Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Thursday 18 June 2015 – 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

1/1/1/1/
P 4 4 9 2 8 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 The wavelength of a line in the spectrum produced by a distant star is found to be shorter than the wavelength of the corresponding line in the spectrum produced by the Sun.

This is because the distant star is

☒ **A** cooler than the Sun.

☒ **B** hotter than the Sun.

☒ **C** moving away from the Earth.

☒ **D** moving towards the Earth.

(Total for Question 1 = 1 mark)

2 The table below gives the range and number of ion pairs per centimetre produced by β particles, compared to α particles of the same energy.

Select the row from the table which shows the correct comparison.

	Range of β particles	Number of ion pairs per centimetre
☒ **A**	greater	greater
☒ **B**	smaller	greater
☒ **C**	greater	smaller
☒ **D**	smaller	smaller

(Total for Question 2 = 1 mark)

3 Recent determinations of the Hubble constant give a much smaller value than that originally obtained.

Compared to original ideas about the universe, the smaller value of the Hubble constant leads to the conclusion that the universe is

- ☒ **A** more dense.
- ☒ **B** less dense.
- ☒ **C** older.
- ☒ **D** younger.

(Total for Question 3 = 1 mark)

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4 When the absolute temperature of an ideal gas is doubled, the internal energy of the gas changes by a factor of

- ☒ **A** 1
- ☒ **B** $\sqrt{2}$
- ☒ **C** 2
- ☒ **D** 4

(Total for Question 4 = 1 mark)

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5 The Millennium Bridge is a pedestrian suspension bridge across the River Thames in London. The bridge had to be closed soon after its opening because of a large swaying motion created by people walking across it. A damping mechanism was installed to fix the problem.

The damping mechanism

- ☒ **A** increased the stiffness of the bridge.
- ☒ **B** increased the natural frequency of the bridge.
- ☒ **C** dissipated energy from the bridge.
- ☒ **D** decreased the forcing frequency on the bridge.

(Total for Question 5 = 1 mark)

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6 A very long pendulum set into oscillation continues to swing for several hours. During this time, as a result of the Earth's rotation, the pendulum will appear to change its direction of swing.

The movement of this pendulum is an example of

☒ **A** critical oscillation.

☒ **B** forced oscillation.

☒ **C** free oscillation.

☒ **D** resonant oscillation.

(Total for Question 6 = 1 mark)

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7 A correct unit for radiant energy flux is

☒ **A** N m^{-1} s^{-1}

☒ **B** Nm^{-1}

☒ **C** W

☒ **D** W m^2

(Total for Question 7 = 1 mark)

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8 When an ideal gas reaches the absolute zero of temperature, the gas

☒ **A** becomes a superfluid.

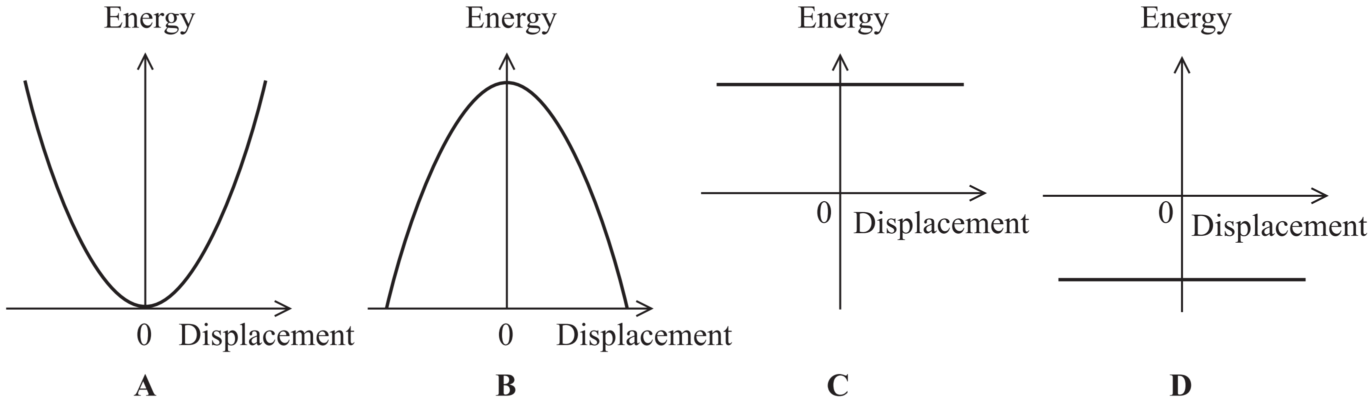
☒ **B** condenses to a liquid.

☒ **C** has maximum molecular potential energy.

☒ **D** exerts no pressure.

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the graphs below.



9 Which graph correctly shows the variation of potential energy with displacement for a particle undergoing simple harmonic motion?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 9 = 1 mark)

10 Which graph correctly shows the variation of total energy with displacement for a particle undergoing simple harmonic motion?

- ☒ **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 gas cylinder of volume 0.052 m^3 contains oxygen gas at a temperature of 22 °C and a pressure of 2.0×10^5 Pa.
Some of the oxygen in the cylinder is used and the gas pressure falls to 1.6×10^5 Pa.
The temperature remains constant.

Calculate the number of molecules removed from the cylinder.

(3)

Number of molecules removed = ...

(Total for Question 11 = 3 marks)

12 A car of mass 1200 kg is travelling at a speed of 25 m s^{-1}. During braking, 25% of the kinetic energy of the car is transferred to the brake pads.

Calculate the increase in temperature of the brake pads.

total mass of brake pads = 5.3 kg
specific heat capacity of brake pads = 450 J kg^{-1} K^{-1}

(4)

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Increase in temperature = ...

(Total for Question 12 = 4 marks)

13 Figure 1 shows a wine glass being driven into oscillation at its natural frequency by a high-power loudspeaker. The loudspeaker is close to, but not touching, the glass. The loudspeaker is driven by a sine-wave generator.

Figure 1

Figure 2

In Figure 2, the amplitude of vibration of the glass has become so large that the glass shatters.

(a) (i) Name the effect being demonstrated.

(1)

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(ii) Explain why this effect occurs.

(2)

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(b) A rubber band may be placed around the glass to provide some damping. This would reduce the amplitude of vibration and prevent the glass from shattering.

Explain how a rubber band around the glass would provide damping.

(2)

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(Total for Question 13 = 5 marks)

14 The Moon has an orbit around the Earth of radius 3.86×10^8 m, with a time period of 2.36×10^6 s.

(a) (i) Using the data provided, show that the product GM is about 4.1×10^{14} m^3 s^{-2}, where M is the mass of the Earth.

(3)

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(ii) At the surface of the Earth g is measured to be 9.81 N kg^{-1}.

Calculate a value for the radius of the Earth.

(2)

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Radius of the Earth = ...

(b) It has been estimated that, at any one time, there may be about a thousand small asteroids orbiting the Earth. These asteroids orbit at between five to ten times the distance of the Moon from the Earth. Most make no more than one orbit before being pulled out of this orbit by the Sun.

Suggest why these asteroids do not remain in a stable orbit around the Earth.

(2)

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(Total for Question 14 = 7 marks)

15 In March 2011, a nuclear meltdown occurred at the Fukushima Nuclear Power Plant and radioactive materials were released into the environment.

A month later, seaweed off the coast near Long Beach, California was found to be contaminated with iodine-131, a radioisotope that decays by emitting β particles. In one sample the activity was found to be 2.5 Bq per gram of dry seaweed.

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

(1)

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(b) A Geiger counter is used to measure the count from a sample of seaweed over a period of 10 minutes. The corrected readings obtained are shown in the table below.

Corrected count 1	Corrected count 2	Corrected count 3	Corrected count rate / Bq
3820	3830	3825	6.38

(i) State why the readings obtained from the Geiger counter have to be corrected.

(1)

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(ii) Explain why the radioactive count is repeated.

(2)

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(iii) The measurements were repeated with the same sample of seaweed 30 days later. Calculate the new corrected count rate of the sample.

half-life of iodine-131 = 8.0 days

(3)

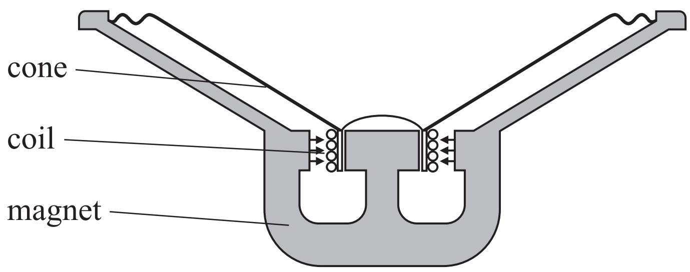
New corrected count rate = ...

(iv) There is a moderate risk to the public from the accumulation of iodine-131 in the seaweed. Explain why.

(2)

(Total for Question 15 = 9 marks)

16 A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate.



*(a) Explain why an alternating current in the coil causes the cone to oscillate with the frequency of the alternating current.

(3)

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(b) The loudspeaker cone undergoes simple harmonic motion.

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

(2)

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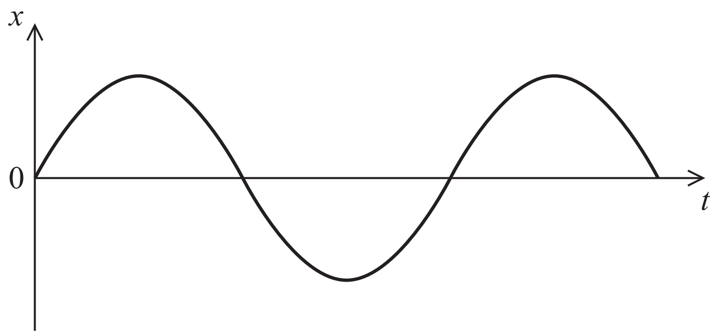
(ii) The graph below shows how the displacement x of the cone varies with time t.

Add another line to the graph to show how the acceleration of the cone varies over the same time interval.

(1)



P 4 4 9 2 8 A 0 1 4 2 8

(c) Some sand is sprinkled onto the cone. The sand oscillates vertically with the frequency of the cone. Keeping the frequency constant, the current is increased. This increases the amplitude of oscillation of the cone.

At a particular amplitude of oscillation the sand begins to lose contact with the cone.

(i) By considering the forces acting on a grain of sand, explain why this happens.

(3)

(ii) At a particular frequency, when the amplitude of the cone is 0.25 mm, a grain of sand loses contact with the cone.

Calculate this frequency.

(3)

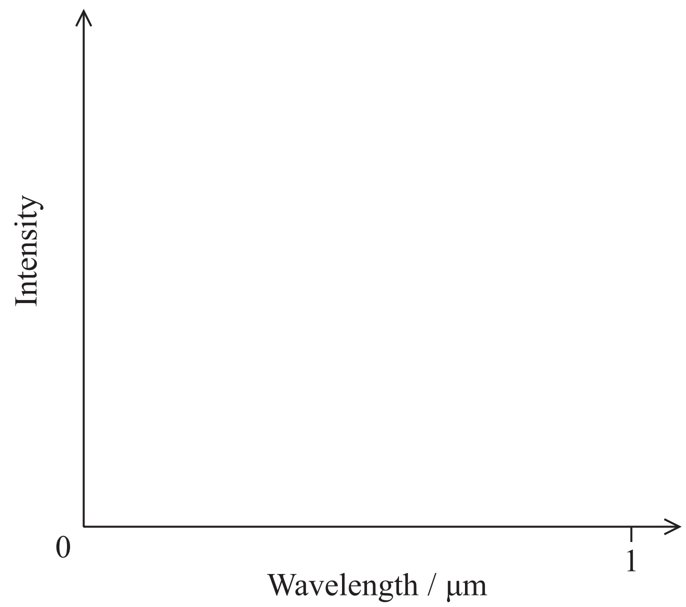
Frequency = ...

(Total for Question 16 = 12 marks)

17 Rigel A in the constellation of Orion is one of the brightest stars in the sky. It is a massive blue variable star with an intensity peak at a wavelength λ_{max} of 0.25 µm.

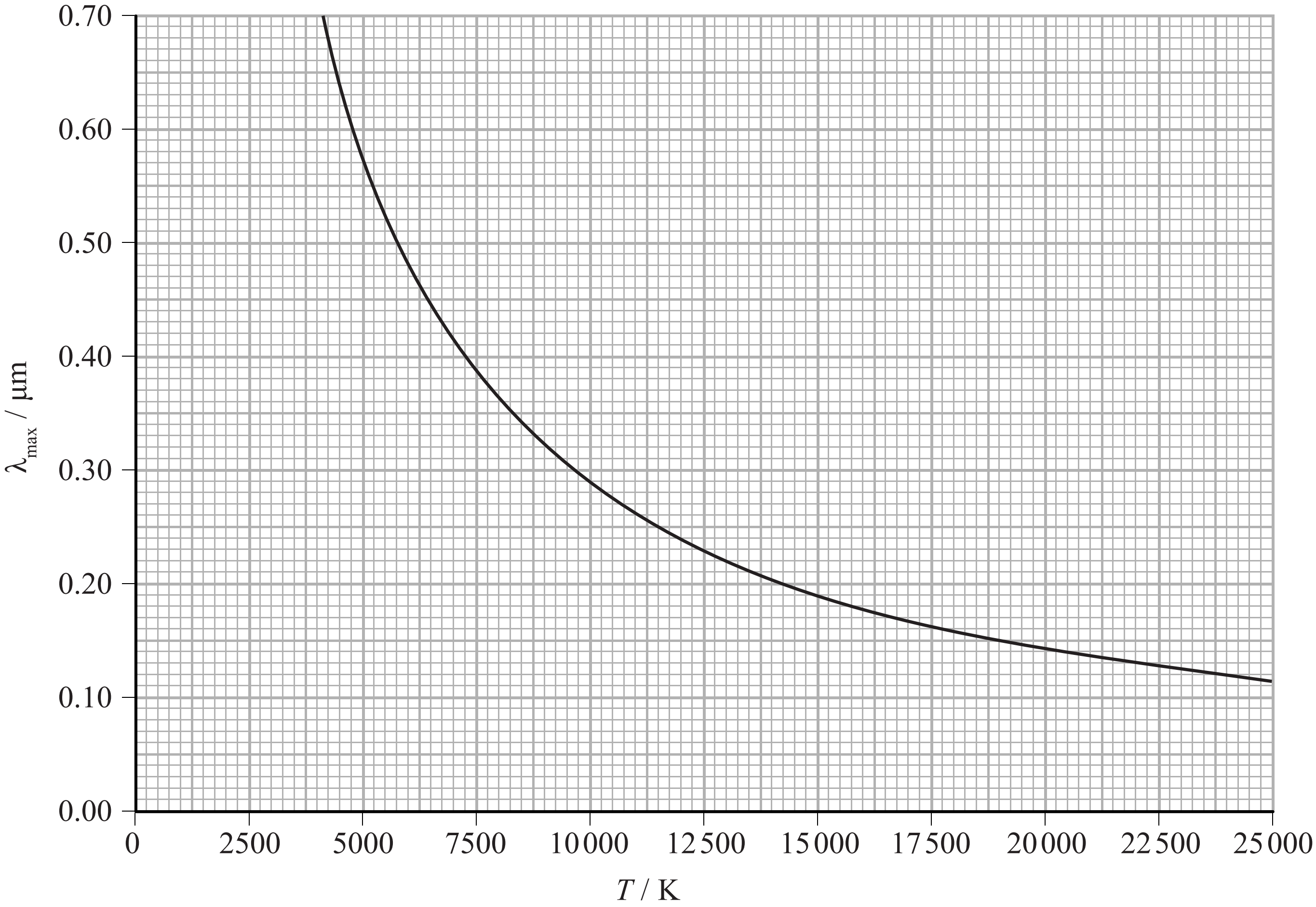
(a) On the axes below, sketch a graph of the intensity of radiation emitted by Rigel A against the wavelength of that radiation.

(2)



P 4 4 9 2 8 A 0 1 6 2 8

(b) The graph below shows how λ_{max} varies with temperature T for a black body radiator.



(i) Use the graph to estimate the surface temperature of Rigel A.

(1)

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(ii) Show that the graph is consistent with Wien's law.

(3)

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(c) RR Lyrae stars are also variable stars. They are used by astronomers as standard candles, although none of them are close enough for trigonometric parallax to be useful.

(i) State what is meant by a standard candle.

(1)

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*(ii) Describe how astronomers use standard candles.

(3)

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(iii) Explain why stars have to be within a certain distance from the Earth for trigonometric parallax to be useful.

(2)

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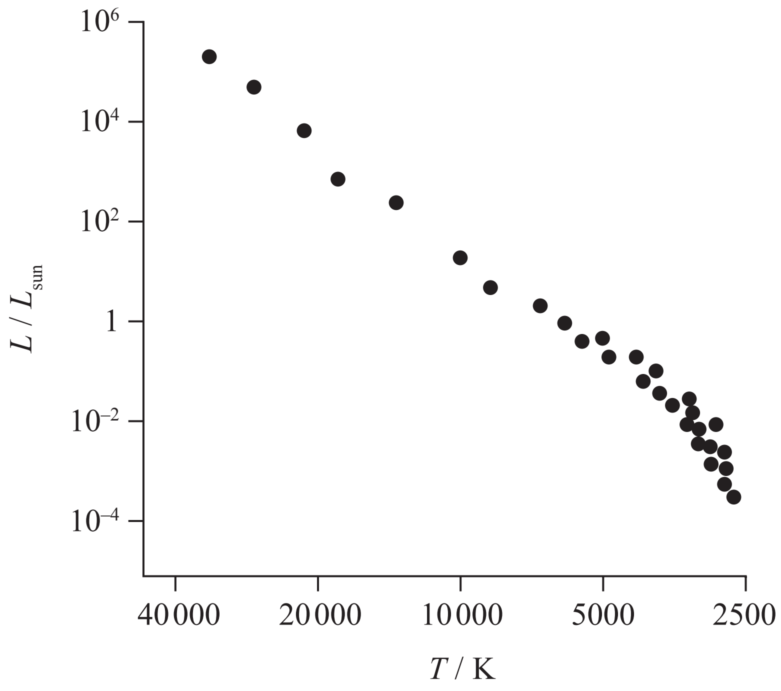
(Total for Question 17 = 12 marks)

18 The Hertzsprung-Russell (H-R) diagram is a plot of luminosity against temperature for a range of stars.

(a) The H-R diagram below shows a number of main sequence stars.



(i) Label the position of our Sun on the diagram.

(1)

(ii) Label on the diagram the regions in which white dwarf and red giant stars would be located.

(2)

*(iii) Stars known as white dwarf stars have small surface areas. Explain how astronomers have deduced this.

(3)

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(b) Most stars lie on the main sequence. In the early 20th century, it was thought that the main sequence represented different evolutionary stages of stars. According to this model, stars form with a high temperature and luminosity and so are located in the top left of the main sequence. As stars radiated energy they would move down the main sequence over time.

Scientists were unaware of fusion in the core of stars providing the energy for the star to shine.

Using this obsolete model explain why, in the absence of fusion, the luminosity of the star would decrease over time.

(3)

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(c) In 1939 Hans Bethe published a paper describing the fusion processes in stars.

In the proton-proton cycle, hydrogen is converted to helium in stages. The nuclear equation below represents one of the stages.

$$^{7}_{3}\text{Li} + {}^{\cdots}_{\cdots}\text{X} \rightarrow 2 \times {}^{4}_{2}\text{He}$$

(i) Complete the equation and identify X.

(2)

X is ....

(ii) Calculate, in joules, the energy emitted in this stage of the cycle.

(3)

	Mass / MeV/c^2
Proton	938.3
Neutron	939.6
Helium	3727.4
Lithium	6533.8

Energy = ... J

(d) In 1967 Bethe received a Nobel Prize in Physics for his work on understanding the fusion processes in stars.

Explain why sustainable fusion has not yet been achieved for the generation of electrical power.

(4)

(Total for Question 18 = 18 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	$v = H_0 d$

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