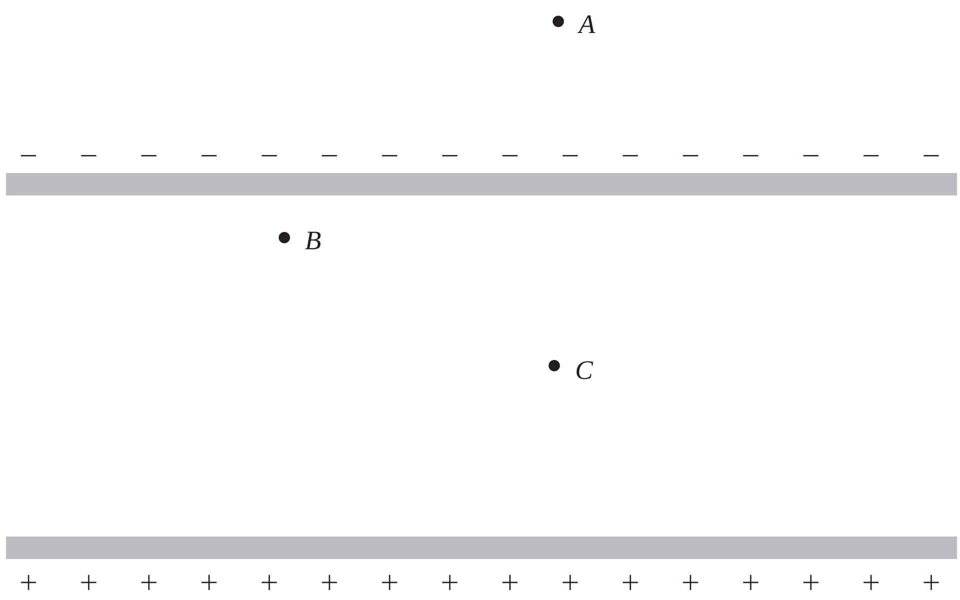
6. A ball is bounced off flat ground. The initial momentum of the ball has a magnitude of $4.54\ \text{kg m s}^{-1}$, with the momentum vector making an angle of $30°$ to the ground. After leaving the ground, the ball travels at the same speed as before it hit the ground. The diagram below shows the momentum vectors of the ball, $\vec{p}_1$ and $\vec{p}_2$, immediately before and after it hit the ground:



Using a vector diagram, calculate the change in momentum $\Delta\vec{p}$ of the ball.

(4 marks)

7. The diagram below shows a section of two very long, oppositely charged parallel conducting plates:



Compare the magnitude of the electric field produced by the conducting plates at points A, B, and C. Give reasons for your answer.

____

____

____

____

____

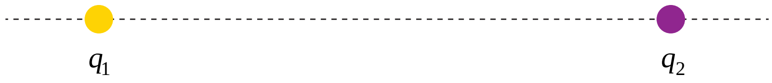
____

____

____

____ (3 marks)

8. The diagram below shows two small charged conducting spheres q_1 and q_2, with a line through their centres. Sphere q_1 has a positive charge of $4.0\,\mu C$ and sphere q_2 has a positive charge of $2.5\,\mu C$. The distance between the centres of the spheres is 0.015 m.



(a) Calculate the electrostatic force that q_1 exerts on q_2.

____

____

____

____

____

____ (3 marks)

(b) Sphere q_3 has a negative charge. It is to be placed on the line through the centres of q_1 and q_2 so that the total force on sphere q_2 is zero.

Explain why sphere q_3 must be placed to the left of sphere q_2.

____

____

____

____

____

____ (2 marks)

9. The photograph below shows a laser printer:

Source: © iStockphoto.com/by_nicholas

A corona wire transfers a negative charge to the paper so that it does not cling to the photoconductive surface of the drum of the laser printer.

Explain how a negative charge is transferred to the paper.

___

___

___

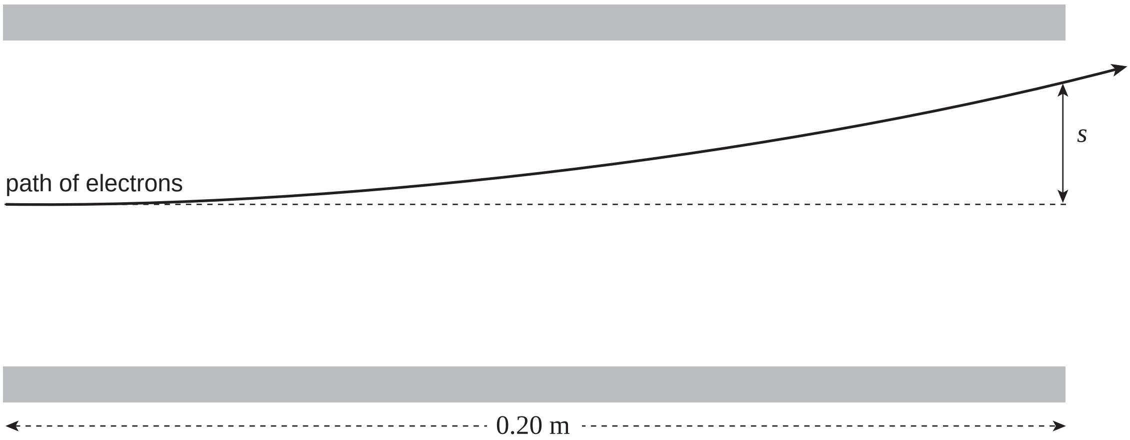
___

___

___

___ (2 marks)

10. There is an electric field between two equally and oppositely charged parallel metal plates $0.20\ \text{m}$ in length. Electrons enter the electric field midway between the plates, at a speed of $3.7\times10^{7}\ \text{m s}^{-1}$. The path of the electrons is shown in the diagram below:



Assume the electric field is uniform between the plates, and ignore the effect of gravity.

The electric field between the parallel plates causes the electrons to accelerate at $1.1\times10^{15}\ \text{m s}^{-2}$.

(a) Show that the time of flight of the electrons through the electric field between the parallel plates is $5.4\times10^{-9}\ \text{s}$.

____

____

____ (1 mark)

(b) Calculate the vertical displacement s of the electrons as they leave the electric field.

____

____

____

____

____ (2 marks)

(c) State how the vertical displacement s of the electrons would change if the distance between the parallel plates was increased, with the potential difference between the plates unchanged. Justify your answer.

____

____

____

____

____

____

____ (3 marks)

11. The photograph below shows the tungsten filament for a globe. The direction of the current flowing through the filament is indicated.

This image cannot be reproduced here for copyright reasons.

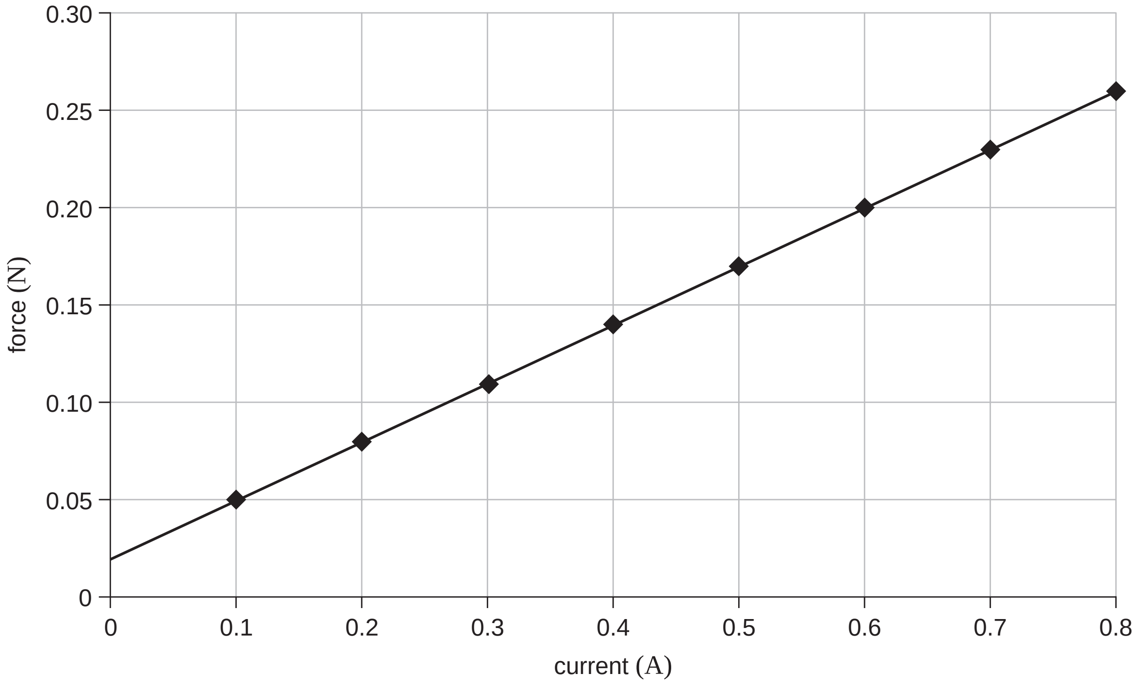
Source: http://image.made-in-china.com

On the photograph above, show the direction of the magnetic field in the coil. (1 mark)

12. A group of students conducted an experiment to verify the relationship $F = I \Delta l B \sin\theta$.
A current-carrying conductor of fixed length was placed in a constant magnetic field. The force acting on the conductor was measured for different currents.

The graph below shows the results obtained by the students.

The equation of the line of best fit is $F = 0.3I + 0.02$.



(a) State one conclusion that can be drawn from the results of this experiment. Give a reason for your answer.

____

____

____

____

____

____

____ (2 marks)

(b) The students repeated the experiment, using a weaker magnetic field, to obtain a second set of results. There was no other change to the apparatus.

On the graph above, draw the line of best fit that you predict for the second set of results. (2 marks)

PLEASE TURN OVER

13. A cyclotron is used to increase the energy of protons by $18\,\mathrm{MeV}$. The cyclotron has a magnetic field of magnitude $0.020\,\mathrm{T}$, and the potential difference across the dees is $45\,\mathrm{V}$.

(a) Determine the period of the circular motion of the protons as they are accelerated by the cyclotron.

(2 marks)

(b) Calculate the time required for the energy of the protons to increase by $18\,\mathrm{MeV}$.

(3 marks)

14. The photograph below shows a television antenna being attached to the roof of a house:

Source: http://tvantennainstallations.weebly.com

State the plane of polarisation of the electromagnetic waves received by the antenna shown above. Give a reason for your answer.

____

____

____

____

____ (2 marks)

15. A two-slit interference pattern, such as the one shown below, can be produced in the laboratory.

(a) State and explain one characteristic of the pattern shown above that confirms that it was produced from two slits rather than from many slits.

____

____

____

____

____

____

____ (2 marks)

(b) Explain how the dark fringes in the pattern above are produced.

____

____

____

____

____

____

____ (2 marks)

(c) Researchers in Germany have produced two-slit interference patterns, using the wave properties of electrons. The images below show four examples of these patterns:

These images cannot be reproduced here for copyright reasons.

Source: Adapted from www.quantum.physik.uni-mainz.de

The slit-to-screen distance and the wavelength of the matter waves were kept constant for all four images.

Identify the change that has caused the differences between the images. Justify your answer.

(3 marks)

16. A student performs two experiments to determine the wavelength of a helium–neon laser.

(a) In the first experiment the student uses two-slit interference, as shown in the photograph below:

The distance between the slits is 6.5×10^{-5} m and the slit-to-screen distance is 0.42 m. The student measures the distance between two adjacent maxima at the centre of the interference pattern on the screen as 4.0 mm.

Calculate the wavelength of the laser, using the student's results.

____

____

____

____

____

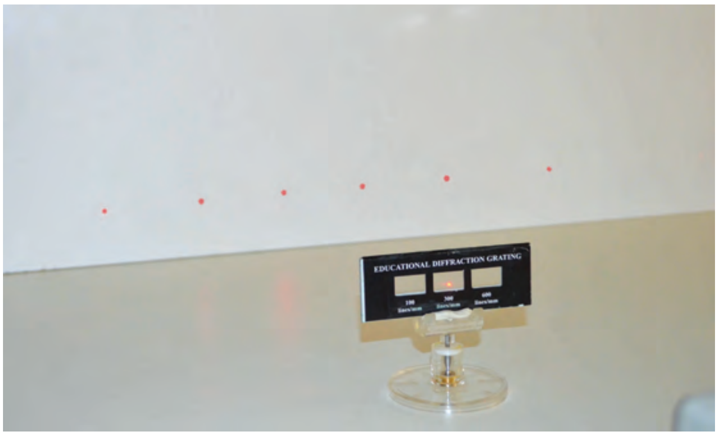
____

____

____

____ (3 marks)

(b) In the second experiment the student uses a diffraction grating, as shown in the photograph below:



The diffraction grating has 300 lines per millimetre. The student determines that the angle of the first-order maxima is $11°$.

Calculate the wavelength of the laser, using the student's results.

(3 marks)

(c) The true value of the wavelength of the laser is $632.8\,\text{nm}$.

State which experiment has produced the more accurate value. Give a reason for your answer.

(2 marks)

17. A laser airborne depth sounder (LADS) has been used to measure the depth of a body of water.

The laser pulses are detected $2.52\ \mu s$ and $2.88\ \mu s$ after transmission. The speed of the light in the water is $2.3\times10^{8}\ m\,s^{-1}$.

Calculate the depth of the water.

(3 marks)

You may write on this page if you need more space to finish your answers to Part 1 of Section A. Make sure to label each answer carefully (e.g. 5(b)(i) continued).

Government of South Australia

SACE Board of SA

External Examination 2013

2013 PHYSICS

FOR OFFICE USE ONLY

SUPERVISOR CHECK

RE-MARKED

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

PHYSICS

QUESTION BOOKLET

2

22 pages, 12 questions

Tuesday 12 November: 1.30 p.m.

Part 2 of Section A

Write your answers to Part 2 of Section A in this question booklet.

SECTION A

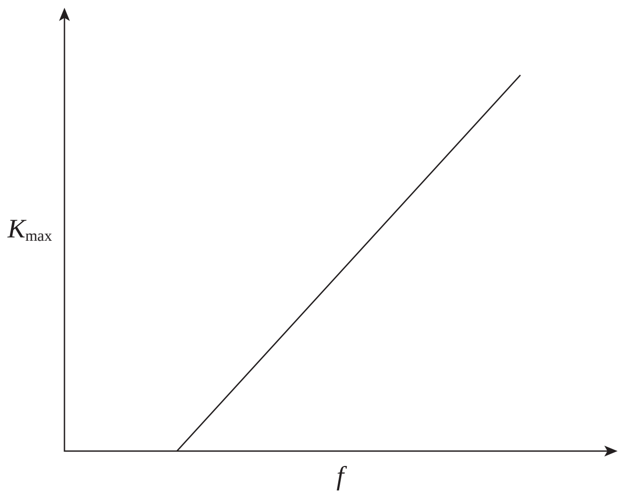
PART 2 (Questions 18 to 29)

(73 marks)

*Answer **all** questions in this part in the spaces provided.*

18. In the photoelectric effect the maximum kinetic energy of the emitted electrons depends on the frequency of the incident light.

    The values of the maximum kinetic energy K_{max} for the emitted electrons can be graphed against frequency f, as shown in the diagram below. The gradient of the line of best fit can give a value for Planck's constant.



Using the law of conservation of energy, show that $K_{max} = hf - W$, and hence explain why the gradient of the line of best fit can give a value for Planck's constant.

(3 marks)

19. The photograph on the right shows a medical scientist using an electron microscope.

In an electron microscope a beam of short-wavelength electrons is produced by accelerating electrons through a potential difference.

Medical scientists often use electron microscopes because they can produce a higher resolution than light microscopes.

Source: © iStockphoto.com/LeggNet

(a) Using the law of conservation of energy, show that the magnitude of the momentum p of the electrons (of mass m and charge e) that have been accelerated by a potential difference of ΔV is given by

$$p = \sqrt{2me\Delta V}.$$

(4 marks)

(b) The resolution of an electron microscope can be improved by changing the potential difference.

State whether the potential difference must be increased or decreased to improve the resolution. Justify your answer, using the equation in part (a).

(4 marks)

20. X-rays are produced by accelerating electrons towards a target in an evacuated tube. The target must be cooled.

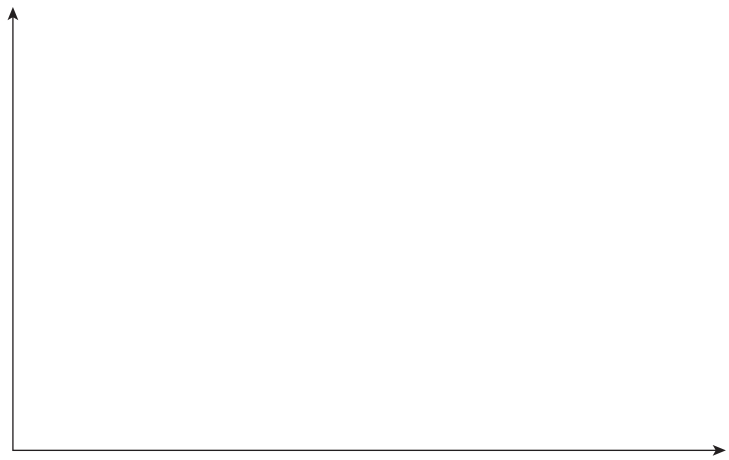
(a) State why the target gets hot.

(1 mark)

(b) *On the axes below*, sketch a graph of a typical X-ray spectrum.

Label the:

- quantities represented on each axis
- three main features of the spectrum.



(4 marks)

21. The diagram below shows the spectrum emitted by excited hydrogen gas:

This image cannot be reproduced here for copyright reasons.

Source: Adapted from www.learner.org

(a) Using the scale on the diagram above, determine the value of λ_1.

____ (1 mark)

(b) Calculate the energy of the photons of wavelength λ_1.

____

____

____

____

____ (2 marks)

22. The image below shows the line absorption spectra of a mixture of different atoms in gaseous state:

Account for the presence of absorption lines in the spectra shown above.

____

____

____

____

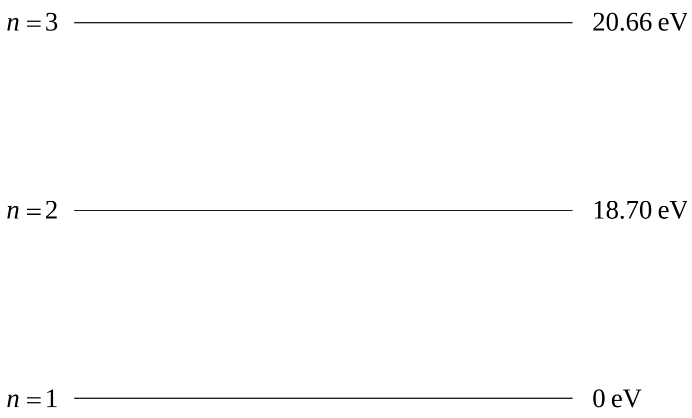
____

____

____

____ (3 marks)

23. The diagram below shows some of the energy levels of neon:



(a) State why neon will not absorb photons of 20.10 eV.

____

____ (1 mark)

(b) The $n = 3$ energy level is a metastable state.

Explain how the presence of a metastable state makes neon a suitable gain medium for a laser.

____

____

____

____

____

____

____

____ (3 marks)

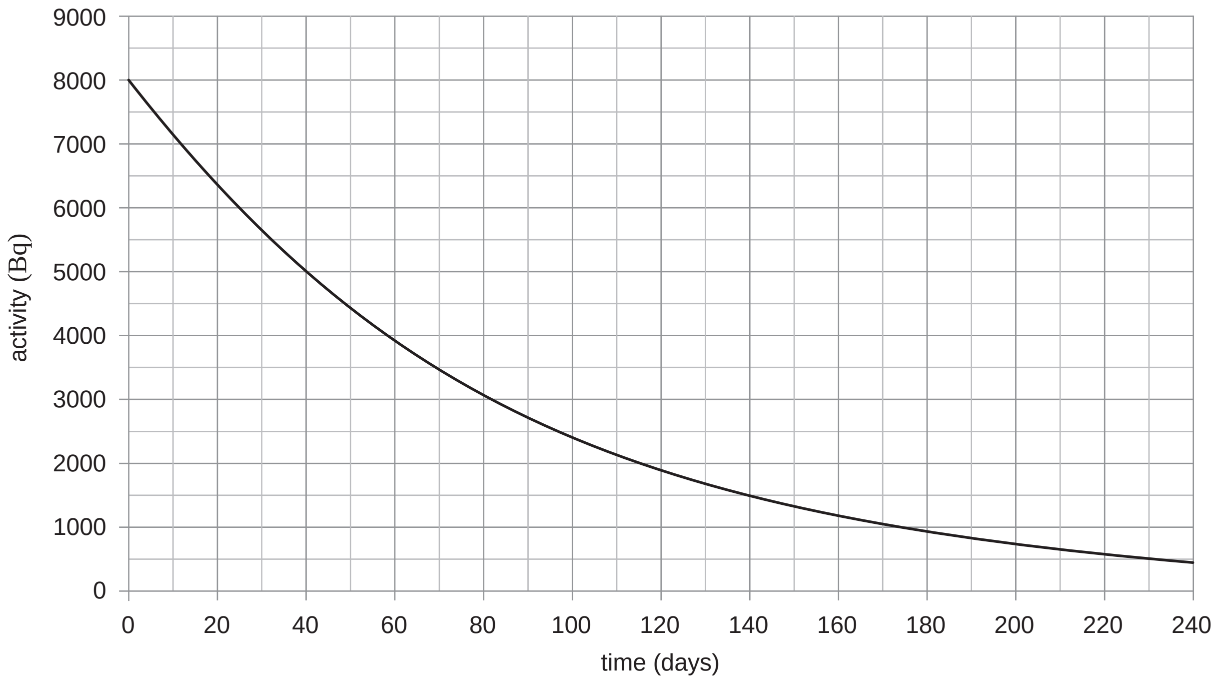
PLEASE TURN OVER

24. The following two radioisotopes of iodine undergo gamma decay:

- iodine-123, which has a half-life of 13 hours
- iodine-125.

Both isotopes can be used in medical imaging because the gamma photons can be detected outside the body.

The graph below shows the activity of a sample of iodine-125 measured over 240 days:



(a) (i) Determine the half-life of iodine-125.

(2 marks)

(ii) Hence explain why a smaller dose of iodine-123 than of iodine-125 can be used in medical imaging.

(2 marks)

(b) A patient is given a dose of iodine-123.

Determine the time needed for the activity of the dose to drop to 3.125% of its original activity.

____

____

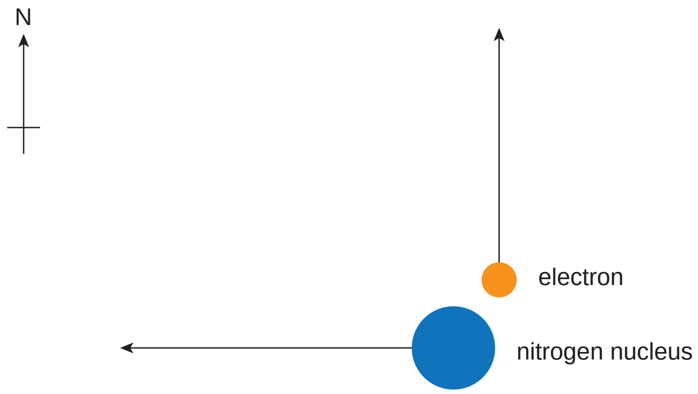
____

____

____ (3 marks)

25. Carbon-14 undergoes beta minus decay, releasing an electron and producing a nitrogen nucleus.

In a particular decay of a stationary carbon-14 nucleus, the electron and the nitrogen nucleus travel at right angles to each other, as shown in the diagram below. The diagram also shows the direction of true north.



The electron travels with a momentum of 4.6×10^{-23} kg m s^{-1}. The nitrogen nucleus travels with a momentum of 4.5×10^{-23} kg m s^{-1}.

(a) Determine the magnitude and direction of the sum of the momenta of the nitrogen nucleus and the electron.

____

____

____

____

____

____

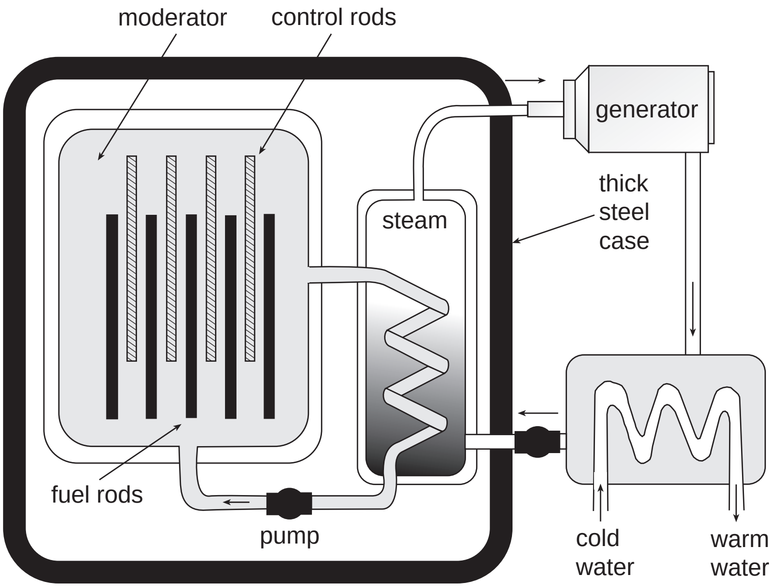
____

____ (4 marks)

(b) Using the law of conservation of momentum, justify the emission of an antineutrino in this decay of carbon-14.

(2 marks)

26. The diagram below shows the main components of a nuclear fission reactor:



Boron is used in some nuclear fission reactors because of its ability to absorb neutrons. The table below shows some of the properties of boron:

Element	Atomic Number	Ability to Scatter Neutrons	Ability to Absorb Neutrons
boron	5	medium	high

(a) State whether boron is likely to be used as a moderator or within control rods in a nuclear fission reactor. Give a reason for your answer.

____

____

____

____

____________________ (2 marks)

(b) A typical neutron-absorption reaction of boron is shown below:

$$^{10}_{5}\mathrm{B} + ^{1}_{0}\mathrm{n} \longrightarrow ^{7}_{3}\mathrm{Li} + ^{4}_{2}\mathrm{He}.$$

The masses of the particles involved in the reaction are shown in the table below:

Particle	Mass (kg)
$^{10}_{5}\mathrm{B}$	1.6627×10^{-26}
$^{1}_{0}\mathrm{n}$	1.6749×10^{-27}
$^{7}_{3}\mathrm{Li}$	1.1650×10^{-26}
$^{4}_{2}\mathrm{He}$	6.6465×10^{-27}

Determine the amount of energy released in this nuclear reaction. Give your answer in MeV.

____

____

____

____

____

____

____

____

____

____

____ (5 marks)

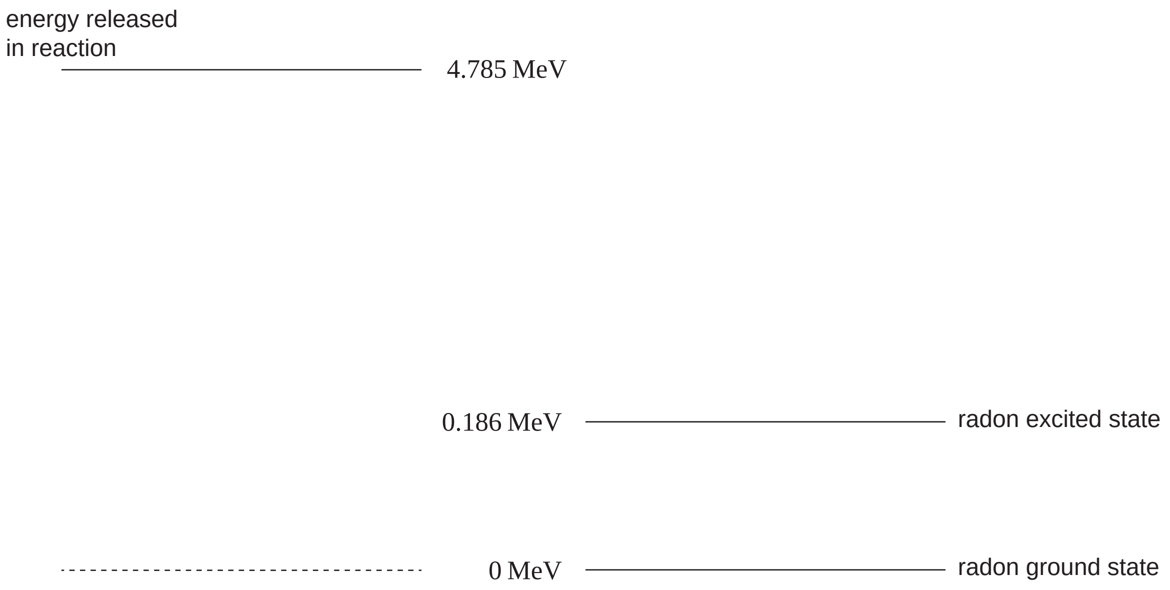
27. A stationary radium nucleus decays to the radon nucleus $^{222}_{86}\mathrm{Rn}$ by alpha decay.

(a) Balance the decay reaction below by writing the atomic and mass numbers of the radium nucleus and the alpha particle.

$$\mathrm{Ra} \longrightarrow {}^{222}_{86}\mathrm{Rn} + \alpha$$

(3 marks)

(b) The alpha decay of radium to radon can be shown on the diagram below:



(i) Determine the maximum kinetic energy emitted in the alpha decay of radium to radon. Give your answer in MeV.

______________________________ (1 mark)

(ii) Determine the maximum-energy gamma photon that can be emitted after the alpha decay of radium to radon. Give your answer in MeV.

______________________________ (1 mark)

28. Using the properties of the strong nuclear force and the electrostatic force between nuclei, explain why high kinetic energies are needed for fusion to occur.

(3 marks)

SACE
BOARD
OF SOUTH
AUSTRALIA

29. The photograph below shows a sonometer. A metal wire (similar to a guitar string) is held taut on the sonometer by suspended masses. The wire vibrates when it is plucked.

Students conduct an experiment, using a sonometer. The tension in the wire is varied by increasing the mass that is suspended from one end of the wire. The lowest frequency of the vibrating wire is measured (in hertz), using an appropriate app (application) on a smartphone, as shown in the photograph on the right.

Source: Adapted from
© Lenta/Dreamstime.com

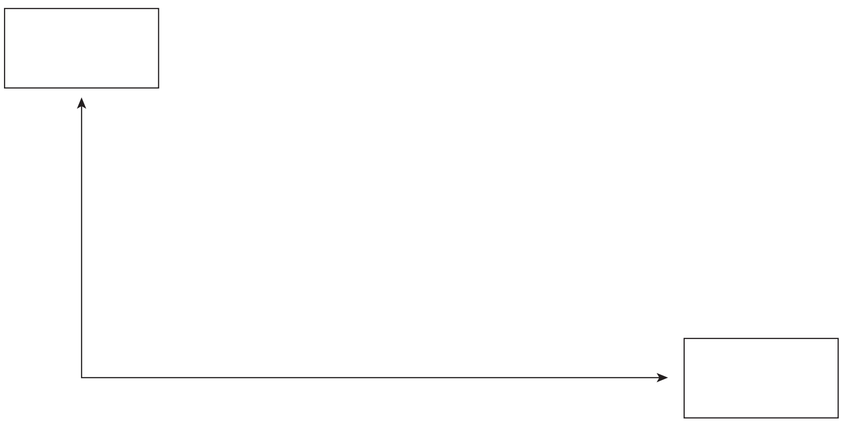
The length of the wire is held constant at $L = 0.325$ m during the experiment.

Research undertaken by the students before conducting the experiment revealed the expected relationship between the frequency (f, in hertz) and the mass (m, in kilograms) to be

$$f^2 = \frac{mg}{4\rho L^2},$$

where ρ is the linear density of the wire (in kg m^{-1}) and g is the acceleration due to gravity.

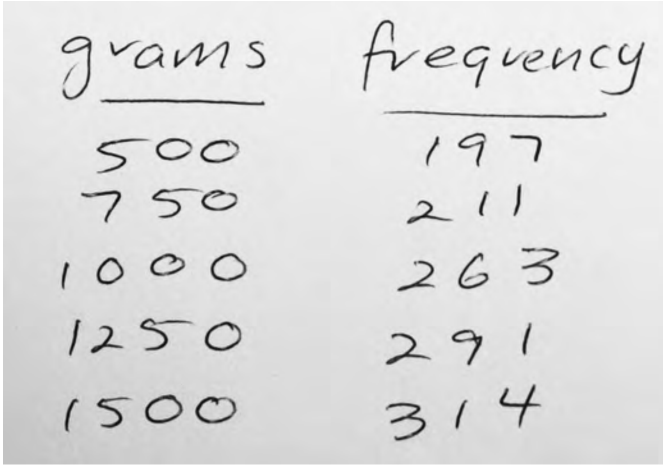
(a) Write in the boxes below to show which quantities should be plotted on the horizontal axis and the vertical axis so that, when graphed, the data will give the expected linear relationship between the independent and dependent variables in the experiment.



(2 marks)

PLEASE TURN OVER

(b) The data recorded by the students are shown below:



grams	frequency
500	197
750	211
1000	263
1250	291
1500	314

Present the data collected in the experiment, and any values calculated from the data, in a table to enable you to draw the graph described in part (a) on page 17.

(3 marks)

(c) *On the page opposite*, plot the data and draw a line of best fit. (6 marks)

(d) Determine the gradient of your line of best fit. Include the units of the gradient.

(3 marks)

(e) Using the gradient of your line of best fit, find the magnitude of ρ, the linear density of the wire.

(3 marks)

(f) Suggest one way of improving the experiment.

Explain how your suggestion would improve the experiment.

(2 marks)

You may write on this page if you need more space to finish your answers to Part 2 of Section A. Make sure to label each answer carefully (e.g. 19(a) continued).

Government of South Australia

SACE Board of SA

External Examination 2013

2013 PHYSICS

SACE REGISTRATION NUMBER			
SEQ	FIGURES	CHECK LETTER	BIN

PHYSICS

QUESTION BOOKLET

3

8 pages, 2 questions

Tuesday 12 November: 1.30 p.m.

Section B

Write your answers to Section B in this question booklet.

SACE
BOARD
OF SOUTH
AUSTRALIA

SECTION B (Questions 30 and 31)

(30 marks)

Questions 30 and 31 are extended-response questions. Answer ***both*** *questions.*

Write your answers in this question booklet:

- Question 30, on pages 4 and 5, is worth 16 marks.
- Question 31, on pages 6 and 7, is worth 14 marks.

In answering these questions, you should:

- communicate your knowledge clearly and concisely
- use physics terms correctly
- present information in an organised and logical sequence
- include only information that is related to the question.

You may use clearly labelled diagrams that are related to your answers.

30. Two balls are launched with the same initial velocity, at an angle θ above the horizontal, as shown in the diagram below. If different forces of air resistance act on the balls, the motion of the balls will be different.

- Identify *two* properties of the balls that affect the size of the forces of air resistance, and describe how each of these properties affects the forces of air resistance.
- Explain the effect that air resistance has on the time the balls take to reach their maximum height.

(16 marks)

31. Alpha, beta, and gamma radiations can be identified by the paths they take in a uniform magnetic field.

- Explain how the features of the different paths allow the different radiations to be identified.

(14 marks)

You may write on this page if you need more space to finish your answers to Questions 30 and 31. Make sure to label each answer carefully (e.g. 31 continued).