# O Level Physics Formula Sheet

## Measurements

<table>
<thead>
<tr>
<th>Base SI Units</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg, m, s, A, K, mol</td>
<td>Mass SI Unit is Kilogram (kg). Length SI unit is metre (m). Time SI Unit is second (s). Current SI unit is Ampere (A). Temperature SI unit is Kelvin (K). Amount of substance is molar (mol).</td>
</tr>
</tbody>
</table>

## Number Prefixes

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>nano (n)</td>
<td>µ (µ)</td>
<td>m (m)</td>
</tr>
</tbody>
</table>

| nano (n) | micro (µ) | milli (m) | centi (c) | deci (d) | kilo (K) | mega (M) |

## Equations in Motion

### Newton's Laws of Motion

<table>
<thead>
<tr>
<th>Newton’s First Law</th>
<th>[ \sum F = 0 ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newton’s Second Law</td>
<td>[ F = ma ]</td>
</tr>
</tbody>
</table>

### Equations

#### Average Speed

\[ s = \Delta d / \Delta t \]

\[ s = \text{distance}, \quad \Delta t = \text{time} \]

#### Average Velocity

\[ v = \Delta x / \Delta t \]

\[ v = \text{slope of distance-time graph} \]

\[ x = \text{displacement}, \quad t = \text{time} \]

#### Acceleration

\[ A = \Delta v / \Delta t \]

\[ v = u + at \]

\[ x = ut + \frac{1}{2} at^2 \]

\[ v = \sqrt{u^2 + 2ax} \]

### Newton’s Third Law

For every force object A acts on object B, object B will exert an equal and opposite force on object A.

## Forces and Torque

### Reaction Forces

Acting in opposite direction. For example, the ground will give a reaction force that is equivalent to the man’s weight.

### Force Resolution on Inclined Plane

\[ F_{\text{horizontal}} = F \cos \theta \]

\[ F_{\text{vertical}} = F \sin \theta \]

\[ \theta \] is the angle between the horizontal surface and the inclined plane.

### Moment of Force

\[ m = F d \]

\[ m = \text{the product of force } F \text{ and perpendicular distance from the pivot } d. \]

### Rotational Balance

Anticlockwise Moment = Clockwise Moment

### Mass, Weight, Density and Pressure

#### Weight

\[ w = mg \]

\[ w = \text{weight of object} \]

#### Density

\[ d = \frac{m}{V} \]

\[ d = \text{density given by the ratio of mass } m \text{ over volume } V. \]

#### Pressure

\[ P = \frac{F}{A} \]

\[ P = \text{pressure } \]

#### Pressure of liquid column

\[ P = \rho gh \]

\[ P = \text{density } \rho \text{ of liquid, height of column } h \text{ and gravitational field strength } g. \]

## Work and Energy

### Work Done

\[ W = Fd \]

\[ W = \text{force } F \text{ of distance } d. \]

### Power

\[ P = \frac{W}{t} = Fv \]

\[ t = \text{time}. \]

### Kinetic Energy

\[ E_k = \frac{1}{2} m v^2 \]

\[ E_k = \text{mass } m \text{ of velocity } v. \]

## Gravitational Energy

\[ E_g = mgh \]

\[ g = \text{gravity}=9.81 \text{ m/s}^2 \]

\[ h = \text{height} \]

### Conservation of Energy

\[ E_1 = E_2 \]

### Thermal Energy

#### Thermal Energy & Specific Heat Capacity

\[ E = m s \Delta T \]

#### Thermal Energy & Latent Heat

For melting, \[ E = m L_{\text{fusion}} \]

For boiling, \[ E = m L_{\text{vaporization}} \]

### Waves

#### Wave Velocity

\[ v = f \lambda \]

The velocity of a wave \( v \) is the product of its frequency \( f \) and wavelength \( \lambda \).

### Period

\[ \tau = \frac{1}{f} \]

Period \( \tau \) is the inverse of frequency \( f \).
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Light and Optics

Law of Reflection
\[ \theta_1 = \theta_2 \]
The angle of incident \( \theta_1 \) is equal to the angle of reflection \( \theta_2 \). Both are with respect to the perpendicular normal of the surface of the mirror.

Snell’s Law (refraction)
\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
The angle of incident \( \theta_1 \) and angle of refraction \( \theta_2 \) is with respect to the perpendicular normal of the surface between the two medium.

Critical Angle
\[ \sin \theta_c = \frac{n_2}{n_1} \]
The critical angle \( \theta_c \) is the angle of incidence beyond which total internal reflection occurs. The index of refraction for the medium in which the incident ray is traveling is \( n_1 \), the index of refraction for the second medium which the refracted ray is traveling is \( n_2 \).

Index of Refraction
\[ n = \frac{c}{v} \]
The higher the index of refraction is for a medium, the slower is the speed of light \( v \) in the medium. \( c \) is the speed of light in vacuum.

The Lens Equation
\[ \frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f} \]
The focal length of the lens \( f \) is:
- Positive for a converging lens
- Negative for a divergent lens
The object distance \( d_o \) is:
- Positive if it is on the side of the lens from which the light is coming
- Negative if on the opposite side
The image distance \( d_i \) is:
- Positive if it is on the opposite side of the lens from which the light is coming
- Negative if on the same side

Magnification
\[ m = \frac{h_i}{h_o} = \frac{d_i}{d_o} \]
For an upright image, the magnification \( m \) is positive and for an inverted image \( m \) is negative.

Focal Length of a mirror
\[ f = \frac{1}{2} r \]
For a spherical mirror, the focal length is half of the radius of curvature.

Electronic Circuits

Current
\[ I = \frac{\Delta C}{\Delta t} \]
\( C = \)Charge \( t = \)time

Ohm’s Law
\[ R = \frac{V}{I} \]
\( V = \)voltage, \( R = \)resistance, \( I = \)current

Resistance of a wire
\[ R = \rho \frac{L}{A} \]
\( \rho = \)resistivity \( L = \)length of wire \( A = \)cross sectional area

Electric Power
\[ P = VI \]
Combining ohm’s law the power \( P \) can be calculated using any combination of these three equation variations.

Electrical Energy
\[ E = Pt = VIt \]
Electrical energy can be calculated by the product of power and time.

Root Mean Square Voltage & Current & Power
\[ V_{rms} = \sqrt{\frac{V^2}{2}} \]
\[ I_{rms} = \sqrt{\frac{I^2}{2}} \]
\[ P_{rms} = \frac{1}{2} P \]
For an AC circuit, the root-mean-square (rms) values can be calculated from the peak values. \( P_{rms} = 0.5 P_{max} \)

Resistance in Series
\[ R_{total} = R_1 + R_2 + R_3 \]
Resistance in series adds up. Having more obstacles along the path for current means more resistance.

Resistance in Parallel
\[ \frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \]
Resistance in parallel takes the reciprocal. Parallel path for current to go through means lesser resistance.

Kirchhoff’s First Law
\[ \sum \text{in} = \sum \text{out} \]
Sum of all incoming currents at a junction is the same as sum of all the outgoing current at a junction.

Kirchhoff’s Second Law
Sum of all potential difference \( V \) in components of a circuit is equal to the electromotive force EMF.

Transformer
\[ \frac{V_p}{V_s} = \frac{n_p}{n_s} \]
The ratio of the voltage \( V_p \) and \( V_s \) in a transformer is proportional to the ratio of the number of coils \( n_p \) and \( n_s \).

Fleming’s Left Hand Rule (Motor Rule)
Thumb is for the motion. Index finger is for the magnetic field. Second finger is for the current.

Fleming’s Right Hand Rule (Generator)
Thumb is for the motion. Index finger is for the magnetic field. Second finger is for the current.

Electromagnetism

Focal Length of a mirror
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\[ \sum V = EMF \]
supplied by the power supply.

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Right Hand Grip Rule
I is the current. B is the magnetic field.

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