Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Wednesday 16 January 2019

Afternoon (Time: 1 hour 35 minutes) | Paper Reference **WPH05/01**

Physics

Advanced
Unit 5: Physics from Creation to Collapse

You must have:
Ruler

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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 5 4 5 6 1 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 A standard candle is a stellar object of known

☒ **A** distance.

☒ **B** luminosity.

☒ **C** radiation flux.

☒ **D** surface temperature.

(Total for Question 1 = 1 mark)

2 Pb-214 is a radioactive isotope of lead. This isotope decays by emitting a particle X shown by the equation

$$^{214}_{82}\text{Pb} \rightarrow {}^{214}_{83}\text{Bi} + \text{X}$$

Particle X is

☒ **A** an alpha particle.

☒ **B** an electron.

☒ **C** a neutron.

☒ **D** a positron.

(Total for Question 2 = 1 mark)

3 Which of the following statements is a correct description of the binding energy of a nucleus?

☒ **A** The energy released when the nucleus forms from individual nucleons.

☒ **B** The energy released when radiation is emitted from the nucleus.

☒ **C** The energy required to overcome the force between nuclei.

☒ **D** The energy required to remove a nucleon from the nucleus.

(Total for Question 3 = 1 mark)

4 Two simple harmonic oscillators have the same frequency.

The first has a mass of 0.50 kg and an amplitude of 30 cm. Its energy of oscillation is E_0.
The second has a mass of 0.25 kg and an amplitude of 60 cm.

What is the energy of oscillation of the second oscillator?

☒ **A** $E_0/4$

☒ **B** $E_0/2$

☒ **C** E_0

☒ **D** $2E_0$

(Total for Question 4 = 1 mark)

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5 The half-life of protactinium is 70 s.

After which of the times below would the activity of a sample of protactinium have decreased to less than 2% of its initial value?

☒ **A** 70 s

☒ **B** 210 s

☒ **C** 350 s

☒ **D** 420 s

(Total for Question 5 = 1 mark)

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6 Quasars are thought to be discs of matter moving around black holes. Light received from all quasars shows large red shifts.

Which of the following can be concluded from this?

☒ **A** Quasars are accelerating away from the Earth at a large rate.

☒ **B** Quasars are accelerating towards the Earth at a large rate.

☒ **C** Quasars are moving away from the Earth very quickly.

☒ **D** Quasars are moving towards the Earth very quickly.

(Total for Question 6 = 1 mark)

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7 The gravitational field strength on the surface of Mars is g. The Moon has about the same density as Mars but only half the radius.

What is the gravitational field strength on the surface of the Moon?

☒ **A** $g/4$

☒ **B** $g/2$

☒ **C** $2g$

☒ **D** $4g$

(Total for Question 7 = 1 mark)

8 The Hubble constant has been determined to be $2.2 \times 10^{-18}\ s^{-1}$, although there is a large uncertainty in this value. Astronomers have used this value to calculate the age of the universe.

Previous data gave a value for the Hubble constant of $2.0 \times 10^{-18}\ s^{-1}$.
The age of the universe calculated from this value would be

☒ **A** 20% smaller.

☒ **B** 10% smaller.

☒ **C** 10% bigger.

☒ **D** 20% bigger.

(Total for Question 8 = 1 mark)

9 Cosmologists predict a number of alternatives for the future evolution of the universe.

Which of the following statements describes an open universe?

☒ **A** The density of the universe equals the critical density.

☒ **B** The universe eventually reaches a maximum size.

☒ **C** The universe will keep on expanding forever.

☒ **D** We cannot predict the eventual fate of the universe.

(Total for Question 9 = 1 mark)

10 A star has a surface temperature of 5700 K. The surface temperature increases to 6000 K and the surface area stays constant.

By what factor would the luminosity of the star change?

- ☒ **A** 0.8
- ☒ **B** 0.9
- ☒ **C** 1.0
- ☒ **D** 1.2

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Iodine-131 is a radioactive isotope used in a range of medical procedures. The activity of a sample of iodine-131 is 1860 MBq.

Calculate the number of atoms of iodine-131 in the sample.

half-life of iodine-131 = 8.02 days

(3)

Number of atoms in the sample = ...

(Total for Question 11 = 3 marks)

12 Air can be considered to be an ideal gas.

(a) A sample of air is contained in a volume of 2.00×10^{-3} m^3. The pressure of the air is 1.35×10^5 Pa and its temperature is 295 K.

Calculate the number of molecules in the sample of air.

(2)

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Number of molecules = ...

(b) A fixed mass of air has an initial temperature of 12 °C. The internal energy of the air doubles.

Calculate the final temperature of the air.

(3)

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Final temperature of air = ...

(Total for Question 12 = 5 marks)

13 A new hairdryer is advertised as being one of the fastest hairdryers available.

(a) The heater in the hairdryer draws a current of 6.75 A when connected to a 230 V supply.

Show that the power of the heater is about 1.5 kW.

(2)

(b) (i) Air enters the hairdryer at a temperature of 18 °C. The fan in the hairdryer blows the air across the heater at a rate of $0.048\,kg\,s^{-1}$.

Calculate the temperature of the air as it leaves the hairdryer.

specific heat capacity of air = $1.01 \times 10^3\,J\,kg^{-1}\,K^{-1}$

(2)

Temperature of air as it leaves the hairdryer = ...

(ii) State why the actual temperature of the air as it leaves the hairdryer will be less than the value calculated in (b)(i).

(1)

(Total for Question 13 = 5 marks)

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14 A student investigated the relationship between the pressure exerted by a fixed mass of air and its volume.

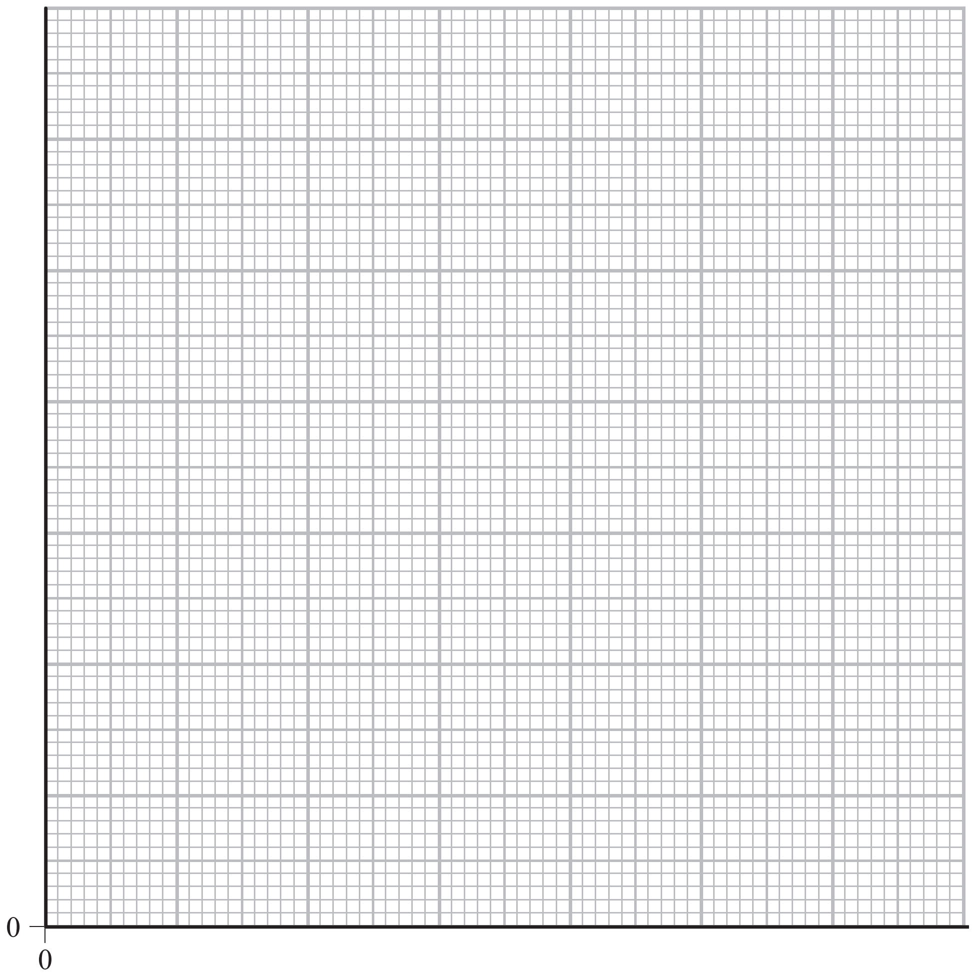
The air was maintained at a constant temperature during the investigation.

(a) The student's results are shown in the table.

***p* / kPa**	***V* / cm^3**	**1/*V* / cm^{-3}**
50	18.0	0.056
85	11.0	
100	9.3	0.11
168	6.3	0.16
250	4.4	

Complete the table and draw a graph of *p* against 1/*V* on the grid.

(6)



(b) Boyle's law states that, under certain conditions, the pressure exerted by a fixed mass of gas is inversely proportional to the volume occupied by the gas.

Use your graph to explain whether the data in (a) supports Boyle's law.

(2)

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(Total for Question 14 = 8 marks)

15 The water level in a harbour varies with simple harmonic motion.

(a) Explain what is meant by simple harmonic motion.

(2)

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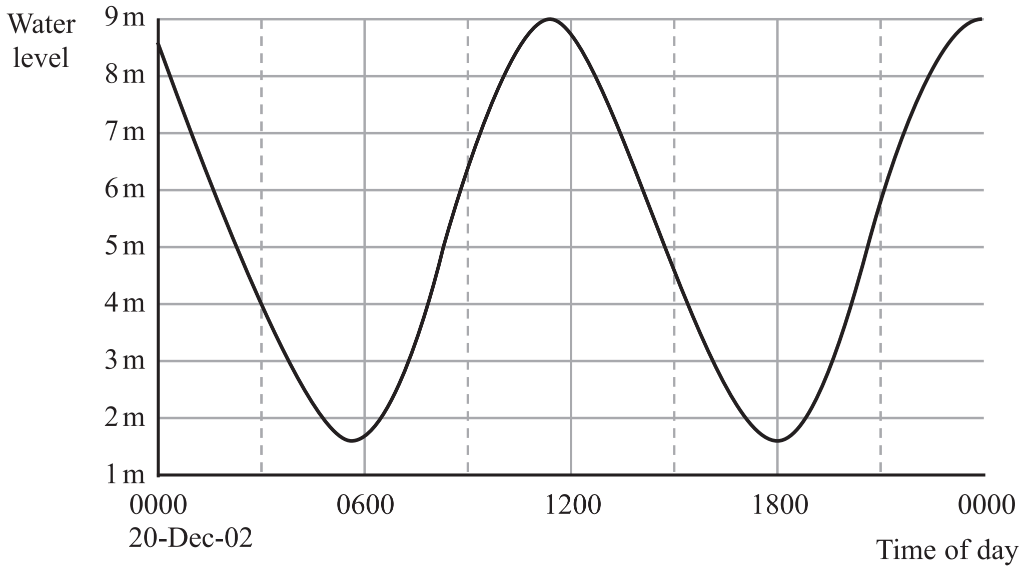
(b) The graph shows the variation in water level in a harbour on a particular day.



Liverpool (Alfred Dock), England. From midnight local time (+0000 GMT) on 20-Dec-02. Times do NOT take Daylight Saving Time into account –

(i) Determine the amplitude and the time period of the variation in water level.

(2)

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Amplitude = ...

Time period = ...

(ii) Show that the maximum rate of change of water level in the harbour is about 2 m hour^{-1}.

(3)

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(iii) Add a curve to the graph to show the rate of change of water level in the harbour over the 24-hour time period.

Use the middle of the grid as your time axis, no vertical scale is required.

(2)

(Total for Question 15 = 9 marks)

*16 The energy source for a main sequence star is the fusion of hydrogen to helium in the core. Scientists have been unable to develop this process to produce a viable source of energy on Earth.

Explain why fusion is a viable source of energy for stars, but has yet to be developed as a viable source of energy on Earth.

In your answer you should refer to the conditions necessary for fusion to occur.

(5)

(Total for Question 16 = 5 marks)

17 A student determined the count rate near a radioactive source. She used an americium source, which is an alpha emitter.

The student connected a detector to a counter.

(a) Explain why the detector should be positioned a small, fixed distance from the source.

(2)

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(b) The student measures the count for 2 minutes and divides this count by 120 to determine the count rate.

Explain two modifications to the student's method that would improve her value for the count rate from the source.

(4)

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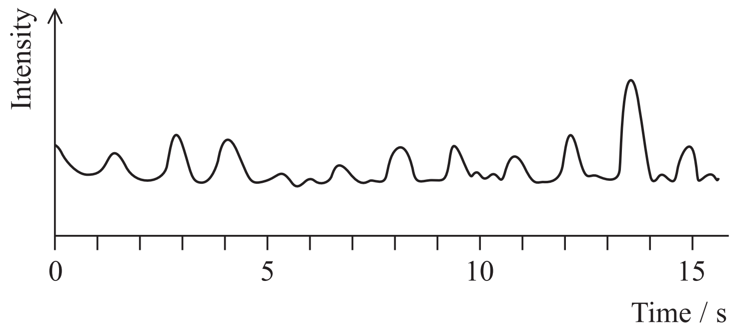
(Total for Question 17 = 6 marks)

18 In 1967 Jocelyn Bell discovered the first radio pulsars while she was a research student at the University of Cambridge. These astronomical objects emit pulses of radio waves at regular intervals.

The graph shows the variation in intensity of the radio waves received from the pulsar.

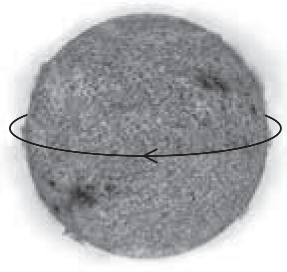


(a) Use the graph to show that the frequency of pulsing of radio waves from the source is between 0.7 Hz and 0.8 Hz.

(3)

(b) The pulsing frequency was thought to be too high to have been produced by anything as large as a star like the Sun.

Consider the Sun to be rotating with a frequency of 0.80 Hz about an axis through its centre, as shown.



(i) Calculate the speed of a point on the Sun's equator if it rotates at this frequency.

diameter of Sun = 1.4×10^9 m

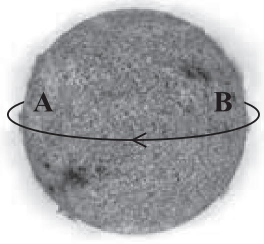
(3)

Speed = ...

(ii) State why the Sun could **not** be rotating at this frequency.

(1)

(c) The Sun actually rotates with a much smaller frequency than given in (b) and the maximum speed of a point on the Sun's equator is $4.00 \times 10^3\,\mathrm{m\,s^{-1}}$.



Light emitted from the centre of the Sun with a wavelength of 5.90×10^{-7} m, is observed on Earth as a line in the Sun's spectrum.

(i) The wavelength of this line differs slightly from 5.90×10^{-7} m when light emitted from A or B is analysed.

Explain why.

(2)

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(ii) Calculate the difference between the wavelengths of the line observed in the spectrum from A and the line observed in the spectrum from B.

(2)

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Difference in wavelengths = ...

(Total for Question 18 = 11 marks)

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19 The Hipparcos satellite was the first satellite used to determine accurately the position of stars. Data for more than 100 000 stars was collected by Hipparcos using a parallax method.

(a) State what is meant by parallax.

(1)

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(b) Star A is twice as far away from the Earth as star B.

Describe what would be observed when trigonometric parallax is used to determine the distances of these stars from the Earth.

(2)

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(c) It was intended that Hipparcos would orbit the Earth, directly above the equator, with a period of 24 hours.

(i) Explain why this orbit was used.

(2)

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(ii) Calculate the height of the satellite above the equator when in this orbit.

mass of Earth = 6.0×10^{24} kg
radius of Earth = 6.4×10^{6} m

(4)

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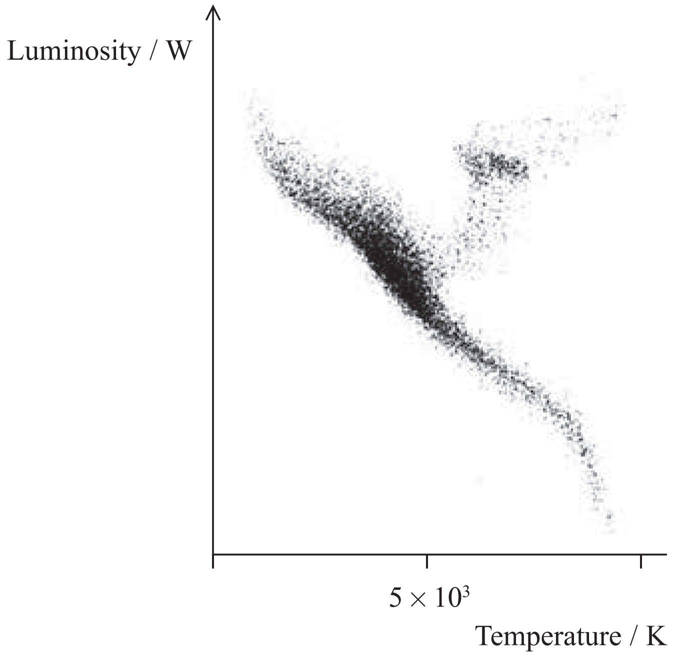
Height of satellite = ...

(d) A Hertzsprung-Russell diagram for a star cluster in our galaxy is shown.
The star cluster consists of main sequence stars and a group of red giant stars.



(i) Complete the scale on the temperature axis. **(2)**

(ii) Explain how we know that red giant stars are large in size. **(3)**

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*(iii) Explain how this diagram shows that the star cluster is neither very young, nor very old.

(4)

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(Total for Question 19 = 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	$g = 9.81\ \text{m s}^{-2}$	(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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

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	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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	$Q = Q_0 e^{-t/RC}$
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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