Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number

Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Tuesday 28 June 2016 – 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 ▶

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1/1/1/

P 4 6 6 4 9 A 0 1 2 4

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 Nuclear particles and nuclear radiation may cause ionisation as they pass through matter.

Which of the following is the most ionising?

☐ **A** α particles

☐ **B** β particles

☐ **C** γ rays

☐ **D** neutrons

(Total for Question 1 = 1 mark)

2 A child's toy consists of a wooden bee attached to a spring. The toy is hung from a support and the bee is displaced vertically 7.5 cm from its equilibrium position and released.

After oscillating for 1 minute the amplitude has become 2.5 cm.

The ratio of the total energy of oscillation at the start to the total energy of oscillation after 1 minute is

☐ **A** 1/9

☐ **B** 1/3

☐ **C** 3

☐ **D** 9

(Total for Question 2 = 1 mark)

3 Standard candles are stars for which we know the

- ☒ **A** brightness.
- ☒ **B** colour when observed from Earth.
- ☒ **C** distance from the observer.
- ☒ **D** luminosity.

(Total for Question 3 = 1 mark)

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4 A guitar string is plucked and set into oscillation. Over time the amplitude of oscillation of the string decreases.

The oscillation of the string is said to be

- ☒ **A** damped.
- ☒ **B** forced.
- ☒ **C** natural.
- ☒ **D** resonant.

(Total for Question 4 = 1 mark)

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5 Energy is supplied to a fixed mass of gas in a container and the absolute temperature of the gas doubles.

The mean square speed of the gas molecules

- ☒ **A** remains constant.
- ☒ **B** increases by a factor of $\sqrt{2}$.
- ☒ **C** increases by a factor of 2.
- ☒ **D** increases by a factor of 4.

(Total for Question 5 = 1 mark)

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6 An unstable nucleus recoils as it emits an alpha particle.

This is due to the conservation of

- ☒ **A** charge.
- ☒ **B** kinetic energy.
- ☒ **C** momentum.
- ☒ **D** total energy.

(Total for Question 6 = 1 mark)

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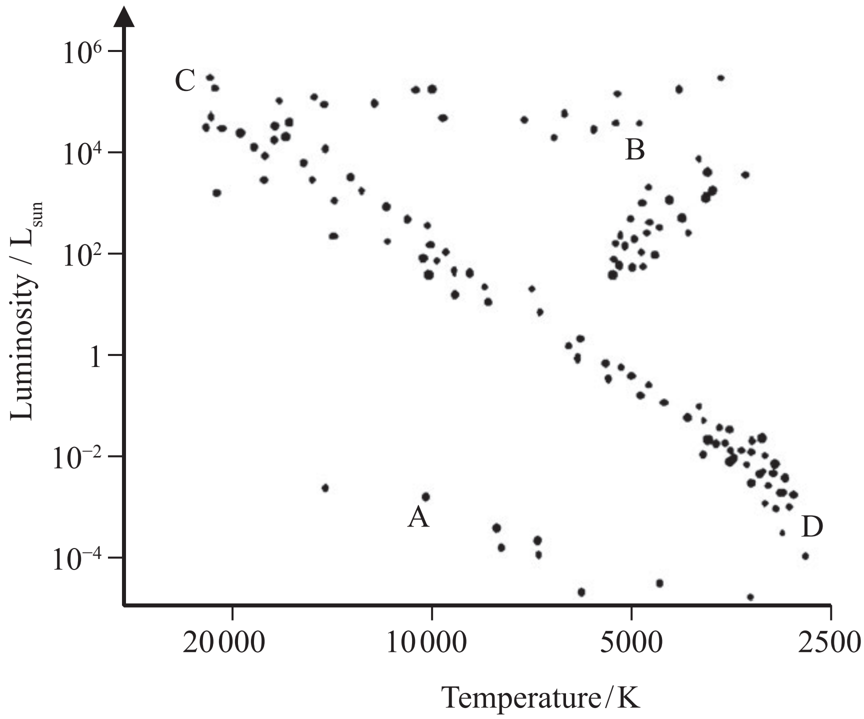
7 T Tauri stars are very young low mass stars, still in the process of gravitational contraction.

The Hertzsprung-Russell diagram below shows data for a range of stars.



Identify in which area, A, B, C or D, on the Hertzsprung-Russell diagram T Tauri stars are likely to be found.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8 Two stars have the same surface temperature but different sizes. Star X has twice the diameter of star Y.

Which of the following statements is correct?

☒ **A** Star X has twice the luminosity of star Y.

☒ **B** Star X has four times the luminosity of star Y.

☒ **C** Star X has eight times the luminosity of star Y.

☒ **D** Star X has sixteen times the luminosity of star Y.

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the information below.

In a shop window an illuminated spot on a display oscillates between positions W and Z with simple harmonic motion.

The diagram shows the display with a scale added.

9 The acceleration of the spot at position X is $+1.5\,\mathrm{m\,s^{-2}}$.

What is the acceleration of the spot at position Y?

- ☒ **A** $+1.5\,\mathrm{m\,s^{-2}}$
- ☒ **B** $+3.0\,\mathrm{m\,s^{-2}}$
- ☒ **C** $-1.5\,\mathrm{m\,s^{-2}}$
- ☒ **D** $-3.0\,\mathrm{m\,s^{-2}}$

(Total for Question 9 = 1 mark)

10 The maximum velocity of the spot is $1.2\,\mathrm{m\,s^{-1}}$.

What is the angular frequency ω of the spot?

- ☒ **A** $\frac{1}{2}$ rad $\mathrm{s^{-1}}$
- ☒ **B** $\sqrt{2}$ rad $\mathrm{s^{-1}}$
- ☒ **C** 2 rad $\mathrm{s^{-1}}$
- ☒ **D** 4 rad $\mathrm{s^{-1}}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A large copper saucepan has a mass of 1.08 kg and is filled with 2.85 kg of raspberries. The pan is heated at a constant rate of 650 W.

(a) The pan and raspberries are initially at a temperature of 22 °C.

Calculate the theoretical rise in temperature of the raspberries after being heated for 5 minutes.

specific heat capacity of copper = 386 J kg^{-1} K^{-1}

specific heat capacity of raspberries = 3890 J kg^{-1} K^{-1}

(3)

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Rise in temperature = ...

(b) State why the actual rise will be less than this.

(1)

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(Total for Question 11 = 4 marks)

12 The table shows data for a number of metals.

Metal	Specific heat capacity / J kg^{-1} K^{-1}	Atomic mass / u
Aluminium	910	27.0
Copper	386	63.5
Silver	233	108

It is stated in a textbook that the specific heat capacity of a metal is inversely proportional to its atomic mass.

(a) Show that this statement is approximately correct.

(2)

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(b) A simple model suggests that, at a given temperature, the internal energy per atom should be the same in all metals.

Explain how this accounts for the relationship between specific heat capacity and atomic mass.

(2)

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(Total for Question 12 = 4 marks)

13 In a science fiction television programme the gravitational field strength on the Moon becomes equal to that of the Earth. The radius of the Moon stays constant.

(a) Calculate the mass of the Moon that would be required for the gravitational field strength at its surface to equal the gravitational field strength at the surface of the Earth.

radius of the Moon = 1.74×10^6 m

(2)

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Mass of Moon required = ...

(b) Explain why a more massive Moon would have no effect on the time taken for the Moon to orbit the Earth.

(2)

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(c) Suggest what effect a more massive Moon would have at the Earth's surface.

(1)

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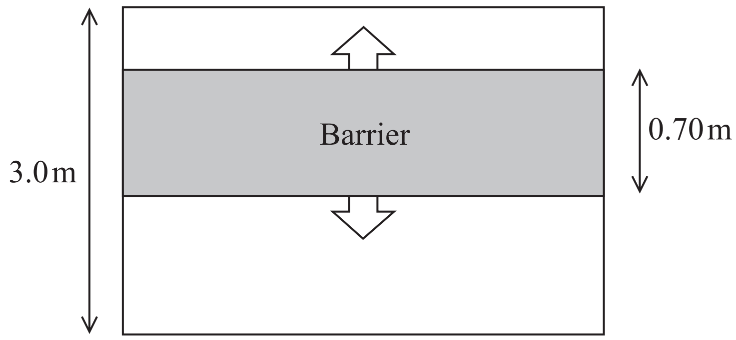
(Total for Question 13 = 5 marks)

14 In a television game show contestants have to pass under a barrier. The barrier has a vertical height of 0.70 m and moves up and down with simple harmonic motion.



(a) State the conditions which must be met for an object to move with simple harmonic motion.

(2)

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(b) The bottom edge of the barrier is initially in contact with the ground and moves up to a height of 2.3 m before returning back to its starting position. The bottom edge of the barrier touches the ground every 4.5 s.

A contestant requires a space at least 0.60 m high to get under the barrier.

Calculate the maximum time this contestant has to get under the barrier.

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Maximum time = ...

(Total for Question 14 = 7 marks)

15 The physics department in a college has a number of radioactive sources which are used to demonstrate the properties of ionising radiations.

The sources include Am-241 which emits alpha radiation, Sr-90 which emits beta radiation and Co-60 which emits gamma radiation.

(a) The physics teacher checks the internet to assess the risks to students of using the sources.

(i) Explain why Am-241 only poses a health risk when ingested or inhaled.

(2)

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(ii) State why external exposure to the Co-60 source is dangerous.

(1)

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(iii) Suggest how the Sr-90 source should be handled and stored so that it poses minimal health risk.

(2)

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(b) The decay of each radioactive isotope is described in a textbook as being random. A student states that this means that we cannot be sure which nuclei will decay and that we cannot determine when the activity of the source will be at a safe level.

Comment on the student's statement.

(2)

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(Total for Question 15 = 7 marks)

16 The Pleiades star cluster is a prominent sight in the night sky. All the stars in the cluster were formed from the same gas cloud. Hence the stars have nearly identical ages and compositions, but vary in mass.

Earth-based parallax measurements have led to the conclusion that the Pleiades star cluster is about 435 light-years from Earth.

(a) (i) Explain how Earth-based parallax measurements can be used to determine the distance of the Pleiades star cluster from the Earth.

(3)

(ii) Suggest why this method of distance measurement is only suitable for the stars and star clusters closest to the Earth.

(1)

*(b) Since 1989 the Hipparcos satellite has been measuring the distances to a range of stars and star clusters. Using results from Hipparcos a more accurate distance of 392 light-years has been obtained for the Pleiades star cluster. This changed the luminosities of stars in the Pleiades star cluster as calculated by astronomers.

Explain how this variation in distance measurement has implications for our measurements of distance to the farthest galaxies.

(4)

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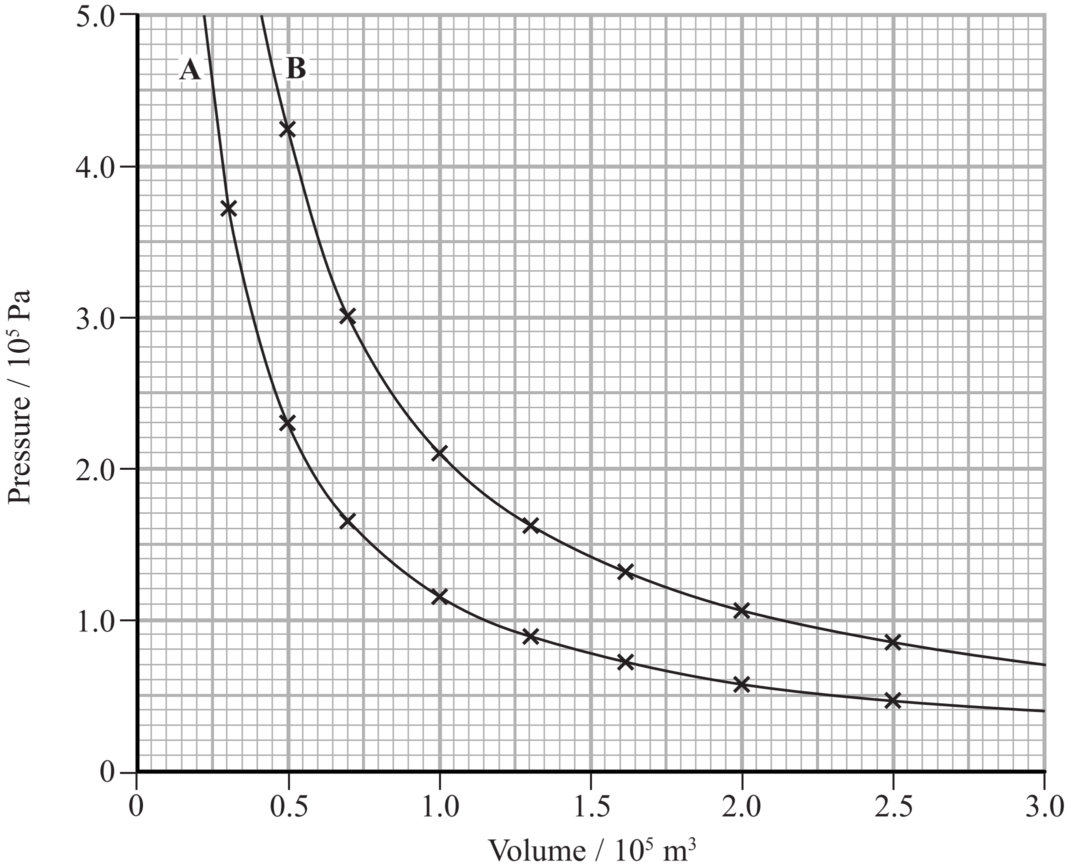
(Total for Question 16 = 8 marks)

17 The graph shows the variation of pressure with volume for a sample of air at two different fixed temperatures. The air behaves as an ideal gas under these conditions. The number of molecules of air in the sample is constant. For curve A the temperature of the sample is 25 °C.



(a) (i) Use the graph to determine the number of molecules of air in the sample.

(4)

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Number of molecules of air in sample = ...

(ii) Use the graph to determine the temperature of the sample for curve B.

(2)

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Temperature of sample = ...

*(b) When the sample of air is cooled at constant volume, the pressure exerted by the air decreases as the temperature falls.

Explain, including ideas of momentum, why the pressure exerted by the air decreases.

(4)

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(Total for Question 17 = 10 marks)

18 The table shows the properties of three stars.

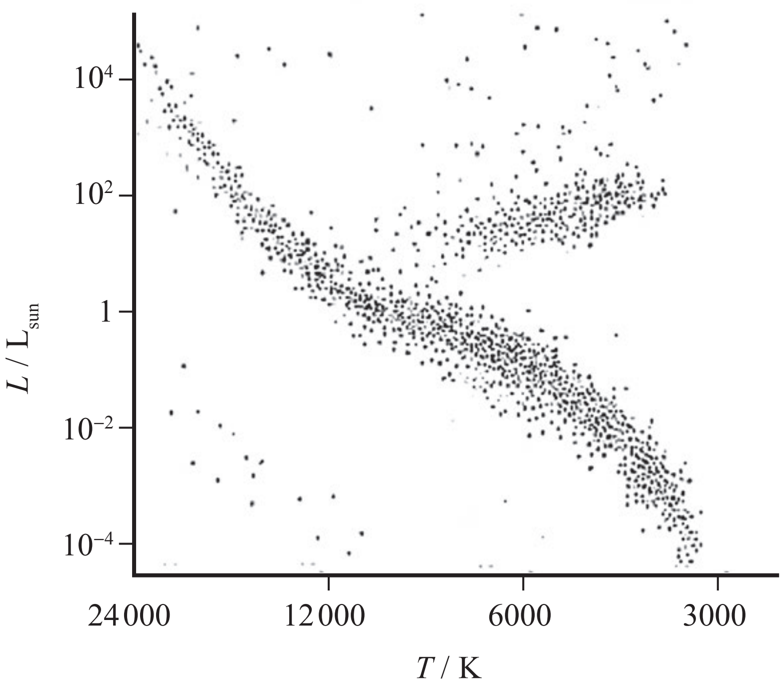
Star	Luminosity / L_{Sun}	Temperature / K	Type of star
Spica (S)	2.25×10^3	22,500	
Vega (V)	50.1	9,500	
Barnard's Star (B)	4.33×10^{-4}	3,000	Red Dwarf

(a) (i) Complete the table.

(2)

(ii) Use the letters S, V, and B to mark the approximate position of each star on the Hertzsprung-Russell diagram.

(1)



(b) By means of a calculation show that Barnard's Star would appear as a red star in the sky.

(3)

(c) Calculate the radius of Vega.

luminosity of the Sun = 3.85×10^{26} W

(2)

Radius of Vega = ...

(d) Vega appears to be much brighter than Spica in the night sky, although Spica has a much greater luminosity.

Explain why this is the case.

(3)

(Total for Question 18 = 11 marks)

P 4 6 6 4 9 A 0 1 7 2 4

19 Tritium is an isotope of hydrogen which can be produced in the upper atmosphere by the bombardment of nitrogen with neutrons produced from cosmic rays.

(a) Complete the nuclear equation for the production of tritium

(2)

$$ {}^{14}_{\dots}\mathrm{N} + {}^{\dots}_{\dots}\mathrm{n} \rightarrow {}^{\dots}_{6}\mathrm{C} + {}^{3}_{1}\mathrm{H} $$

(b) Tritium can be used to date water samples that are less than about 75 years old, as tritium is radioactive with a half-life of 12.3 years. 1 m^3 of water collected in 2015 from an underground pool of water was measured to have a corrected activity of 1.08 Bq.

(i) State why the activity must be corrected.

(1)

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(ii) State how the accuracy of the activity obtained for 1 m^3 of water could be improved.

(1)

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(iii) Calculate what the corrected activity of 1 m^3 of water from the same pool would have been in 1950. No further water has been added to the pool since 1950.

(4)

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Corrected activity = ...

(c) Tritium is used in nuclear fusion experiments. A large amount of energy is released in its reaction with deuterium.

$$^{3}H + {}^{2}H \rightarrow {}^{4}He + n$$

Nucleus	Mass / u
n	1.0087
^{2}H	2.0136
^{3}H	3.0155
^{4}He	4.0015

(i) Calculate the energy, in J, released when a tritium nucleus undergoes fusion with a deuterium nucleus.

(4)

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Energy released = ... J

(ii) Explain the conditions necessary for a nuclear fusion experiment to maintain a continuous power output.

(2)

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(Total for Question 19 = 14 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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 e^{-\lambda t}$

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	$v = H_0 d$