Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 24 May 2024

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/01**

Physics

Advanced
PAPER 1: Advanced Physics I

You must have:
Scientific calculator and ruler
Data, Formulae and Relationships Booklet (enclosed)

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

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.
- You are advised to show your working in calculations including units where appropriate.

Turn over

P74468A

F:1/1/1/1/

P 7 4 4 6 8 A 0 1 2 4

Pearson

Answer ALL questions.

All multiple choice questions must be answered with a cross in the box ☒ for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following is the base unit for charge?

☐ **A** As

☐ **B** C

☐ **C** $J V^{-1}$

☐ **D** Q

(Total for Question 1 = 1 mark)

2 Which of the following could **not** be accelerated in a LINAC?

☐ **A** electron

☐ **B** helium atom

☐ **C** proton

☐ **D** uranium ion

(Total for Question 2 = 1 mark)

3 A toy car moves up a slope at a constant speed, as shown. The car is moved by a motor with a power output of 5.2 W. The car gains a gravitational potential energy of 0.40 J in a time of 1.1 s.

Which of the following expressions gives the work done, in J, against resistive forces?

☐ **A** $5.2 - (0.40 \times 1.1)$

☐ **B** $(5.2 \times 1.1) - 0.40$

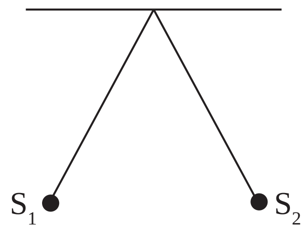
☐ **C** $(5.2 \div 1.1) + 0.40$

☐ **D** $(5.2 \times 1.1) + 0.40$

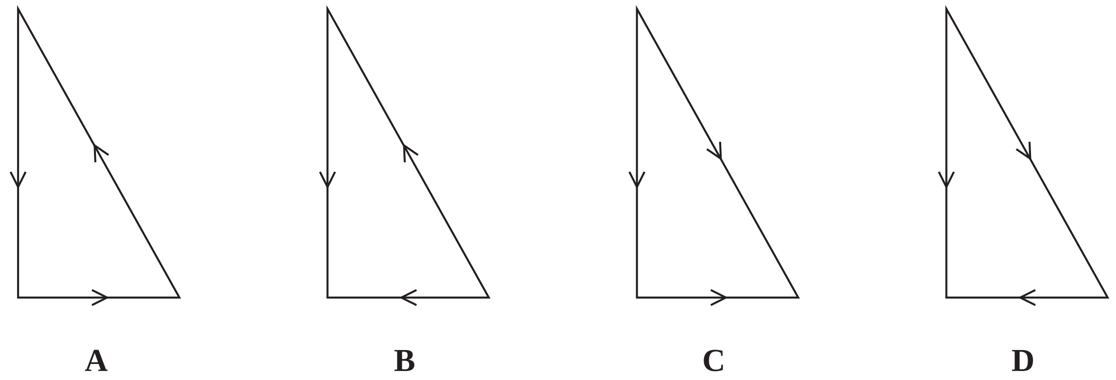
(Total for Question 3 = 1 mark)

P 7 4 4 6 8 A 0 2 2 4

Questions 4 and 5 refer to two small positively charged spheres S_1 and S_2 suspended by threads, as shown.



4 Which of the following vector diagrams shows the forces acting on S_2?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 4 = 1 mark)

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5 The electrostatic force between the two charges is initially F.

The charge on S_1 is doubled whilst the charge on S_2 is unchanged. The distance between S_1 and S_2 doubles.

Which of the following is the new force on S_2?

☒ **A** $\frac{F}{4}$

☒ **B** $\frac{F}{2}$

☒ **C** F

☒ **D** $2F$

(Total for Question 5 = 1 mark)

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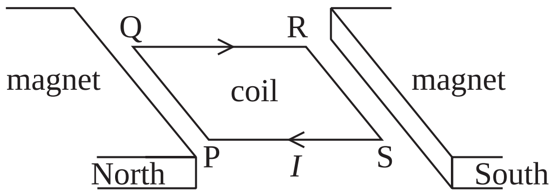
6 A square coil has sides of length l and carries a current I, as shown. The plane of the coil is parallel to a magnetic field of flux density B.



Which row of the table gives the magnetic force on the named side of the coil?

		Named side	Magnetic force
☒	**A**	PQ	*BIl* to the left
☒	**B**	QR	*BIl* to the right
☒	**C**	RS	*BIl* upwards
☒	**D**	SP	*BIl* downwards

(Total for Question 6 = 1 mark)

7 A length of wire has a non-uniform cross-sectional area. There is an electric current in the wire.

Which of the following is **not** constant along the length of this wire?

☒ **A** electric current

☒ **B** electron charge

☒ **C** electron drift velocity

☒ **D** number of free electrons per unit volume

(Total for Question 7 = 1 mark)

8 A roundabout completes 5.0 revolutions in 20 s.

Which of the following is the angular velocity of the roundabout?

☒ **A** $1.6\,\text{rad s}^{-1}$

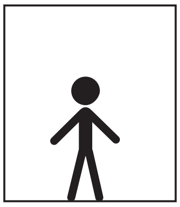
☒ **B** $16\,\text{rad s}^{-1}$

☒ **C** $25\,\text{rad s}^{-1}$

☒ **D** $630\,\text{rad s}^{-1}$

(Total for Question 8 = 1 mark)

9 A person of mass 70 kg is standing on the floor of a lift, as shown. The lift is accelerating downwards at 1.5 m s^{-2}.



Which of the following gives the normal reaction *R*, in N, acting on the person?

☒ **A** $R = 70 \times 9.81$

☒ **B** $R = 70 \times 1.5$

☒ **C** $R = (70 \times 9.81) + (70 \times 1.5)$

☒ **D** $R = (70 \times 9.81) - (70 \times 1.5)$

(Total for Question 9 = 1 mark)

10 An object was thrown so that it followed the path shown. Assume drag forces were negligible.

The object was thrown with an initial vertical component of velocity *u*. The time taken to reach maximum height is *t*.

Which of the following could **not** be used to determine the maximum vertical height *s* reached by the object?

☒ **A** $s = ut - \frac{1}{2}gt^2$

☒ **B** $s = ut$

☒ **C** $s = \frac{1}{2}ut$

☒ **D** $s = \frac{u^2}{2g}$

(Total for Question 10 = 1 mark)

11 A film involves a gang of bank robbers making a getaway on a bus loaded with gold bars. The bus spins out of control and ends up balancing on the edge of a cliff, as shown.

(Source: © maforche/Shutterstock)

(a) State what is meant by the moment of a force about a point.

(1)

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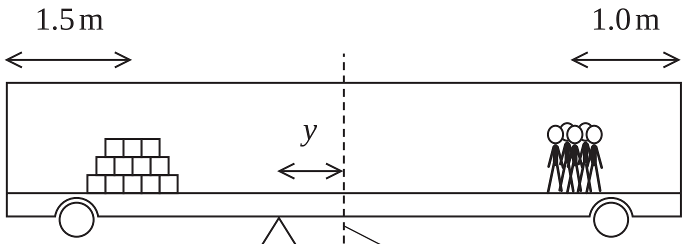
(b) The bus is balanced on a pivot that is a distance *y* from the centre of the bus.

The centre of mass of the gold is 1.5 m from one end of the bus. The centre of mass of the bank robbers is 1.0 m from the other end of the bus, as shown.



The unloaded bus can be treated as a uniform body with a weight of 32 000 N.

Calculate the distance y when the bus is balanced.

length of bus = 11.0 m
weight of gold bars = 31 000 N
weight of bank robbers = 8700 N

(4)

y = ...

(Total for Question 11 = 5 marks)

12 Electrical power is transmitted from Norway to Britain using a cable laid under the North Sea.

The following information is published on a website.

The cable has a diameter of 15 cm and a length of 720 km.

It is made of copper of resistivity $1.7 \times 10^{-8}\,\Omega\,m$.

The electrical power transmitted from Norway is 1400 MW and the transmission potential difference is 1100 kV.

The efficiency of this process is almost 100%.

Deduce, by calculation, whether the claim for efficiency is correct.

(Total for Question 12 = 6 marks)

13 Beams of antiprotons are often used in particle physics experiments.

(a) Show that the rest mass of an antiproton is about 900 MeV/c^2.

(4)

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(b) Antiprotons can be produced by accelerating and colliding two protons moving in opposite directions. A website suggests a possible outcome for a collision between these protons is described by the nuclear equation:

$$p + p \rightarrow p + p + p + \bar{p}$$

Deduce, by using conservation laws, whether it should be possible to produce an antiproton in this way.

(4)

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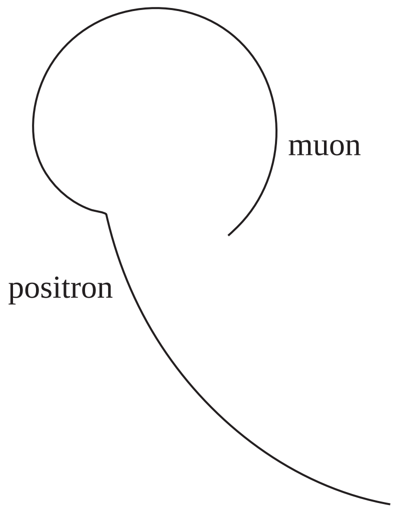
(Total for Question 13 = 8 marks)

14 The decay of a positive muon produced a positron, an electron neutrino and a muon antineutrino. The diagram shows the tracks formed in a particle detector.



(a) A muon belongs to a family of particles called leptons.

State two features that all particles in the lepton family have in common.

(2)

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(b) Write a nuclear equation for the decay of the muon (μ) described above.

(2)

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(c) Describe the role of the magnetic field in a particle detector.

(3)

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(d) Explain how the diagram gives evidence that a particle or particles, other than the positron, were produced in this decay.

(4)

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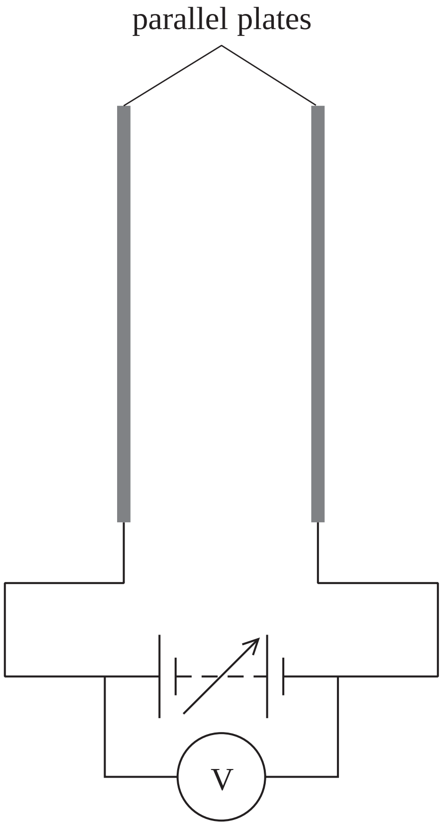
(Total for Question 14 = 11 marks)

15 A teacher demonstrates the electric field produced between two parallel metal plates. The plates are connected to a variable power supply, as shown. The power supply has a very large internal resistance and includes a voltmeter that indicates its output.



(a) (i) Add to the diagram to show the electric field between the two plates.

(3)

(ii) Explain why the reading on the voltmeter indicates the e.m.f. of the power supply.

(2)

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(b) The power supply output is increased until sparks are heard and are seen in the gap between the plates. Sparks form in air when the electric field strength exceeds $3.0 \times 10^6\,\text{V m}^{-1}$ and the air becomes conducting for a short time.

(i) Calculate the minimum potential difference across the plates for sparks to be created.

distance between parallel plates = 2.0 mm

(2)

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Minimum potential difference = ...

(ii) Explain why the voltmeter reading decreases significantly whenever sparks are produced.

(3)

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(Total for Question 15 = 10 marks)

16 A student is investigating circuits that include a filament bulb. The filament bulb is labelled ‘1.5 V, 0.50 W’.

(a) Show that the resistance of the filament bulb when operating normally is about 5 Ω.

(2)

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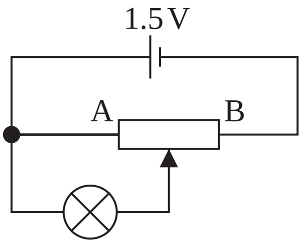
*(b) The student wishes to control the brightness of the filament bulb using a potentiometer. The student connects the circuit shown. The total resistance of the potentiometer is very much larger than the resistance of the filament bulb.



Explain how the brightness of the filament bulb changes as the potentiometer slider is moved from A to B.

(6)

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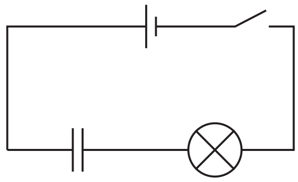
(c) The student connects the filament bulb in the circuit shown below. The capacitor is initially uncharged and has a capacitance of 1.2 F.

The resistance of the filament bulb is 5 Ω.



Explain how the brightness of the filament bulb will vary as the switch is closed.

(4)

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(Total for Question 16 = 12 marks)

17 Over one hundred years ago, Rutherford supervised a series of experiments using a source of alpha particles and thin gold foil.

(a) Describe the model of the atom that Rutherford proposed as a result of this series of experiments.

(3)

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(b) The initial kinetic energy of an alpha $\left({}^{4}_{2}\alpha\right)$ particle is 7.3×10^{-13} J.

(i) In a textbook, it states that an alpha particle with this energy would be brought to rest when it reached a distance of 5.0×10^{-14} m from the centre of the gold nucleus $\left({}^{197}_{79}\text{Au}\right)$.

Deduce whether this statement is correct.

(4)

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(ii) Determine the initial momentum of the alpha particle.

(3)

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Initial momentum = ...

(c) An alpha particle moves along a path directly towards a gold nucleus, as shown.

(i) An elastic interaction occurs and the alpha particle recoils.

State what is meant by an elastic interaction.

(1)

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(ii) State what happens to the atoms in the gold foil as a result of these interactions.

(1)

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(Total for Question 17 = 12 marks)

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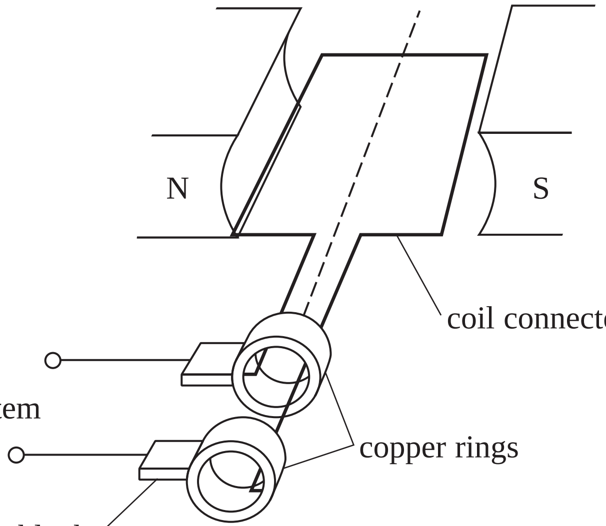
18 Regenerative braking supplies a current back to the power transmission system whilst slowing a vehicle. The arrangement shown can be used as a regenerative braking system on a train.



The coil rotates with the wheels of the train. Two copper rings are connected to the ends of the coil. The rings rotate with the coil and two carbon blocks make electrical contact with the rings as they rotate.

(a) Describe how this arrangement can be used as a regenerative brake.

(4)

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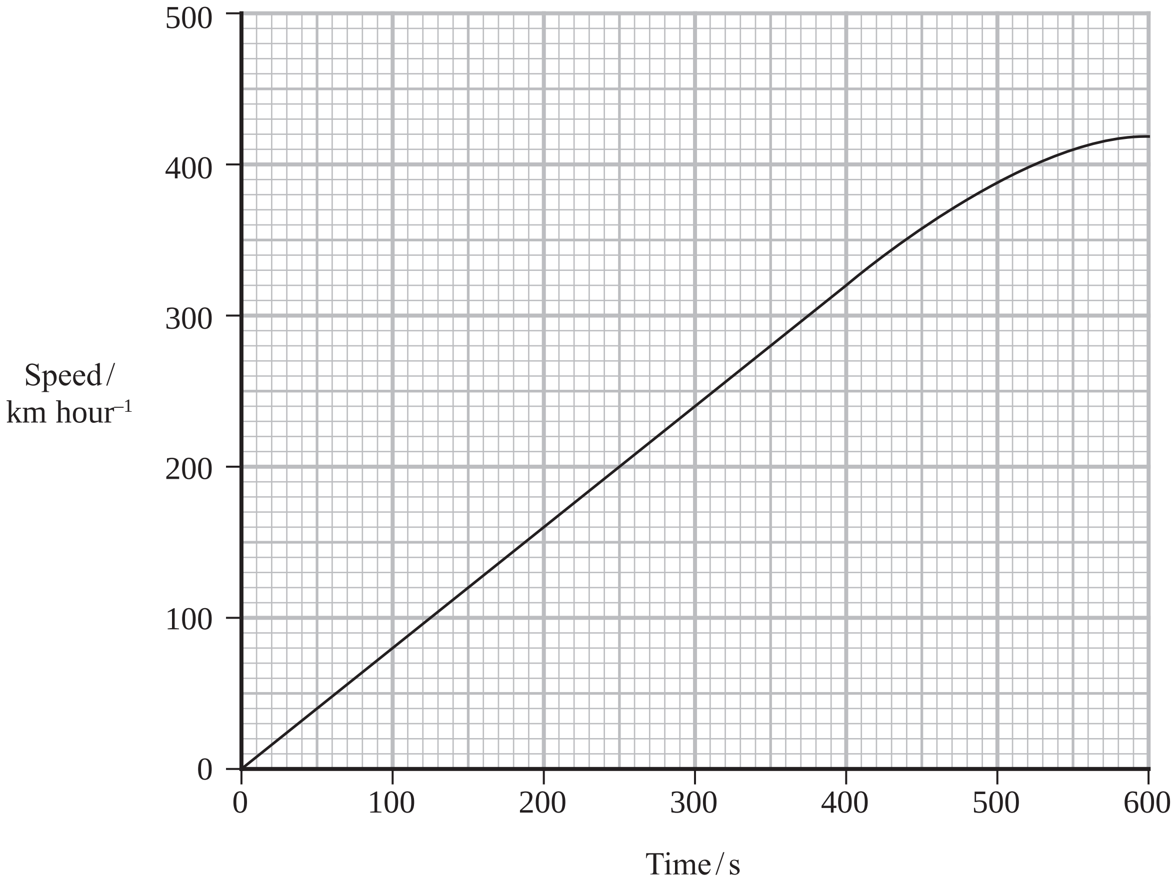
(b) A specification for a new train states that the train should be able to accelerate to a speed of 360 km hour^{-1} from rest, and that this acceleration should be completed within 40 km of level track.

The graph shows the performance of the train on a test run.



(i) Calculate the acceleration of the train as it accelerates to a speed of 360 km hour^{-1}.

(3)

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Acceleration of train = ...

(ii) Deduce whether the performance of the train met the specification on this test run.

(3)

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(c) On curved tracks there is a maximum safe speed for the train.

(i) Explain why there is a maximum safe speed for a train travelling on a curved track.

(4)

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(ii) When the train travels at 200 km $hour^{-1}$, the minimum safe radius of curvature of the track is 1800 m.

Calculate the minimum safe radius of curvature for a speed of 360 km $hour^{-1}$.

(2)

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Minimum safe radius of curvature = ...

(Total for Question 18 = 16 marks)

TOTAL FOR PAPER = 90 MARKS

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Pearson Edexcel Level 3 GCE

Friday 24 May 2024

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/01**

Physics

Advanced

PAPER 1: Advanced Physics I

Data, Formulae and Relationships Booklet
Do not return this Booklet with the question paper.

Turn over

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P 7 4 4 6 8 A

Pearson

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 law constant	$k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$	
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	$u = 1.66 \times 10^{-27} \text{ kg}$	

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

$$\text{moment of force} = Fx$$

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

$$E_k = \tfrac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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

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

Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$$\Delta E_{el} = \tfrac{1}{2}F\Delta x$$

Waves and particle nature of light

Wave speed

$$v = f\lambda$$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$$P = P_1 + P_2 + P_3 + \ldots$$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$$n\lambda = d \sin \theta$$

Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$$E = hf$$

Einstein's photoelectric equation

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

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

Further mechanics

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

Motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$F = ma = \frac{mv^2}{r}$$

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

$$F = mr\omega^2$$

Fields

Coulomb's law

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$$

Electric field strength

$$E = \frac{F}{Q}$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in a capacitor

$$W = \tfrac{1}{2}QV$$

$$W = \tfrac{1}{2}CV^2$$

$$W = \tfrac{1}{2}\frac{Q^2}{C}$$

Capacitor discharge

$$Q = Q_0 e^{-t/RC}$$

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field

$$F = BIl \sin\theta$$

$$F = Bqv \sin\theta$$

Faraday's and Lenz's laws

$$\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$$

Root-mean-square values

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

Ideal gas equation

$$pV = NkT$$

Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = 4\pi r^2\sigma T^4$$

Wien's law

$$\lambda_{max}T = 2.898 \times 10^{-3}\ \text{m K}$$

Space

Intensity

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Nuclear radiation

Mass-energy

$$\Delta E = c^2\Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{½}}$$

$$N = N_0\, e^{-\lambda t}$$

$$A = A_0\, e^{-\lambda t}$$

Gravitational fields

Gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

Gravitational field strength

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

Gravitational potential

$$V_{grav} = \frac{-Gm}{r}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

END OF DATA, FORMULAE AND RELATIONSHIPS LIST

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