# *Every formula*

Cambridge IGCSE Physics

*The syllabus introduces every one with the words “recall and use”, and 0625 provides no formula sheet in any paper. Compiled by GioPhysics from the published syllabus. This is an independent study aid, not a Cambridge document; the official syllabus is the authority.*

## 1 Motion, forces and energy

### 1.1 Physical quantities and measurement techniques

SUPP.

**Resultant of two vectors at right angles**

$$R = \sqrt{(x^2 + y^2)}$$

R — resultant of the two vectors
x, y — the two perpendicular components

*Forces or velocities only. A scale drawing is an accepted method — the syllabus asks for the resultant by calculation or graphically.*

### 1.2 Motion

CORE

**Speed**

$$v = s / t$$

$s = vt$ · $t = s / v$

v — speed (m/s)
s — distance travelled (m)
t — time taken (s)

CORE

**Average speed**

$$\text{average speed} = \text{total distance travelled} / \text{total time taken}$$

distance — the whole journey (m)
time — the whole journey (s)

CORE

**Speed from a distance-time graph**

$$\text{speed} = \text{gradient of a distance–time graph}$$

gradient — rise ÷ run of a straight-line section

CORE

**Distance from a speed-time graph**

$$\text{distance travelled} = \text{area under a speed–time graph}$$

area — of the region between the line and the time axis

*For motion at constant speed or constant acceleration.*

SUPP.

**Acceleration**

$$a = \Delta v / t$$

$\Delta v = at$

a — acceleration (m/s²)
Δv — change in velocity (m/s)
t — time taken (s)

*A deceleration is a negative acceleration, and is used as such in calculations.*

SUPP. **Acceleration from a speed-time graph**

$$\text{acceleration} = \text{gradient of a speed–time graph}$$

gradient — rise ÷ run

## 1.3 Mass and weight

CORE **Gravitational field strength**

$$g = W / m$$

$W = mg$ · $m = W / g$

- $g$ — gravitational field strength (N/kg)
- $W$ — weight (N)
- $m$ — mass (kg)

*The syllabus asks you to know that g is equivalent to the acceleration of free fall.*

## 1.4 Density

CORE **Density**

$$\rho = m / V$$

$m = \rho V$ · $V = m / \rho$

- $\rho$ — density (g/cm$^3$, kg/m$^3$)
- $m$ — mass (kg, g)
- $V$ — volume (m$^3$, cm$^3$)

## 1.5.1 Effects of forces

SUPP. **Resultant force and acceleration**

$$F = ma$$

$a = F / m$ · $m = F / a$

- $F$ — resultant force (N)
- $m$ — mass (kg)
- $a$ — acceleration (m/s$^2$)

*The force and the acceleration are in the same direction. $F = mv^2/r$ is explicitly not required at 0625.*

SUPP. **Spring constant**

$$k = F / x$$

$F = kx$ · $x = F / k$

- $k$ — spring constant (N/m, N/cm)
- $F$ — force (load) (N)
- $x$ — extension (m, cm)

*Valid up to the limit of proportionality. An understanding of the elastic limit is not required.*

## 1.5.2 Turning effect of forces

CORE **Moment of a force**

$$\text{moment} = F \times d$$

- $F$ — force (N)
- $d$ — perpendicular distance from the pivot (m)
- moment — turning effect (N m)

CORE **Principle of moments**

$$\text{sum of clockwise moments} = \text{sum of anticlockwise moments}$$

about — the same pivot, for an object in equilibrium

*Core covers one force each side of the pivot; Supplement extends it to more than one force each side.*

1.5.3 Centre of gravity

*No equations. This point is examined through experiment and qualitative reasoning about stability.*

## 1.6 Momentum

SUPP. **Momentum**

$$p = mv$$

$m = p / v$ · $v = p / m$

- p — momentum (kg m/s, N s)
- m — mass (kg)
- v — velocity (m/s)

SUPP. **Impulse**

$$\text{impulse} = F\Delta t = \Delta(mv)$$

- F — force (N)
- $\Delta t$ — time for which the force acts (s)
- $\Delta(mv)$ — change in momentum (kg m/s, N s)

SUPP. **Resultant force from momentum**

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

- F — resultant force (N)
- $\Delta p$ — change in momentum (kg m/s)
- $\Delta t$ — time taken (s)

SUPP. **Conservation of momentum**

$$\text{total momentum before} = \text{total momentum after}$$

- p — summed for every object, with direction

*Simple problems in one dimension only.*

## 1.7.1 Energy

SUPP. **Kinetic energy**

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

$v = \sqrt{(2E_k / m)}$

- Ek — kinetic energy (J)
- m — mass (kg)
- v — speed (m/s)

SUPP. **Change in gravitational potential energy**

$$\Delta E_p = mg\Delta h$$

- $\Delta E_p$ — change in g.p.e. (J)
- m — mass (kg)
- g — gravitational field strength (N/kg)
- $\Delta h$ — change in height (m)

CORE **Conservation of energy**

$$\text{total energy before} = \text{total energy after}$$

- stores — kinetic, gravitational potential, chemical, elastic, nuclear, electrostatic, internal

*Core applies this to simple flow diagrams; Supplement to multi-stage examples and Sankey diagrams.*

## 1.7.2 Work

CORE

**Mechanical work done**

$$W = Fd = \Delta E$$

$F = W / d$ · $d = W / F$

- $W$ — work done (J)
- $F$ — force (N)
- $d$ — distance moved in the direction of the force (m)
- $\Delta E$ — energy transferred (J)

## 1.7.3 Energy resources

SUPP.

**Efficiency, by energy**

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

- energy — both terms in the same unit (J)

*Multiply by 100% for a percentage. Core needs the idea of efficiency qualitatively; the equation is Supplement.*

SUPP.

**Efficiency, by power**

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

- power — both terms in the same unit (W)

*Multiply by 100% for a percentage.*

## 1.7.4 Power

CORE

**Power from work done**

$$P = W / t$$

$W = Pt$ · $t = W / P$

- $P$ — power (W, kW, MW)
- $W$ — work done (J)
- $t$ — time taken (s)

CORE

**Power from energy transferred**

$$P = \Delta E / t$$

- $P$ — power (W)
- $\Delta E$ — energy transferred (J)
- $t$ — time taken (s)

## 1.8 Pressure

CORE

**Pressure**

$$p = F / A$$

$F = pA$ · $A = F / p$

- $p$ — pressure ($N/m^2$, Pa)
- $F$ — force normal to the surface (N)
- $A$ — area ($m^2$, $cm^2$)

SUPP.

**Change in pressure beneath a liquid surface**

$$\Delta p = \rho g \Delta h$$

- $\Delta p$ — change in pressure (Pa)
- $\rho$ — density of the liquid ($kg/m^3$)
- $g$ — gravitational field strength (N/kg)
- $\Delta h$ — change in depth (m)

## 2 Thermal physics

## 2.1.3 Gases and the absolute scale of temperature

CORE

**Kelvin and Celsius**

$$T \text{ (in K)} = \theta \text{ (in °C)} + 273$$

$\theta$ (in °C) = $T$ (in K) − 273

- $T$ — absolute temperature (K)
- $\theta$ — temperature (°C)

*−273 °C is absolute zero, where particles have least kinetic energy.*

SUPP.

**Pressure and volume of a fixed mass of gas**

$$pV = \text{constant}$$

$p_1V_1 = p_2V_2$

- $p$ — pressure (Pa)
- $V$ — volume ($m^3$)

*For a fixed mass of gas at constant temperature. You may also be asked to represent this graphically.*

## 2.2.2 Specific heat capacity

SUPP.

**Specific heat capacity**

$$c = \Delta E / (m\Delta\theta)$$

$\Delta E = mc\Delta\theta$ · $\Delta\theta = \Delta E / (mc)$

- $c$ — specific heat capacity (J/(kg °C), J/(g °C))
- $\Delta E$ — energy supplied (J)
- $m$ — mass (kg, g)
- $\Delta\theta$ — temperature rise (°C)

## 2.2.3 Melting, boiling and evaporation

*No equations. 0625 does not examine specific latent heat — melting, boiling and evaporation are described in terms of energy and particles.*

## 2.3 Transfer of thermal energy

*No equations. Conduction, convection and radiation are examined qualitatively and through experiment.*

# 3 Waves

## 3.1 General properties of waves

CORE

**Wave speed**

$$v = f\lambda$$

$f = v / \lambda$ · $\lambda = v / f$

- $v$ — wave speed (m/s)
- $f$ — frequency (Hz, kHz)
- $\lambda$ — wavelength (m, cm)

## 3.2.1 Reflection of light

CORE

**Law of reflection**

$$\text{angle of incidence} = \text{angle of reflection}$$

- $i$ — angle of incidence, from the normal (degree (°))
- $r$ — angle of reflection, from the normal (degree (°))

## 3.2.2 Refraction of light

SUPP.

**Refractive index from angles**

$$n = \sin i / \sin r$$

$\sin r = \sin i / n$

- n — refractive index
- i — angle of incidence (degree (°))
- r — angle of refraction (degree (°))

SUPP.

**Refractive index from the critical angle**

$$n = 1 / \sin c$$

$\sin c = 1 / n$

- n — refractive index
- c — critical angle (degree (°))

SUPP.

**Refractive index as a ratio of speeds**

$$n = \text{speed in region 1} / \text{speed in region 2}$$

- n — refractive index

*The syllabus defines refractive index as the ratio of the speeds of a wave in two different regions.*

## 3.2.3 Thin lenses

*No equations. 0625 examines lenses through ray diagrams and image characteristics — the lens equation is not required.*

## 3.3 Electromagnetic spectrum

SUPP.

**Speed of electromagnetic waves**

$$c = 3.0 \times 10^8 \text{ m/s}$$

- c — speed in a vacuum (m/s)

*Approximately the same in air. All electromagnetic waves travel at this speed in a vacuum, which Core candidates must know qualitatively.*

## 3.4 Sound

CORE
DERIVED

**Speed of sound by an echo**

$$v = 2d / t$$

- v — speed of sound (m/s)
- d — distance to the reflecting surface (m)
- t — time for the echo to return (s)

*Not printed in the syllabus: it is v = s/t with the pulse counted there and back. The syllabus asks for a method involving a measurement of distance and time.*

SUPP.
DERIVED

**Depth or distance from an ultrasound pulse**

$$d = vt / 2$$

- d — depth or distance (m)
- v — wave speed in the medium (m/s)
- t — time for the pulse to return (s)

*Not printed in the syllabus: it is v = s/t with the pulse counted there and back. The syllabus requires depth or distance to be calculated from time and wave speed for sonar, medical scanning and non-destructive testing.*

# 4 Electricity and magnetism

## 4.1 Simple phenomena of magnetism

*No equations. Magnetism at 0625 is field patterns, induced magnetism and the properties of magnetic materials.*

## 4.2.2 Electric current

SUPP.

### Electric current

$$I = Q / t$$

$Q = It$ · $t = Q / I$

- $I$ — current (A, mA)
- $Q$ — charge (C)
- $t$ — time (s)

*Conventional current is from positive to negative; free electrons flow from negative to positive.*

## 4.2.3 Electromotive force and potential difference

SUPP.

### Electromotive force

$$E = W / Q$$

- $E$ — e.m.f. (V)
- $W$ — electrical work done by the source (J)
- $Q$ — charge moved around the complete circuit (C)

SUPP.

### Potential difference

$$V = W / Q$$

$W = QV$

- $V$ — potential difference (V, mV, kV)
- $W$ — work done by the charge in the component (J)
- $Q$ — charge passing through (C)

## 4.2.4 Resistance

CORE

### Resistance

$$R = V / I$$

$V = IR$ · $I = V / R$

- $R$ — resistance (Ω)
- $V$ — potential difference (V)
- $I$ — current (A)

SUPP.

### Resistance of a metallic conductor

$$R \propto l \cdot R \propto 1 / A$$

- $l$ — length of the wire (m)
- $A$ — cross-sectional area ($m^2$)

*A proportionality, not a formula: 0625 does not use resistivity. Core candidates state the relationship qualitatively.*

## 4.2.5 Electrical energy and electrical power

CORE

### Electrical power

$$P = IV$$

$I = P / V$ · $V = P / I$

- $P$ — power (W, kW)
- $I$ — current (A)
- $V$ — potential difference (V)

CORE **Electrical energy**

$$E = IVt$$

E — energy transferred (J, kWh)
I — current (A)
V — potential difference (V)
t — time (s)

*The syllabus also expects the kilowatt-hour to be defined and used to calculate the cost of running an appliance.*

## 4.3.2 Series and parallel circuits

CORE **Resistors in series**

$$R = R_1 + R_2 + \dots$$

R — combined resistance (Ω)

CORE **Cells in series**

$$\text{combined e.m.f.} = E_1 + E_2 + \dots$$

E — e.m.f. of each source (V)

CORE **Current in a series circuit**

**current is the same at every point**

I — current (A)

SUPP. **Resistors in parallel**

$$1 / R = 1 / R_1 + 1 / R_2$$

R — combined resistance (Ω)

*Two resistors. The combined resistance is always less than either resistor alone — which Core candidates state without calculating.*

SUPP. **Currents at a junction**

**sum of currents in = sum of currents out**

I — current in each branch (A)

SUPP. **Potential differences in a series circuit**

$$\text{total p.d.} = V_1 + V_2 + \dots$$

V — p.d. across each component (V)

*Across parallel branches the p.d. is the same as across any one branch.*

## 4.3.3 Action and use of circuit components

SUPP. **Two resistors as a potential divider**

$$R_1 / R_2 = V_1 / V_2$$

$R_1$, $R_2$ — the two resistances (Ω)
$V_1$, $V_2$ — the p.d. across each (V)

## 4.4 Electrical safety

*No new equations. Fuse ratings and trip settings are chosen using P = IV from 4.2.5.*

## 4.5.6 The transformer

CORE

**Transformer turns and voltage**

$$V_p / V_s = N_p / N_s$$

$V_p$, $V_s$ — primary and secondary p.d. (V)
$N_p$, $N_s$ — turns on primary and secondary coils

SUPP.

**Transformer at 100% efficiency**

$$I_p V_p = I_s V_s$$

$I_p$, $I_s$ — primary and secondary current (A)
$V_p$, $V_s$ — primary and secondary p.d. (V)

SUPP.

**Power loss in transmission cables**

$$P = I^2 R$$

P — power dissipated in the cable (W)
I — current (A)
R — resistance of the cable (Ω)

*Used to explain why losses are smaller when transmission voltage is greater.*

## 5 Nuclear physics

### 5.1.2 The nucleus

CORE

**Nuclide notation**

$$^{A}_{Z}X$$

A — nucleon number (mass number)
Z — proton number (atomic number)
X — chemical symbol of the element

CORE

**Number of neutrons**

$$\text{number of neutrons} = A - Z$$

A — nucleon number
Z — proton number

### 5.2.1 Detection of radioactivity

SUPP.

**Corrected count rate**

$$\text{corrected count rate} = \text{measured count rate} - \text{background count rate}$$

count rate — counts per second or per minute (counts/s, counts/min)

### 5.2.3 Radioactive decay

SUPP.

**Alpha decay**

A decreases by 4 · Z decreases by 2

α — an alpha particle is a helium nucleus, $^{4}_{2}He$

*Written as a decay equation in nuclide notation.*

SUPP.

**Beta decay**

A unchanged · Z increases by 1

β — a beta particle is an electron, $^{0}_{-1}e$

*In the nucleus: neutron → proton + electron. $\beta^+$ is not included; β means $\beta^-$.*

SUPP.

**Gamma emission**

A unchanged · Z unchanged

γ — electromagnetic radiation from the nucleus

## 5.2.4 Half-life

CORE

**Half-life**

$$\text{half-life} = \text{time for half the nuclei of an isotope to decay}$$

$t_{1/2}$ — half-life (s, min, h, days, weeks, years)

*Calculations at Core will not include background radiation; Supplement calculates half-life from decay curves that still contain it.*

CORE
DERIVED

**Fraction remaining after n half-lives**

$$\text{fraction remaining} = (\tfrac{1}{2})^n$$

$n$ — number of half-lives elapsed

*Not printed in the syllabus: it is the definition of half-life applied repeatedly, and it is how most half-life questions are answered.*

# 6 Space physics

## 6.1.1 The Earth

SUPP.

**Average orbital speed**

$$v = 2\pi r / T$$

$v$ — average orbital speed (m/s)
$r$ — average radius of the orbit (m)
$T$ — orbital period (s)

## 6.1.2 The Solar System

CORE
DERIVED

**Travel time of light**

$$t = d / c$$

$t$ — time taken (s)
$d$ — distance (m)
$c$ — speed of light (m/s)

*Not printed in the syllabus: it is $v = s/t$. The syllabus asks you to calculate the time light takes to cross Solar System distances.*

## 6.2.2 Stars

SUPP.

**Light-year**

$$1 \text{ light-year} = 9.5 \times 10^{15} \text{ m}$$

ly — distance light travels in one year in a vacuum (m)

*Core candidates define the light-year without being given the value.*

## 6.2.3 The Universe

SUPP.

**Hubble constant**

$$H_0 = v / d$$

$v = H_0 d$ · $d = v / H_0$

$H_0$ — Hubble constant ($s^{-1}$)
$v$ — speed the galaxy is receding at (m/s)
$d$ — distance of the galaxy from Earth (m)

SUPP. **Estimated age of the Universe**

$$d / v = 1 / H_0$$

$1 / H_0$ — an estimate of the age of the Universe (s)

*Evidence for all the matter in the Universe having once been at a single point.*

## M Maths you must recall

CORE **Circumference of a circle**

$$C = 2\pi r = \pi d$$

C — circumference (m, cm)
r — radius (m, cm)
d — diameter (m, cm)

CORE **Area of a rectangle**

$$A = l \times w$$

A — area ($m^2$, $cm^2$)
l, w — length and width (m, cm)

CORE **Area of a triangle**

$$A = \frac{1}{2} \times b \times h$$

A — area ($m^2$, $cm^2$)
b — base (m, cm)
h — perpendicular height (m, cm)

*This is what the area under a speed–time graph usually comes down to.*

CORE **Area of a circle**

$$A = \pi r^2$$

A — area ($m^2$, $cm^2$)
r — radius (m, cm)

CORE **Volume of a rectangular block**

$$V = l \times w \times h$$

V — volume ($m^3$, $cm^3$)
l, w, h — length, width and height (m, cm)

CORE **Volume of a cylinder**

$$V = \pi r^2 h$$

V — volume ($m^3$, $cm^3$)
r — radius (m, cm)
h — height (m, cm)

CORE **Pythagoras' theorem**

$$c^2 = a^2 + b^2$$

c — hypotenuse of a right-angled triangle
a, b — the other two sides

*How a resultant of two perpendicular vectors is calculated. The sine, cosine and tangent functions are Extended candidates only.*

## – Values to know

| | | |
|---|---|---|
| CORE | Acceleration of free fall near the Earth's surface, g | $\approx 9.8$ m/$s^2$ |
| CORE | Absolute zero | −273 °C = 0 K |
| SUPP. | Speed of electromagnetic waves in a vacuum, c | $3.0 \times 10^8$ m/s |
| CORE | Speed of sound in air | ≈ 330–350 m/s |

| | | |
|---|---|---|
| CORE | Range of human hearing | **20 Hz to 20 000 Hz** |
| CORE | Relative charges of proton, neutron, electron | **+1 · 0 · −1** |
| SUPP. | One light-year | **$9.5 \times 10^{15}$ m** |
| CORE | Diameter of the Milky Way | **≈ 100 000 light-years** |
| SUPP. | Current estimate of the Hubble constant, $H_0$ | **$2.2 \times 10^{-18}\ s^{-1}$** |