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

Wednesday 18 January 2017 – 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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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 Police use radar speed guns to determine vehicle speeds. The speed gun sends out radio waves towards the vehicle which reflects them back to the speed gun.

If the vehicle is moving towards the speed gun the radio waves experience an increase in

☒ **A** amplitude.

☒ **B** frequency.

☒ **C** speed.

☒ **D** wavelength.

(Total for Question 1 = 1 mark)

2 An ideal gas is maintained at a constant temperature in a sealed container and the volume of the container is varied.

Which of the following is the correct statement about the pressure exerted by the gas?

☒ **A** The pressure is directly proportional to the volume.

☒ **B** The pressure is independent of the volume.

☒ **C** The pressure is inversely proportional to the volume.

☒ **D** The pressure is proportional to the square of the volume.

(Total for Question 2 = 1 mark)

3 When compared to the Sun, red giant stars are

☒ **A** cooler and brighter.

☒ **B** cooler and dimmer.

☒ **C** hotter and brighter.

☒ **D** hotter and dimmer.

(Total for Question 3 = 1 mark)

4 Dark matter is known to exist because it

☒ **A** emits high energy X-rays.

☒ **B** exerts gravitational forces on matter.

☒ **C** is predicted by the Standard Model.

☒ **D** obscures distant galaxies.

(Total for Question 4 = 1 mark)

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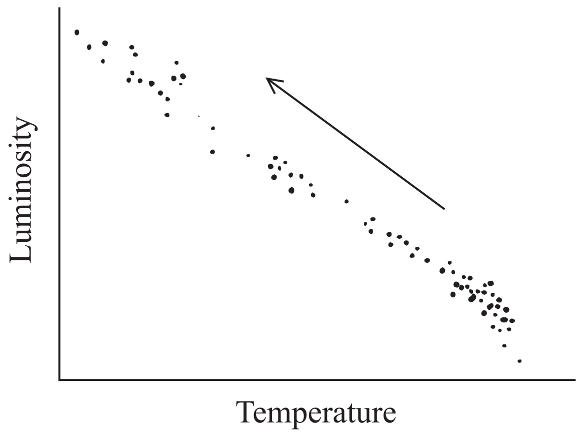
5 The Hertzsprung-Russell diagram shows a range of main sequence stars.



Moving along the sequence in the direction shown, the stars follow a trend of

☒ **A** decreasing mass and increasing temperature.

☒ **B** decreasing mass and decreasing luminosity.

☒ **C** increasing mass and increasing temperature.

☒ **D** increasing mass and decreasing luminosity.

(Total for Question 5 = 1 mark)

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6 When a liquid is heated at its boiling point, the temperature remains constant until all the liquid has turned to vapour.

Select the row in the table which correctly shows what happens to the molecular kinetic energy and molecular potential energy.

	Molecular kinetic energy	**Molecular potential energy**
☒ **A**	increases	stays the same
☒ **B**	increases	decreases
☒ **C**	stays the same	increases
☒ **D**	stays the same	decreases

(Total for Question 6 = 1 mark)

7 The average molecular kinetic energy of a sample of nitrogen gas is E_k. The gas is heated and its temperature changes from 200 K to 400 K.

Which of the following is the new average molecular kinetic energy?

☒ **A** $\frac{E_k}{4}$

☒ **B** $\frac{E_k}{2}$

☒ **C** $2E_k$

☒ **D** $4E_k$

(Total for Question 7 = 1 mark)

8 In an incandescent light bulb a metal filament is heated to a high temperature by passing an electric current through it until the filament glows. The wavelength λ_{max} at which peak energy emission occurs and the rate at which radiation energy is emitted P both depend upon the filament temperature.

What happens to λ_{max} and P when the current through the filament is increased?

☒ **A** λ_{max} and P both decrease

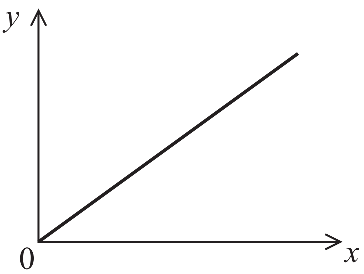
☒ **B** λ_{max} and P both increase

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

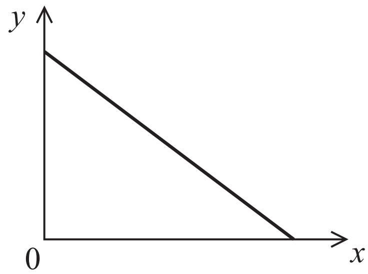
☒ **D** λ_{max} increases and P decreases

(Total for Question 8 = 1 mark)

Questions 9 and 10 relate to the graphs below.



A



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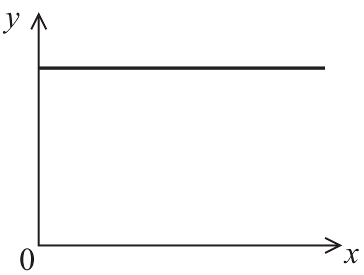

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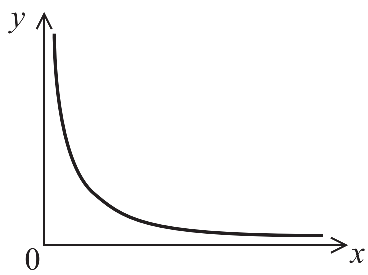

D

9 A mass moves with simple harmonic motion.

Which graph correctly shows how the total energy y of the mass varies with distance x from the equilibrium position?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

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10 A mass moves with simple harmonic motion.

Which graph correctly shows how the time taken for one oscillation y varies with the frequency x of the oscillation?

☒ **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 series of observations are made of nearby stars over a number of years. The stars are seen to undergo a very small oscillatory motion, appearing to "wobble" against the background of more distant stars.

Describe how astronomers use this "wobble" to calculate the distance to a nearby star.

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(Total for Question 11 = 3 marks)

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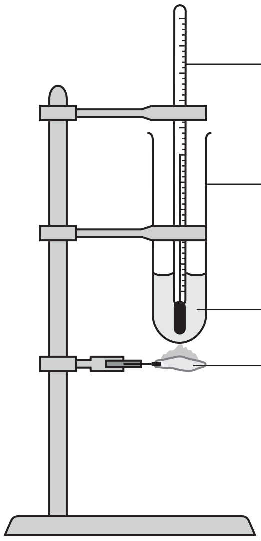
12 A student carried out an experiment to investigate the amount of energy stored in potato crisps. He placed 22.5 cm^3 of water into a test-tube and recorded the temperature. He then placed a crisp of mass 1 gram in a holder and set light to the crisp and placed it under the test-tube.



Once the crisp had finished burning, the student recorded the final temperature of the water. The experiment was carried out three times using a crisp of the same mass.

Initial water temperature / °C	**Final water temperature / °C**
21.5	52.1
21.5	52.8
21.5	52.6

(a) Use the student's data to show that the energy released by burning a crisp is about 2900 J.

density of water = 1.00 g cm^{-3}

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

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(b) Explain one precaution that the student should take when carrying out the experiment to make the energy calculated as accurate as possible.

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(c) It states on the crisp packet that the energy per gram for the crisps is 21.9 kJ.

Compare this value with the value calculated from the student's data and suggest a reason for the difference.

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(Total for Question 12 = 7 marks)

13 The International Space Station (ISS) is an artificial satellite in a low Earth orbit.

The ISS has a mass of 4.19×10^5 kg and orbits at a height of 4.10×10^5 m above the surface of the Earth in a circular orbit.

radius of Earth = 6.37×10^6 m

mass of Earth = 5.98×10^{24} kg

(a) Calculate the time taken for the ISS to complete one orbit of the Earth.

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Time taken = ...

(b) Calculate the gravitational field strength exerted by the Earth at the height of the ISS.

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Gravitational field strength = ...

(c) Astronauts on board the ISS experience apparent weightless conditions.

Explain why the gravitational force exerted on the astronauts by the Earth appears to be absent.

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(Total for Question 13 = 7 marks)

14 Low-activity, sealed radioactive sources are used in schools to demonstrate the properties of ionising radiations. Three sources have been mixed up.

The sources and the radiations that they emit are shown in the table.

Source	Radiation emitted
Americium	α
Radium	α, β, γ
Strontium	β, γ

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

(1)

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*(b) Describe an experiment using absorbers of different materials that could be carried out to identify the sources.

You must explain how the data collected could be used to distinguish between the three sources.

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(c) The school also has a γ source with a stated activity of 185 kBq. The current activity of the source is determined to be 25.7 kBq.

Calculate the time elapsed since the source was produced.

half-life of source = 5.26 years

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Time elapsed = ...

(Total for Question 14 = 10 marks)

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15 In a nuclear power station, nuclear reactions release energy which is used to produce steam which drives the turbines that generate the electricity.

(a) In 1939, Lise Meitner discovered that the uranium isotope U-235 undergoes fission when struck by a slow neutron. Nuclei of barium and krypton were emitted along with three neutrons.

This reaction releases about 200 MeV of energy, most of which appears as kinetic energy of the products.

(i) Complete the nuclear equation which represents this reaction.

(1)

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{141}_{\dots}\text{Ba} + ^{\dots}_{36}\text{Kr} + 3 \times ^{1}_{0}\text{n}$$

(ii) Explain why energy is released in this reaction.

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(iii) Explain why the fragments must move away from each other after the fission takes place.

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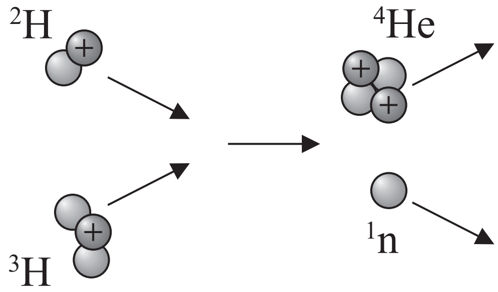
(b) The diagram represents a nuclear fusion reaction.



(i) Write a nuclear equation, in the space below, for this fusion reaction.

(2)

(ii) Calculate the energy released, in joules, when this fusion reaction occurs.

(3)

	Mass / MeV/c²
^{1}n	939.6
^{2}H	1875.1
^{3}H	2807.9
^{4}He	3726.4

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Energy released = ... J

(iii) Explain why extremely high temperatures are required for this reaction to take place.

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(c) State two advantages of obtaining nuclear power on Earth from fusion rather than fission.

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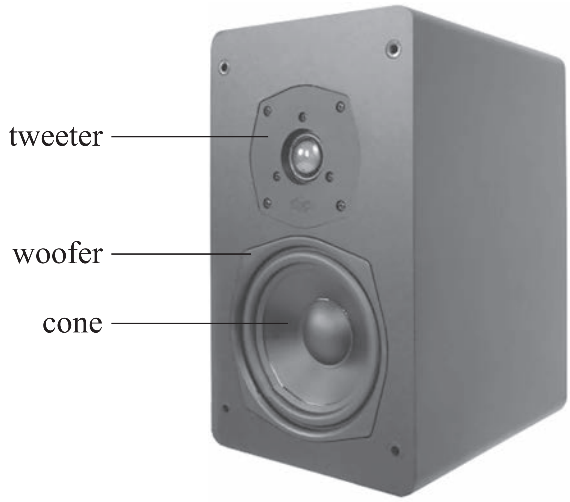
(Total for Question 15 = 14 marks)

16 The diagram shows a loudspeaker unit. The unit contains two different loudspeakers, a woofer and a tweeter. Each loudspeaker contains a cone.



A signal applied to a coil attached to the centre of each cone causes the cone to vibrate and set the air into vibration.

The tweeter is used to produce high frequency sounds and the woofer is used to produce low frequency sounds.

(a) A sinusoidal signal is applied to the woofer. The woofer cone moves with simple harmonic motion and emits a sound of frequency 100 Hz. The centre of the cone moves with an amplitude of 2.5 mm.

(i) State the conditions for an object to move with simple harmonic motion.

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(ii) Calculate the maximum velocity of the centre of the woofer cone.

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Maximum velocity = ...

(iii) The graph shows how the displacement x of the cone varies with time t.

Add a line to the graph to show how the velocity of the cone varies over the same time interval.

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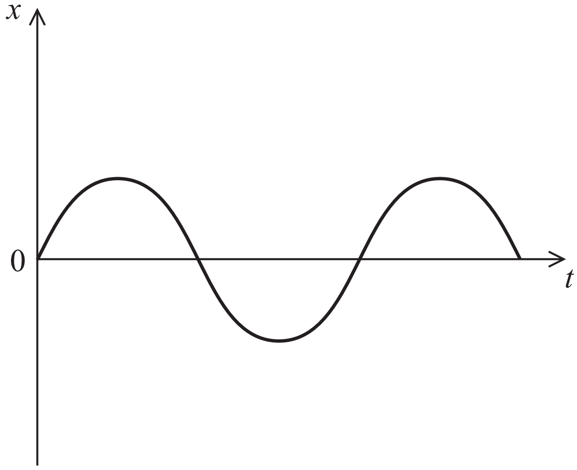

(b) At a particular frequency the sound produced is distorted as the loudspeaker unit starts to oscillate with increasing amplitude.

*(i) Explain why the loudspeaker unit starts to oscillate with increasing amplitude.

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(ii) Explain how the effect described may be reduced.

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(c) Suggest why the woofer and the tweeter are different sizes.

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(Total for Question 16 = 14 marks)

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17 In the early 20^{th} century, Edwin Hubble analysed the light from the stars in distant clusters of galaxies and deduced that these clusters of galaxies are receding.

(a) Explain how Hubble was able to deduce that the distant clusters of galaxies are receding.

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(b) The table shows some of Hubble's original data on the distances to some clusters of galaxies and the speed with which these clusters are receding.

Cluster of galaxies	**Distance from Earth / 10^{23} m**	**Speed / 10^5 m s^{-1}**
Virgo	0.6	9
Pisces	2.3	47
Perseus	3.4	52
Ursa Major	6.8	120
Leo	9.9	190

Another cluster, Pegasus, was calculated to have a distance from Earth of 2.2×10^{23} m and to be receding with a speed of 39×10^5 m s^{-1}.

(i) Comment on these values in relation to the data provided in the table.

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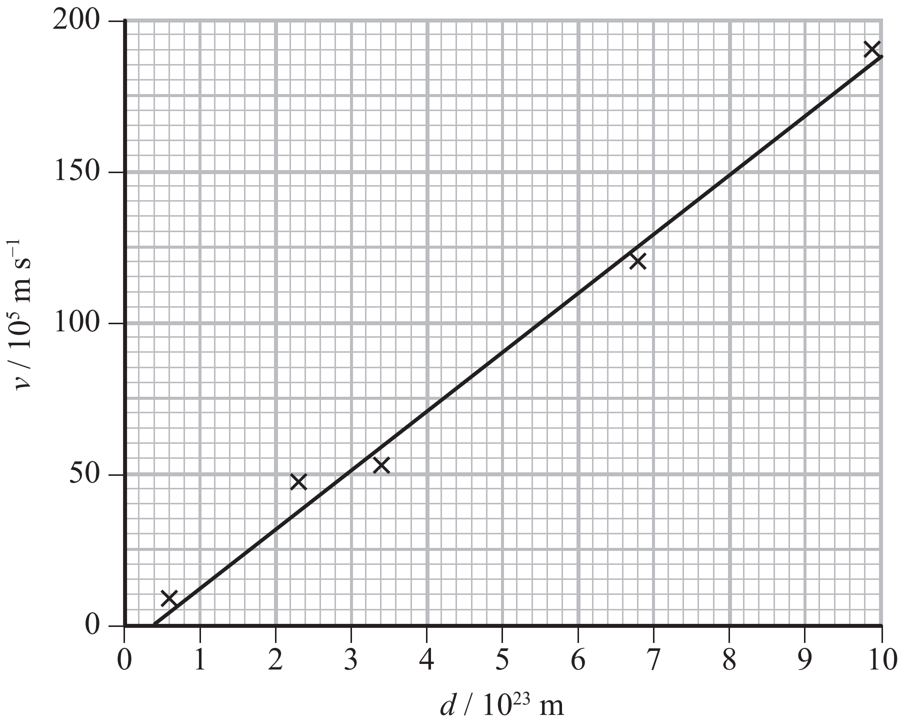
(ii) The cluster Pegasus is too far away from the Earth for parallax to be used to determine its distance from the Earth.

Explain how the distance to Pegasus could be determined.

(3)

(c) Hubble's data has been used to plot a graph of speed v against distance d from the Earth.



(i) Use the graph to show that Hubble's data suggests that the age of the universe is about 5×10^{16} s.

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(ii) The currently accepted value of the age of the universe is 4.3×10^{17} s.

Suggest why Hubble's original data led to a value almost 10 times smaller.

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(iii) Hubble's law is generally accepted as an indication that the universe is expanding. However, the idea of an expanding universe has been challenged by some scientists.

These scientists suggest that the mass of electrons in the atom increases over time causing the photons emitted by the atoms to be more energetic.

Use this suggestion to explain how scientists might conclude that the universe is not expanding.

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(Total for Question 17 = 15 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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

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	$F = Gm_1 m_2/r^2$

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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