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 22 January 2015 – Afternoon
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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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 A source of alpha radiation is dangerous if taken into the body.

This is because alpha particles are

☒ **A** charged.

☒ **B** massive.

☒ **C** very ionising.

☒ **D** very penetrating.

(Total for Question 1 = 1 mark)

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2 A student carries out an experiment to measure the specific heat capacity of a block of aluminium by heating the block with an electric heater. The value obtained by the student is less than the textbook value.

The most likely reason for this is that

☒ **A** the heater was inefficient.

☒ **B** the mass of the block was overestimated.

☒ **C** the thermometer scale didn't start from zero.

☒ **D** thermal energy was transferred to the surroundings.

(Total for Question 2 = 1 mark)

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3 A pan contains water at a temperature of 300 K. The water temperature is increased to 330 K. Assuming that the pan behaves like a black body, the rate at which energy is emitted as radiation from the pan changes by a factor of

☒ **A** 0.9

☒ **B** 1.1

☒ **C** 1.2

☒ **D** 1.5

(Total for Question 3 = 1 mark)

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4 Scientists believe that a significant proportion of the universe consists of dark matter.

Dark matter is

☒ **A** antimatter.

☒ **B** black dwarf stars.

☒ **C** undetectable.

☒ **D** invisible.

(Total for Question 4 = 1 mark)

5 Uranium-238 decays by emitting alpha particles. It is **not** possible to influence when the decay of a particular nucleus of uranium-238 will occur.

This is because radioactive decay

☒ **A** involves high energy.

☒ **B** is spontaneous.

☒ **C** occurs randomly.

☒ **D** occurs very quickly.

(Total for Question 5 = 1 mark)

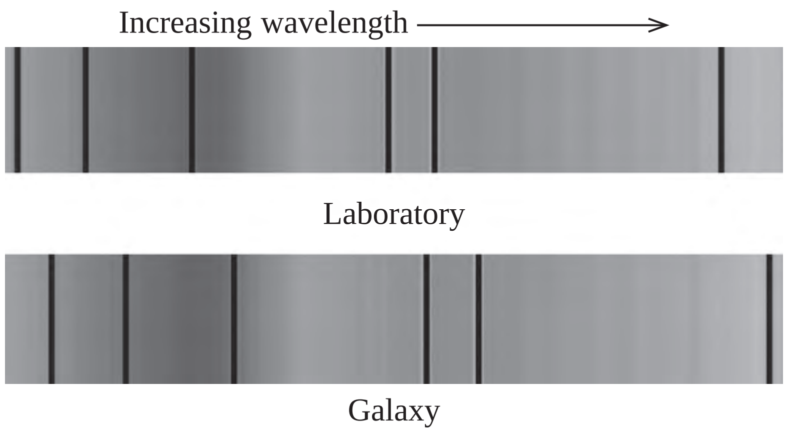
6 Scientists believe that the universe is expanding and that there is a critical density ρ_c which will determine the ultimate fate of the universe.

Choose the row of the table that correctly identifies the ultimate fate of the universe for different average densities.

	Average density of the universe > ρ_c	**Average density of the universe = ρ_c**
☒ **A**	closed	flat
☒ **B**	flat	closed
☒ **C**	closed	open
☒ **D**	open	flat

(Total for Question 6 = 1 mark)

7 The diagram shows the line spectrum produced by a source in the laboratory and by light from a distant galaxy.



A correct deduction is that the galaxy is

☒ **A** accelerating away from the Earth.

☒ **B** accelerating towards the Earth.

☒ **C** moving away from the Earth.

☒ **D** moving towards the Earth.

(Total for Question 7 = 1 mark)

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8 All objects at a temperature above absolute zero radiate energy. Both the wavelength λ_{max} at which peak energy emission occurs and the rate of energy emitted per unit surface area P depend upon the temperature of the object.

If the temperature of the object is increased

☒ **A** λ_{max} and P both decrease.

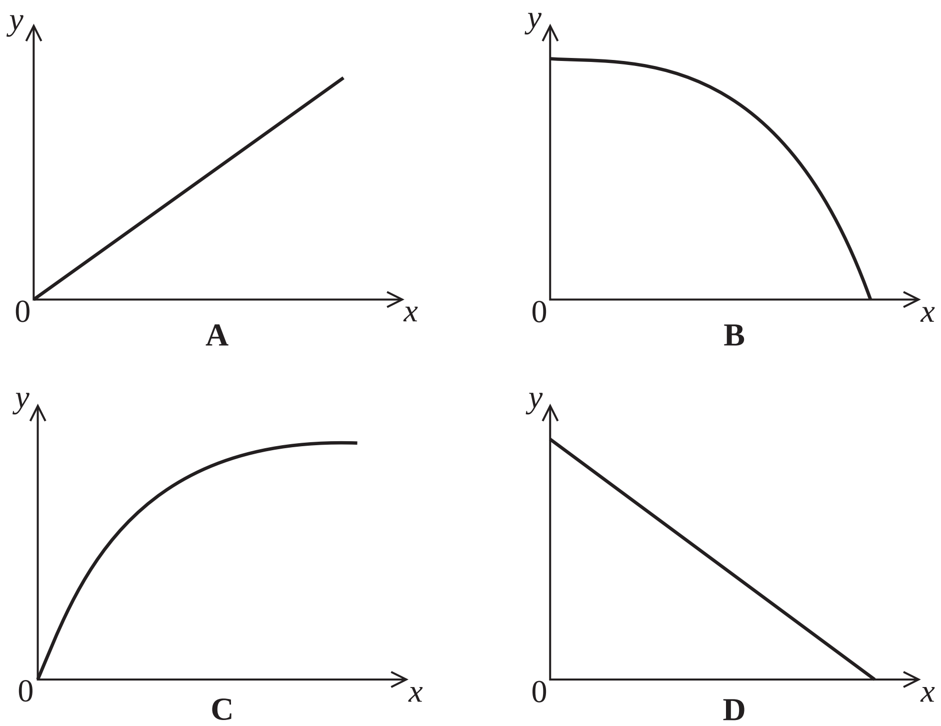
☒ **B** λ_{max} and P both increase.

☒ **C** λ_{max} decreases and P increases.

☒ **D** λ_{max} increases and P decreases.

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the graphs below.



9 Which graph shows how the kinetic energy of a mass undergoing simple harmonic motion varies with its distance x from the equilibrium position?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 Which graph shows how the magnitude of the resultant force on a mass undergoing simple harmonic motion varies with its distance x from the equilibrium position?

☒ **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 Light from either end of the Sun's diameter is analysed and compared to light from the centre of the Sun. A hydrogen line in light from the centre of wavelength 490 nm is shifted in wavelength by 3.4×10^{-3} nm compared with light from the centre.

Calculate a value for the angular velocity of the Sun.

diameter of Sun = 1.4×10^{9} m

(3)

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Angular velocity of Sun = ...

(Total for Question 11 = 3 marks)

12 In 2013 an attempt by Jonathan Trappe to cross the Atlantic Ocean suspended from 370 helium-filled balloons had to be abandoned after 12 hours due to technical problems.

© Barcroft Media

(a) Helium at a temperature of 18 °C was used to inflate each balloon to a volume of 8.5 m^3 at a pressure of 0.11 MPa.

Calculate the number of helium molecules that each balloon contained.

(2)

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Number of helium molecules = ...

*(b) If a helium-filled balloon is left in direct sunlight the temperature, and hence the pressure, of the helium increases.

By considering the motion of the molecules in the helium gas, explain why the pressure increases.

(3)

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(Total for Question 12 = 5 marks)

13 "Hot-Spot" is an infrared imaging system introduced in cricket in 2005 to check if the ball has struck a batsman on his pads or the bat. The Hot-Spot system shows a bright spot where the ball has made contact.

(a) Suggest why a bright spot is produced on the image where the ball makes contact with the bat.

(1)

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(b) The bat is initially at a temperature of 20.0 °C. The smallest temperature change that can be detected by the system is 0.015 °C.

The wavelength at which peak energy emission occurs is λ_{max}. Assuming that the bat behaves as a black body radiator, calculate the change in λ_{max} for a temperature change of 0.015 °C.

(3)

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Change in λ_{max} = ...

(c) There is an increase in temperature of 0.50 K in the region of the bat where the ball has made contact. The wood from which the bat is made is a poor thermal conductor, so the heating caused by the ball is localised in a small region.

Calculate the energy transferred to the bat.

mass of contact region = 15 g

specific heat capacity of wood = 1700 J kg^{-1} K^{-1}

(2)

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Energy transferred to the bat = ...

(d) In the test series between England and Australia in the summer of 2013, it was claimed that some players had used silicone tape on their bats.

Suggest and explain a reason why using silicone tape may reduce the chances of a bright spot being produced.

(2)

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(Total for Question 13 = 8 marks)

14 So far, manned space flight has only taken us to the Moon. There are plans to send a manned mission to Mars, our nearest planetary neighbour, later this century.

(a) Calculate the weight of an astronaut of mass 72.0 kg on the surface of Mars.

mass of Mars = 6.42×10^{23} kg

diameter of Mars = 6.79×10^{6} m.

(2)

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Weight of astronaut = ...

(b) (i) It takes Mars 5.94×10^7 s to orbit the Sun.

Show that the radius of the orbit is about 2×10^{11} m. Assume the orbit is circular.

mass of Sun = 1.99×10^{30} kg

(3)

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(ii) Mars does **not** have a circular orbit. As Mars completes one orbit of the Sun, the distance from Mars to the Sun varies by ±10% of the average distance to the Sun.

Calculate the ratio of the maximum radiation flux from the Sun at the surface of Mars F_{max} to the minimum radiation flux F_{min} over one orbit.

(3)

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F_{max} / F_{min} = ...

(Total for Question 14 = 8 marks)

15 The first example of an artificially produced radioactive isotope was produced in 1934 by Frederic and Irene Joliot-Curie. They bombarded aluminium with alpha particles to produce an unstable isotope of phosphorus.

(a) (i) Complete the nuclear equation representing this process and identify the particle X.

(3)

$$^{27}_{13}\mathrm{Al} + {}^{\dots\dots}_{\dots\dots}\alpha \rightarrow {}^{30}_{15}\mathrm{P} + {}^{\dots\dots}_{\dots\dots}\mathrm{X}$$

X is ....

(ii) The alpha particle had a kinetic energy of 5.3 MeV.

Calculate the total kinetic energy of the reaction products.

	Mass / u
proton	1.007276
neutron	1.008665
alpha particle	4.001506
Al-27	26.98154
P-30	29.97831

(4)

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Total kinetic energy = ...

(b) P-30 is a positron emitter.

State what is meant by a positron, and suggest why positron emission is unlikely to occur for nuclei with an excess of neutrons.

(2)

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(c) P-30 has a half-life of 150 s. At a particular instant a sample of P-30 contains 2.2×10^{16} atoms.

(i) Calculate the activity of the sample at this instant.

(3)

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Activity of sample = ...

(ii) Determine the activity of the sample 15 minutes later.

(3)

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Activity after 15 minutes = ...

(Total for Question 15 = 15 marks)

16 A car suspension system can be thought of as a mass-spring system. The natural frequency of the system is determined by the force constant of the suspension k and the total mass of the system m.

(a) (i) A car is set into vertical oscillation by applying a momentary downwards force.

Show that the frequency of oscillation f is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

(4)

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(ii) The car is displaced through a vertical distance of 27.5 mm when a man of mass 85.0 kg sits in the car.

Show that k is about 30 kN m^{-1}.

(2)

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(iii) Calculate the natural frequency of oscillation of the car with the man sitting in it.

mass of car = 1130 kg

(2)

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Natural frequency = ...

(b) Car suspension systems are examples of damped systems.

*(i) State what is meant by damping, and explain why this is desirable for a car suspension system.

(3)

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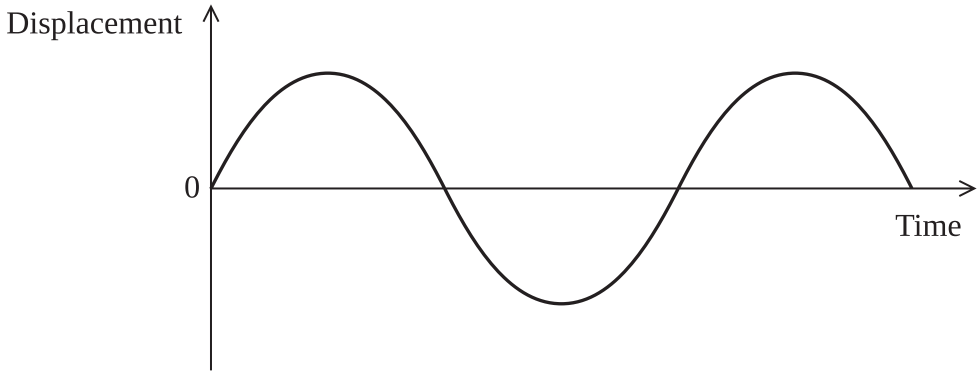
(ii) The graph shows the way in which the displacement varies with time for an undamped mass-spring system.



On the axes below draw a graph to show how the velocity varies with time for the damped system over the same time interval.

(2)

(Total for Question 16 = 13 marks)

17 (a) Stars are formed from gas clouds within galaxies. As the gas cloud contracts, an extremely dense core at a very high temperature is formed. Within the core the hydrogen begins to fuse into helium.

(i) Explain why the core must be extremely dense and at a very high temperature for fusion to take place.

(2)

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(ii) As the gas cloud contracts the internal energy of the system increases.

Explain how energy conservation applies to the system during this period of contraction.

(2)

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(iii) Explain how the fusion of hydrogen into helium in the core enables large amounts of energy to be released.

(3)

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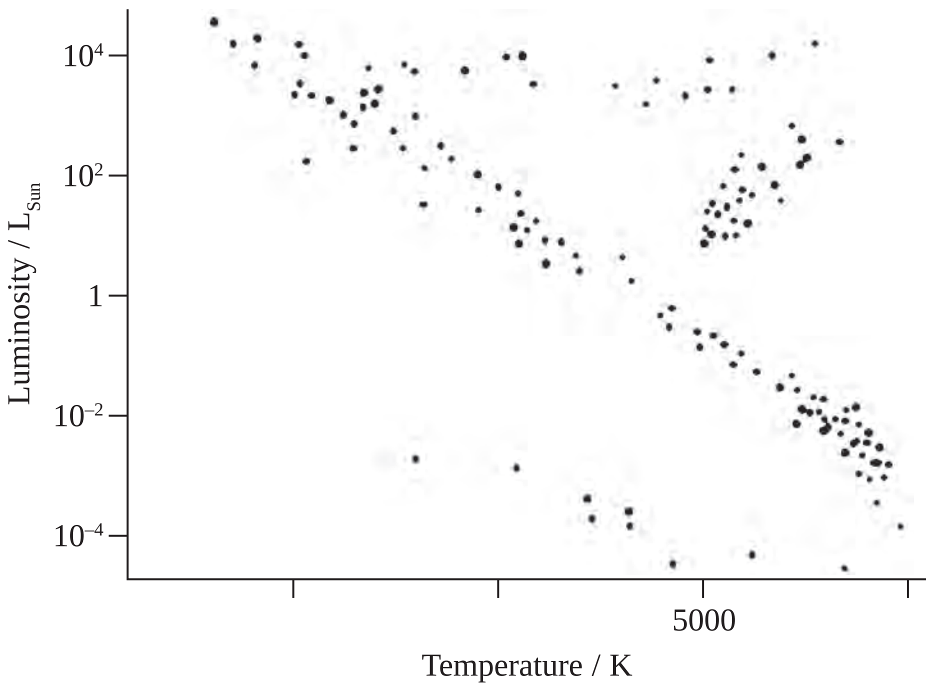
(b) The Hertzsprung-Russell diagram is used by astronomers to show the relationship between luminosity and temperature for stars.

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

(2)



(ii) The table shows the luminosity and temperature of a range of stars.

Star	**Luminosity / L_{Sun}**	**Temperature / K**	**Star type**
A	0.001	8 000	
B	0.1	4 400	main sequence
C	160	3 600	red giant
D	160	13 600	

Complete the table.

(2)

(iii) On the Hertzsprung-Russell diagram indicate where each of the stars A, B, C, and D is located.

(2)

(c) Polaris is the nearest variable star to the Earth and is an example of a standard candle.

(i) State what astronomers mean by a standard candle.

(1)

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*(ii) Recent measurements indicate that Polaris may be significantly closer to the Earth than previously thought.

Explain why this would have a significant impact on our estimation of the age of the universe.

(4)

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(Total for Question 17 = 18 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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$
	$\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$
	$\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$hf = \phi + ½mv^2_{max}$

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	$Q = Q_0e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

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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