

PHYSICS

Higher 1 (2017)

(Syllabus 8866)

CONTENTS

	<i>Page</i>
INTRODUCTION	2
AIMS	2
ASSESSMENT OBJECTIVES	3
SCHEME OF ASSESSMENT	4
ADDITIONAL INFORMATION	5
SUBJECT CONTENT	6
MATHEMATICAL REQUIREMENTS	15
GLOSSARY OF TERMS USED IN PHYSICS PAPERS	17
TEXTBOOKS	18
SUMMARY OF KEY QUANTITIES, SYMBOLS AND UNITS	19
DATA AND FORMULAE	20



INTRODUCTION

The syllabus has been designed to build on and extend the content coverage at O level. Candidates will be assumed to have knowledge and understanding of Physics at O level, either as a single subject or as part of a balanced science course.

AIMS

These are not listed in order of priority.

The aims of a course based on this syllabus should be to:

1. provide, through well-designed studies of experimental and practical Physics, a worthwhile educational experience for all students, whether or not they go on to study Physics beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:
 - 1.1 become confident citizens in a technological world and able to take or develop an informed interest in matters of scientific importance
 - 1.2 recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life
 - 1.3 be suitably prepared for studies beyond A level.
2. develop abilities and skills that:
 - 2.1 are relevant to the study and practice of science
 - 2.2 are useful in everyday life
 - 2.3 encourage efficient and safe practice
 - 2.4 encourage effective communication.
3. develop attitudes relevant to science such as:
 - 3.1 concern for accuracy and precision
 - 3.2 objectivity
 - 3.3 integrity
 - 3.4 the skills of enquiry
 - 3.5 initiative
 - 3.6 inventiveness.

4. promote an awareness:
 - 4.1 that the study and practice of Physics are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations
 - 4.2 that the implications of Physics may be both beneficial and detrimental to the individual, the community and the environment
 - 4.3 of the importance of the use of IT for communications, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results
 - 4.4 that Physics transcends national boundaries and that the language of science, correctly and rigorously applied, is universal.
5. stimulate students and create a sustained interest in Physics so that the study of the subject is enjoyable and satisfying.

ASSESSMENT OBJECTIVES

The assessment objectives listed below reflect those parts of the aims that will be assessed in the examination.

A Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, theories
2. scientific vocabulary, terminology, conventions (including symbols, quantities and units)
3. scientific instruments and apparatus, including techniques of operation and aspects of safety
4. scientific quantities and their determination
5. scientific and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these objectives will often begin with one of the following words: *define*, *state*, *describe* or *explain*. (See the glossary of terms)

B Handling, applying and evaluating information

Candidates should be able – in words or by using written, symbolic, graphical and numerical forms of presentation – to:

1. locate, select, organise and present information from a variety of sources
2. translate information from one form to another
3. manipulate numerical and other data
4. use information to identify patterns, report trends, draw inferences and report conclusions
5. present reasoned explanations for phenomena, patterns and relationships
6. make predictions and put forward hypotheses

7. apply knowledge, including principles, to novel situations
8. evaluate information and hypotheses
9. demonstrate an awareness of the limitations of physical theories and models.

These assessment objectives cannot be precisely specified in the syllabus content because questions testing such skills may be based on information that is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *predict*, *suggest*, *deduce*, *calculate* or *determine*. (See the glossary of terms).

While candidates are not assessed on their practical skills, it is expected that they engage in practical work in their routine lessons to support the learning of the subject and develop the necessary skills that are essential in scientific exploration and investigation.

SCHEME OF ASSESSMENT

All school candidates are required to enter for Papers 1 and 2.

Paper	Type of Paper	Duration	Marks	Weighting (%)
1	Multiple Choice	1 h	30	33
2	Structured Questions	2 h	80	67

Paper 1

30 multiple-choice questions. All questions will be of the direct choice type with 4 options.

Paper 2

This paper will consist of 2 sections. All answers will be written in spaces provided on the Question Paper.

Section A (40 marks)

This section will consist of a variable number of structured questions including one data-based question, all compulsory.

Section B (40 marks)

This section will consist of three 20-mark questions of which candidates will answer two. The questions will require candidates to integrate knowledge and understanding from different areas of the syllabus.

Marks allocated to assessment objectives

Theory Papers (Papers 1 and 2)

<i>Knowledge with understanding</i>	(Assessment Objectives A1–A5)	40%
<i>Handling, applying and evaluating information</i>	(Assessment Objectives B1–B9)	60%

ADDITIONAL INFORMATION

Mathematical Requirements

The mathematical requirements are given on pages 15 and 16.

Data and Formulae

Data and Formulae, as printed on page 20, will appear as page 2 in *Papers 1* and *2*.

Symbols, Signs and Abbreviations

Wherever symbols, signs and abbreviations are used in examination papers, the recommendation made in the ASE publication *SI Units, Signs, Symbols and Abbreviations* (1981) will be followed, except where these have been superseded by *Signs, Symbols and Systematics (The ASE Companion to 16–19 Science, 2000)*. The units kWh, atmosphere and eV may be used in examination papers without further explanation.

Disallowed Subject Combinations

Candidates may not simultaneously offer Physics at H1 and H2 levels.

SUBJECT CONTENT

SECTION I MEASUREMENT

1. Measurement

Content

- SI Units
- Errors and uncertainties
- Scalars and vectors

Learning Outcomes

Candidates should be able to:

- recall the following base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)
- express derived units as products or quotients of the base units and use the named units listed in 'Summary of Key Quantities, Symbols and Units' as appropriate
- show an understanding of and use the conventions for labelling graph axes and table columns as set out in the ASE publication *SI Units, Signs, Symbols and Abbreviations*, except where these have been superseded by *Signs, Symbols and Systematics (The ASE Companion to 16–19 Science, 2000)*
- use the following prefixes and their symbols to indicate decimal sub-multiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)
- make reasonable estimates of physical quantities included within the syllabus
- show an understanding of the distinction between systematic errors (including zero errors) and random errors
- show an understanding of the distinction between precision and accuracy
- assess the uncertainty in a derived quantity by simple addition of actual, fractional or percentage uncertainties (a rigorous statistical treatment is not required)
- distinguish between scalar and vector quantities, and give examples of each
- add and subtract coplanar vectors
- represent a vector as two perpendicular components.

SECTION II NEWTONIAN MECHANICS**2. Kinematics****Content**

- Rectilinear motion
- Non-linear motion

Learning Outcomes

Candidates should be able to:

- define displacement, speed, velocity and acceleration
- use graphical methods to represent distance travelled, displacement, speed, velocity and acceleration
- find displacement from the area under a velocity-time graph
- use the slope of a displacement-time graph to find the velocity
- use the slope of a velocity-time graph to find the acceleration
- derive, from the definitions of velocity and acceleration, equations which represent uniformly accelerated motion in a straight line
- solve problems using equations which represent uniformly accelerated motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance
- describe qualitatively the motion of bodies falling in a uniform gravitational field with air resistance
- describe and explain motion due to a uniform velocity in one direction and a uniform acceleration in a perpendicular direction.

3. Dynamics**Content**

- Newton's laws of motion
- Linear momentum and its conservation

Learning Outcomes

Candidates should be able to:

- state each of Newton's laws of motion
- show an understanding that mass is the property of a body which resists change in motion
- describe and use the concept of weight as the effect of a gravitational field on a mass
- define linear momentum and impulse
- define force as rate of change of momentum
- recall and solve problems using the relationship $F = ma$, appreciating that force and acceleration are always in the same direction
- state the principle of conservation of momentum

- (h) apply the principle of conservation of momentum to solve simple problems including elastic and inelastic interactions between two bodies in one dimension, (knowledge of the concept of coefficient of restitution is not required)
- (i) recognise that, for a perfectly elastic collision between two bodies, the relative speed of approach is equal to the relative speed of separation
- (j) show an understanding that, whilst the momentum of a system is always conserved in interactions between bodies, some change in kinetic energy usually takes place.

4. Forces

Content

- Types of force
- Equilibrium of forces
- Centre of gravity
- Turning effects of forces

Learning Outcomes

Candidates should be able to:

- (a) recall and apply Hooke's law in problem solving
- (b) deduce the elastic potential energy in a deformed material from the area under the force-extension graph
- (c) describe the forces on mass, charge and current in gravitational, electric and magnetic fields, as appropriate
- (d) solve problems using the equation $p = \rho gh$
- (e) show a qualitative understanding of frictional forces and viscous forces including air resistance. (No treatment of the coefficients of friction and viscosity is required.)
- (f) use a vector triangle to represent forces in equilibrium
- (g) show an understanding that the weight of a body may be taken as acting at a single point known as its centre of gravity.
- (h) show an understanding that a couple is a pair of forces which tends to produce rotation only
- (i) define and apply the moment of a force and the torque of a couple
- (j) show an understanding that, when there is no resultant force and no resultant torque, a system is in equilibrium
- (k) apply the principle of moments.

5. Work, Energy and Power

Content

- Work
- Energy conversion and conservation
- Potential energy and kinetic energy
- Power

Learning Outcomes

Candidates should be able to:

- (a) show an understanding of the concept of work in terms of the product of a force and displacement in the direction of the force
- (b) calculate the work done in a number of situations including the work done by a gas which is expanding against a constant external pressure: $W = p\Delta V$
- (c) give examples of energy in different forms, its conversion and conservation, and apply the principle of energy conservation to simple examples
- (d) derive, from the equations of motion, the formula $E_k = \frac{1}{2}mv^2$
- (e) recall and apply the formula $E_k = \frac{1}{2}mv^2$
- (f) distinguish between gravitational potential energy, electric potential energy and elastic potential energy
- (g) show an understanding of and use the relationship between force and potential energy in a uniform field to solve problems
- (h) derive, from the defining equation $W = Fs$, the formula $E_p = mgh$ for potential energy changes near the Earth's surface
- (i) recall and use the formula $E_p = mgh$ for potential energy changes near the Earth's surface
- (j) show an appreciation for the implications of energy losses in practical devices and use the concept of efficiency to solve problems
- (k) define power as work done per unit time and derive power as the product of force and velocity.

SECTION III WAVES**6. Wave Motion****Content**

- Progressive waves
- Transverse and longitudinal waves
- Polarisation
- Determination of frequency and wavelength

Learning Outcomes

Candidates should be able to:

- show an understanding and use the terms displacement, amplitude, phase difference, period, frequency, wavelength and speed
- deduce, from the definitions of speed, frequency and wavelength, the equation $v = f\lambda$
- recall and use the equation $v = f\lambda$
- show an understanding that energy is transferred due to a progressive wave
- recall and use the relationship, $intensity \propto (amplitude)^2$
- analyse and interpret graphical representations of transverse and longitudinal waves
- show an understanding that polarisation is a phenomenon associated with transverse waves
- determine the frequency of sound using a calibrated c.r.o.
- determine the wavelength of sound using stationary waves.

7. Superposition**Content**

- Stationary waves
- Diffraction
- Interference
- Two-source interference patterns

Learning Outcomes

Candidates should be able to:

- explain and use the principle of superposition in simple applications
- show an understanding of experiments which demonstrate stationary waves using microwaves, stretched strings and air columns
- explain the formation of a stationary wave using a graphical method, and identify nodes and antinodes
- explain the meaning of the term diffraction

- (e) show an understanding of experiments which demonstrate diffraction including the diffraction of water waves in a ripple tank with both a wide gap and a narrow gap
- (f) show an understanding of the terms interference and coherence
- (g) show an understanding of experiments which demonstrate two-source interference using water, light and microwaves
- (h) show an understanding of the conditions required if two-source interference fringes are to be observed
- (i) recall and solve problems using the equation $\lambda = ax/D$ for double-slit interference using light.

SECTION IV ELECTRICITY AND MAGNETISM**8. Current of Electricity****Content**

- Electric current
- Potential difference
- Resistance and resistivity
- Sources of electromotive force

Learning Outcomes

Candidates should be able to:

- (a) show an understanding that electric current is the rate of flow of charged particles
- (b) define charge and the coulomb
- (c) recall and solve problems using the equation $Q = It$
- (d) define potential difference and the volt
- (e) recall and solve problems using $V = W/Q$
- (f) recall and solve problems using $P = VI$, $P = I^2R$
- (g) define resistance and the ohm
- (h) recall and solve problems using $V = IR$
- (i) sketch and explain the I - V characteristics of a metallic conductor at constant temperature, a semiconductor diode and a filament lamp
- (j) sketch the temperature characteristic of a thermistor
- (k) recall and solve problems using $R = \rho l/A$
- (l) define e.m.f. in terms of the energy transferred by a source in driving unit charge round a complete circuit
- (m) distinguish between e.m.f. and p.d. in terms of energy considerations
- (n) show an understanding of the effects of the internal resistance of a source of e.m.f. on the terminal potential difference and output power.

9. D.C. Circuits

Content

- Practical circuits
-
- Series and parallel arrangements

Learning Outcomes

Candidates should be able to:

- recall and use appropriate circuit symbols as set out in *SI Units, Signs, Symbols and Abbreviations* (ASE, 1981) and *Signs, Symbols and Systematics* (ASE, 2000)
- draw and interpret circuit diagrams containing sources, switches, resistors, ammeters, voltmeters, and/or any other type of component referred to in the syllabus
- solve problems using the formula for the combined resistance of two or more resistors in series
- solve problems using the formula for the combined resistance of two or more resistors in parallel
- solve problems involving series and parallel circuits for one source of e.m.f.

10. Electromagnetism

Content

- Force on a current-carrying conductor
- Force on a moving charge
- Magnetic fields due to currents
- Force between current-carrying conductors

Learning Outcomes

Candidates should be able to:

- show an appreciation that a force might act on a current-carrying conductor placed in a magnetic field
- recall and solve problems using the equation $F = BIl\sin\theta$, with directions as interpreted by Fleming's left-hand rule
- define magnetic flux density and the tesla
- show an understanding of how the force on a current-carrying conductor can be used to measure the flux density of a magnetic field using a current balance
- predict the direction of the force on a charge moving in a magnetic field
- sketch flux patterns due to a long straight wire, a flat circular coil and a long solenoid
- show an understanding that the field due to a solenoid may be influenced by the presence of a ferrous core
- explain the forces between current-carrying conductors and predict the direction of the forces.

SECTION V MODERN PHYSICS**11. Quantum Physics****Content**

- Energy of a photon
- The photoelectric effect
- Wave-particle duality
- Energy levels in atoms
- Line spectra

Learning Outcomes

Candidates should be able to:

- (a) show an appreciation of the particulate nature of electromagnetic radiation
- (b) recall and use $E = hf$
- (c) show an understanding that the photoelectric effect provides evidence for a particulate nature of electromagnetic radiation while phenomena such as interference and diffraction provide evidence for a wave nature
- (d) recall the significance of threshold frequency
- (e) recall and use the equation $\frac{1}{2}mv_{max}^2 = eV_s$, where V_s is the stopping potential
- (f) explain photoelectric phenomena in terms of photon energy and work function energy
- (g) explain why the maximum photoelectric energy is independent of intensity whereas the photoelectric current is proportional to intensity
- (h) recall, use and explain the significance of $hf = \Phi + \frac{1}{2}mv_{max}^2$
- (i) describe and interpret qualitatively the evidence provided by electron diffraction for the wave nature of particles
- (j) recall and use the relation for the de Broglie wavelength $p = h/\lambda$
- (k) show an understanding of the existence of discrete electron energy levels in isolated atoms (e.g. atomic hydrogen) and deduce how this leads to spectral lines
- (l) distinguish between emission and absorption line spectra
- (m) recall and solve problems using the relation $hf = E_1 - E_2$.

MATHEMATICAL REQUIREMENTS

Arithmetic

Candidates should be able to:

- recognise and use expressions in decimal and standard form (scientific) notation
- use appropriate calculating aids (electronic calculator or tables) for addition, subtraction, multiplication and division. Find arithmetic means, powers (including reciprocals and square roots), sines, cosines, tangents (and the inverse functions), exponentials and logarithms (lg and ln)
- take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified
- make approximate evaluations of numerical expressions (e.g. $\pi^2 = 10$) and use such approximations to check the magnitude of machine calculations

Algebra

Candidates should be able to:

- change the subject of an equation. Most relevant equations involve only the simpler operations but may include positive and negative indices and square roots
- solve simple algebraic equations. Most relevant equations are linear but some may involve inverse and inverse square relationships. Linear simultaneous equations and the use of the formula to obtain the solutions of quadratic equations are included
- substitute physical quantities into physical equations using consistent units and check the dimensional consistency of such equations
- formulate simple algebraic equations as mathematical models of physical situations, and identify inadequacies of such models
- recognise and use the logarithmic forms of expressions like ab , a/b , x^n , e^{kx} ; understand the use of logarithms in relation to quantities with values that range over several orders of magnitude
- manipulate and solve equations involving logarithmic and exponential functions
- express small changes or errors as percentages and *vice versa*
- comprehend and use the symbols $<$, $>$, \leq , \geq , \ll , \gg , \approx , \propto , $\langle x \rangle$ ($= \bar{x}$), Σ , Δx , δx , $\sqrt{\quad}$

Geometry and trigonometry

Candidates should be able to:

- calculate areas of right-angled and isosceles triangles, circumference and area of circles, areas and volumes of rectangular blocks, cylinders and spheres
- use Pythagoras' theorem, similarity of triangles, the angle sum of a triangle
- use sines, cosines and tangents (especially for 0° , 30° , 45° , 60° , 90°). Use the trigonometric relationships for triangles:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}; \quad a^2 = b^2 + c^2 - 2bc \cos A$$

- (d) use $\sin \theta \approx \tan \theta \approx \theta$ and $\cos \theta \approx 1$ for small θ , $\sin^2 \theta + \cos^2 \theta = 1$
- (e) understand the relationship between degrees and radians (defined as arc/radius), translate from one to the other and use the appropriate system in context

Vectors

Candidates should be able to:

- (a) find the resultant of two coplanar vectors, recognising situations where vector addition is appropriate
- (b) obtain expressions for components of a vector in perpendicular directions, recognising situations where vector resolution is appropriate.

Graphs

Candidates should be able to:

- (a) translate information between graphical, numerical, algebraic and verbal forms
- (b) select appropriate variables and scales for graph plotting
- (c) for linear graphs, determine the slope, intercept and intersection
- (d) choose, by inspection, a straight line which will serve as the line of best fit through a set of data points presented graphically
- (e) recall standard linear form $y = mx + c$ and rearrange relationships into linear form where appropriate
- (f) sketch and recognise the forms of plots of common simple expressions like $1/x$, x^2 , $1/x^2$, $\sin x$, $\cos x$, e^{-x}
- (g) use logarithmic plots to test exponential and power law variations
- (h) understand, draw and use the slope of a tangent to a curve as a means to obtain the gradient, and use notation in the form dy/dx for a rate of change
- (i) understand and use the area below a curve where the area has physical significance.

Any calculator used must be on the Singapore Examinations and Assessment Board list of approved calculators.

GLOSSARY OF TERMS USED IN PHYSICS PAPERS

It is hoped that the glossary will prove helpful to candidates as a guide, although it is not exhaustive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context. They should also note that the number of marks allocated for any part of a question is a guide to the depth of treatment required for the answer.

1. *Define (the term(s) ...)* is intended literally. Only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, being required.
2. *What is meant by ...* normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *Explain* may imply reasoning or some reference to theory, depending on the context.
4. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.
5. *List* requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.
6. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended should be interpreted in the light of the indicated mark value.
7. *Discuss* requires candidates to give a critical account of the points involved in the topic.
8. *Deduce/Predict* implies that candidates are not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.
9. *Suggest* is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a 'novel' situation, one that formally may not be 'in the syllabus'.
10. *Calculate* is used when a numerical answer is required. In general, working should be shown.
11. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.
12. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young modulus, relative molecular mass.
13. *Show* is used when an algebraic deduction has to be made to prove a given equation. It is important that the terms being used by candidates are stated explicitly.
14. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

15. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.
16. *Sketch*, when applied to diagrams, implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important details.
17. *Compare* requires candidates to provide both similarities and differences between things or concepts.

TEXTBOOKS

Teachers may find reference to the following books helpful.

Practice in Physics (3rd Edition), by Akrill et al, published by Hodder & Stoughton, ISBN 0-340-75813-9

New Understanding Physics for Advanced Level (4th Edition), by J Breithaupt, published by Nelson Thornes, ISBN 0-748-74314-6

Advanced Physics (4th Edition), by T Duncan, published by John Murray, ISBN 0-719-57669-5

Advanced Physics (2nd Edition), by K Gibbs, published by Cambridge University Press, ISBN 0-521-56701-7

Bath Advanced Science: Physics (2nd Edition), by R Hutchings, published by Nelson Thornes, ISBN 0-174-38731-8

Teachers are encouraged to choose texts for class use that they feel will be of interest to their students and will support their own teaching style.

SUMMARY OF KEY QUANTITIES, SYMBOLS AND UNITS

The following list illustrates the symbols and units that will be used in question papers.

Quantity	Usual symbols	Usual unit
<i>Base Quantities</i>		
mass	m	kg
length	l	m
time	t	s
electric current	I	A
thermodynamic temperature	T	K
amount of substance	n	mol
<i>Other Quantities</i>		
distance	d	m
displacement	s, x	m
area	A	m^2
volume	V, v	m^3
density	ρ	kg m^{-3}
speed	u, v, w, c	m s^{-1}
velocity	u, v, w, c	m s^{-1}
acceleration	a	m s^{-2}
acceleration of free fall	g	m s^{-2}
force	F	N
weight	W	N
momentum	p	N s
work	w, W	J
energy	E, U, W	J
potential energy	E_p	J
kinetic energy	E_k	J
power	P	W
pressure	p	Pa
torque	T	N m
angle	θ	$^\circ, \text{rad}$
period	T	s
frequency	f	Hz
angular frequency	ω	rad s^{-1}
wavelength	λ	m
speed of electromagnetic waves	c	m s^{-1}
electric charge	Q	C
elementary charge	e	C
electric potential	V	V
electric potential difference	V	V
electromotive force	E	V
resistance	R	Ω
resistivity	ρ	$\Omega \text{ m}$
electric field strength	E	$\text{N C}^{-1}, \text{V m}^{-1}$
magnetic flux	Φ	Wb
magnetic flux density	B	T
number density (number per unit volume)	n	m^{-3}
Planck constant	h	J s
work function energy	ϕ	J

DATA AND FORMULAE

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ Js}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$