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
6PH05/01R

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 The average kinetic energy of the molecules in an ideal gas is

☐ **A** directly proportional to the square root of the absolute temperature.

☐ **B** directly proportional to the absolute temperature.

☐ **C** independent of the absolute temperature.

☐ **D** inversely proportional to the absolute temperature.

(Total for Question 1 = 1 mark)

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2 A sample of an ideal gas at 27 °C is placed in a sealed container. The gas is heated at constant volume to a temperature of 324 °C.
The ratio of the final pressure to the initial pressure exerted by the gas is approximately

☐ **A** 1

☐ **B** 2

☐ **C** 4

☐ **D** 12

(Total for Question 2 = 1 mark)

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3 If an oscillating system is completely undamped, the system

☐ **A** exhibits simple harmonic motion.

☐ **B** is said to be a free oscillation.

☐ **C** obeys Hooke's law.

☐ **D** oscillates indefinitely.

(Total for Question 3 = 1 mark)

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4 A mass is hanging vertically from a spring. The mass is set into small amplitude vertical oscillations.
The total energy of the undamped oscillating system is

☒ **A** a maximum at an extreme position of the mass.

☒ **B** a maximum at the mean position of the mass.

☒ **C** a minimum at the mean position of the mass.

☒ **D** the same at all positions of the mass.

(Total for Question 4 = 1 mark)

5 If the surface temperature of the Sun were to double, the rate at which energy from the Sun is received on the Earth would increase by a factor of

☒ **A** 2

☒ **B** 4

☒ **C** 8

☒ **D** 16

(Total for Question 5 = 1 mark)

6 When light from the galaxy in Andromeda is analysed, it is found that the wavelengths are shorter than expected.
This tells us that the galaxy is

☒ **A** moving towards us.

☒ **B** moving away from us.

☒ **C** a very distant galaxy.

☒ **D** rotating on an axis.

(Total for Question 6 = 1 mark)

7 Water at 100 °C turns into steam at 100 °C.
Which of the following statements is true?

☒ **A** The internal energy is unchanged, but the kinetic energy of the molecules increases.

☒ **B** The internal energy is unchanged, but the potential energy of the molecules increases.

☒ **C** Both the internal energy and the kinetic energy of the molecules increase

☒ **D** Both the internal energy and the potential energy of the molecules increase

(Total for Question 7 = 1 mark)

8 The SI unit for mass is the kilogram. However, particle physicists often use the alternative unit

☒ **A** MeV

☒ **B** MeV/c

☒ **C** MeV/c^2

☒ **D** MeV^2/c^2

(Total for Question 8 = 1 mark)

9 The fuel used in a nuclear fission reactor is uranium.
Which of the following is required for fission to proceed?

☒ **A** Neutrons must be removed from the reactor core.

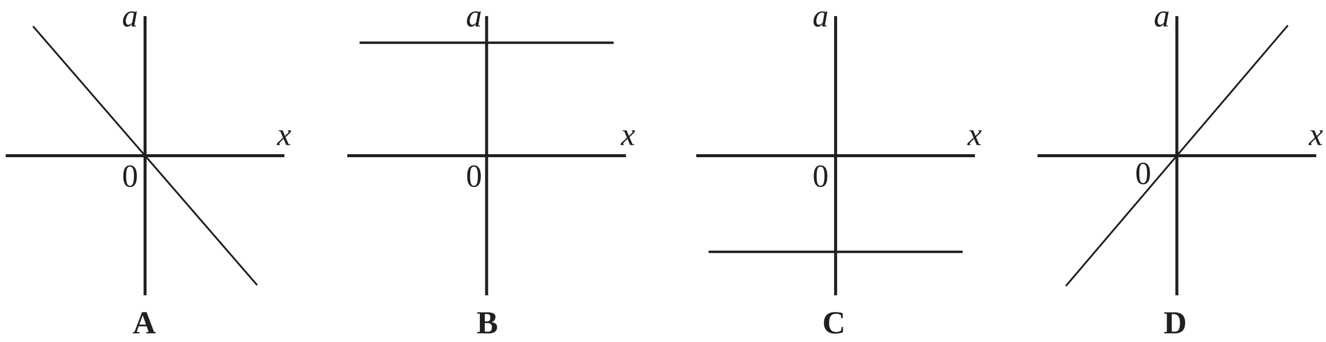
☒ **B** The reactor core must be very hot.

☒ **C** The uranium nuclei must absorb neutrons.

☒ **D** The uranium nuclei must absorb protons.

(Total for Question 9 = 1 mark)

10 An object is undergoing simple harmonic motion.
Which graph shows how the acceleration *a* varies with displacement *x* from the equilibrium position?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

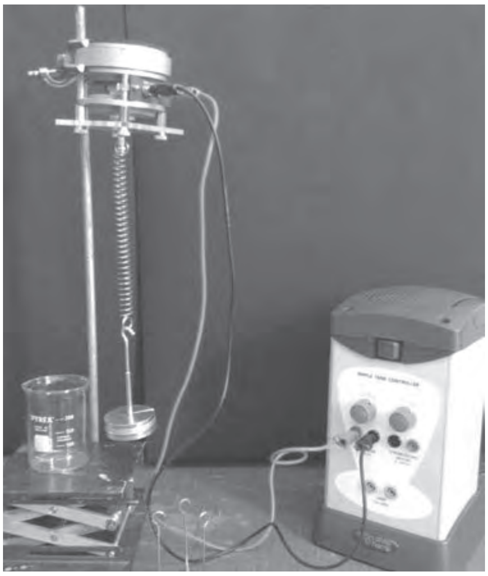
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

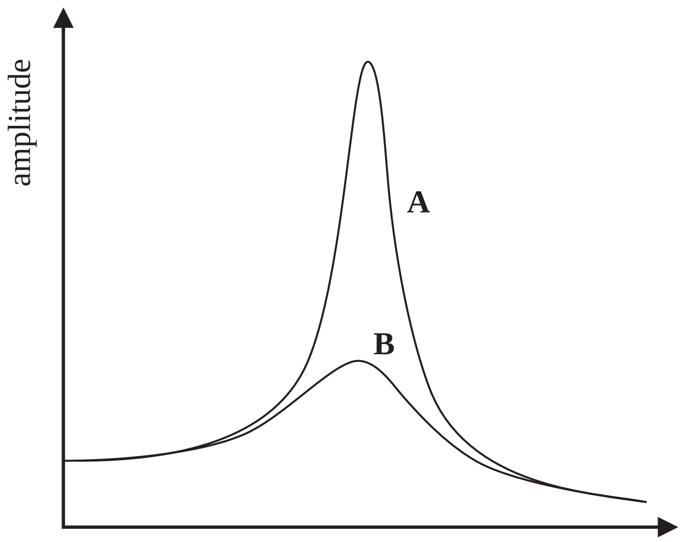
SECTION B

Answer ALL questions in the spaces provided.

***11** A student uses the apparatus shown below to investigate the behaviour of a mass-spring system when it is forced into oscillation.



The graph shows how the amplitude of the oscillating mass varies over a range of forcing frequencies.



Curve A shows the results of the investigation using the apparatus as shown.

The student repeats the investigation with the oscillating mass in a beaker of water. Curve B shows these results.

Making reference to important features in the graph, describe and explain the two sets of results.

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(Total for Question 11 = 4 marks)

12 In 2012, building commenced on the International Thermonuclear Experimental Reactor (ITER) in France. The aim is for this fusion reactor to be working by 2020.

(a) (i) Describe the process of nuclear fusion.

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(ii) Explain why it is difficult to maintain the conditions needed for nuclear fusion in a reactor.

(2)

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(b) Explain why the fusion of hydrogen nuclei should release energy.

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(Total for Question 12 = 6 marks)

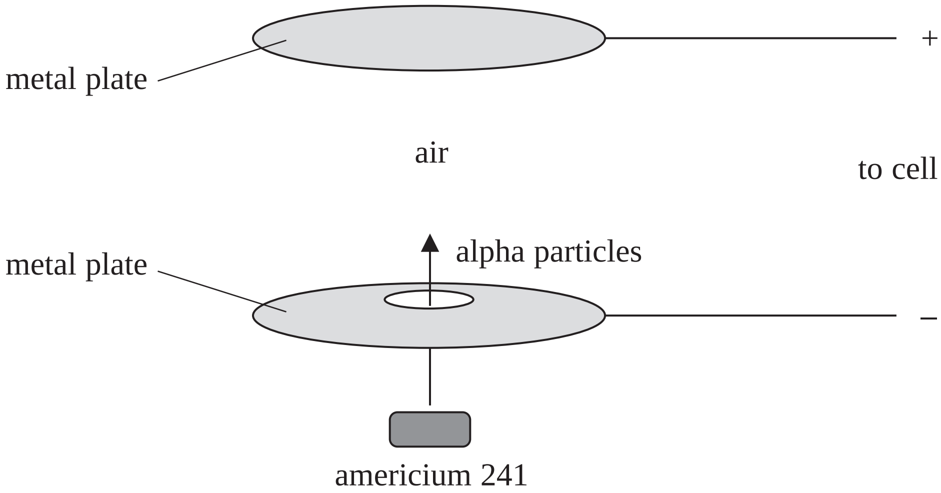
***13** Describe the similarities and differences between electric and gravitational fields.

(6)

(Total for Question 13 = 6 marks)

14 Some types of smoke detector contain a radioactive isotope of americium, ^{241}Am. The nuclei of ^{241}Am decay by emitting an alpha particle.

The diagram shows part of a smoke detector.
The detectors use a small amount of ^{241}Am to make the air between two metal plates conduct charge.



(a) (i) Explain why a stream of alpha particles will cause charge to flow between the metal plates.

(2)

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(ii) Suggest how smoke particles entering the space between the plates will cause the current to decrease.

(1)

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(b) (i) The decay of ^{241}Am is said to be random and spontaneous.
State what is meant by random and spontaneous.

(2)

Random

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Spontaneous

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(ii) Complete the equation for the decay of ^{241}Am.

(2)

$$^{241}_{\dots}\mathrm{Am} \rightarrow {}^{\dots}_{93}\mathrm{Np} + {}^{\dots}_{\dots}\alpha$$

(Total for Question 14 = 7 marks)

15 It is suggested that before making tea in a teapot, the teapot should be warmed by pouring hot water into it. This allows more flavour to be extracted from the tea.

(a) Suggest why a pre-warmed teapot may allow more flavour to be extracted.

(1)

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(b) (i) 0.26 kg of water at 95 °C is added to a stainless steel teapot. In a very short time the teapot and water both reach a temperature of 81 °C.

Show that the energy transferred from the water is about 15 kJ.

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

(2)

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(ii) Calculate the specific heat capacity of stainless steel, stating any assumption you make.

mass of teapot = 0.43 kg
initial temperature of teapot = 22 °C

(3)

Assumption ....

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Specific heat capacity = ... J kg^{-1} K^{-1}

(iii) The accepted value for the specific heat capacity of stainless steel is about 500 J kg^{-1} K^{-1}. Compare this with the value you have calculated and explain the difference.

(2)

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(Total for Question 15 = 8 marks)

16 Radioactive isotopes are often used as markers, so that chemical substances can be traced around the body. In one medical procedure tritium is used as a means of studying protein absorption by the intestine.

A patient was given a sample containing the tritium to drink and then monitored. The initial activity of the sample was 3450 Bq.

Tritium is a beta-emitter with a half-life of 3.89×10^8 s.

(a) State what is meant by the activity of a radioactive source.

(1)

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(b) Show that the decay constant of the tritium is about $1.8 \times 10^{-9}\ s^{-1}$ and hence calculate the number of tritium nuclei in the initial sample.

(3)

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Number of nuclei = ...

(c) (i) Show that the time taken for the activity of the sample to fall to 10% of its initial value is about 40 years.

(3)

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(ii) Comment on the time given in (c) (i).

(1)

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(Total for Question 16 = 8 marks)

17 The first satellite weather picture was taken in 1960. Today more than 200 weather satellites are in use. Some of these satellites are in a geostationary orbit around the Earth, so that they remain at the same point above the Earth's surface all the time.

(a) (i) Show that the magnitude of the gravitational field strength g at a point outside of the Earth is given by

$$g = \frac{GM}{r^2}$$

where r is the distance of the point from the centre of the Earth and M is the mass of the Earth.

(2)

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(ii) Use this expression together with an expression for the centripetal acceleration to show that the radius of a satellite's orbit is given by

$$r^3 = \frac{GMT^2}{4\pi^2}$$

where T is the time for one orbit of the satellite.

(3)

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(iii) Hence calculate a value for the radius of the geostationary orbit.

$$M = 6.0 \times 10^{24}\ \text{kg}$$

(3)

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Radius = ...

(b) State why all geostationary satellites are in an orbit above the Earth's equator.

(1)

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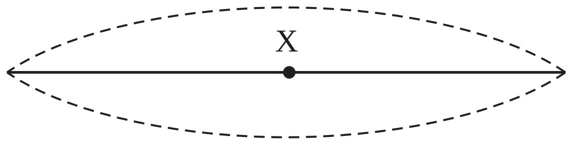
(Total for Question 17 = 9 marks)

18 Guitar strings can oscillate with simple harmonic motion.

Shortly after the string is plucked, a standing wave exists on the string. The simplified diagram below shows a string in three positions of the standing wave.



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

(2)

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(b) (i) Describe the acceleration of point X on the string as it moves between the extreme positions of its motion.

(2)

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(ii) Comment on the energy changes in the string as it moves between the extreme positions of its motion.

(3)

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(c) The oscillating string has a length of 0.53 m. Calculate the frequency of the sound emitted when the string oscillates as shown previously.

speed of the wave on the string = 270 m s^{-1}

(3)

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Frequency = ...

(Total for Question 18 = 10 marks)

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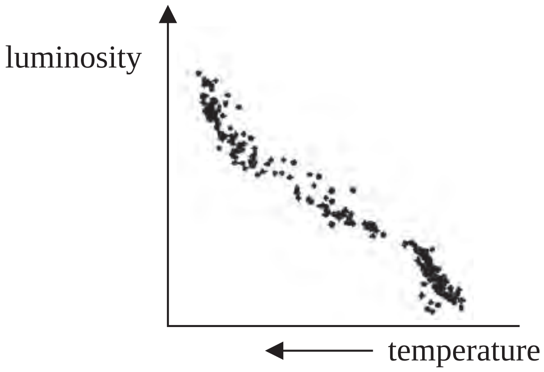
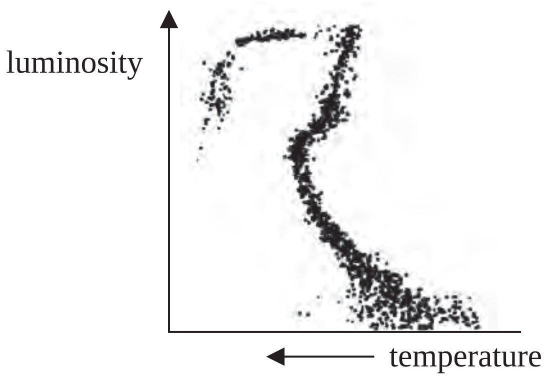
19 (a) The Herzsprung-Russell (H-R) diagram is one of the most important tools in the study of stellar evolution.

The H-R diagrams below are for a young star cluster and an old star cluster.



Young star cluster



Old star cluster

Use the diagrams to describe and explain how the old star cluster is different from the young star cluster.

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(b) Trigonometric parallax is one way in which stellar distances can be measured.

Astronomers measure the parallax angle for two nearby stars. The parallax angle for star A is 3.74×10^{-6} rad and that for star B is 1.84×10^{-7} rad.

(i) Without calculation, state what can be deduced from this data about the relative distances of the two stars.

(1)

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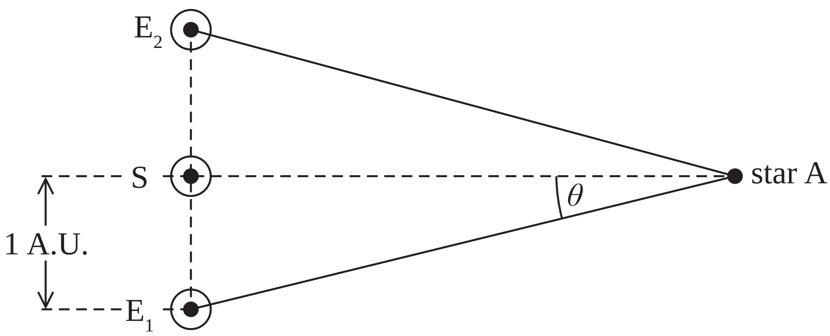
(ii) The diagram shows the parallax angle for star A.

Calculate the distance of star A from the Earth.

1 A.U. is 1.50×10^{11} m

(2)



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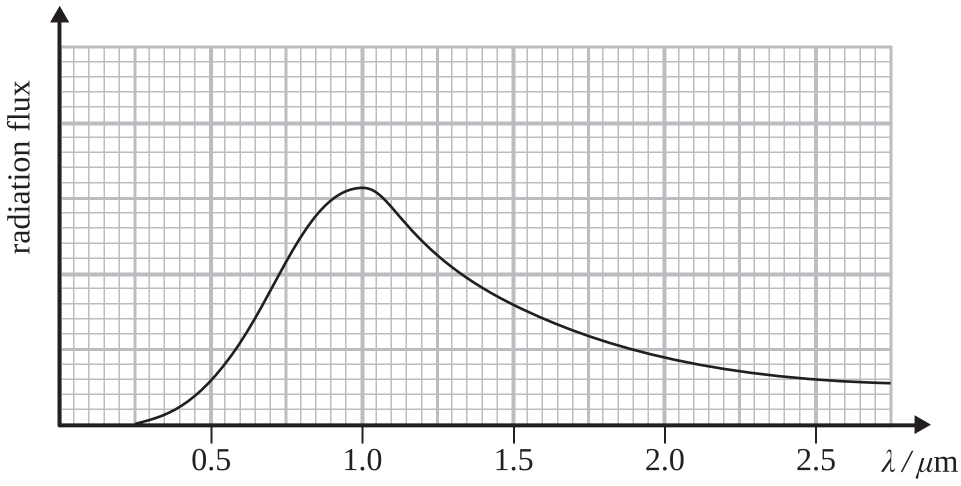
Distance = ...

(c) In addition to finding the distances to stars astronomers are interested in determining the temperatures of stars.

The spectrum of star A is shown below.



Use data from the graph to determine the surface temperature of star A.

(3)

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Temperature = ...

(Total for Question 19 = 12 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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

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

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

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	$hf = \phi + \frac{1}{2}mv^2_{max}$

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

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	$F = Gm_1 m_2/r^2$

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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