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 19 June 2014 – 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 ▶

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 A sample of gas is made of a mixture of nitrogen and oxygen. At a given temperature the average molecular kinetic energy is

☐ **A** the same for molecules of both gases.

☐ **B** greater for nitrogen molecules.

☐ **C** greater for oxygen molecules.

☐ **D** dependent upon the amount of each gas.

(Total for Question 1 = 1 mark)

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2 A person stands on the surface of the Earth.

The gravitational force between the person and the Earth does **not** depend on

☐ **A** the mass of the person.

☐ **B** the mass of the Earth.

☐ **C** the rate of rotation of the Earth.

☐ **D** the position of the person.

(Total for Question 2 = 1 mark)

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3 Trigonometric parallax can only be used to determine distances to

☐ **A** nearby stars.

☐ **B** distant stars.

☐ **C** nearby galaxies.

☐ **D** distant galaxies.

(Total for Question 3 = 1 mark)

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4 A system is made to oscillate by a driver force.

Which of the following conditions must be met for resonance of the system to occur?

☒ **A** The driver force must be large.

☒ **B** The frequency of the driver must equal the natural frequency of the system.

☒ **C** The initial amplitude of the system must be small.

☒ **D** The system must have no damping.

(Total for Question 4 = 1 mark)

5 Internal energy of a system is the

☒ **A** sum of the molecular kinetic and potential energies.

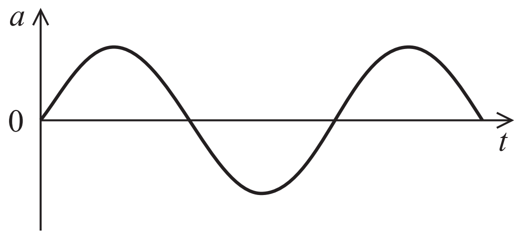
☒ **B** molecular kinetic energy alone.

☒ **C** molecular potential energy alone.

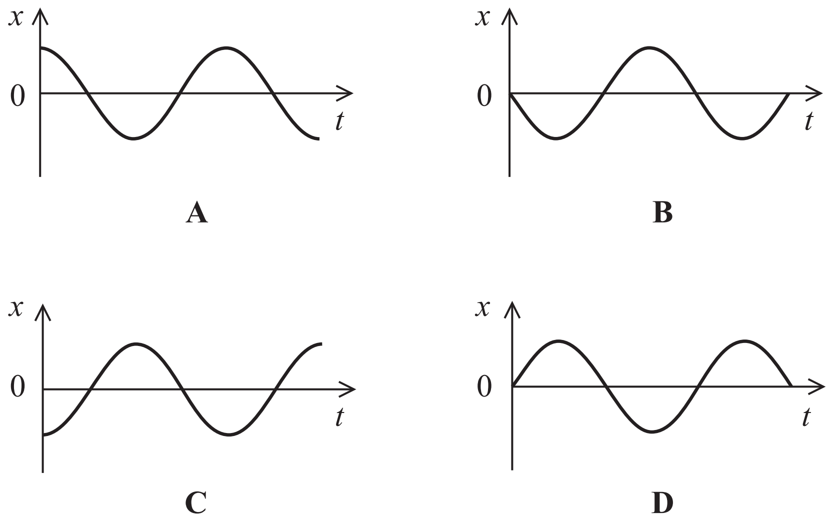
☒ **D** difference between the molecular kinetic and potential energies.

(Total for Question 5 = 1 mark)

6 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 displacement of the object varies with time?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 1 mark)

7 Dark energy appears to be increasing the rate at which the universe expands.

As a result it is more likely that the universe is

☒ **A** closed.

☒ **B** open.

☒ **C** infinite in size.

☒ **D** younger than we thought.

(Total for Question 7 = 1 mark)

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8 For a system to undergo simple harmonic motion which of these energies must remain constant?

total energy   kinetic energy   potential energy

☒ **A** all of these energies

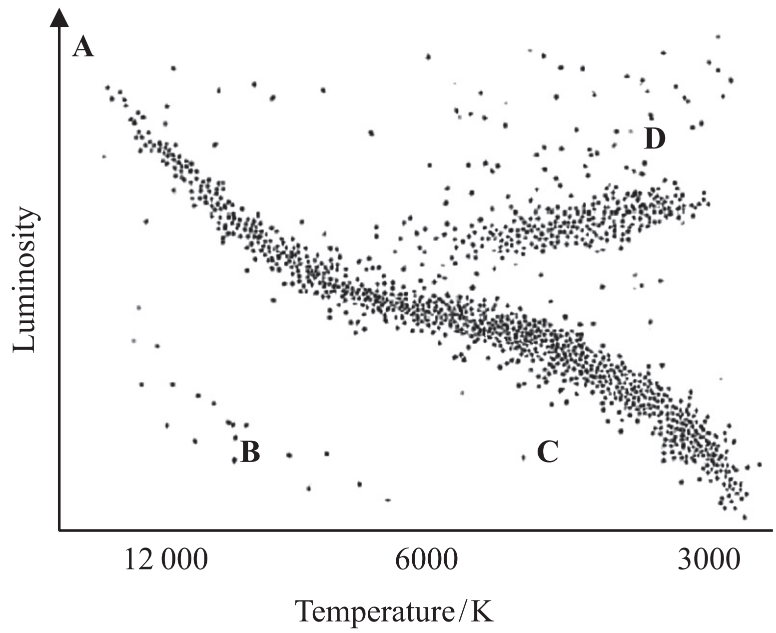
☒ **B** kinetic energy only

☒ **C** potential energy only

☒ **D** none of these energies

(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 red giant 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 main sequence star would be shown?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

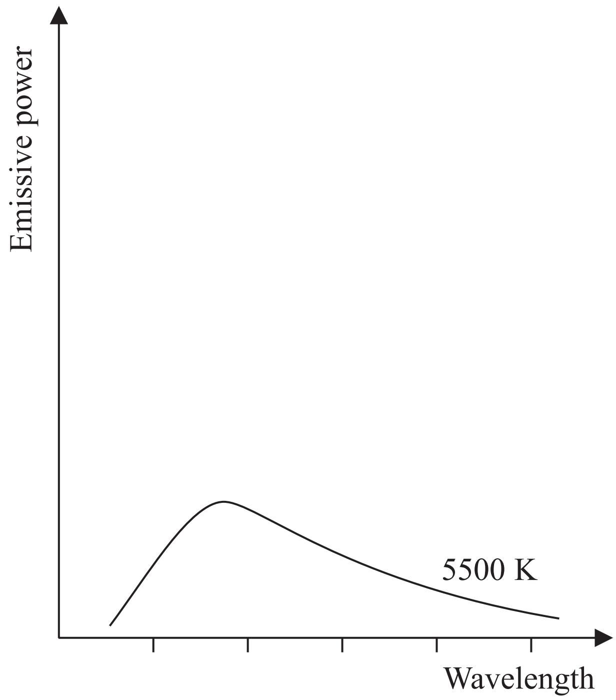
SECTION B

Answer ALL questions in the spaces provided.

11 The graph shows how the emissive power varies with wavelength for a star of surface temperature 5500 K.

On the same axes sketch graphs to show how the emissive power varies with wavelength for stars with surface temperatures of 5000 K and 6000 K. Label each graph clearly.

(3)



(Total for Question 11 = 3 marks)

12 In October 2012, Felix Baumgartner completed his world record free-fall attempt, jumping from just above the atmosphere from a height of 36.6 km.

(a) At the surface of the Earth the gravitational field strength has a magnitude of 9.81 N kg^{-1}. Calculate the magnitude of the gravitational field strength at the position from which Baumgartner jumped.

Earth radius = 6400 km

(3)

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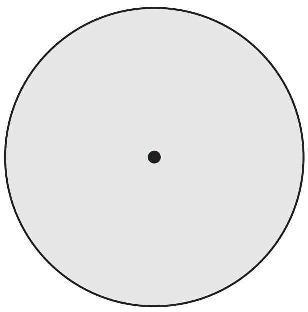
Gravitational field strength = ...

(b) The Earth is represented by the shaded circle in the diagram below. Add to the diagram to indicate the gravitational field around the Earth.

(2)



P 4 2 9 2 9 A 0 8 2 4

(c) Explain why the gravitational field can be thought of as approximately uniform over the distance of the jump.

(2)

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(Total for Question 12 = 7 marks)

13 An outdoor swimming pool is heated using an electric heater.

(a) The swimming pool contains 1.6×10^4 kg of water at a temperature of 12 °C.

Calculate how much energy an electric heater must supply to raise the temperature of the water to 20 °C. State any assumption that you have made.

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

(3)

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Energy = ...

Assumption ....

....

(b) The electric heater runs from a 230 V supply and takes 30 hours to supply 0.55 GJ of thermal energy.

Calculate the current in the heater.

(3)

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Current = ...

(Total for Question 13 = 6 marks)

14 Proxima Centauri is a red dwarf star about 4.2 light years away from the Earth with an average surface temperature of 3.04×10^3 K.

(a) Calculate the wavelength λ_{max} at which peak power emission from Proxima Centauri occurs.

(2)

λ_{max} = ...

(b) The radius of Proxima Centauri is estimated to be 3.2×10^6 m.

(i) Show that its luminosity is about 6×10^{20} W.

(2)

(ii) When measured on the surface of the Earth the radiation flux from the Sun is 1.38×10^3 W m^{-2}.

At a point in space the radiation flux from Proxima Centauri also has this magnitude.

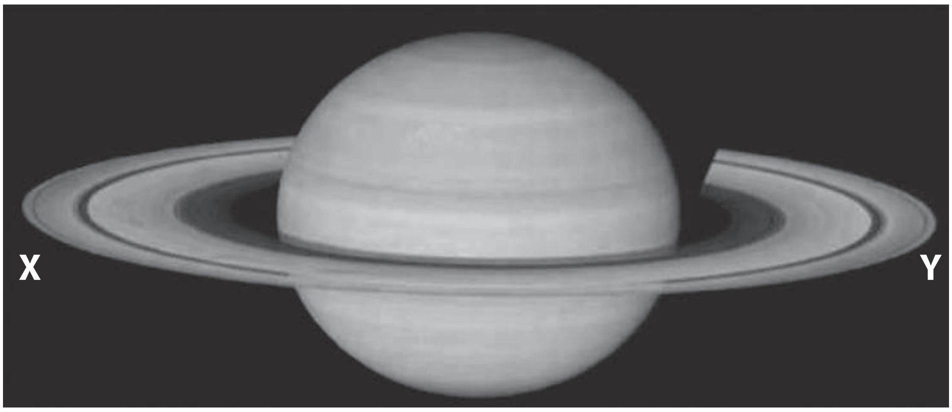
Calculate the distance of this point from Proxima Centauri.

(2)

Distance ....

(Total for Question 14 = 6 marks)

15 The rings of Saturn consist of countless small pieces of ice and rock orbiting the planet. The particles range in size from a few centimetres to a few metres.



(a) When the rings are observed from the Earth, sunlight reflected from X is found to have slightly longer wavelengths than sunlight reflected from Y.

Suggest a reason for these observations.

(2)

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P 4 2 9 2 9 A 0 1 2 2 4

(b) A rock of mass 2500 kg, in one of the rings, is orbiting at a distance of 1.75×10^8 m from the centre of Saturn. The rock has a speed of 1.45×10^4 m s^{-1} as it orbits the planet.

(i) Calculate the time in hours the rock takes to complete one orbit.

(3)

Time for one orbit = ... hours

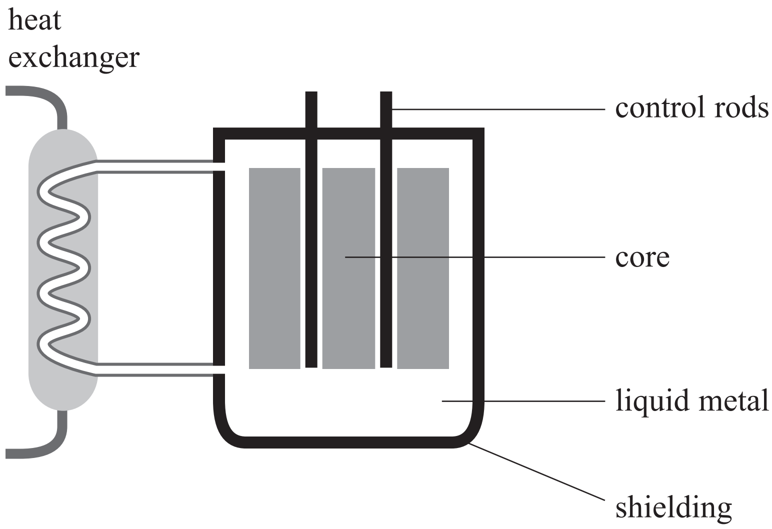
(ii) By considering the gravitational force acting on this orbiting rock calculate a value for the mass of Saturn.

(3)

Mass of Saturn = ...

(Total for Question 15 = 8 marks)

16 In one type of fission reactor the coolant is a liquid metal alloy of sodium and potassium. The sodium absorbs neutrons from the reactor core and becomes the isotope sodium-24. Sodium-24 emits both beta and gamma radiation.



*(a) State what is meant by nuclear fission and explain why energy is released during the fission of a nucleus such as uranium.

(3)

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(b) A sample of coolant from the reactor contains 1.2×10^{13} nuclei of sodium-24.

Calculate the activity of this sample when it is first removed from the reactor.

decay constant of sodium-24 = $1.3 \times 10^{-5}\ s^{-1}$

(2)

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Activity = ...

(c) Shielding is placed around the core of the reactor.

State **one** physical property this shielding must have and name the material that is usually used.

(2)

Property ....

Material ....

(d) Many governments are funding research into replacing fission reactors with fusion reactors. Suggest why.

(2)

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(Total for Question 16 = 9 marks)

17 Tennis balls used in tournaments are filled with nitrogen gas and have a mass of 57.0 g. These balls are tested by dropping them from rest through a vertical distance of 2.54 m to check the bounce height.

(a) Calculate the kinetic energy of one of these balls just before impact with the ground.

(2)

Kinetic energy = ...

(b) During the impact with the ground, the pressure and temperature of the gas inside the ball increase.

The table gives values of the pressure, volume and temperature of the gas inside the ball before the test and at the instant the ball is stationary during impact with the ground.

	Pressure of gas / kPa	Volume of gas / cm^3	Temperature / °C
Before ball is dropped	182	107	20
Ball stationary during impact with the ground	197	101	

*(i) Using ideas about molecules and momentum, explain why the pressure of the gas increases.

(4)

(ii) Calculate the temperature of the gas inside the tennis ball at the instant the tennis ball is stationary during impact with the ground.

(2)

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Temperature = ...

(iii) Show that the number of nitrogen molecules inside the tennis ball is about 5×10^{21} and hence find the change in total kinetic energy of the nitrogen molecules during the impact.

(4)

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Change in total kinetic energy = ...

(iv) Explain how the change in total kinetic energy will affect the bounce height of the tennis ball.

(2)

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(Total for Question 17 = 14 marks)

18 The element polonium was discovered by Marie and Pierre Curie in 1898 whilst they were investigating the radioactive substance pitchblende. Polonium is an unstable element and decays by alpha emission.

(a) The decay of polonium is said to be random and spontaneous.

Explain what is meant by a decay that is

(i) random

(1)

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....

(ii) spontaneous.

(1)

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(b) A particular isotope of polonium decays to lead.

(i) Complete the nuclear equation representing this decay.

(2)

$$^{\dots}_{84}\mathrm{Po} \rightarrow {}^{206}_{\dots}\mathrm{Pb} + {}^{4}_{\dots}\alpha$$

(ii) In this decay the α-particle is emitted with a kinetic energy of 8.50×10^{-13} J.

Show that the initial speed of the α-particle is about 2×10^{7} m s^{-1}.

alpha particle mass = 6.64×10^{-27} kg

(2)

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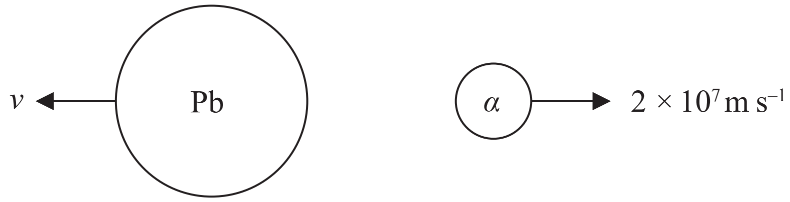
(iii) The diagram shows the products of this decay.



(1) Explain why the lead nucleus recoils during the decay.

(2)

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(2) Calculate the speed at which the lead nucleus begins to recoil.

(2)

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Speed = ...

(iv) Explain why most of the energy released in this decay is transferred to the alpha particle.

(2)

(c) Polonium has been used as an energy source for thermoelectric cells.

This isotope of polonium has a decay constant of 5.0×10^{-3} day^{-1}. A sample of polonium, with mass 0.50 g, releases energy at a rate of about 70 W.

(i) The activity of the sample is 8.1×10^{7} MBq and the α-particle is emitted with a kinetic energy of 8.50×10^{-13} J.

Show that this sample releases energy at a rate of about 70 W.

(2)

(ii) This sample of polonium would **not** be suitable to provide energy for a period of several years.

Explain why, using a calculation in your answer.

(3)

(Total for Question 18 = 17 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	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

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

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

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	$v = H_0 d$