Government of South Australia

SACE Board of SA | South Australian Certificate of Education

Physics
November 2018 sample paper

Question Booklet 2

2

- Questions 12 to 20 (57 marks)
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 15 if you need more space
- Allow approximately 60 minutes

Copy the information from your SACE label here

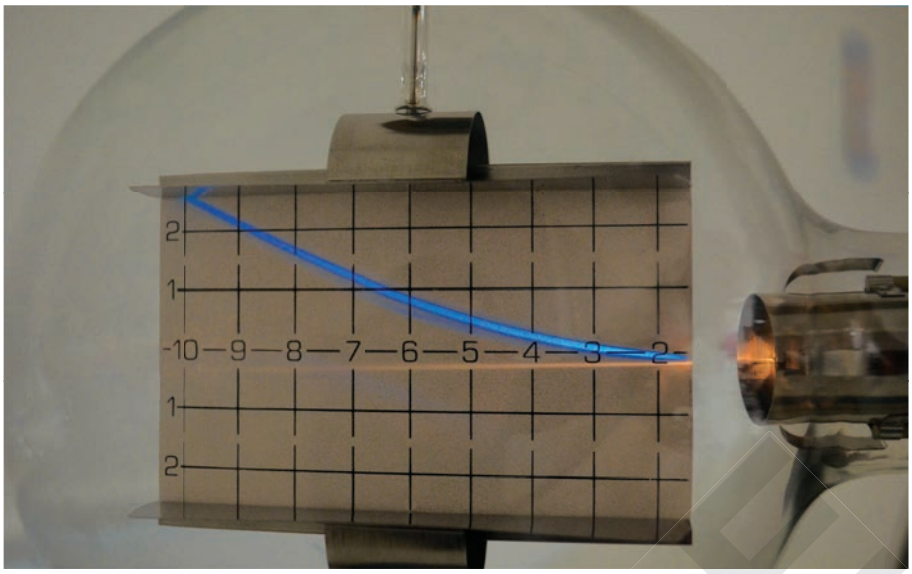
SEQ	FIGURES	CHECK LETTER	BIN

For office use only

Supervisor check	Re-marked

12. A Teltron tube is a device used to accelerate electrons, as shown in the photograph below.

Electrons are deflected when they enter the region between two parallel plates to which a potential difference has been applied.



Explain why electrons will experience an electric force of constant magnitude when they are between two very long parallel plates to which a constant potential difference has been applied.

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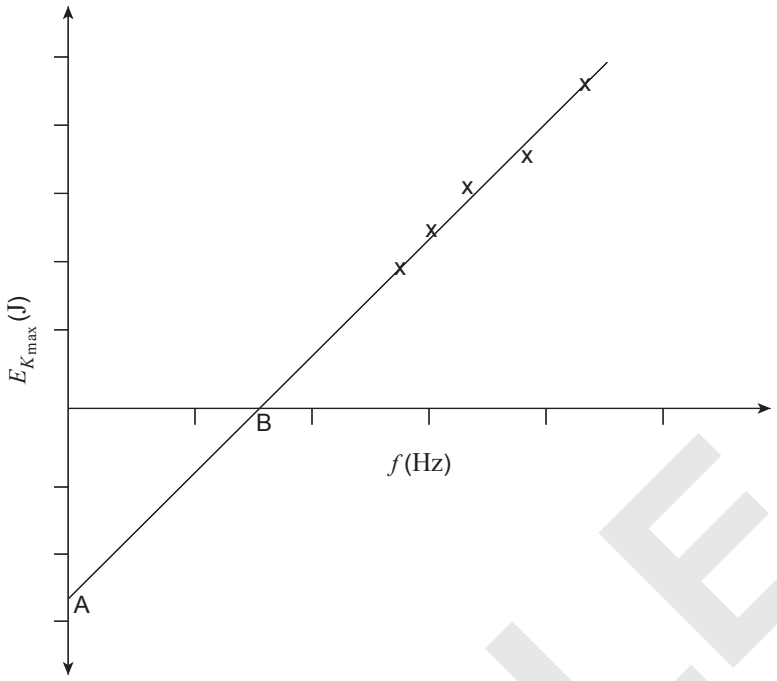
_____ (2 marks)

13. In an experiment on the photoelectric effect, the maximum kinetic energy $E_{K_{\max}}$ of the emitted electrons was measured for different frequencies, f, of light incident on a cathode. The graph below was drawn using the data that were collected.



The line of best fit intersects the $E_{K_{\max}}$ axis at A and the f axis at B.

(a) Identify the physical significance of A and B.

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_____ (2 marks)

(b) Explain how a value for Planck's constant, h, can be obtained by relating the equation $E_{K_{\max}} = hf - W$ to the graph above.

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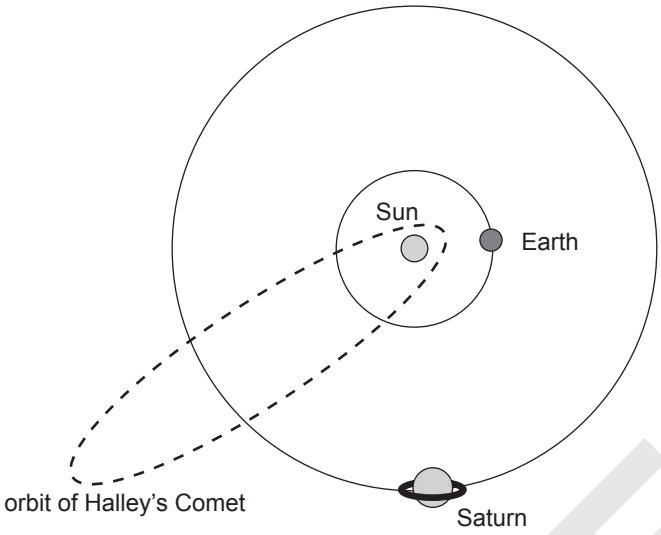
_____ (2 marks)

14. Halley's Comet is visible from the Earth once approximately every 76 years. Its orbit is highly elliptical and is shown against the orbits of the Earth and Saturn below:



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

Halley's Comet can be seen without optical equipment only when it is close to the Earth.

Using one of Kepler's Laws, explain why Halley's Comet can be seen for only a brief time during its orbit period of approximately 76 years.

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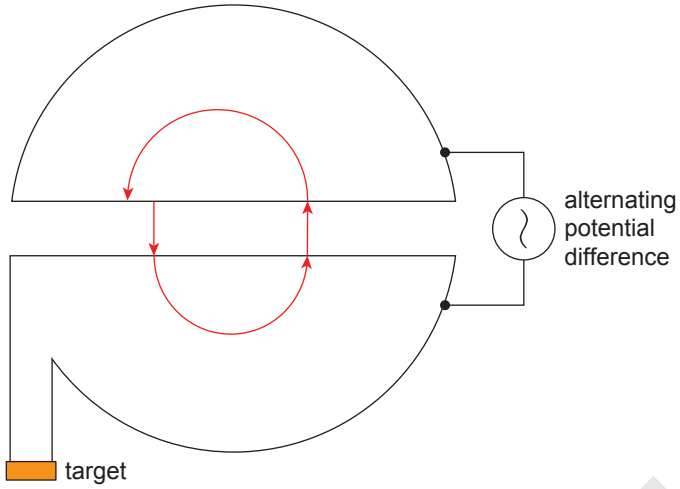
_____ (3 marks)

15. The diagram below shows a cyclotron that accelerates negative ions with a charge of magnitude 1.6×10^{-19} C and a mass of 1.7×10^{-27} kg:



(a) State the direction of the magnetic field in the cyclotron above that would cause the negative ions to move in an anticlockwise direction.

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_____ (1 mark)

(b) Show that as an ion moves in a circular path, the frequency of its motion is given by

$$f = \frac{qB}{2\pi m}.$$

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_____ (3 marks)

The magnetic field in the cyclotron has a magnitude of 0.83 T.

(c) Using the equation in part (b), calculate the frequency of the motion of an ion.

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This sample Physics paper shows the format of the examination for November 2018.

16. The following reaction shows the decay of a tau particle into a charged pion, a neutral pion, and a tau neutrino:

$$\tau^- \rightarrow \pi^- + \pi^0 + \nu_\tau$$

The table below shows the properties of some subatomic particles:

Name	Symbol	L_τ	L_e	Charge (e)
Tau particle	τ^-	+1	0	–1
Tau neutrino	ν_τ	+1	0	0
Electron	e^-	0	+1	–1
Neutral pion	π^0	0	0	0
Anti-pion	π^-	0	0	–1

(a) *Using information in the table above*, show that both the charge and the lepton numbers are conserved in the decay of the tau particle shown in the reaction above.

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_____ (2 marks)

(b) *Using the information in the table above*, determine whether it is possible for a tau particle to decay into an electron, a neutral pion, and a tau neutrino, as summarised in the following equation:

$$\tau^- \rightarrow e^- + \pi^0 + \nu_\tau$$

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(c) In 2011 scientists working on the Oscillation Project with Emulsion-tRacking Apparatus (OPERA) published results of an experiment showing the speed of muon neutrinos to be 0.002% faster than the speed of light. The controversial results were reported by the media as being one of the biggest scientific discoveries of the century.

OPERA scientists recognised the possibility of an error, but they were unable to find its source. Their results were published online so that other scientists could analyse the data to find the source of the possible error. In 2012 it was discovered that the error was due to a loose cable.

The research director Sergio Bertolucci noted at the time:

> [a]lthough this result isn't as exciting as some would have liked, it is what we all expected deep down. The story captured the public imagination, and has given people the opportunity to see the scientific method in action — an unexpected result was put up for scrutiny, thoroughly investigated and resolved in part thanks to collaboration between normally competing experiments. That's how science moves forward.

Using the information above, explain how science relies on clear communication and on review and verification of results.

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_____ (5 marks)

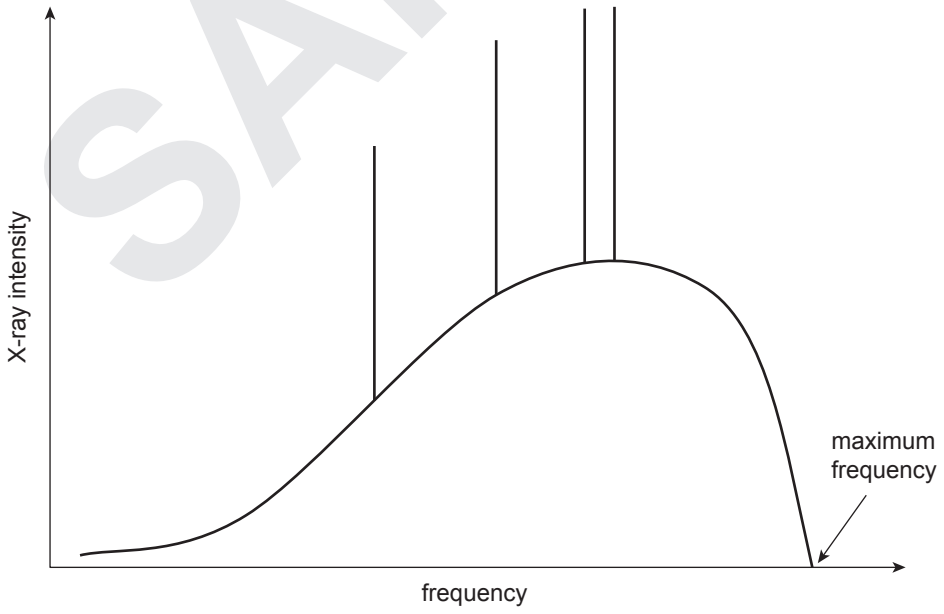
17. The photograph below shows a scientist using a handheld X-ray fluorescence analyser to study a historical artefact:

Source: www.fieldmuseum.org

(a) Calculate the potential difference, ΔV, necessary to produce X-rays with a maximum frequency of 1.4×10^{19} Hz.

(3 marks)

The diagram below shows the spectrum from an X-ray tube:



(b) Using the law of conservation of energy, explain how a decrease in potential difference across the X-ray tube changes the maximum frequency.

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_____ (3 marks)

18. Muons can be formed as the by-products of cosmic rays colliding with molecules in the upper atmosphere.

A muon travelling at a speed of $0.998\ c$ is formed at a height of $10\ 000\ \text{m}$ above the surface of the Earth.

(a) Show that the Lorentz factor, γ, for a muon travelling at $0.998\ c$ is 15.8.

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_____ (2 marks)

The lifetime of a stationary muon is approximately $2.197\ \mu s$ before it decays.

(b) *Using calculations*, explain why relativistic effects allow a muon travelling at $0.998\ c$ to reach the surface of the Earth.

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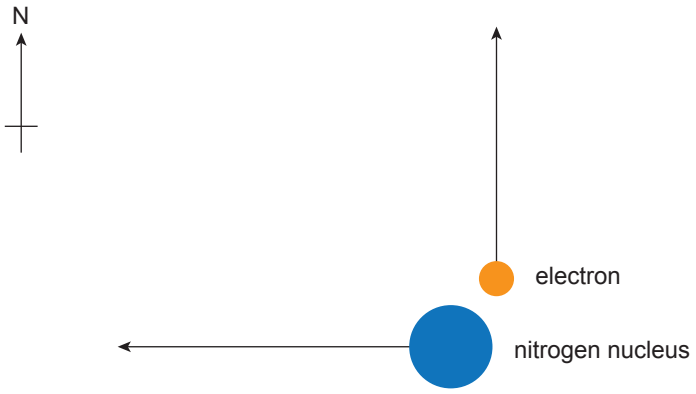
_____ (3 marks)

19. 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 another particle in this decay of carbon-14.

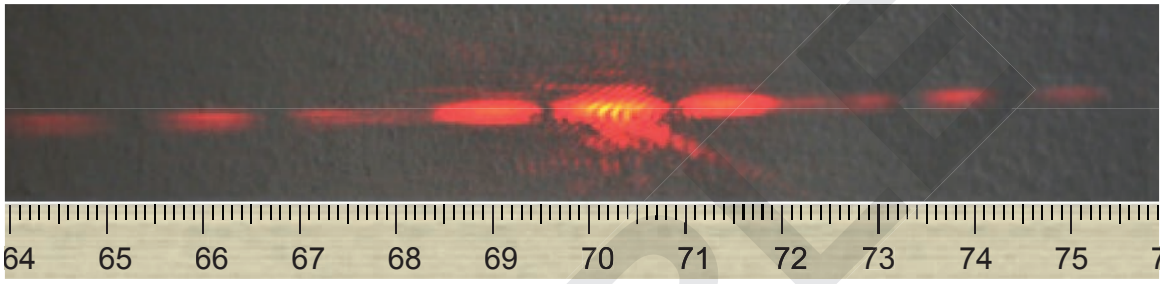
(2 marks)

20. A group of students conducted an experiment to determine the spacing between two parallel slits using a helium-neon laser of wavelength $\lambda = 633$ nm. They changed the slit-to-screen distance, L, five times, and each time they measured the distance between adjacent maxima in the interference pattern, Δy.

The table below shows the data collected in the experiment. This data has been graphed on page 13.

L (m)	Δy (m)
0.25	0.0033
0.50	0.0067
0.75	0.0094
1.00	
1.25	0.014

The interference pattern when $L = 1.00$ m is shown in the image below.



(a) Determine the distance between adjacent maxima in the interference pattern Δy for the image above.

Convert your answer to metres, write the value in the shaded cell in the data table above, and plot the point on the graph on page 13. (3 marks)

(b) (i) *On the graph on page 13*, draw a line of best fit. (1 mark)

(ii) Determine the magnitude of the gradient of the line of best fit.

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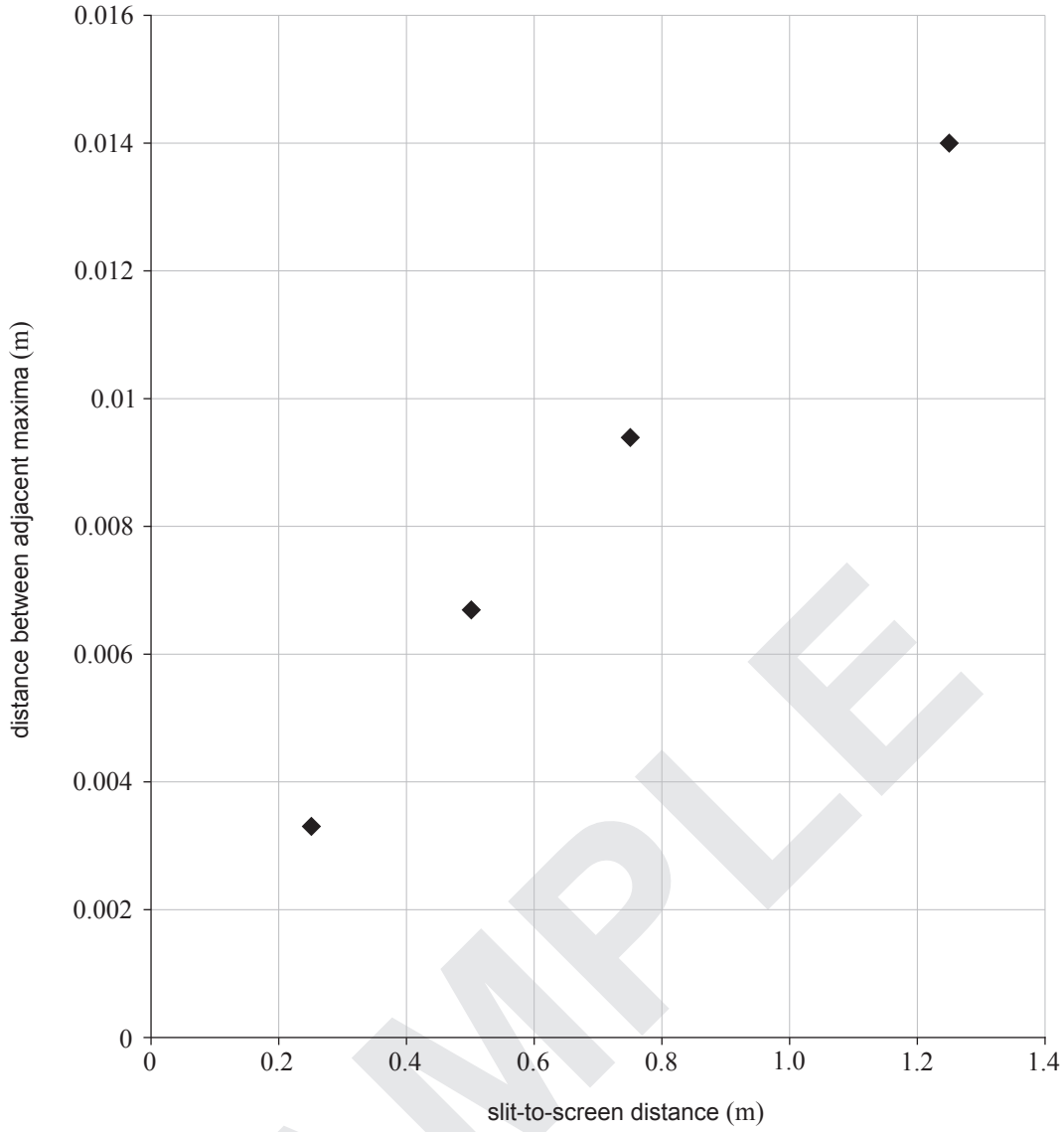

(c) Using the gradient of the line of best fit, determine the distance between the two parallel slits.

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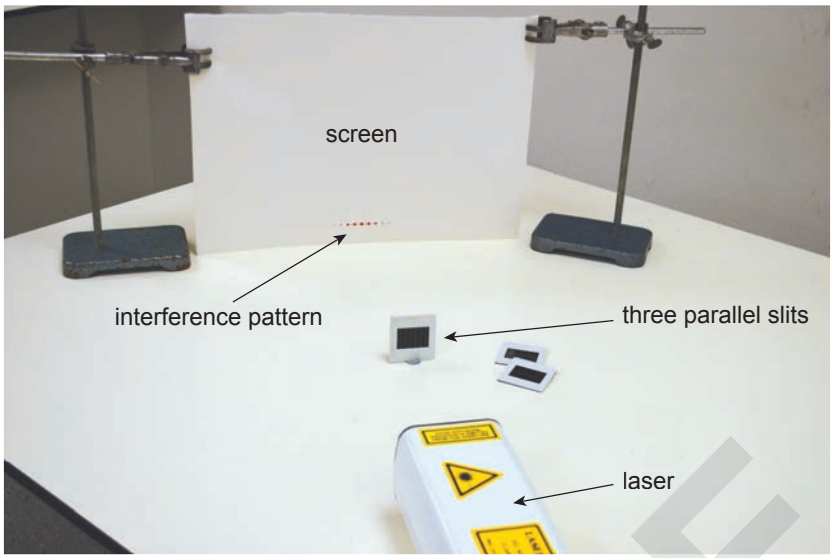
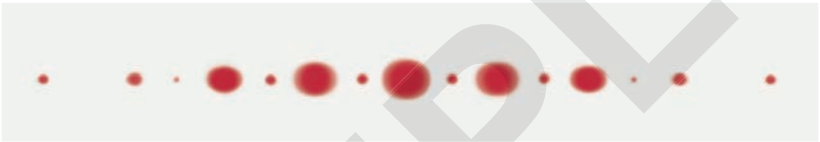
_____ (3 marks)

(d) After observing the interference pattern produced by light from a helium-neon laser illuminating two parallel slits, the students illuminated three parallel, equally spaced slits.

The photograph below shows the equipment used by the students:



The students observed the interference pattern shown below:



In a second experiment, the students want to investigate the effect of the distance between the three slits on the interference pattern above.

Discuss the variables that they need to consider in the design of their experiment.

(6 marks)

You may write on this page if you need more space to finish your answers to Question Booklet 2. Make sure to label each answer carefully (e.g. 16(c) continued).

NOVEMBER 2018 SAMPLE PHYSICS PAPER

The purpose of this sample paper is to show the structure of the Physics examination and the style of questions that may be used. The following extract is from the 2018 subject outline for Physics:

EXTERNAL ASSESSMENT

Assessment Type 3: Examination (30%)

Students undertake one 2-hour examination.

Stage 2 science inquiry skills and science understanding from all topics may be assessed.

Questions:

- will be of different types
- may require students to show an understanding of science as a human endeavour
- may require students to apply their science understanding from more than one topic.

For the examination, students are given a sheet containing symbols of common quantities, the magnitude of physical constants, some formulae, and standard SI prefixes.

All specific features of the assessment design criteria for this subject may be assessed in the external examination.

Source: *Physics 2018 Subject Outline Stage 2*, p 55, on the SACE website, www.sace.sa.edu.au

This sample Physics paper shows the format of the examination for November 2018.