Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 5 June 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WPH15/01**

Physics

International Advanced Level
UNIT 5: Thermodynamics, Radiation, Oscillations and Cosmology

You must have:
Scientific calculator

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

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

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 a box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Massive nuclei may undergo nuclear fission.

Which of the following is correct for a fission process?

☒ **A** A high density of nuclei is required.

☒ **B** A high temperature is required.

☒ **C** The binding energy of the nuclei stays constant.

☒ **D** The total mass of the nuclei decreases.

(Total for Question 1 = 1 mark)

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2 Some isotopes are unstable and undergo radioactive decay.

Which of the following is **not** correct for radioactive decay?

☒ **A** Radioactive decay is a random process.

☒ **B** Radioactive decay is a spontaneous process.

☒ **C** It is possible to predict what the decay products might be.

☒ **D** It is possible to predict which nucleus will decay next.

(Total for Question 2 = 1 mark)

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3 Nucleus X decays to nucleus Y by emitting an alpha particle (α).

Which of the following gives the energy released in this decay?

☒ **A** [mass of α] $\times c^2$

☒ **B** [mass of α – mass of Y] $\times c^2$

☒ **C** [mass of X – mass of Y – mass of α] $\times c^2$

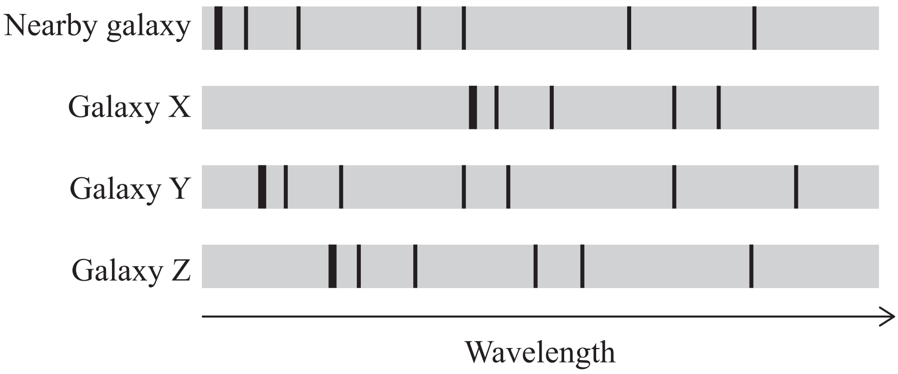
☒ **D** [mass of X – mass of Y + mass of α] $\times c^2$

(Total for Question 3 = 1 mark)

P 7 9 3 5 3 A 0 2 3 2

4 The spectra of light from a nearby galaxy and three distant galaxies are observed in a laboratory.

The diagram shows the observed spectra.



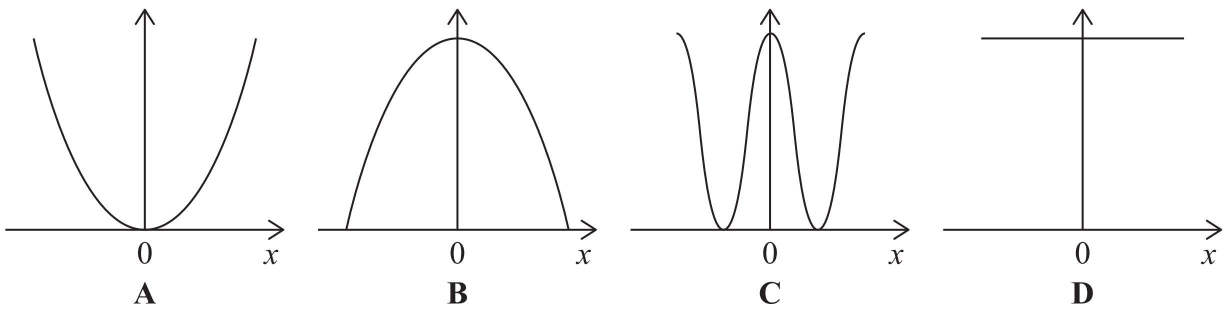
Which of the following gives the galaxies in order of increasing distance from Earth?

- ☒ **A** X Y Z
- ☒ **B** Y X Z
- ☒ **C** Y Z X
- ☒ **D** Z Y X

(Total for Question 4 = 1 mark)

5 A mass is hung from a spring. The mass is displaced and released so that it oscillates vertically.

Which of the following shows how the kinetic energy of the mass varies with displacement x?



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 5 = 1 mark)

6 A planet has a mass of 1.3×10^{25} kg and a radius of 7.9×10^{6} m.

A spacecraft of mass 750 kg lands on the surface of the planet.

Which of the following gives the weight of the spacecraft at the surface of the planet?

☒ **A** $\dfrac{6.67 \times 10^{-11} \times 1.3 \times 10^{25}}{7.9 \times 10^{6}}$

☒ **B** $\dfrac{6.67 \times 10^{-11} \times 1.3 \times 10^{25} \times 750}{7.9 \times 10^{6}}$

☒ **C** $\dfrac{6.67 \times 10^{-11} \times 1.3 \times 10^{25}}{\left(7.9 \times 10^{6}\right)^{2}}$

☒ **D** $\dfrac{6.67 \times 10^{-11} \times 1.3 \times 10^{25} \times 750}{\left(7.9 \times 10^{6}\right)^{2}}$

(Total for Question 6 = 1 mark)

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7 A proton produces an electric field. The proton also produces a gravitational field.

Which of the following is **not** correct?

☒ **A** The field lines are radial for each field.

☒ **B** The equipotentials are spherical for each field.

☒ **C** The potential for each field is proportional to $\left(\dfrac{1}{\text{distance from proton}}\right)$

☒ **D** The field strength for each field is proportional to $\left(\dfrac{1}{\text{distance from proton}}\right)$

(Total for Question 7 = 1 mark)

8 An object, of mass 1200 kg, is launched from the surface of the Earth to a height of 2000 m.

The Earth has a mass M_E and a radius R_E.

Which of the following gives the change in gravitational potential energy of the object?

☒ **A** $-GM_E \times \left(\frac{1200}{R_E} - \frac{1200}{2000}\right)$

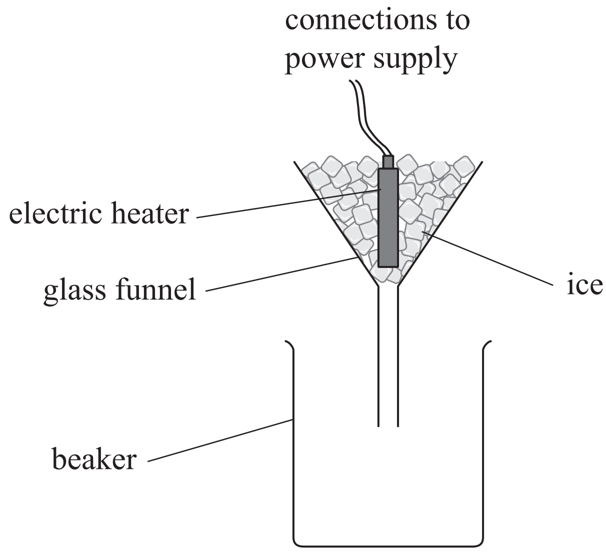
☒ **B** $-GM_E \times \left(\frac{1200}{R_E + 2000} - \frac{1200}{2000}\right)$

☒ **C** $-GM_E \times \left(\frac{1200}{2000} - \frac{1200}{R_E + 2000}\right)$

☒ **D** $-GM_E \times \left(\frac{1200}{R_E + 2000} - \frac{1200}{R_E}\right)$

(Total for Question 8 = 1 mark)

9 A student determined the specific latent heat L of ice, using the apparatus shown.



The student switched on the heater and started a stopwatch. He switched off the heater and recorded a time t. He determined the mass of water in the beaker.

The heater has a stated power P.

The student's calculated value for L was less than the accepted value.

Which of the following is a possible reason for this?

☒ **A** Energy was transferred to the surroundings.

☒ **B** The initial temperature of the ice was less than 0 °C.

☒ **C** The heater was switched on for a time greater than t.

☒ **D** The power of the heater was less than P.

(Total for Question 9 = 1 mark)

10 The luminosity of the Sun is $L_\odot$

When the Sun becomes a red giant star, its radius and its surface temperature will change.

The radius will increase by a factor of 200.
The surface temperature will decrease by a factor of 2.

Which of the following will be the new luminosity of the Sun?

☒ **A** $1.0 \times 10^2 L_\odot$

☒ **B** $2.5 \times 10^3 L_\odot$

☒ **C** $4.0 \times 10^4 L_\odot$

☒ **D** $4.0 \times 10^8 L_\odot$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A sealed cylinder contains oxygen gas at a temperature of 18 °C.

The pressure of the gas is 2.33×10^7 Pa.

The cylinder is placed in a warm room and the temperature of the gas increases to 32 °C.

Calculate the pressure exerted by the gas at a temperature of 32 °C.

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Pressure exerted by the gas = ...

(Total for Question 11 = 3 marks)

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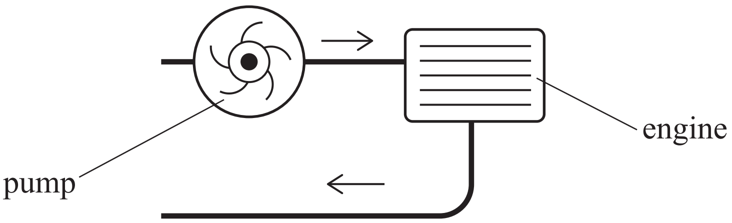
12 The engine of a car heats up when the engine is working. To prevent overheating, a liquid is pumped through pipes around the engine, as shown.



Energy is transferred away from the engine by the liquid.

The specific heat capacity of the liquid is $2.3 \times 10^3\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

(a) The liquid enters the pipes around the engine at a temperature of 85 °C and leaves at a temperature of 98 °C. The rate of flow of the liquid is $75\,\mathrm{kg\,min^{-1}}$.

Calculate the rate of transfer of energy away from the engine.

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Rate of transfer of energy = ...

(b) The original liquid is replaced by water of specific heat capacity $4.2 \times 10^3\,\mathrm{J\,kg^{-1}\,K^{-1}}$. The rate of flow of liquid does not change.

Explain how replacing the original liquid with water would affect the change in temperature between entering and leaving the engine.

You do not need to carry out any calculations.

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(Total for Question 12 = 6 marks)

13 The kinetic theory is used to explain the behaviour of ideal gases.

(a) Show that the internal energy U of an ideal gas is given by the expression

$$U = \frac{3}{2}pV$$

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(b) A sample of an ideal gas contains 8.5×10^{22} molecules in a volume of $2.6 \times 10^{-3}\,\text{m}^3$. The gas exerts a pressure of $1.4 \times 10^5\,\text{Pa}$.

Calculate the average kinetic energy of a molecule in the gas.

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Average kinetic energy of a molecule = ...

(Total for Question 13 = 5 marks)

14 Ice cream consists of ice crystals in a mixture of other ingredients.

A container holds $1.5 \times 10^{-3}\,m^3$ of ice cream.

The ice crystals make up 32% of the total mass of the ice cream.

Calculate the energy required to melt the ice crystals without changing the temperature of the ice cream.

density of ice cream = $550\,kg\,m^{-3}$
specific latent heat of ice = $3.3 \times 10^5\,J\,kg^{-1}$

Energy required = ...

(Total for Question 14 = 4 marks)

15 A ‘Gatso camera’ is a device that can determine the speed of a car.

A Gatso camera emits radio waves of frequency 24.1 GHz. The radio waves are reflected from cars as the cars approach the camera.

A car approaches the camera.

The difference in frequency between the waves reflected from the car and the waves received back at the camera is 2.88 kHz.

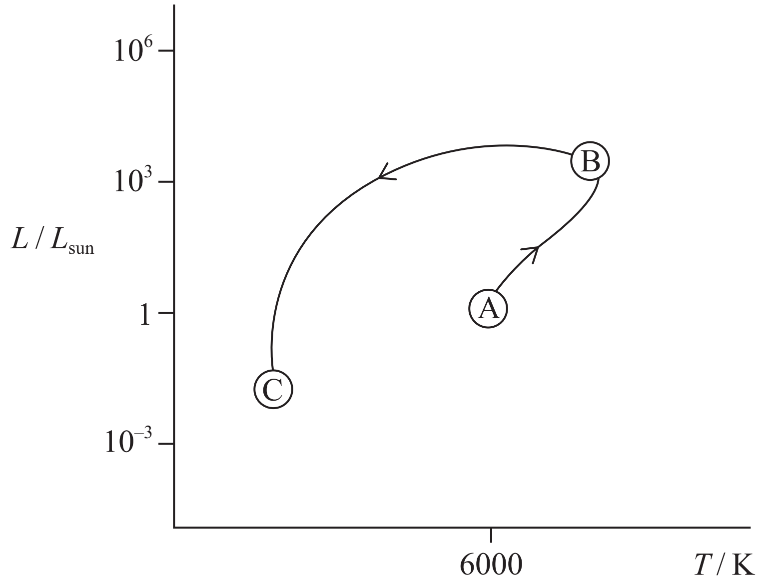
The speed limit on a road is $31\,\mathrm{m\,s^{-1}}$.

The recorded speed of the car must not be more than 10% greater than the speed limit for the road.

Deduce whether the speed limit is exceeded.

(Total for Question 15 = 4 marks)

16 An incomplete Hertzsprung-Russell (H-R) diagram is shown.



(a) Complete the scale on the temperature axis.

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*(b) The evolution of a star like the Sun is shown on the H-R diagram.

Explain how the star evolves by considering the positions A, B and C on the H-R diagram.

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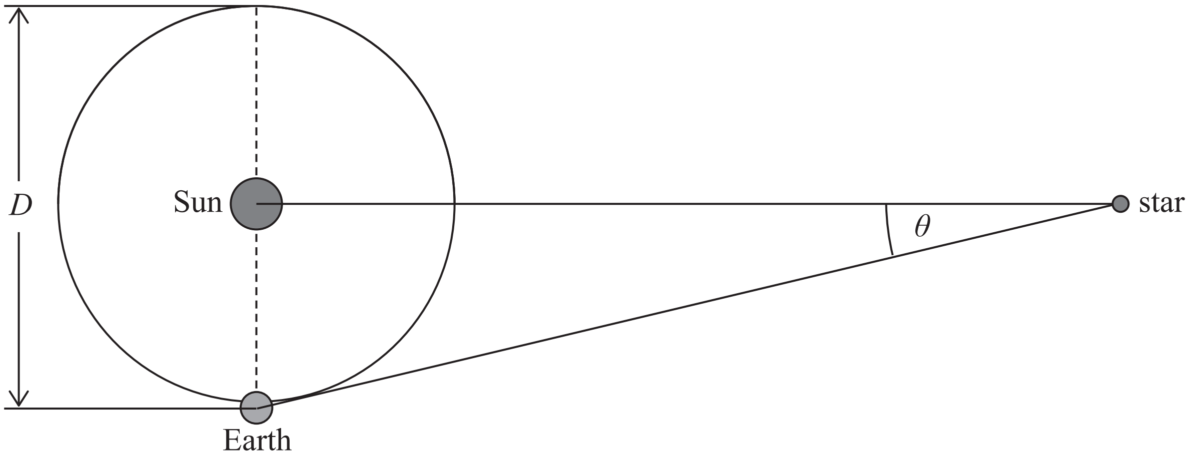
(Total for Question 16 = 8 marks)

17 Astronomers use a variety of methods to determine the distances to stars and galaxies.

(a) The diagram shows the parallax angle θ for a star.



The smallest parallax angle θ that can be measured is 4.75×10^{-9} rad.

The Blaze Star is 2.8×10^{19} m away from the Sun.

Deduce whether the distance to the Blaze Star could be determined by trigonometric parallax.

$D = 3.00 \times 10^{11}$ m

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(b) Describe how the distances to the most distant galaxies can be determined.

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(Total for Question 17 = 6 marks)

18 Torbernite is a naturally occurring mineral. Torbernite is radioactive because it contains uranium.

A 2.75 g sample of torbernite has an activity of 2.15×10^{4} Bq.

Uranium makes up 65% of the mass of a typical sample of torbernite.

(a) Deduce whether the sample used is a typical sample.

decay constant of uranium = $4.92 \times 10^{-18}\,\text{s}^{-1}$
mass of uranium atom = 238 u

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(b) The uranium decays by emitting alpha particles.

Explain why the sample of torbernite is relatively safe.

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(Total for Question 18 = 7 marks)

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19 Fusion reactions in a star release energy.

(a) Explain the conditions necessary for nuclear fusion to take place in a star.

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(b) Tritium ^{3}H is produced in stars. Tritium decays by emitting a beta particle.

(i) Complete the nuclear equation for the decay of tritium.

$$^{3}_{1}H \rightarrow \,^{\dots\dots}_{\dots\dots}He + \,^{\dots\dots}_{\dots\dots}\beta + \,^{0}_{0}\overline{\nu}_{e}$$

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(ii) Tritium is used in some watches to make the display glow in the dark. For the display to glow, the minimum activity of the tritium must be 2.78×10^{8} Bq.

A watch manufacturer claims that a tritium display will glow for 20 years.

Deduce whether the claim made by the watch manufacturer is correct.

initial number of tritium atoms = 5.17×10^{17}
half-life of tritium = 12.3 years
1 year = 3.15×10^{7} s

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(Total for Question 19 = 11 marks)

20 The photograph shows a donkey and carriage.

(Source: © WINDCOLORS/Shutterstock)

The carriage consists of a seat attached to a metal frame. The frame is attached to the wheels by a system of springs.

(a) When the carriage is displaced vertically, it oscillates with simple harmonic motion.

State the conditions required for an object to move with simple harmonic motion.

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(b) When a woman of mass 75 kg sits in the carriage, the springs compress by 1.2 cm.

(i) Show that the stiffness constant of the spring system is about $6 \times 10^4\,\mathrm{N\,m^{-1}}$

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(ii) The mass of the carriage is 350 kg.

Two people with a total mass of 125 kg sit in the carriage.

Calculate the natural frequency of oscillation when the two people sit in the carriage.

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Natural frequency = ...

(c) The donkey starts to pull the carriage along a rough road surface.

As the donkey accelerates, the amplitude of oscillation of the carriage increases. At a particular speed, the amplitude of oscillation has a maximum value.

(i) Explain why the amplitude of oscillation has a maximum value at a particular speed.

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(ii) Explain how the spring system can be modified to reduce the maximum amplitude of oscillation.

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(Total for Question 20 = 13 marks)

21 The Sun is at the centre of our solar system.

(a) The planets closest to the Sun move in circular orbits.

(i) The Earth makes one complete orbit of the Sun in 365 days.

Calculate the time, in days, for Venus to make one complete orbit of the Sun.

distance from Venus to Sun = 1.09×10^{11} m
distance from Earth to Sun = 1.50×10^{11} m

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Time for Venus to make one complete orbit = ... days

(ii) The mass of the Sun is decreasing.

Explain how this will affect the radius of the Earth's orbit about the Sun.

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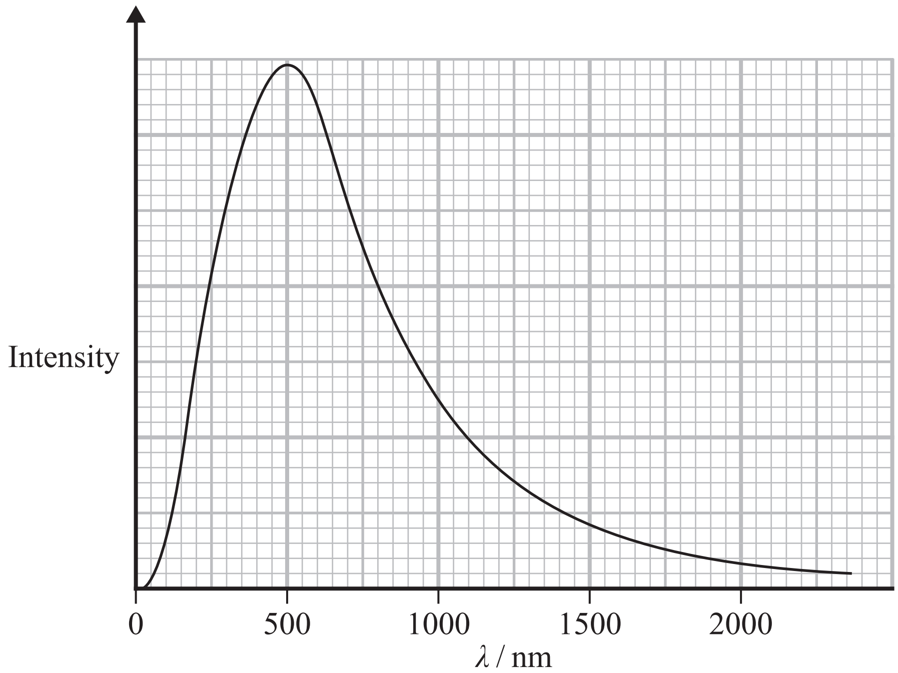
(b) (i) The graph shows how the intensity of radiation emitted by the Sun varies for a range of wavelengths.



Show that the surface temperature of the Sun is about 6000 K.

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(ii) Only 25% of the radiation incident at the top of the atmosphere reaches the surface of the Earth.

The radiation from the Sun that reaches the surface of the Earth has an intensity of $340\,\mathrm{W\,m^{-2}}$

Calculate the radius of the Sun.

distance between Sun and Earth = $1.49 \times 10^{11}\,\mathrm{m}$

(5)

Radius of Sun = ...

(Total for Question 21 = 13 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

List of data, formulae and relationships

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

Unit 1

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

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

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

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

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

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

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

Efficiency

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

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

Materials

Density $\rho = \dfrac{m}{V}$

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

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

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

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\dfrac{T}{\mu}}$
Intensity of radiation	$I = \dfrac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \dfrac{c}{v}$
Critical angle	$\sin C = \dfrac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \dfrac{W}{Q}$
Resistance	$R = \dfrac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \dfrac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \dfrac{\rho l}{A}$
Current	$I = \dfrac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \dfrac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$

Unit 4

Mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \frac{p^2}{2m}$
motion in a circle	$v = \omega r$
	$T = \frac{2\pi}{\omega}$
	$a = \frac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \frac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \frac{F}{Q}$
Coulomb's law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \frac{V}{d}$
Electrical potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \frac{Q}{V}$
Energy stored in capacitor	$W = \frac{1}{2}QV$
	$W = \frac{1}{2}CV^2$
	$W = \frac{1}{2}\frac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

Resistor-capacitor discharge $\quad I = I_0 e^{-t/RC}$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field $\quad F = Bqv \sin\theta$

$$F = BIl \sin\theta$$

Faraday's and Lenz's laws $\quad \mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field $\quad r = \frac{p}{BQ}$

Mass-energy $\quad \Delta E = c^2 \Delta m$

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Unit 5

Thermodynamics

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

Nuclear decay

Mass-energy	$\Delta E = c^2\Delta m$
Radioactive decay	$A = \lambda N$
	$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$N = N_0 \mathrm{e}^{-\lambda t}$
	$A = A_0 \mathrm{e}^{-\lambda t}$

Oscillations

Simple harmonic motion	$F = -kx$
	$a = -\omega^2 x$
	$x = A\cos\omega t$
	$v = -A\omega\sin\omega t$
	$a = -A\omega^2\cos\omega t$
	$T = \frac{1}{f} = \frac{2\pi}{\omega}$
	$\omega = 2\pi f$
Simple harmonic oscillator	$T = 2\pi\sqrt{\frac{m}{k}}$
	$T = 2\pi\sqrt{\frac{l}{g}}$

Astrophysics and Cosmology

Gravitational field strength	$g = \dfrac{F}{m}$
Gravitational force	$F = \dfrac{Gm_1m_2}{r^2}$
Gravitational field	$g = \dfrac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \dfrac{-Gm}{r}$
Stephan-Boltzman law	$L = \sigma A T^4$
Wein's law	$\lambda_{\max} T = 2.898 \times 10^{-3}\,\mathrm{m\,K}$
Intensity of radiation	$I = \dfrac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$
Cosmological expansion	$v = H_0 d$