Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number

Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Thursday 19 June 2014 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

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 ▶

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 Radioactive decay is said to be a spontaneous process.

This means that

☒ **A** we cannot know when a nucleus will decay.

☒ **B** we cannot know which nucleus will decay next.

☒ **C** we cannot know how many nuclei will decay.

☒ **D** we cannot influence when a nucleus will decay.

(Total for Question 1 = 1 mark)

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2 A standard candle, within a nearby star cluster, is a distance D from the Earth. It produces a radiation flux F at the surface of the Earth.

The flux at the surface of the Earth, for a standard candle of the same luminosity in a second star cluster, is $4F$.

The distance of the second star cluster from the Earth is

☒ **A** $4D$

☒ **B** $2D$

☒ **C** $\frac{D}{2}$

☒ **D** $\frac{D}{4}$

(Total for Question 2 = 1 mark)

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3 In an experiment to measure the activity of a radioactive source the measured activity should always be corrected by

☒ **A** adding the background count.

☒ **B** adding the background count rate.

☒ **C** subtracting the background count.

☒ **D** subtracting the background count rate.

(Total for Question 3 = 1 mark)

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4 Exoplanets are planets orbiting stars other than our own Sun. Most exoplanets discovered so far are giant planets similar to the planet Jupiter. The exoplanet Kepler-7b has a mass about 0.43 times the mass of Jupiter, and a radius about 1.6 times the radius of Jupiter.

Take the gravitational field strength at the surface of Kepler-7b to be g_K, and the gravitational field strength at the surface of Jupiter to be g_J.

The ratio $\frac{g_K}{g_J}$ is

☒ **A** 0.17

☒ **B** 0.27

☒ **C** 0.69

☒ **D** 1.1

(Total for Question 4 = 1 mark)

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5 Star A has twice the radius of star B but only half the surface temperature.

The ratio of the luminosity of star A to luminosity of star B is

☒ **A** 1:4

☒ **B** 1:2

☒ **C** 2:1

☒ **D** 4:1

(Total for Question 5 = 1 mark)

6 Whilst a car is being driven over a bridge, it sets the bridge into vibration. Which of the following terms definitely describes the oscillations of the bridge?

The oscillations of the bridge are

☒ **A** free.

☒ **B** forced.

☒ **C** natural.

☒ **D** resonant.

(Total for Question 6 = 1 mark)

7 The damping force acting on an oscillating system is always

☒ **A** in the opposite direction to the acceleration.

☒ **B** in the opposite direction to the velocity.

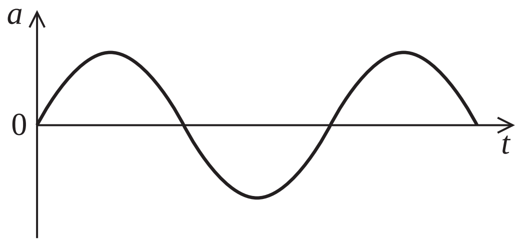
☒ **C** in the same direction as the acceleration.

☒ **D** in the same direction as the velocity.

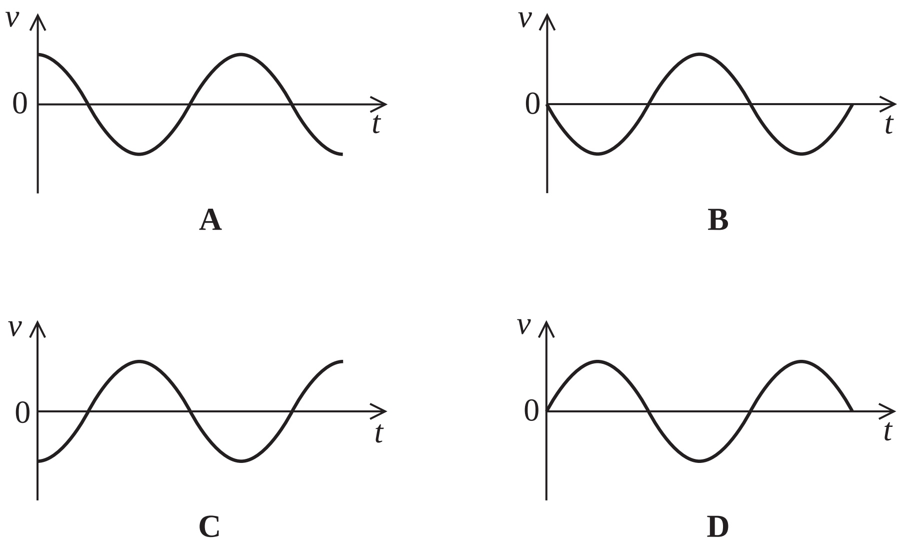
(Total for Question 7 = 1 mark)

P 4 3 1 2 4 A 0 4 2 8

8 The graph shows how the acceleration varies with time for an object undergoing simple harmonic motion.



Which of the following graphs, **A**, **B**, **C** or **D**, shows how the velocity of the object varies with time?



☒ **A**

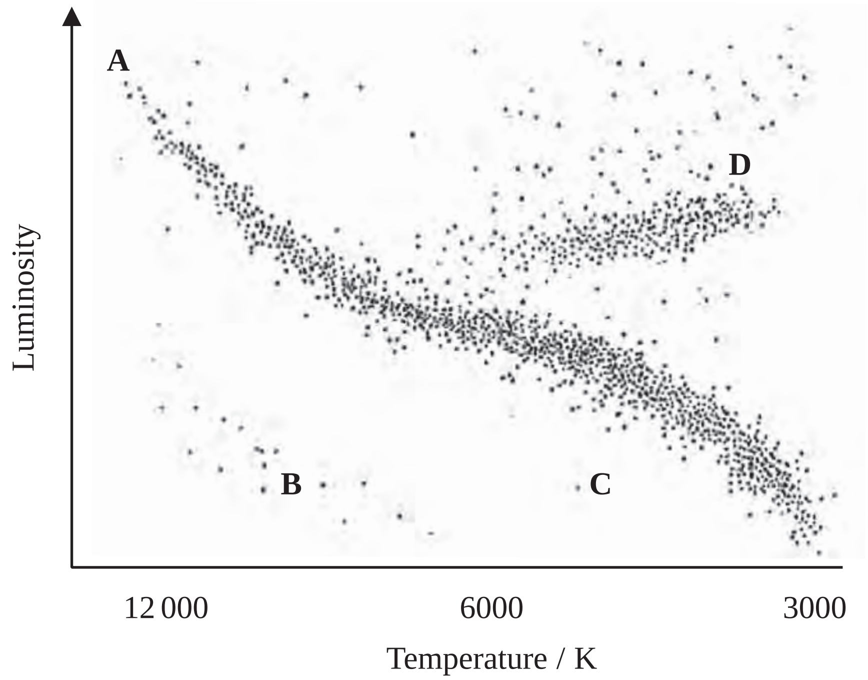
☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the Hertzsprung-Russell diagram below.



9 Which letter, **A**, **B**, **C** or **D**, indicates the region where a white dwarf star would be shown?

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

(Total for Question 9 = 1 mark)

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10 Which letter, **A**, **B**, **C** or **D**, indicates the region where a blue giant star would be shown?

- ☒ **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 Mars is our nearest neighbour in the solar system. In August 2003 the distance between Mars and the Earth was the closest in recorded history at 5.6×10^{10} m.

mass of Mars = 6.4×10^{23} kg

mass of Earth = 6.0×10^{24} kg

Calculate the gravitational force between Mars and the Earth when they were at this distance.

(2)

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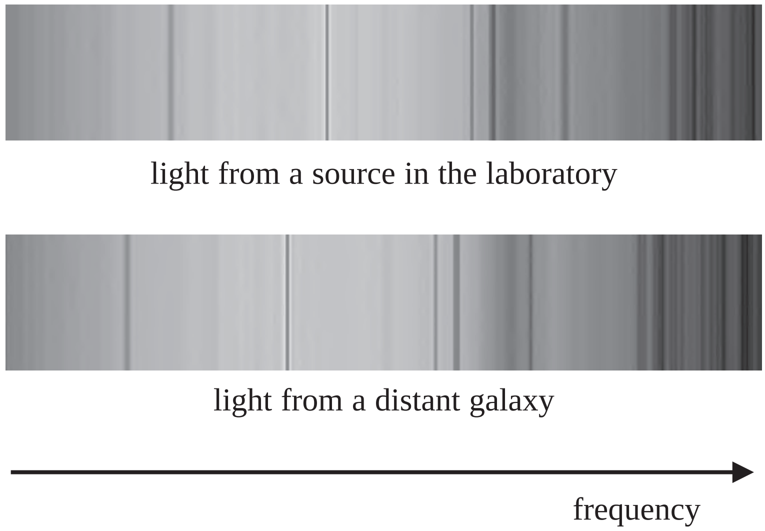
Gravitational force = ...

(Total for Question 11 = 2 marks)

12 The spectra below show dark absorption lines against a continuous visible spectrum.



A particular line in the spectrum of light from a source in the laboratory has a frequency of 4.570×10^{14} Hz.
The same line in the spectrum of light from a distant galaxy has a frequency of 4.547×10^{14} Hz.

With the aid of a calculation state what should be concluded about the distant galaxy.

(3)

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(Total for Question 12 = 3 marks)

13 (a) Explain what is meant by internal energy of a liquid.

(2)

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(b) A cup of tea contains 175 g of water at a temperature of 85.0 °C. Milk at a temperature of 4.5 °C is added to the tea and the temperature of the mixture becomes 74.0 °C.

(i) Show that the internal energy of the water decreases by about 8 kJ as its temperature decreases.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(2)

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(ii) Calculate the mass of milk that was added to the tea. State an assumption that must be made.

Specific heat capacity of milk = 3900 J kg^{-1} K^{-1}

(3)

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Mass of milk = ...

Assumption ....

....

(Total for Question 13 = 7 marks)

14 A bicycle tyre contains air at 20 °C. The volume occupied by the air is 2.9×10^{-4} m^3. Assume that this volume remains fixed.

(a) The pressure of the air in the tyre is 5.8×10^5 Pa. In an attempt to improve performance air is pumped into the tyre until the pressure at 20 °C is 6.5×10^5 Pa.

Calculate the number of air molecules that must be pumped into the tyre.

(3)

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Number of molecules = ...

(b) After cycling in a race the air pressure in the tyre has risen from 6.5×10^5 Pa to 6.8×10^5 Pa.

Calculate the increase in temperature of the air in the tyre.

(3)

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Increase in temperature = ...

(c) Explain why the pressure increases when the air is heated in a tyre of fixed volume.

(3)

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(Total for Question 14 = 9 marks)

15 When a photographic film that is not exposed to light is placed near to a source of ionising radiation the film darkens.

(a) (i) State what is meant by ionising radiation.

(1)

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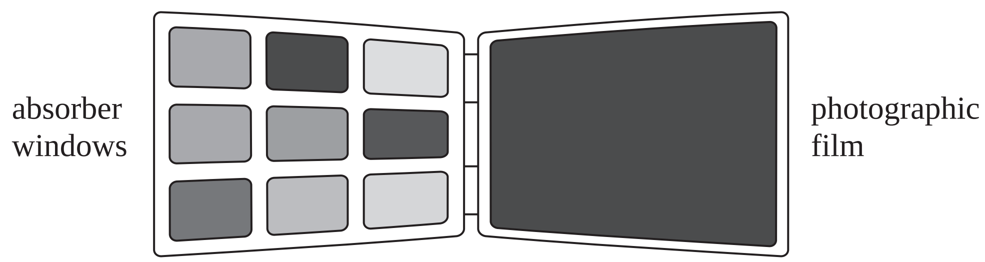
(ii) Complete the table to show α, β, and γ radiations in order of increasing ionising power.

(1)

Least ionising → Most ionising		

(b) In a physics lesson some students are learning about the use of a film badge to monitor exposure to ionising radiation.

Each absorber window is made from a different material and the type of radiation can be determined from the extent to which the film is darkened.



film badge

The students are asked to predict what would happen if α, β, and γ radiations were incident upon absorber windows made from paper, aluminium and lead.

(i) Complete the table to show the penetration of α, β, and γ radiations through each material.

Use the words “passes through” or “stopped”.

(3)

	Paper	**0.5 cm aluminium**	**0.5 cm lead**
α **radiation**		stopped	
β **radiation**			stopped
γ **radiation**	passes through		

(ii) In a nuclear power plant there may be other radiation present which would **not** be detected by a film badge.

Suggest what type of radiation this is and why it would not be detected by a film badge.

(2)

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(Total for Question 15 = 7 marks)

16 Almost a century ago Edwin Hubble was investigating the light spectra emitted from a large number of galaxies. He used redshift values obtained from these spectra to determine the velocity of the galaxies relative to the Earth. He also measured the distances to each galaxy using Cepheid variable stars, which are a type of standard candle. From these measurements Hubble was able to formulate a law linking the velocity of distant galaxies to their distance from the Earth.

(a) (i) Explain what is meant by redshift.

(2)

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*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

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(b) State what is meant by a standard candle.

(1)

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(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

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(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

(3)

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(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

(2)

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(Total for Question 16 = 13 marks)

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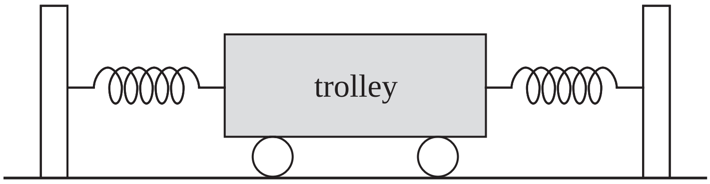
17 The diagram shows a mass-spring system that consists of a trolley held in equilibrium by springs attached to two fixed supports.



The trolley has a mass *m* and the spring arrangement has a force constant *k*.

(a) (i) The trolley is displaced towards one of the supports through a distance *x* and then released. Show that the initial acceleration of the trolley when it is released is given by $a = -\frac{kx}{m}$ and explain the significance of the minus sign.

(2)

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(ii) Use the expression in (i) to show that the trolley will oscillate with a time period *T* given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

(3)

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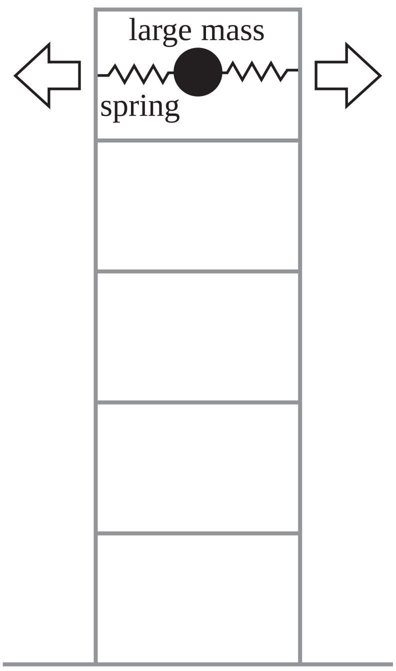
(b) Mass-spring systems are sometimes used in tall buildings to reduce the oscillation of the building due to strong winds.



As the top of the building moves the mass is set into oscillation. The mass-spring system is designed to have a natural frequency equal to that of the building.

(i) In one building a mass-spring system has a mass of 3.5×10^5 kg and the spring arrangement has a force constant of 4.8×10^6 N m^{-1}.

Show that the natural frequency of the mass-spring system is about 0.6 Hz.

(3)

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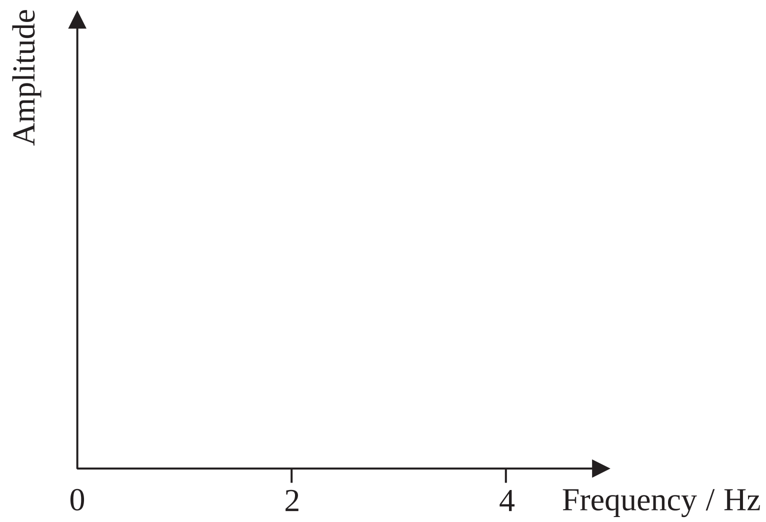
(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)



(iii) In order to be effective the mass-spring system needs to be damped.

Explain what is meant by damping in this context and suggest why damping is a desirable feature of the mass-spring system in a tall building.

(3)

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(Total for Question 17 = 14 marks)

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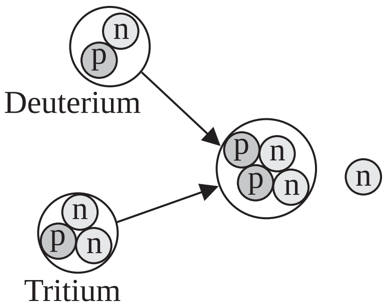
18 The following passage is adapted from a recent article in a British newspaper:

"Every year, one typical coal-fired power station devours several million tonnes of fuel and produces even more carbon dioxide. That volume of carbon dioxide is damaging the atmosphere and, in the longer term, the fuel will run out. It is clear that the world needs an alternative for generating energy.

Nuclear fusion looks like offering a solution to the problem. Using the equivalent of a bath tub of water, fusion has the potential to deliver the same amount of energy as 100 tonnes of coal. There would be no carbon dioxide emission, it would be inherently very safe, and would not produce any significant radioactive waste."

(Adapted from an article in The Observer newspaper, Sunday 16th September 2012)

(a) The latest proposed fusion reactor will fuse deuterium and tritium, which are isotopes of hydrogen. This fusion reaction is illustrated below.



(i) Complete the nuclear equation below to represent this fusion reaction.

(2)

$$^{\dots}_{\dots}\mathrm{H} + {}^{\dots}_{\dots}\mathrm{H} \rightarrow {}^{\dots}_{\dots}\mathrm{He} + {}^{\dots}_{\dots}\mathrm{n}$$

(ii) Calculate the energy released in the fusion of one deuterium nucleus with one tritium nucleus.

Particle	Mass / GeV/c^2
Proton	0.938272
Neutron	0.939566
Deuterium	1.875600
Tritium	2.808900
Helium	3.727400

(2)

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Energy released = ...

(iii) Explain why most of the energy released in the fusion of one deuterium nucleus with one tritium nucleus is transferred to kinetic energy of the neutron.

(3)

(b) A sample of tritium is produced. Tritium is unstable and decays by β^- emission with a half-life of 12.3 years.

Calculate the time taken, in years, for the activity of the sample to fall to 10% of its initial value.

(3)

Time taken = ... years *(c) The article states that “it would be inherently very safe, and would not produce any significant radioactive waste.”

Comment on this statement and outline the technical difficulties of producing a practical nuclear fusion reactor.

(5)

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(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\,s^{-2}}$	(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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

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

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	$\lambda = h/p$

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	$v = H_0 d$

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