Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Friday 8 June 2018 – Morning
Time: 1 hour 35 minutes

Paper Reference
WPH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

1/1/1/1/1/1/
P 5 1 9 4 5 A 0 1 2 8
Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Current theories give a number of alternatives for the future evolution of our universe.

Which of the following is a correct statement for an open universe?

☐ **A** It eventually reaches a maximum size.

☐ **B** It has a future that cannot be predicted.

☐ **C** It will eventually collapse in on itself.

☐ **D** It keeps expanding forever.

(Total for Question 1 = 1 mark)

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2 A system is oscillating with simple harmonic motion. The energy of oscillation of the system doubles.

The amplitude of oscillation increases by a factor of

☐ **A** $\frac{1}{\sqrt{2}}$

☐ **B** $\frac{1}{2}$

☐ **C** 2

☐ **D** $\sqrt{2}$

(Total for Question 2 = 1 mark)

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3 About 25% of the mass of the universe is thought to consist of dark matter.

Which of the following is a correct statement about dark matter?

☐ **A** It absorbs all electromagnetic radiation.

☐ **B** It emits no electromagnetic radiation.

☐ **C** It exerts no gravitational force.

☐ **D** It provides direct evidence for the Big Bang.

(Total for Question 3 = 1 mark)

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4 A mixture of helium He and hydrogen H_2 gases is maintained at a temperature of 300 K. The average kinetic energy of the He molecules is E_k and their average speed is v.

Which of the following is a correct statement?

☒ **A** The average kinetic energy of the H_2 molecules is less than E_k.

☒ **B** The average kinetic energy of the H_2 molecules is the same as E_k.

☒ **C** The average speed of the H_2 molecules is less than v.

☒ **D** The average speed of the H_2 molecules is the same as v.

(Total for Question 4 = 1 mark)

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5 A source of alpha radiation is dangerous if taken into the body.

This is because alpha particles are

☒ **A** positively charged.

☒ **B** massive particles.

☒ **C** very ionising.

☒ **D** very penetrating.

(Total for Question 5 = 1 mark)

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6 A protostar is a young star, the temperature of which is still increasing. The surface temperature of a protostar increases from 2800 K to 3100 K.

As a result, the rate at which energy is radiated away from a 1 m^2 surface area of the protostar changes by a factor of

☒ **A** 0.9

☒ **B** 1.1

☒ **C** 1.2

☒ **D** 1.5

(Total for Question 6 = 1 mark)

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7 Two stars are being observed. Star X is twice as far away as star Y and the radiation flux received from star X is half that from star Y.

Which of the following statements is correct?

- ☒ **A** Star X has half the luminosity of star Y.
- ☒ **B** Star X has the same luminosity as star Y.
- ☒ **C** Star X has twice the luminosity of star Y.
- ☒ **D** Star X has eight times the luminosity of star Y.

(Total for Question 7 = 1 mark)

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8 The gravitational field strength at the surface of the Earth is $9.81\,\mathrm{N\,kg^{-1}}$. A satellite is orbiting at a height above the surface of the Earth equal to twice the radius of the Earth.

What is the gravitational field strength at this height?

- ☒ **A** $1.1\,\mathrm{N\,kg^{-1}}$
- ☒ **B** $2.5\,\mathrm{N\,kg^{-1}}$
- ☒ **C** $3.3\,\mathrm{N\,kg^{-1}}$
- ☒ **D** $4.9\,\mathrm{N\,kg^{-1}}$

(Total for Question 8 = 1 mark)

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9 When a solid is heated at its melting point, the temperature remains constant until all the solid has turned to liquid.

Select the row in the table that correctly gives the change in the mean molecular kinetic and potential energies.

	Mean molecular kinetic energy	**Mean molecular potential energy**
☒ **A**	increases	stays the same
☒ **B**	increases	increases
☒ **C**	stays the same	increases
☒ **D**	stays the same	decreases

(Total for Question 9 = 1 mark)

10 Stellar parallax can be used to determine the distances to stars which are relatively close to the Earth.

Why is this method unsuitable for more distant stars?

- ☒ **A** The radiation flux from these stars is too low.
- ☒ **B** The luminosity of these stars is too low.
- ☒ **C** The parallax angle is too large.
- ☒ **D** The parallax angle is too small.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A microwave oven uses electromagnetic waves to transfer energy to certain substances such as water.

(a) The frequency of the electromagnetic waves generated in a microwave oven is 2.45 GHz.

Calculate the wavelength of the microwaves produced by the oven.

(2)

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Wavelength = ...

(b) A teacher determines the efficiency of a microwave oven. She places a glass beaker containing 225 g of water in the microwave oven. The microwave oven has an input power of 550 W.

The microwave oven is switched on for 120 s and the temperature of the water increases from 15.0 °C to 67.5 °C.

(i) Calculate the efficiency of the microwave oven.

(3)

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

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Efficiency = ...

(ii) State a reason why the efficiency is less than 100%.

(1)

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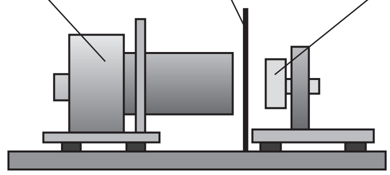
(Total for Question 11 = 6 marks)

12 A student was investigating the penetrating power of nuclear radiations. He placed a radioactive source close to a Geiger-Müller (GM) tube and placed different absorbers between the source and the GM tube.



The student's readings are shown below.

Absorber	Count recorded for 2 minutes with absorber in place
air	225
paper	224
aluminium sheet of thickness 1 mm	194
aluminium sheet of thickness 5 mm	110
lead sheet of thickness 5 mm	52

(a) Criticise the student's results.

(2)

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(b) Explain which radiations were emitted from the source.

(3)

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(Total for Question 12 = 5 marks)

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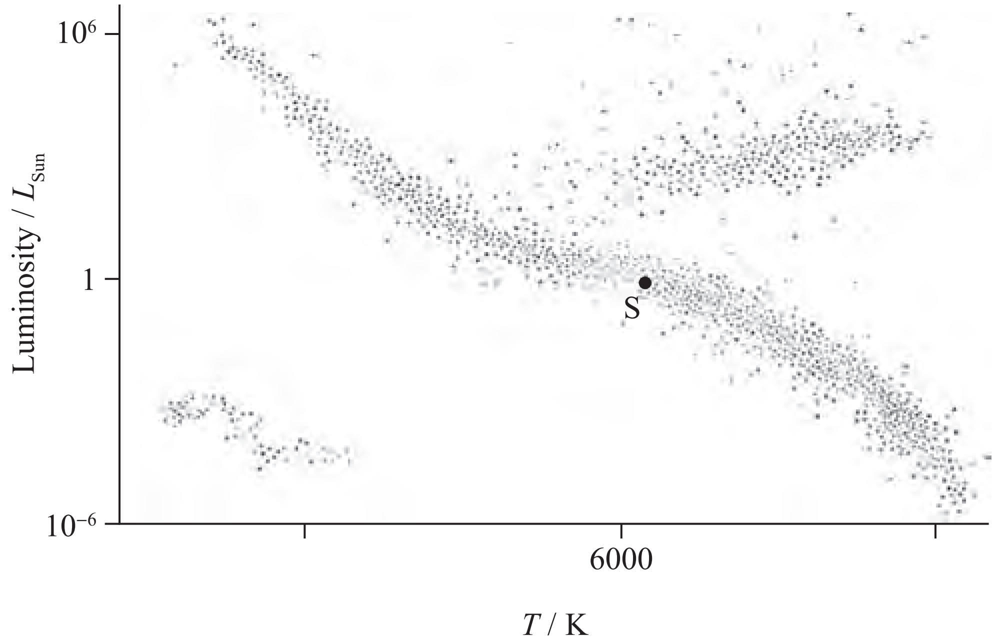
13 A Hertzsprung-Russell diagram shows how luminosity varies with surface temperature for a range of stars. The Sun is a yellow main sequence star. The position of the Sun in the diagram is marked with S.



(a) Complete the temperature scale on the Hertzsprung-Russell diagram.

(2)

(b) Compared with the Sun, white dwarf stars have a lower luminosity and produce whiter light. It is not possible to directly measure the size of these stars, due to their large distance from the Earth.

Explain how astronomers have deduced that these stars have a relatively small surface area compared to that of the Sun.

(3)

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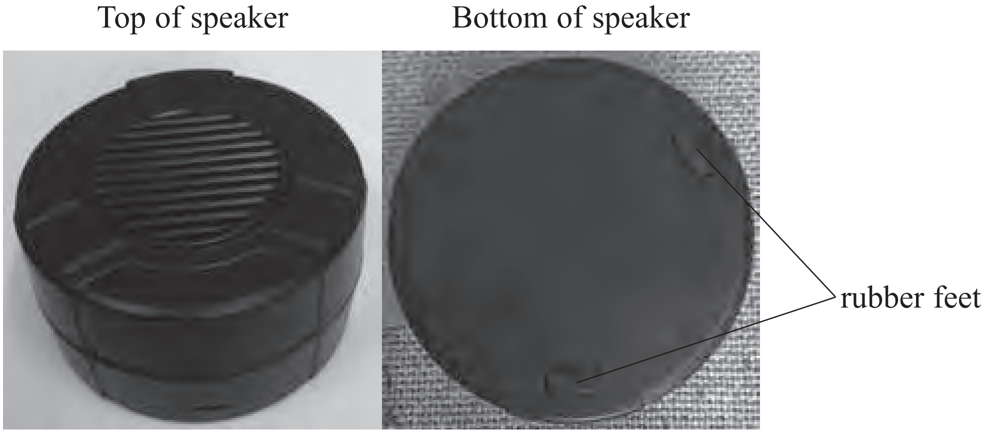
(Total for Question 13 = 5 marks)

14 A Bluetooth speaker enables music to be played from a phone or other mobile device without the need for wire connections. The speaker rests on three rubber feet as shown.



(a) The rubber feet maintain contact between the speaker and the surface it is on.

Explain why the sound is loud when the speaker is on a hard wooden surface.

(2)

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(b) For certain frequencies of sound there is a much larger increase in the loudness of the sound produced.

Explain why this increase in sound occurs for certain frequencies.

(3)

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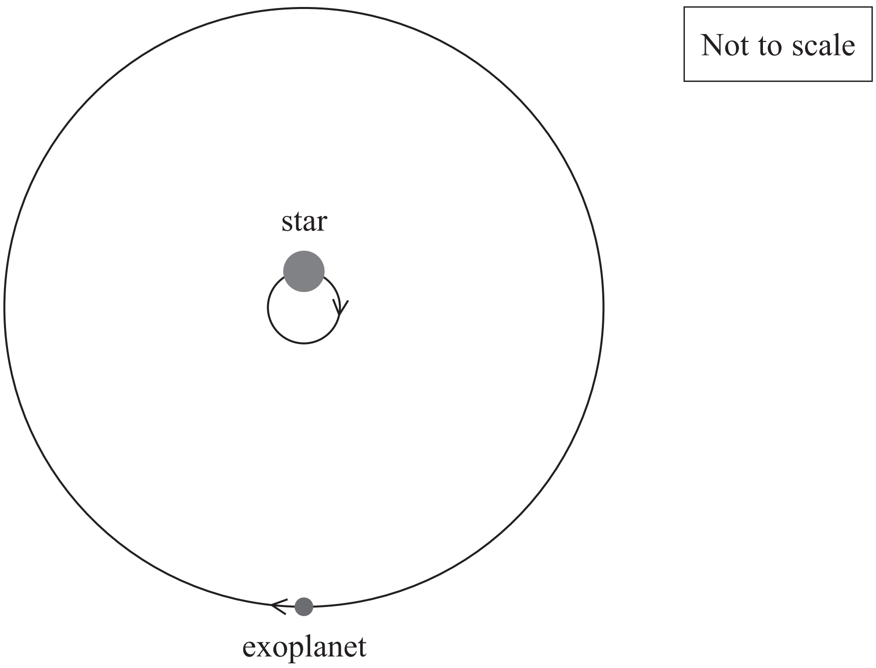
(Total for Question 14 = 5 marks)

15 An exoplanet is a planet orbiting a star other than the Sun. One of the first exoplanets to be found is Tau Boötis b in the Tau Boötis star system. Both the star and the exoplanet are in orbit about a point just outside of the star. The exoplanet was detected by changes in the wavelength of the light received from the star.



(a) Because of the circular path of the star, the wavelength of light detected from the star changes.

(i) Explain why the wavelength of the light detected from the star would change.

(3)

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(ii) For a spectral line of wavelength 622 nm, the maximum change in wavelength observed was $\pm 9.73 \times 10^{-4}$ nm.

Calculate the speed of the star.

(2)

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Speed of the star = ...

*(b) Tau Boötis is a main sequence star that is more massive than the Sun.

Explain how the temperature of Tau Boötis would compare with the temperature of the Sun.

(3)

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(c) The exoplanet has a mass more than four times the mass of Jupiter.

Suggest why much less massive exoplanets are much harder to detect by measuring changes in the wavelength of the light received from the star.

(2)

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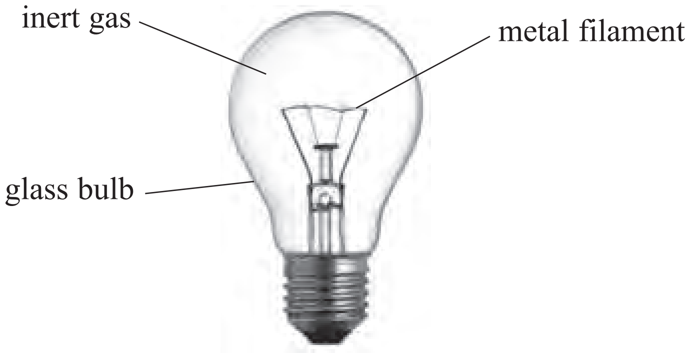
(Total for Question 15 = 10 marks)

16 In an incandescent lamp, a metal filament is heated to a high temperature so that it emits light. The filament is enclosed in a glass bulb filled with an inert gas.



(a) In one type of lamp the filament is heated to a temperature of 2630 K.

(i) Show that the wavelength λ_{max} of peak power emission from the filament is approximately 1×10^{-6} m.

(2)

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(ii) Suggest, using the value of λ_{max}, why the lamp is inefficient as a light source.

(2)

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(iii) The pressure of the inert gas inside the bulb is 58.5 kPa at a temperature of 18.0 °C. When the lamp is on, the temperature of the gas is 165 °C.

Calculate the pressure of the gas when the lamp is on.

(3)

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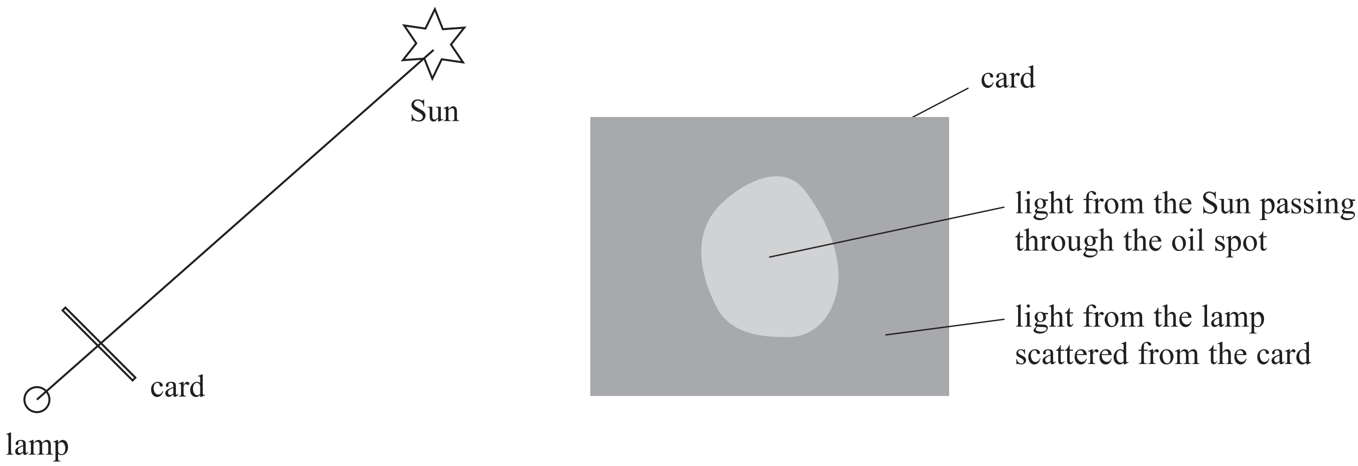
Pressure of gas = ...

(b) A student uses a lamp to estimate the luminosity *L* of the Sun.

She places a small drop of cooking oil at the centre of a sheet of card and spreads it out to form a small circle. She holds the card between the lamp and the Sun. Light from the Sun passes through the oil spot and light from the lamp is scattered off the card.



She adjusts the position of the card until the brightness of the scattered light is the same as the brightness of the light passing through the card. She measures the distance between the card and the lamp.

(i) Calculate a value for L.

(2)

distance from the Earth to the Sun = 1.50×10^{11} m
distance from card to lamp = 0.125 m
power of lamp = 200 W

L = ...

(ii) Suggest reasons why this method is likely to result in a poor estimate of the Sun's luminosity.

(2)

(Total for Question 16 = 11 marks)

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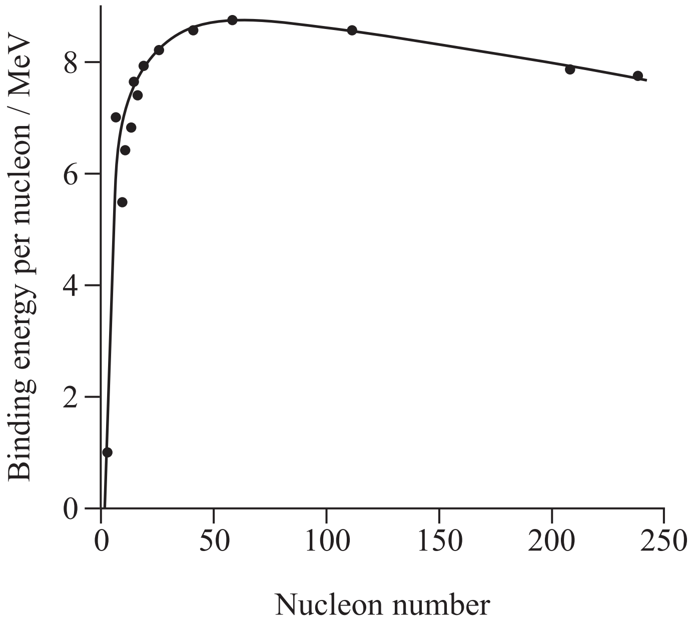
17 The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.



(a) (i) State what is meant by the binding energy of a nucleus.

(1)

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(ii) Use the graph to explain why nuclear fission is only possible as an energy source using massive nuclei.

(2)

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(b) In a nuclear reactor, a uranium-235 nucleus absorbs a neutron and then undergoes fission into two nuclei and some neutrons.

(i) Complete the nuclear reaction.

(2)

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{111}_{\ldots}Ru + ^{\ldots}_{48}Cd + 3^{1}_{0}n$$

(ii) The fission of one uranium-235 nucleus in this reaction releases 3.2×10^{-11} J of energy.

Calculate the change in mass Δm that occurs in this fission.

(2)

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Δm = ...

*(iii) The neutrons and product nuclei move away from each other after the fission. A student suggests that this is because of electrostatic repulsion.

Comment on this suggestion.

(3)

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(c) Plutonium-241 is a possible product from a fission reactor. It is a beta emitter with a half-life of 14 years.

Calculate the time for 95% of the plutonium-241 in a sample to decay.

(3)

Time = ...

(Total for Question 17 = 13 marks)

18 When a ship is sailing on a rough sea, the waves can set the ship into simple harmonic motion. This can result in passengers becoming seasick.

(a) State what is meant by simple harmonic motion.

(2)

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(b) At one position on a ship, passengers experience a vertical oscillation of amplitude 0.85 m with a period of 6.0 s.

(i) Calculate the maximum acceleration of the passengers.

(3)

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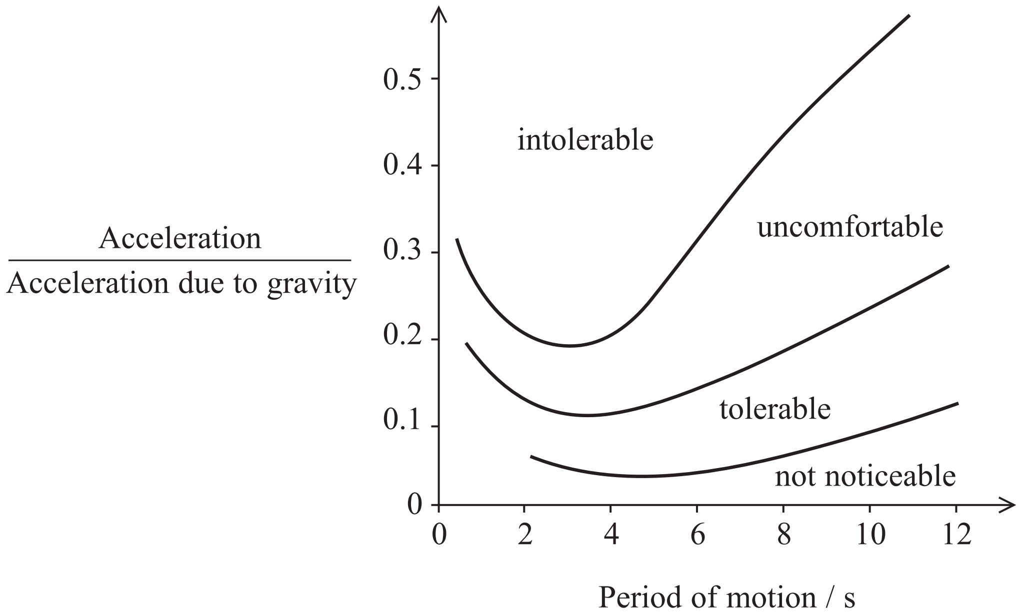
Maximum acceleration = ...

(ii) Passengers on a ship may suffer from seasickness as the ship rises and falls on the waves. The graph shows the limits of passengers' tolerance to the oscillatory motion.



Determine whether the passengers are likely to feel seasick as a result of the ship's motion.

You should use your value from (b)(i) and show how you have used the graph.

(2)

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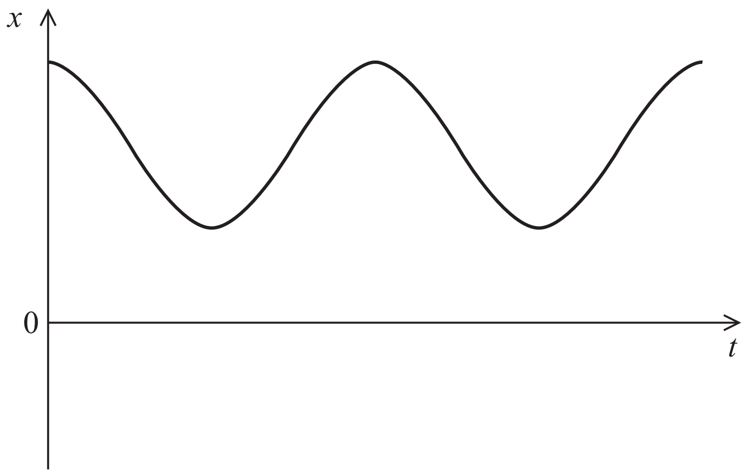
(c) The graph shows how the vertical displacement x of a passenger varies with time t.

Add to the graph to show how the acceleration of the passenger varies over the same time interval.

(2)



(d) A passenger on the ship stands on weighing scales. When the sea is calm the reading on the weighing scales is 75 kg.

(i) Draw a free-body force diagram for this passenger.

(1)

*(ii) On a rough sea the ship oscillates vertically with a large amplitude.

Explain why the reading on the weighing scales will vary.

(3)

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(iii) Whilst the passenger is standing on the weighing scales, the maximum acceleration of the ship is $0.70\,\mathrm{m\,s^{-2}}$.

Calculate the maximum reading on the weighing scales.

(2)

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Maximum reading = ...

(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

Unit 1

Mechanics

Kinematic equations of motion

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

Forces

$\Sigma F = ma$

$g = F/m$

$W = mg$

Work and energy

$\Delta W = F\Delta s$

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

$\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where

Stress $\sigma = F/A$

Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i / \sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin \theta$ $F = Bqv \sin \theta$ $r = p/BQ$
Faraday's and Lenz's laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

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Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{1/2}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's Law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$