SSABSA
SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA
EXTERNAL EXAMINATION 2007

2007 PHYSICS

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET
1
22 pages, 10 questions

Tuesday 6 November: 9 a.m.

Time: 3 hours

Part 1 of Section A

Examination material: Question Booklet 1 (22 pages)
Question Booklet 2 (16 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 divided between Question Booklet 2 and Question Booklet 3.

   Section A (Questions 1 to 17)
   This section consists of short-answer and extended questions.
   Answer Part 1 of Section A (Questions 1 to 10) in the spaces provided in Question Booklet 1.
   Write on page 22 of Question Booklet 1 if you need more space to finish your answers.
   Answer Part 2 of Section A (Questions 11 to 17) in the spaces provided in Question Booklet 2.
   Write on page 16 of Question Booklet 2 if you need more space to finish your answers.

   Section B (Questions 18 to 20)
   This section consists of one experimental skills question and two extended-response questions.
   Answer Part 1 of Section B (Question 18) in the spaces provided in Question Booklet 2.
   Write on page 16 of Question Booklet 2 if you need more space to finish your answers.
   Answer Part 2 of Section B (Questions 19 and 20) 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	75 marks	72 minutes
Part 2	60 marks	58 minutes
Section B		
Part 1	15 marks	15 minutes
Part 2	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 represented by symbols in bold type.

6. Marks may be deducted if you do not clearly show all steps in the solution of problems 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 marks for the examination cancelled or amended;
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as SSABSA determines.

EQUATION SHEET

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

Symbols of Common Quantities

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

Physical Constants

Acceleration of 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

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

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

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

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

$v_v = v \sin\theta$

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

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

$\bar{\mathbf{a}} = \frac{\Delta\mathbf{v}}{\Delta t}$ — $\bar{\mathbf{a}}$ = 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

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

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

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

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

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

PLEASE TURN OVER

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

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

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

$W = q\Delta V$

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

$\boldsymbol{a} = \frac{q\boldsymbol{E}}{m}$

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

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

$r = \frac{mv}{qB}$ 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

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

$\Delta y = \frac{\lambda L}{d}$ Δy = 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

$f_{max} = \frac{e\Delta V}{h}$ ΔV = 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}

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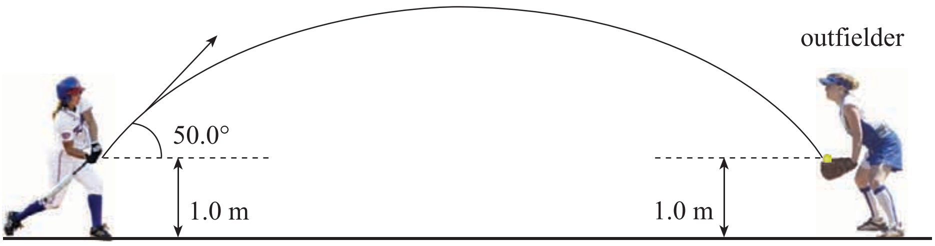
SECTION A

Part 1 (Questions 1 to 10)

(75 marks)

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

1. A softball is hit at a height of 1.0 m above the ground with an initial velocity of 34 m s^{-1} at 50.0º above the horizontal, as shown in the diagram below. The ball is caught by an outfielder as it returns to a height of 1.0 m above the ground. *Ignore the effects of air resistance*.



[*This diagram is not drawn to scale.*]

(a) Calculate the time the ball takes to reach the outfielder.

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____(3 marks)

(b) A tennis ball is now hit at the same height and with the same initial velocity as for the softball in part (a). The two balls are shown in the photograph below:

tennis ball　　　　softball

State *one* difference between the balls and describe how it affects the force of air resistance.

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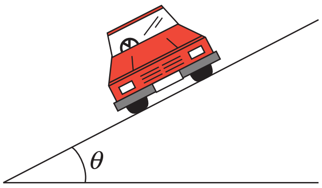
______________________________________(2 marks)

2. The exit of a freeway has been designed so that a car can travel safely around the curved section of the ramp when the road is wet. The banking angle θ enables a car to travel around the curved section of the ramp without relying on friction, as shown in the diagram below:



(a) On the diagram above, draw and label a vector to show the normal force acting on the car. (1 mark)

(b) Using the vector you have drawn in part (a), explain how the banking angle enables the car to travel around the curved section of the ramp without relying on friction.

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____(3 marks)

(c) The curved section of the ramp has a radius of 150 m and a banking angle of 11°.

Calculate the maximum speed at which the car can travel around the curve without relying on friction.

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____(2 marks)

3. The binary star system known as Sirius is shown, at one point in time, in the diagram below.

The mass of Sirius A, measured using data obtained from the Hubble Space Telescope in 2005, is much larger than that of its partner star, Sirius B.

[*This diagram is not drawn to scale.*]

(a) On the diagram above, draw vectors to show the gravitational force acting on each of these stars at this point in time. (2 marks)

(b) Explain why Newton's law of universal gravitation is consistent with Newton's third law of motion.

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____ (3 marks)

4. The polar-orbiting satellite NOAA-N was launched in May 2005, as shown in the photograph below:

Source: www.nasa.gov/mission_pages/noaa-n/main/index.html

The satellite is now moving in a circular orbit above the Earth's surface at an altitude of 870 km. The mass of the Earth is 5.97×10^{24} kg and its mean radius is 6.38×10^{6} m.

(a) Show that the orbital speed of the satellite is 7.41×10^{3} m s^{-1}.

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____(2 marks)

(b) Calculate the magnitude of the acceleration due to gravity at the satellite's altitude.

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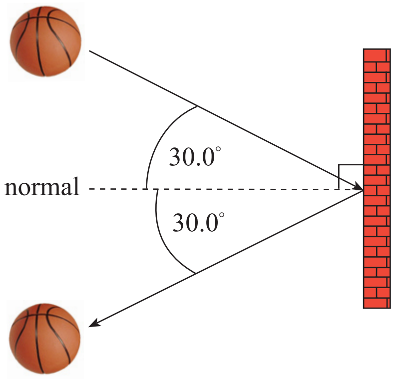
____(3 marks)

(c) Explain why the centre of the circular orbit of any Earth satellite must coincide with the centre of the Earth.

(3 marks)

5. A basketball moving at a speed of 5.0 m s^{-1} collides with a wall. The basketball is in contact with the wall for 0.050 s and bounces off the wall without a change of speed.

The basketball is moving at 30.0º to the normal immediately before and after the collision, as shown in the diagram below:



[*This diagram is not drawn to scale.*]

(a) (i) Draw a labelled vector diagram to determine the change in velocity of the basketball as a result of the collision with the wall. *Use the initial and final velocity vectors in your diagram.*

(3 marks)

(ii) Hence show that the magnitude of the change in velocity of the basketball as a result of the collision is 8.7 m s^{-1}.

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____ (3 marks)

(b) Calculate the magnitude of the average acceleration of the basketball during the collision.

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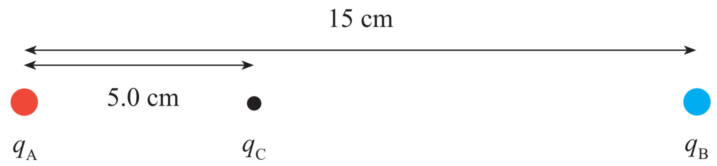
____(2 marks)

6. Charges q_A and q_B are in a vacuum and have a distance of 15 cm between their centres. Charge q_C is placed on the line joining q_A and q_B, at a point where it experiences zero net force. This point is 5.0 cm from charge q_A, as shown in the diagram below:



[*This diagram is not drawn to scale.*]

Using proportionality, calculate the ratio of charge q_B to charge q_A.

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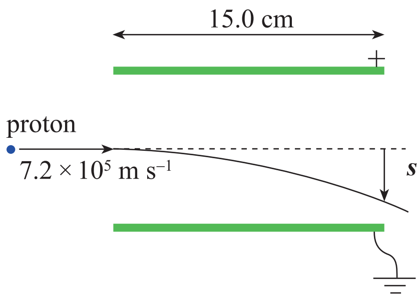
____ (4 marks)

7. A proton is fired horizontally into a vacuum halfway between two oppositely charged parallel conducting plates at a speed of 7.2×10^5 m s^{-1}, as shown in the diagram below. The plates are 15.0 cm long and between them is a uniform electric field of 1.0×10^4 V m^{-1} directed downwards. *Ignore end effects and the effect of gravity*.



(a) Show that the time of flight of the proton through the uniform electric field is 2.1×10^{-7} s.

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____(1 mark)

(b) Calculate the vertical deflection ***s*** of the proton while it is in the uniform electric field.

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____(3 marks)

(c) Explain why the motion of the proton is similar to that of a projectile launched horizontally near the surface of the Earth. *Ignore the effects of air resistance*.

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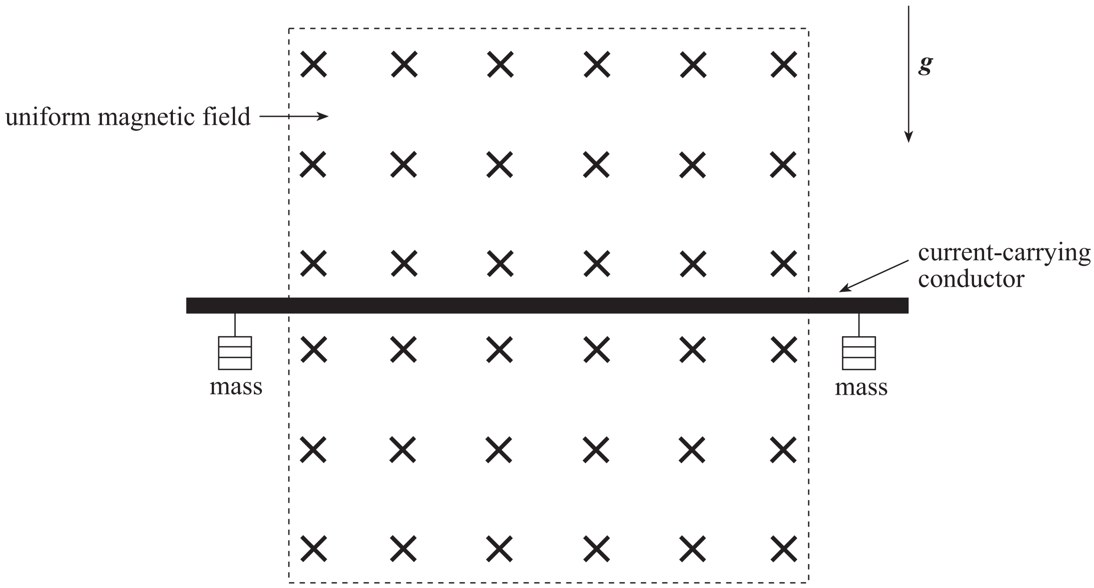
____(4 marks)

8. The diagram below represents an experiment designed to investigate the relationship between magnetic field strength and magnetic force.

A horizontal current-carrying conductor is placed so that it is perpendicular to a uniform magnetic field and the acceleration due to gravity at the Earth's surface. Small masses are added to the conductor to increase its total weight. After this addition of mass the magnetic field strength is increased until the magnetic force on the conductor is equal in magnitude, but opposite in direction, to its total weight. The strength of this magnetic field is then recorded.



[*This diagram is not drawn to scale.*]

(a) State the direction of the current in the conductor.

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____(1 mark)

(b) State *one* observation that would indicate that the magnetic force on the conductor is equal in magnitude to its total weight.

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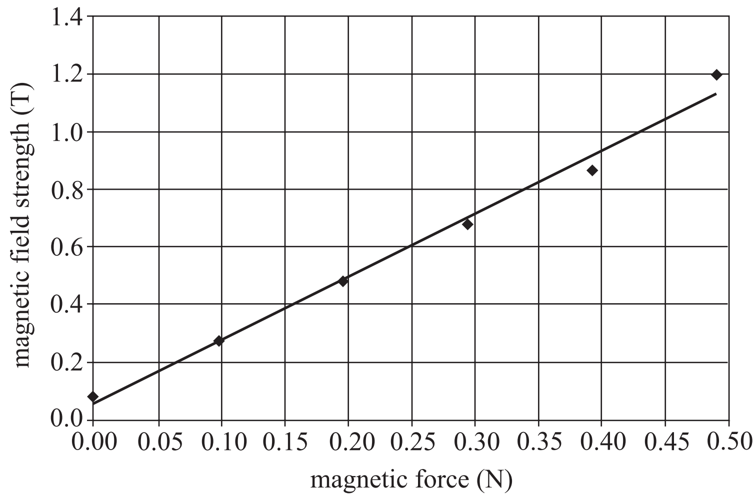
____(1 mark)

(c) The total weight of the conductor is used to determine the magnetic force on the conductor. A graph of magnetic field strength versus magnetic force for the results of the experiment is shown below:



(i) Using the graph, state evidence that a systematic error has occurred in this experiment and identify *one* possible source of the error.

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____(2 marks)

(ii) Using the graph, state evidence that random errors have occurred in this experiment and suggest how their effect could be minimised.

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____(2 marks)

(iii) (1) Using the units shown on the graph, determine the unit of the gradient of the line of best fit.

____(1 mark)

(2) By using the expected relationship between the magnetic field strength and the magnetic force, state an alternative unit to the one you determined in part (1).

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____(2 marks)

9. An oscillating electric charge produces electromagnetic radiation.

(a) Describe the fields produced by an oscillating electric charge.

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____(2 marks)

(b) Calculate the wavelength in a vacuum of electromagnetic radiation produced by an electron oscillating with a frequency of 6.99×10^{14} Hz. Write your answer in nanometres.

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____(3 marks)

(c) When electromagnetic radiation is incident on a material, electrons may be emitted from the material via the photoelectric effect.

(i) Show that the energy of a photon of frequency 6.99×10^{14} Hz is 4.63×10^{-19} J.

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____(1 mark)

(ii) Calculate the range of possible energies of electrons emitted by photons of this frequency from a metal with a work function of 2.14 eV.

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____(3 marks)

(iii) Explain why the energies of the electrons emitted from the metal would *not* be affected by the intensity of the incident electromagnetic radiation.

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____ (3 marks)

10. (a) Give *one* reason why light from an incandescent source is not coherent. Explain your answer.

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____(2 marks)

(b) A beam of laser light illuminates two slits that are separated by a distance of 0.15 mm. An interference pattern is observed on a screen that is parallel to the plane of the slits and 2.50 m from the slits.

Calculate the fringe separation of the interference pattern observed if the laser light has a wavelength of 6.94×10^{-7} m.

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____(3 marks)

(c) The beam of laser light is replaced with a parallel beam of electrons of constant energy. The same two-slit apparatus is used but the interference pattern is now observed on a fluorescent screen. The angular positions of the maxima of the interference pattern produced by the beam of electrons are the same as for the laser light.

(i) Explain why the de Broglie wavelength of the electrons in the beam is 6.94×10^{-7} m.

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____(2 marks)

(ii) Calculate the energy of an electron in the beam.

(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. 7(b) continued).

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SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA
EXTERNAL EXAMINATION 2007

2007 PHYSICS

SACE REGISTRATION NUMBER

SEQ	FIGURES	CHECK LETTER	BIN

PHYSICS

QUESTION BOOKLET
2
16 pages, 8 questions

Tuesday 6 November: 9 a.m.

Part 2 of Section A and Part 1 of Section B

Write your answers to Part 2 of Section A and Part 1 of Section B in this question booklet.

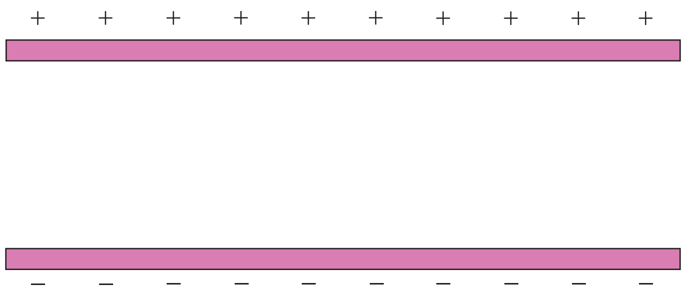
SECTION A

Part 2 (Questions 11 to 17)

(60 marks)

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

11. (a) Sketch the electric field between, and at the ends of, the finite oppositely charged parallel plates in the diagram below.



(3 marks)

(b) Xenon ions (Xe^{+}) of mass 2.2×10^{-25} kg enter the electric field through a small hole in the centre of the positive plate that is shown in part (a). These ions are accelerated by a potential difference of 1315 V between the plates.

(i) Show that the increase in kinetic energy of one of the xenon ions is 2.10×10^{-16} J.

(2 marks)

(ii) Show that the increase in speed of one of the xenon ions is 4.4×10^{4} m s^{-1}.

(2 marks)

(iii) Calculate the magnitude of the change in momentum of one of the xenon ions.

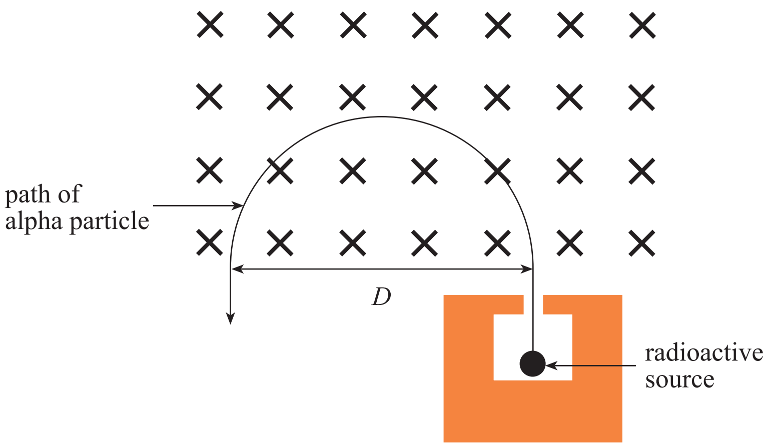
(2 marks)

(c) Xenon ions accelerated by an electric field may be used to increase the velocity (in a straight line) of a spacecraft.

Explain qualitatively, *in terms of the law of conservation of momentum*, the increase in velocity of a spacecraft as a result of the emission of discrete xenon ions. *Assume the effects of gravity are negligible*.

(4 marks)

12. An alpha particle of charge q_α is released from a radioactive source and enters a vacuum where there is a uniform magnetic field directed perpendicularly into the page, as shown in the diagram below:



[*This diagram is not drawn to scale.*]

(a) (i) Explain why the alpha particle follows a circular path.

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____ (3 marks)

(ii) Derive the formula $D = \frac{2m_\alpha v}{q_\alpha B}$ for the diameter of the circular path followed by the alpha particle above.

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____ (4 marks)

(b) An electron enters the magnetic field, travelling in the same direction and with the same speed as the alpha particle in part (a).

Explain qualitatively the *direction* and *diameter* of the path followed by the electron compared with the alpha particle.

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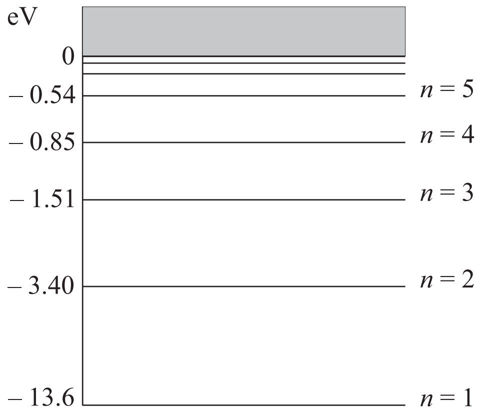
____ (4 marks)

13. Explain how the interference of laser light can be used to read the information stored on a compact disc.

(4 marks)

14. Some of the energy levels of hydrogen are shown in the diagram below:



[*This diagram is not drawn to scale.*]

(a) On the diagram above, draw an arrow to represent the transition that produces the lowest-energy photon and ends in the ground state. (1 mark)

(b) Determine the frequency of a photon produced when an electron makes a transition from the n = 3 to the n = 2 energy level.

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____ (4 marks)

15. A cyclotron is used to produce a radioisotope that is required for positron emission tomography (PET).

(a) The cyclotron has a radius of 1.00 m and accelerates protons $\left({}_{1}^{1}\text{H ions}\right)$ to an energy of 10.0 MeV.

Show that the magnetic field strength needed to achieve this energy is 0.457 T.

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____ (3 marks)

(b) These high-energy protons are then made to collide with ${}_{8}^{18}\text{O}$ nuclei.

(i) Complete the following equation, clearly indicating the mass number and the atomic number of the radioisotope *X* produced.

$${}_{1}^{1}\text{H} + {}_{8}^{18}\text{O} \longrightarrow {}_{Z}^{A}X + {}_{0}^{1}\text{n}$$

A = ________________________

Z = ________________________ (2 marks)

(ii) Identify the *two* laws used in completing the equation above.

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____ (2 marks)

(c) The radioisotope *X* that is produced in turn decays and produces a positron, which undergoes positron–electron annihilation and produces two photons.

(i) Calculate the energy of each of the two photons produced in this positron–electron annihilation*, given that they have equal and opposite momenta*.

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____ (3 marks)

(ii) Explain why the photon detectors used in PET must be placed in a ring surrounding the patient.

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____ (2 marks)

16. $^{232}_{92}U$ has a nuclear mass of 3.85215×10^{-25} kg.

(a) Write a definition for the binding energy of a nucleus.

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____ (2 marks)

(b) Calculate the binding energy of this uranium nucleus.

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____ (4 marks)

17. The following reaction shows the fission of ${}^{235}_{92}U$ which is induced when a neutron is absorbed:

$$ {}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n $$

The products have a large amount of kinetic energy.

(a) Explain why the neutrons have to be slowed down in order to produce fission in ${}^{235}_{92}U$.

(2 marks)

(b) Explain how the neutrons are slowed down in a nuclear reactor.

(3 marks)

(c) The Australian Government is investigating nuclear power generated by fission as a possible future source of power.

Discuss *one* scientific advantage and *one* disadvantage of nuclear fission in comparison with fossil fuel power stations.

(4 marks)

SECTION B

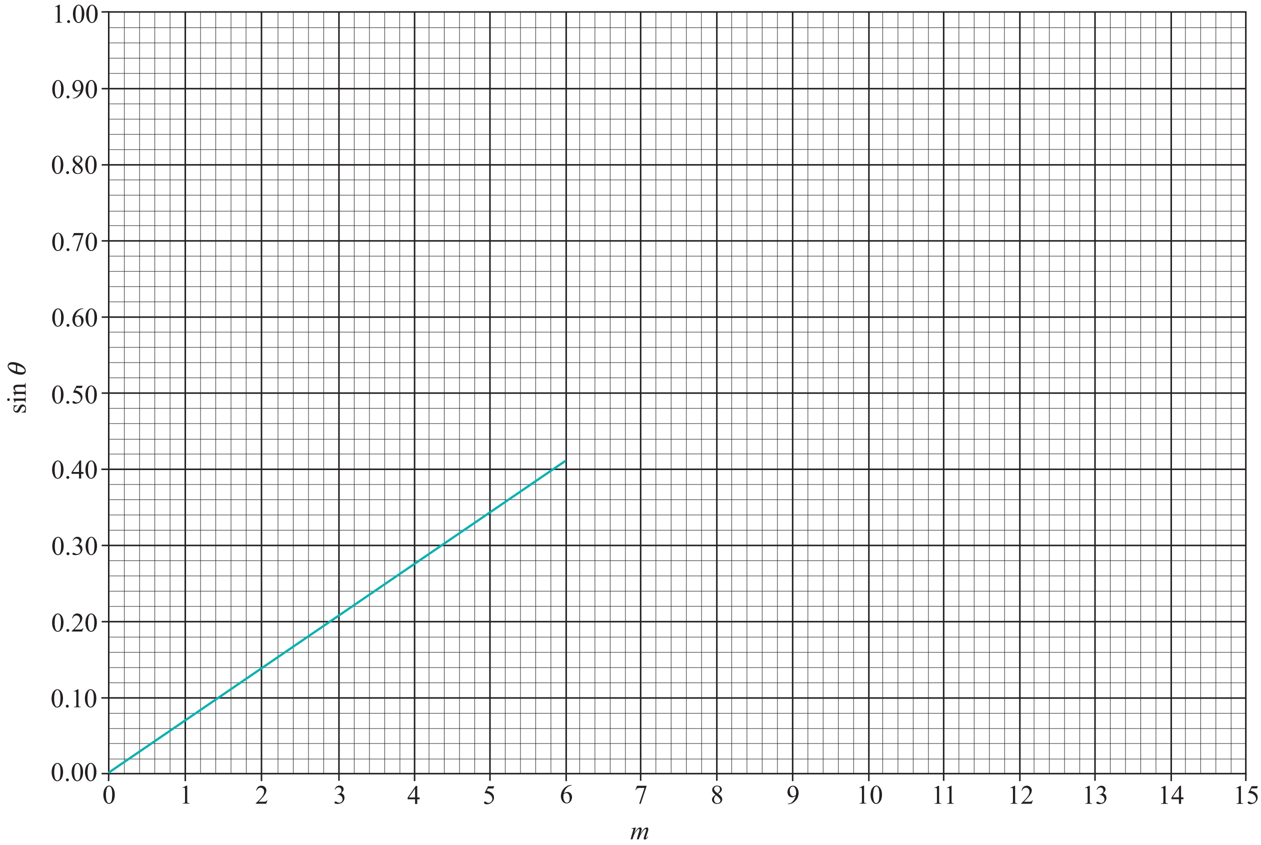
Part 1 (Question 18)

(15 marks)

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

18. (a) A student performs an experiment in which a diffraction grating with 100 slits per millimetre is illuminated at normal incidence by laser light of wavelength λ.

A graph of the sine of the angular position of each maximum in the diffraction pattern, $\sin\theta$, versus the order of the maximum m is shown below:



(i) Calculate the gradient of the line of best fit for the graph above, clearly labelling on the graph the points you have used.

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____ (2 marks)

(ii) Using the gradient of the line of best fit, calculate the wavelength λ of the laser light being used in this experiment.

(3 marks)

(iii) Using the graph opposite, determine the maximum order that can be produced by this diffraction grating. Clearly indicate on the graph how you have arrived at your answer.

(3 marks)

(b) The student repeats the experiment with another diffraction grating. The angular position of each maximum on either side of the central maximum is measured. The average of each angular position θ is recorded for each order of the maximum m, as shown in the table below. The student has calculated the sine of these angular positions, sin θ, to four decimal places.

m	θ (°)	*sin* θ	
0	0.0	0.0000	
1	8.5	0.1478	
2	18	0.3090	
3	26	0.4384	
4	34	0.5592	
5	45	0.7071	

(i) In the fourth column of the table, write the student's calculated values of sin θ to the correct number of significant figures. (1 mark)

(ii) On the page opposite, plot (*in pencil*) a graph of the sine of the angular position sin θ (on the vertical axis) versus the order of the maximum m (on the horizontal axis), and draw the line of best fit. (4 marks)

(iii) State and explain whether the number of slits per millimetre on this diffraction grating is greater or less than on the diffraction grating used in part (a).

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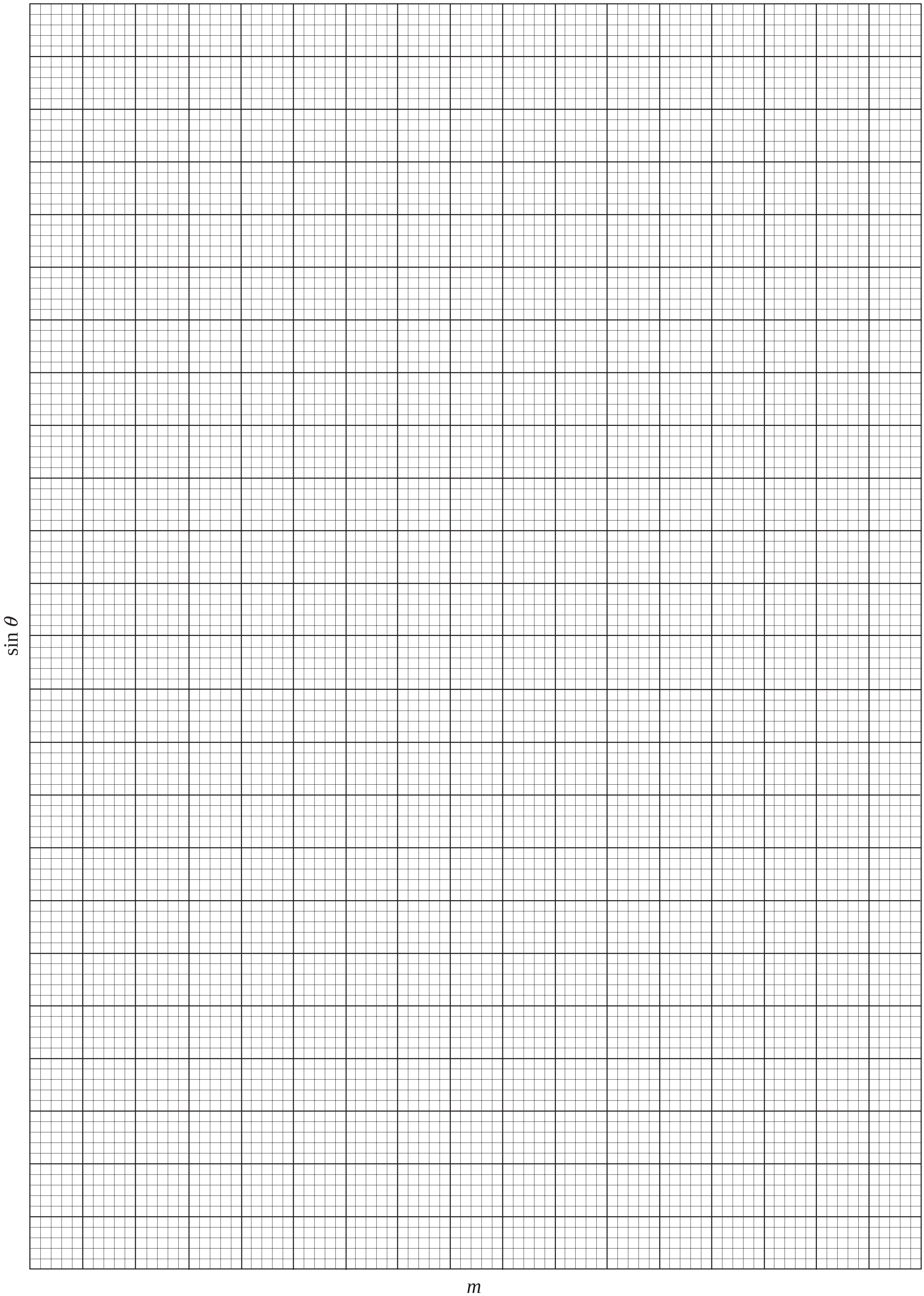
___ (2 marks)


sin θ
m

You may write on this page if you need more space to finish your answers to Part 2 of Section A or to Part 1 of Section B. Make sure to label each answer carefully (e.g. 17(b) continued).

SSABSA

SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA

EXTERNAL EXAMINATION 2007

2007 PHYSICS

SACE REGISTRATION NUMBER			
SEQ	FIGURES	CHECK LETTER	BIN

PHYSICS

QUESTION BOOKLET

3

8 pages, 2 questions

Tuesday 6 November: 9 a.m.

Part 2 of Section B

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

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SECTION B

Part 2 (Questions 19 and 20)

(30 marks)

*Questions 19 and 20 are extended-response questions. Answer **both** questions.*

Write your answers in this question booklet:

- Question 19, on pages 4 and 5, is worth 14 marks.
- Question 20, on pages 6 and 7, is worth 16 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.

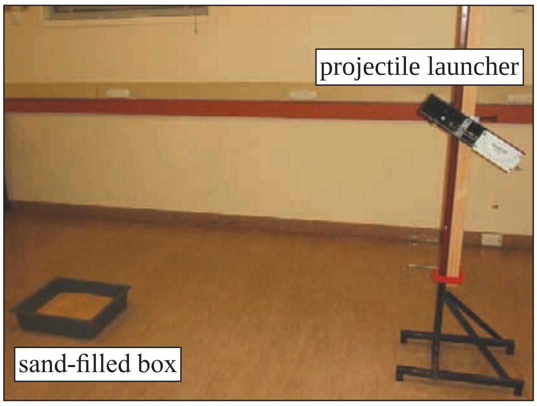
You may use clearly labelled diagrams that are related to your answer.

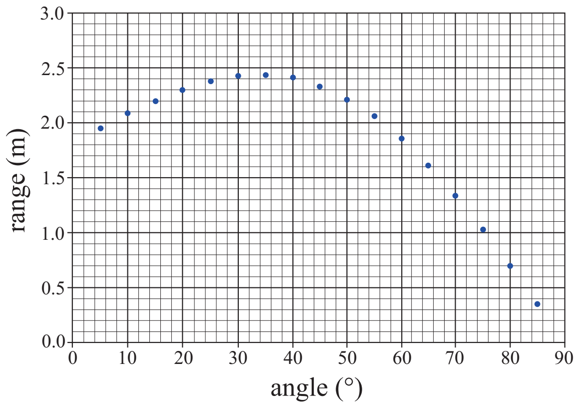
19. Medical radiographers use ionising radiation (X-rays) to create images for medical diagnosis. A radiographer, as shown in the photograph below, can adjust the settings of the X-ray tube:

Source: www.dbh.nhs.uk/library/mediaservicesimages

- Identify *one* change that can be made to the settings of the X-ray tube and explain the effect of this change on the X-rays produced.
- Discuss the precautions that radiographers should take to protect themselves and their patients from the harmful effects of ionising radiation. (14 marks)

20. Two students perform a projectile motion experiment to find the launch angle that will result in the maximum range when the launch height of a projectile is above the ground. They launch a small metal ball from a projectile launcher set at a number of different launch angles. They measure the range using a sand-filled box placed at a position on the ground where they predict the ball will land. The students' experimental apparatus and their results are shown in the photograph and graph below:





- Discuss the variables in this experiment, clearly identifying the independent and dependent variables and at least *one* variable, other than launch height, that must be held constant.
- Using the graph, state the launch angle that results in the maximum range in this experiment, and explain why changing this angle decreases the range of the metal ball.

(16 marks)

You may write on this page if you need more space to finish your answers to Questions 19 and 20. Make sure to label each answer carefully (e.g. 19 continued).