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 21 January 2016 – 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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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 brightness of a star depends upon its luminosity and

☐ **A** core temperature.

☐ **B** distance from the observer.

☐ **C** initial mass.

☐ **D** surface temperature.

(Total for Question 1 = 1 mark)

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2 A mass is hung from a spring and set into vertical oscillation. The amplitude of oscillation halves after 10 cycles.

The ratio of the total energy of the system at the start to the total energy of the system after 10 cycles is

☐ **A** ¼

☐ **B** ½

☐ **C** 2

☐ **D** 4

(Total for Question 2 = 1 mark)

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3 A sample of radioactive material has a known half life. Radioactive decay is a random process. This means that we can predict

☐ **A** when a given nucleus will decay.

☐ **B** the time for the whole sample to decay.

☐ **C** the next nucleus that will decay.

☐ **D** the fraction of a sample that will decay in a second.

(Total for Question 3 = 1 mark)

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4 The average density of the universe is unknown. Scientists believe that there is a critical value for this density.

If the density of the universe is less than this critical density the universe will

☒ **A** eventually reach a maximum size.

☒ **B** keep expanding forever.

☒ **C** maintain its present size.

☒ **D** reach a maximum size and then contract.

(Total for Question 4 = 1 mark)

5 Energy is supplied to a fixed mass of gas in a container and the mean squared speed of the gas molecules doubles.

The absolute temperature of the gas

☒ **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)

6 A radioactive sample is a beta-emitter. Beta particles are able to pass through

☒ **A** air only.

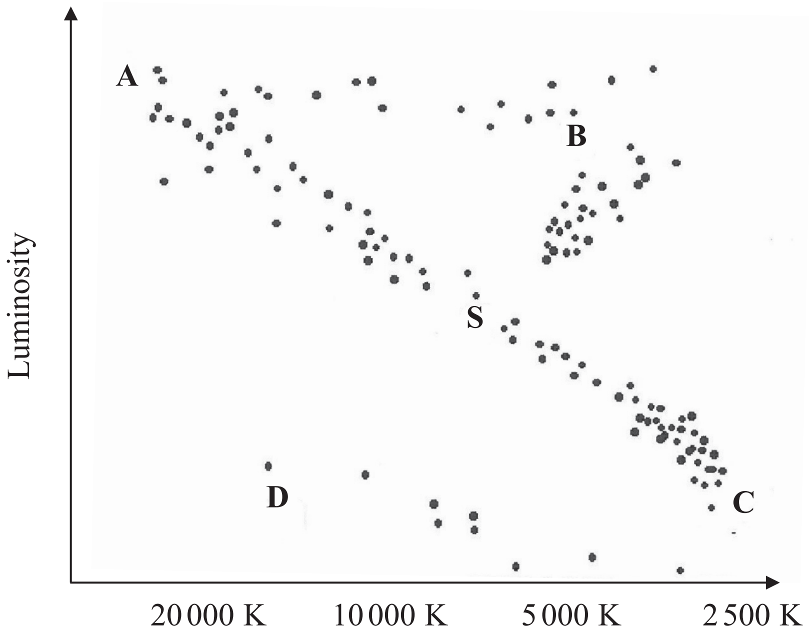
☒ **B** thick card.

☒ **C** 1 cm of aluminium.

☒ **D** 1 mm of lead.

(Total for Question 6 = 1 mark)

7 The figure shows our Sun, S, plotted on a Hertzsprung-Russell diagram.



Once hydrogen fusion has ceased in its core the Sun will move to a new position on the diagram.

The new position of the Sun will be

☒ **A**

☒ **B**

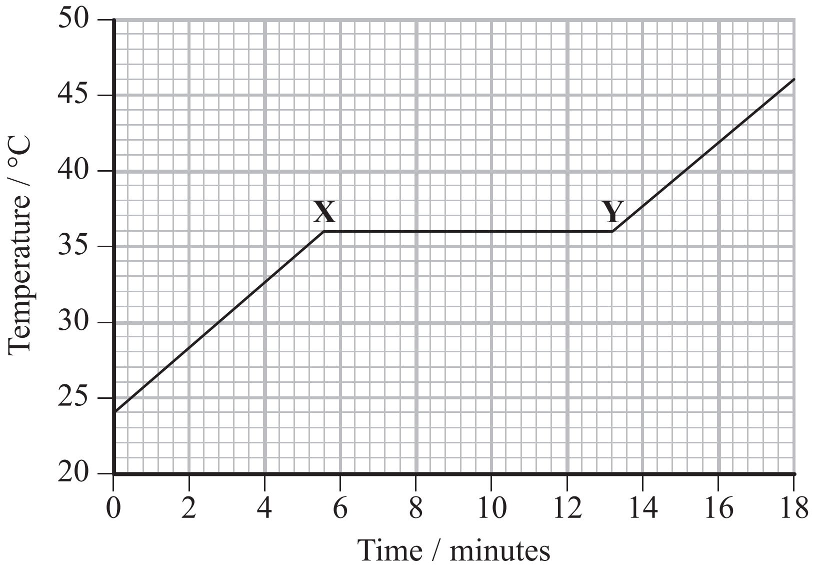
☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8 A piece of chocolate is heated at a constant rate.

The graph shows how the temperature of the chocolate varies with time.



Select the correct statement for the time between X and Y.

☒ **A** The internal energy of the chocolate increases.

☒ **B** The internal energy of the chocolate stays constant.

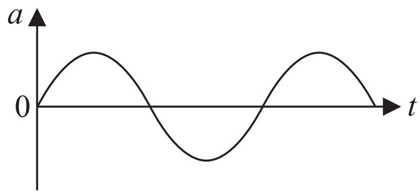
☒ **C** The kinetic energy of the molecules in the chocolate increases.

☒ **D** The potential energy between the molecules in the chocolate stays constant.

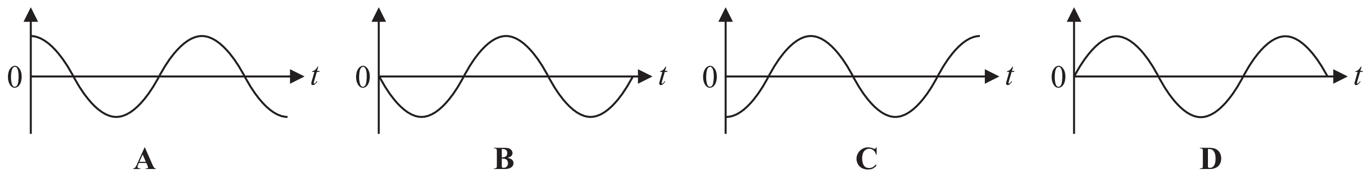
(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the graph below.

The graph shows how the acceleration a varies with time t for an object undergoing simple harmonic motion.



The following graphs show how other quantities for the object may vary over the same time period.



9 Choose the graph that shows the variation of displacement with time.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 Choose the graph that shows the variation of velocity with time.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

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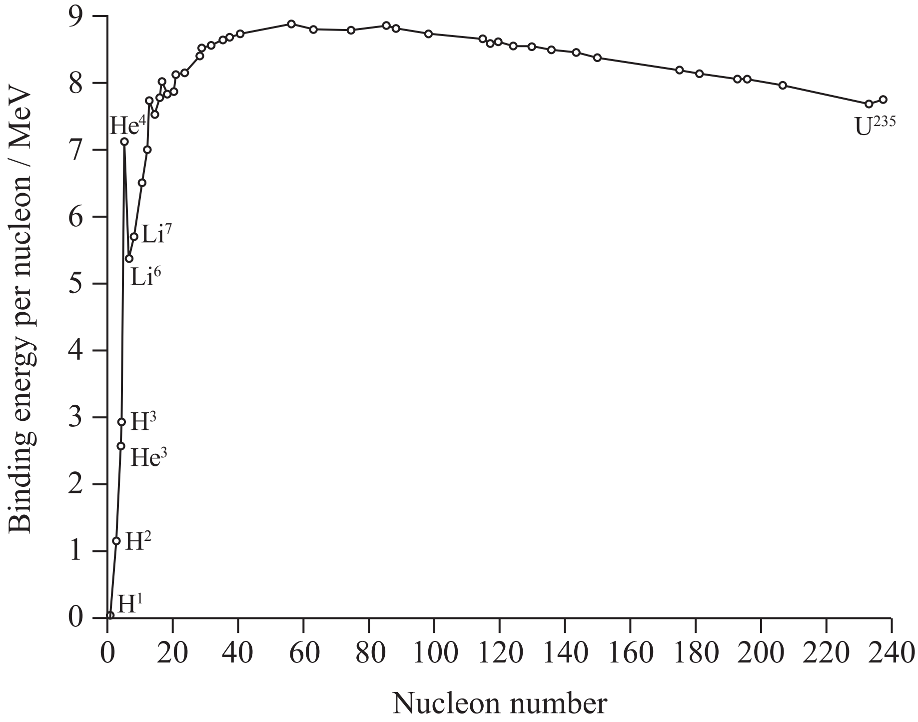
SECTION B

Answer ALL questions in the spaces provided.

11 The graph shows how the binding energy per nucleon varies with nucleon number for a range of isotopes.



(a) Explain why an alpha particle (He^4) is more likely than any other small nucleus to be emitted from a large unstable nucleus.

(2)

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(b) Explain why fission reactors use isotopes such as U-235 as fuel.

Your answer should include reference to the graph.

(3)

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(Total for Question 11 = 5 marks)

12 The maximum recommended temperature at which meat should be maintained when it is being transported is 4°C.

275 kg of meat is being transported to a supermarket. The meat is cooled from 18.5°C to 1.5°C before it is loaded onto the van ready for transportation.

Specific heat capacity of the meat = 3.59×10^3 J kg^{-1} K^{-1}

(a) Calculate the amount of thermal energy that has been removed from the meat.

(2)

Thermal energy removed = ...

(b) When the meat is unpacked at the supermarket it is initially left in a warm environment. The meat warms up uniformly from 1.5°C as energy is transferred to the meat from the surroundings at a rate of 720 W.

Show that there may be a risk in eating the meat if it is left out for longer than an hour.

(3)

(Total for Question 12 = 5 marks)

13 The photograph shows the Millennium Bridge in Salford. The bridge which is 91 m long straddles the Manchester Ship Canal.

When large numbers of people cross the bridge at the same time, the bridge begins to oscillate with large amplitude simple harmonic motion.

(a) Explain why there is large amplitude oscillation of the bridge under these conditions.

(3)

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(b) The bridge oscillates with a frequency of 0.55 Hz. The amplitude of oscillation is greatest at the mid-point and falls gradually to zero at the ends.

Calculate the speed of transverse waves along the bridge.

(3)

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Wave speed = ...

(Total for Question 13 = 6 marks)

14 In the early 20th century Edwin Hubble carried out research on objects known as extra-galactic nebulae. The light spectra emitted by these nebulae were found to be shifted from the wavelengths measured for corresponding sources in the laboratory. We now recognise that these nebulae are galaxies and that the wavelength shifts are evidence for an expanding universe.

(a) Hubble used standard candles to determine the distances to these nebulae.

(i) Explain how a standard candle can be used to determine distance.

(3)

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(ii) Suggest why some standard candles can only be used to determine distances to relatively close galaxies.

(1)

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*(b) Once the distances to the nebulae had been determined, Hubble used the values of the wavelength shifts to conclude that there was a roughly linear relationship between velocities and distances for these nebulae.

Describe how Hubble was able to determine the velocities of the nebulae and explain how his conclusion provides evidence for an expanding universe.

(4)

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(Total for Question 14 = 8 marks)

15 The photograph shows an inflatable globe. This is a flexible plastic sphere on which a map of the world is printed. It is inflated by blowing into it like a balloon.

When fully inflated the globe has a volume of 6.55×10^{-2} m^3. At a temperature of 22°C the pressure exerted by the air in the globe is 1.05×10^5 Pa.

(a) On average there are 1.25×10^{22} molecules in each breath of air that we take.

Show that the number of breaths needed to fully inflate the globe is about 140.

(3)

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(b) The fully inflated globe is left outside and its temperature rises from 22°C to 30°C. The volume of the globe remains constant.

Calculate the new pressure exerted by the air in the globe.

(2)

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New pressure = ...

*(c) Including ideas of momentum, explain why the pressure exerted by the air in the globe increases.

(4)

(Total for Question 15 = 9 marks)

16 The Hubble Space Telescope (HST) was placed in orbit in 1990 with the aim of producing high resolution images of astronomical objects.

HST is in a low Earth orbit at a height of 569 km above the Earth's surface. The orbit is nearly circular and its plane is inclined at an angle of 28.5° to the equatorial plane.

radius of the Earth = 6.36×10^3 km

(a) Show that the strength of the Earth's gravitational field at the height of HST is about 8 N kg^{-1}.

(3)

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(b) By considering the gravitational force acting on HST, calculate the time it takes for HST to make one complete orbit of the Earth.

(4)

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Orbital time = ...

(c) Communications satellites stay above the same place on the Earth's surface at all times.

State and explain two changes to the orbit of HST for it to remain above the same place on the Earth's surface at all times.

(2)

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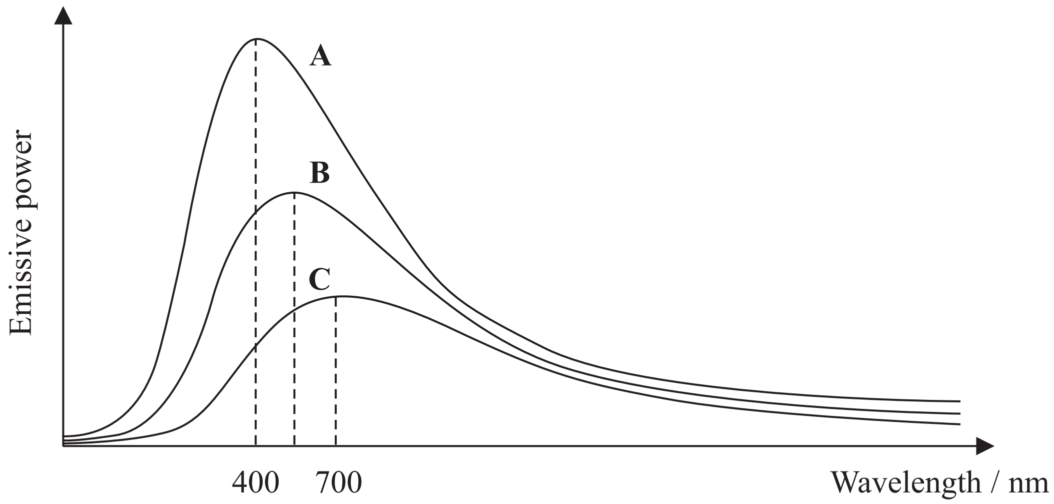
(Total for Question 16 = 9 marks)

17 Curves A, B and C show the radiation spectra of stars with three different surface temperatures.



(a) (i) Curve B represents radiation from the Sun. State what evidence from the graphs suggests that this might be so.

(1)

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(ii) State with a reason which curve represents a star with a greater surface temperature than the Sun.

(1)

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(iii) Use the graphs to explain how the radiation from the star identified in (ii) differs from the radiation from the Sun.

(2)

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(b) Stars other than the Sun are too far away from the Earth for us to make a direct measurement of their diameter.
Explain how we can deduce that some are giant stars and some are dwarf stars.

(3)

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(c) For stars which are relatively close to the Earth, describe how parallax measurements can be used to determine their distances from the Earth.

(4)

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(Total for Question 17 = 11 marks)

18 In the early part of the 20th century the Nobel Prize winner George de Hevesy made the first use of a radioactive tracer. He studied the transportation of a small sample of the isotope lead-212 in a broad bean plant.

(a) Complete the nuclear equation for the decay of Pb-212.

(2)

$$^{212}_{82}\text{Pb} \rightarrow {}^{\dots}_{\dots}\text{Bi} + {}^{\dots}_{\dots}\beta^{-}$$

(b) The half life of ^{212}Pb is 3.83×10^{4} s.

(i) State what is meant by the term half life.

(1)

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(ii) Show that the decay constant of ^{212}Pb is about 2×10^{-5} s^{-1} and hence calculate the fraction of the original sample that will remain after a time of 1 day (86 400 s).

(4)

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Fraction remaining = ...

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(iii) The energy released in this decay is 9.12×10^{-14} J.

Calculate the decrease in mass in kg that occurs in the decay of one Pb-212 atom.

(2)

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Decrease in mass = ... kg

(c) The isotope of bismuth produced by the decay of Pb-212 is itself radioactive. It produces both alpha and beta particles with an overall half life which is much shorter than that of the lead.

Discuss how the decay of the bismuth isotope could affect the measurements made on the activity of the broad bean plant.

(2)

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(d) George de Hevesy also discovered the element hafnium, which is a good absorber of neutrons. Hafnium is sometimes used to control the rate of fission in a nuclear fission reactor.

Suggest why a material which is a good absorber of neutrons would enable the rate of fission to be controlled.

(1)

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(e) Fusion reactors could become a better alternative to fission reactors.

Explain why this is the case and give reasons why practical fusion reactors are still only at the experimental stage.

(5)

(Total for Question 18 = 17 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	$hf = \phi + \frac{1}{2}mv^2_{max}$

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	$\lambda = h/p$

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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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