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

Thursday 18 June 2015 – 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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 4 9 2 9 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 Light from a distant galaxy is analysed. The line spectrum obtained is compared with similar radiation from the Sun.

When compared with the light from the Sun, a line in the spectrum of light from the distant galaxy has a

☒ **A** higher frequency and a greater photon energy.

☒ **B** higher frequency and a smaller photon energy.

☒ **C** lower frequency and a greater photon energy.

☒ **D** lower frequency and a smaller photon energy.

(Total for Question 1 = 1 mark)

2 A Hertzsprung-Russell (H-R) diagram is a plot of luminosity against temperature for a range of stars. One group on the H-R diagram is the main sequence.

Select the row of the table that could describe a main sequence star.

	Temperature	Luminosity	Mass
☒ **A**	low	low	low
☒ **B**	low	high	high
☒ **C**	high	low	high
☒ **D**	high	high	low

(Total for Question 2 = 1 mark)

3 Olympus Mons is the highest mountain on Mars. The height of Olympus Mons is 22 km, which is 0.6% of the radius of Mars.

The change in gravitational field strength from the bottom to the top of Olympus Mons is

☒ **A** – 0.6%

☒ **B** – 1.2%

☒ **C** + 1.2%

☒ **D** + 0.6%

(Total for Question 3 = 1 mark)

4 Which of the following is **not** a unit of field strength?

☒ **A** $N\ A\ m^{-1}$

☒ **B** $N\ C^{-1}$

☒ **C** $N\ kg^{-1}$

☒ **D** $V\ m^{-1}$

(Total for Question 4 = 1 mark)

5 A mass hanging from the end of a vertical spring is set into undamped simple harmonic motion with amplitude A. The total energy of the oscillating system is E.

When the amplitude of oscillation is increased to $2A$ the total energy of the oscillating system becomes

☒ **A** E

☒ **B** $2E$

☒ **C** $4E$

☒ **D** $4E^2$

(Total for Question 5 = 1 mark)

6 A student is using a Geiger counter to measure the number of counts per minute from a weak radioactive source.

To determine the background count rate their best procedure is to measure the count for

- ☒ **A** 1 minute before the source is in position.
- ☒ **B** 1 minute with the source in position.
- ☒ **C** 10 minutes before the source is in position.
- ☒ **D** 10 minutes with the source in position.

(Total for Question 6 = 1 mark)

7 In the early 20th century, Hubble determined the distances to a range of nearby galaxies.

Which of the following methods would have allowed him to do this?

- ☒ **A** measuring trigonometric parallax
- ☒ **B** observing Cepheid variables
- ☒ **C** using radio waves
- ☒ **D** using the formula $v = H_0 d$

(Total for Question 7 = 1 mark)

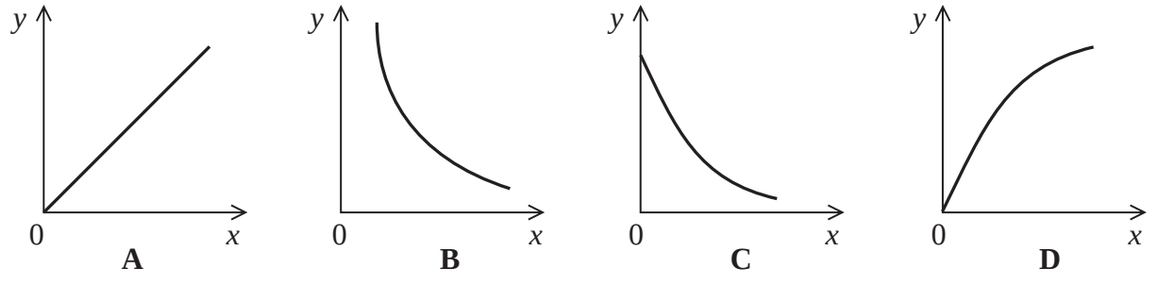
8 In earthquake-proof buildings, the amplitude of vibration of the building is prevented from becoming too large by using materials which deform as the buildings move.

Such materials should

- ☒ **A** be brittle.
- ☒ **B** be stiff.
- ☒ **C** deform elastically.
- ☒ **D** deform plastically.

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the graphs below.



9 Which graph shows how the pressure varies with volume for a fixed mass of an ideal gas maintained at a constant temperature?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 A sample of a radioactive isotope decays to a stable isotope.

Which graph shows how the number of daughter nuclei varies with time?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Cobalt-60 is an artificially produced radioisotope that can be used to treat cancer. It emits beta particles of energy 0.3 MeV and gamma rays of energy 1.3 MeV.

(a) Complete the nuclear equation for the beta decay of cobalt-60.

(2)

$$^{60}_{27}\text{Co} \rightarrow \quad \text{Ni} + \quad \beta^-$$

(b) State, with a reason, the penetrating powers of each of the two types of radiation emitted by the cobalt-60.

(2)

(c) State one risk to a patient associated with the use of radioisotopes to treat cancer.

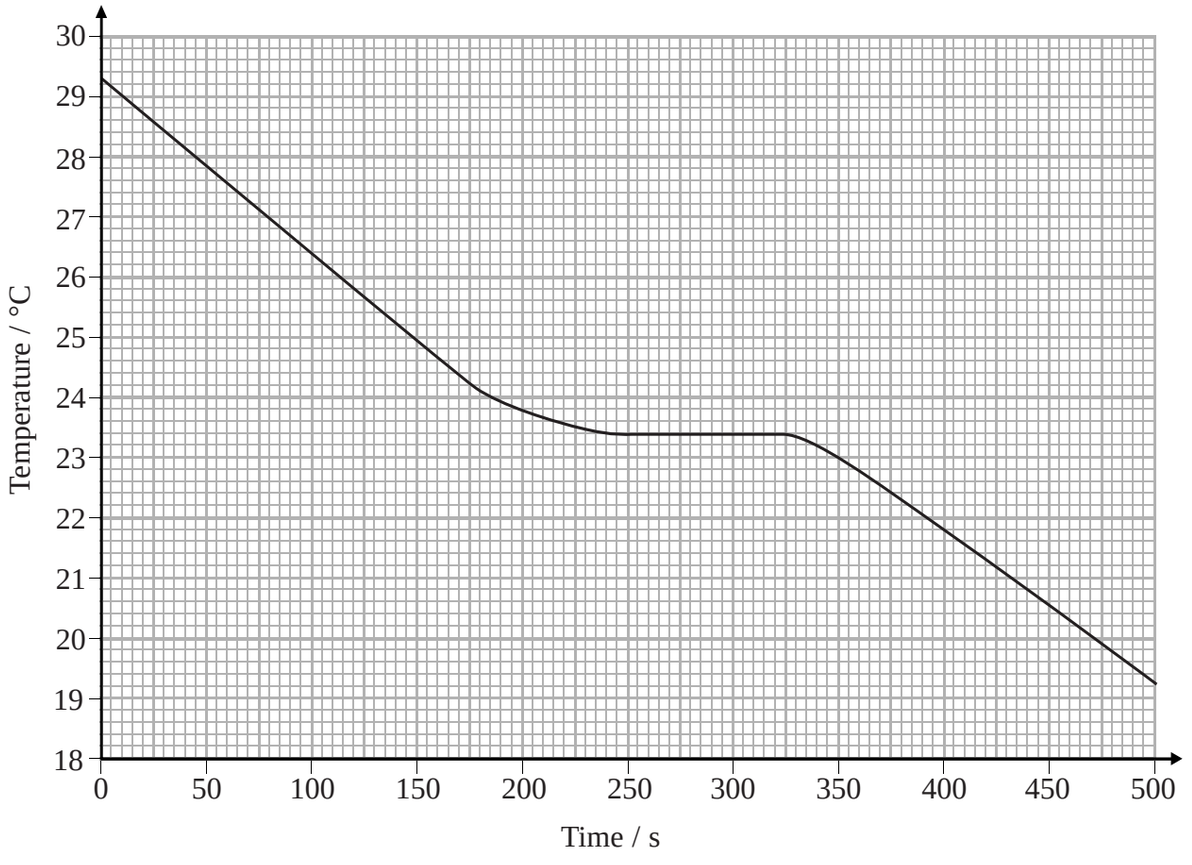
(1)

(Total for Question 11 = 5 marks)

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12 A student investigated the properties of chocolate. He heated 0.75 kg of chocolate until it was a few degrees above its melting point. He then used a temperature sensor connected to a datalogger to monitor the temperature of the chocolate as it cooled in cold surroundings.

The rate at which thermal energy was transferred from the chocolate to the surroundings was approximately constant over the temperature range shown in the graph below.



(a) Use the graph to show that the rate at which thermal energy was transferred from the liquid chocolate was about 50 W.

specific heat capacity of liquid chocolate = 2500 J kg^{-1} K^{-1}

(3)

(b) Explain the shape of the graph between 250 s and 330 s.

(2)

(c) During the last 100 s of cooling the temperature fell at a lower rate than during the first 100 s of cooling.

Suggest why this is the case.

(2)

(Total for Question 12 = 7 marks)

13 Technetium-99m is an unstable isotope which decays by emitting γ radiation. The decay process is random. The half life of this isotope is 2.16×10^4 s.

(a) (i) State what is meant by 'random'.

(1)

(ii) State what is meant by 'half life'.

(1)

(b) A sample containing 7.30×10^{19} atoms of technetium-99m is prepared for use in a medical application.

(i) Show that the activity of the sample when it is prepared is about 2.3×10^{15} Bq.

(3)

(ii) Calculate the activity of the sample 1 day after the sample was prepared.

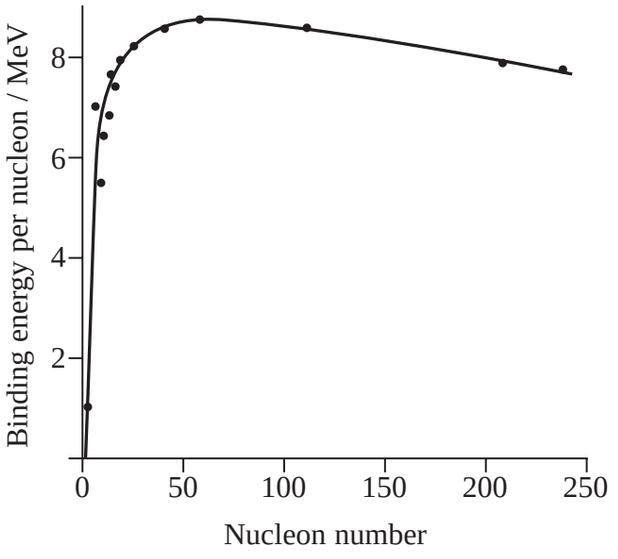
1 day = 86 400 s

(2)

Activity of sample after 1 day =

(Total for Question 13 = 7 marks)

14 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)

(ii) Explain why nuclear fusion is only viable as an energy source if light nuclei are used.

(2)

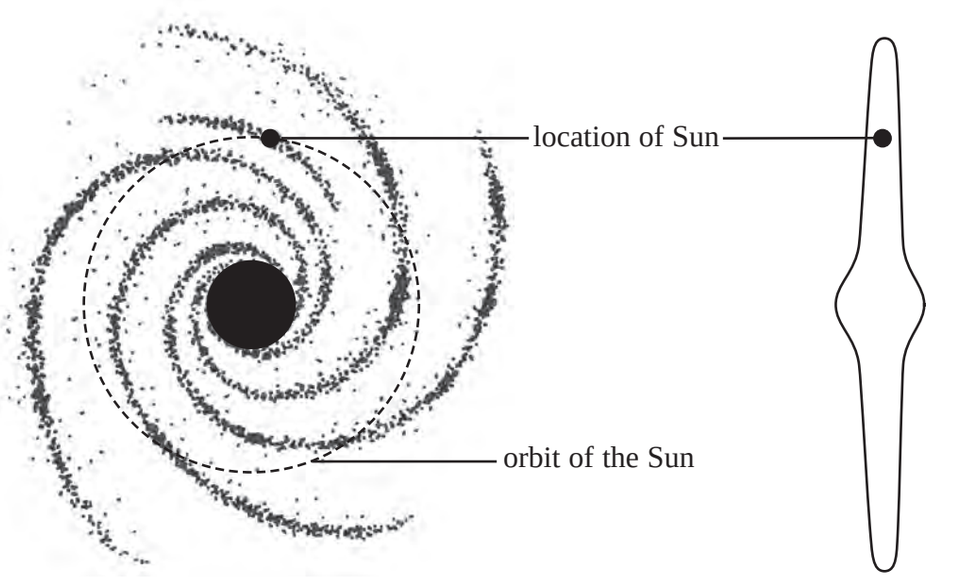
*(b) Outline the conditions necessary for viable fusion to occur and explain why the interiors of stars are ideal for this.

(4)

(Total for Question 14 = 7 marks)

15 The Sun is a typical star in our galaxy, the Milky Way. It is 2.5×10^{20} m from the centre of the galaxy. The Sun orbits the centre of the galaxy at a speed of 220 km s^{-1}.

The diagrams below represent the Milky Way. The central black area represents a very high density of stars, known as the nucleus of the galaxy. The total mass of stars within the orbit of the Sun may be treated as a point mass at the centre of the galaxy.



Face-on view Side-on view

(a) Calculate the mass of the Milky Way within the orbit of the Sun.

(3)

Mass =

(b) (i) The vast majority of stars in the Milky Way are observed to be within the nucleus of the galaxy.

Explain why it might be expected that stars similar to the Sun, but further away from the centre of the galaxy, would orbit at a lower speed than the Sun.

(2)

(ii) Stars similar to the Sun, but further away from the centre of the galaxy, are actually observed to have orbital speeds that are all approximately the same as the Sun's.

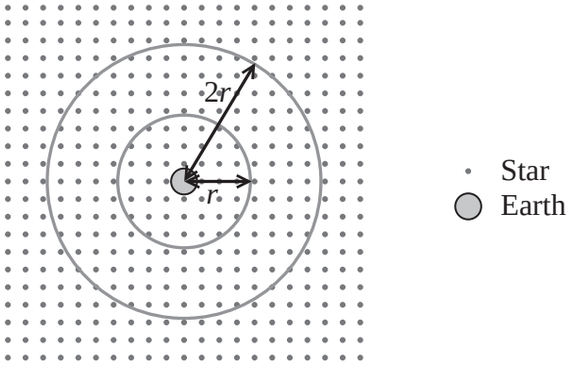
Explain what astronomers can conclude from these observations.

(2)

(Total for Question 15 = 7 marks)

16 In the early 19th century, Heinrich Olbers asked the question, "Why is the night sky dark?" He reasoned that in an infinite universe light from very distant stars should make the whole of the visible sky bright.

To see how much distant stars contribute to light reaching the Earth, the universe can be modelled as a uniform distribution of identical stars. If this universe is divided into a series of thin concentric 'shells' centred on Earth, there will be a certain number of stars on each shell.



The diagram shows two shells of equal thickness at distances r and $2r$ from the centre of the Earth.
There are four times as many stars on the shell at $2r$ than on the shell at r.

(a) Explain why the total radiation flux received at the Earth from the stars on each shell is the same.

(2)

(b) One explanation proposed for why the night sky is not bright was that there is too much dust in space for distant stars to be seen. However, such dust would absorb radiation and heat up.

(i) Space is estimated to be at a temperature of 2.7 K. Use this value to calculate the radiant power emitted per m^2 of a body at this temperature.

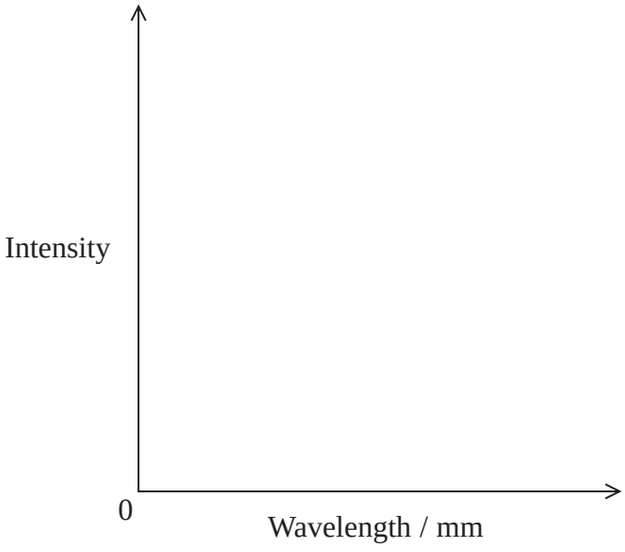
(2)

Radiant power emitted per m^2 = W m^{-2}

(ii) Calculate the value of λ_{max} for the radiation emitted by a black body at a temperature of 2.7 K, and sketch a graph of the radiation spectrum.

(4)

λ_{max} =



(iii) State how your graph would change if the black body were at a higher temperature.

(2)

(c) The commonly accepted solution to Olbers' question is that the universe is expanding and has a finite age.

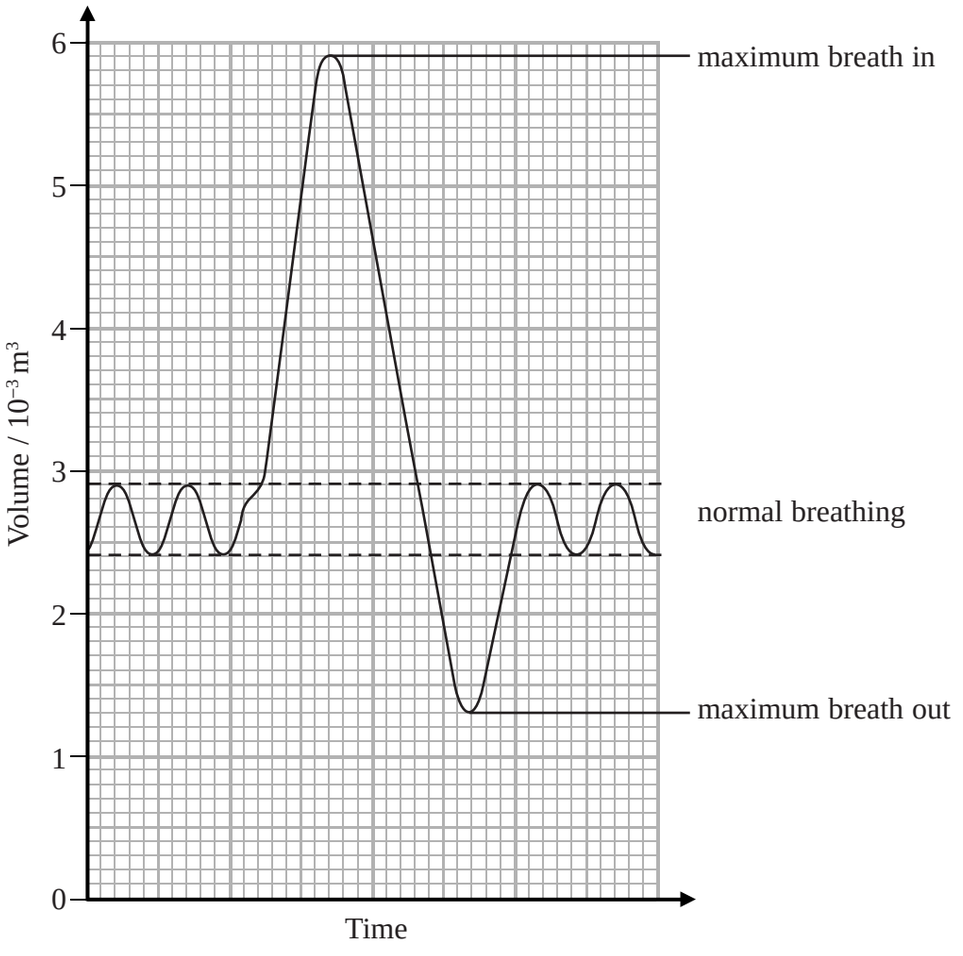
Suggest why some stars may be unobservable in a universe of finite age.

(1)

(Total for Question 16 = 11 marks)

17 A spirometer is a device used in medical tests to investigate breathing. The spirometer measures the volume of air entering and leaving the lungs.

A patient is asked to breathe normally, take a maximum breath in and a maximum breath out, then breathe normally again. The results are shown on the graph.



(a) Whilst in the lungs the air was at a temperature of 37.0 °C and a pressure of 1.02×10^5 Pa.

(i) Show that the number of air molecules expelled from the lungs between the maximum breath in and the maximum breath out is about 1×10^{23}.

(3)

(ii) Calculate the total kinetic energy of the air molecules expelled from the lungs between the maximum breath in and the maximum breath out.

(2)

Total kinetic energy of air molecules =

(iii) Explain why the internal energy of the air can be taken as the total kinetic energy of the molecules of the air.

(2)

(b) Air is a mixture of mainly nitrogen and oxygen. Oxygen molecules are more massive than nitrogen molecules. Nitrogen accounts for about 80% of the molecules in a given sample of air.

(i) Compare the mean square speed of the oxygen molecules to the mean square speed of the nitrogen molecules in a sample of air.

(2)

*(ii) The pressure exerted by the air in a sample is partly due to the oxygen molecules and partly due to the nitrogen molecules.

Explain why the nitrogen molecules would account for 80% of the pressure exerted by the air.

(3)

(Total for Question 17 = 12 marks)

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18 A child of mass 35 kg is standing on a trampoline. At equilibrium the surface of the trampoline is displaced vertically by 22 cm from the unloaded position.



(a) Show that the force constant of the trampoline is about 1600 N m^{-1}.

(2)

(b) The child bounces up and down, always staying in contact with the trampoline. The motion is simple harmonic.

(i) Calculate the child's frequency of oscillation.

(3)

Frequency of oscillation =

(ii) The height of each bounce above the equilibrium position is 21 cm.

Calculate the maximum speed of the child and identify the position at which she has this speed.

(3)

Maximum speed of child =

Position =

(c) (i) The child bends her knees and pushes against the surface of the trampoline at each bounce. Her amplitude of oscillation gradually increases.

Name this effect and explain why there is an increase in amplitude.

(3)

Name of effect

Explanation

*(ii) As her amplitude of oscillation increases she starts to lose contact with the surface of the trampoline.

Explain why the motion can no longer be described as simple harmonic.

(3)

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 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	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$\dfrac{1}{R} \quad \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

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

P 4 4 9 2 9 A 0 2 6 2 8

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	$Q = Q_0e^{-t/RC}$
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	$\lambda = h/p$

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

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	$v = H_0 d$