Symbols, units and equations

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## SCIENTIFIC NOTATION

Scientific notation allows us to easily represent very big or very small numbers.

Some examples:

The speed of light is approximately three hundred million metres per second.

We write this number mathematically as follows:

300 000 000 m s-1 or, using scientific notation, 3 × 108 m s-1

It takes approximately 200 000 (2 × 105) Joules of heat to boil a kettle and 50 000 000 (5 × 107) Joules to heat a bath of water.

We can also use prefixes as shorthand for some scientific notation:

|  |  |  |
| --- | --- | --- |
| Prefix | Symbol | Factor |
| milli- | m | × 10-3 |
| micro- | μ | × 10-6 |
| nano- | n | × 10-9 |
| pico- | p | × 10-12 |
|  |  |  |
|  |  |  |
| kilo- | k | × 103 |
| mega- | M | × 106 |
| giga- | G | × 109 |
| tera- | T | × 1012 |
|  |  |  |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 1 thousandth | .001 | 1 × 10-3 |
| 1 millionth  | .000 001 | 1 × 10-6 |
| 1 billionth  | .000 000 001 | 1 × 10-9 |
|  |  |  |
|  |  |  |
| 1 thousand | 1000 | 1 × 103 |
| 1 million | 1000 000 | 1 × 106 |
| 1 billion | 1000 000 000 | 1 × 109 |
|  |  |  |

For example 1 million joules = 1 × 106 J = 1 megajoule = 1 MJ

.0052 metres = 5.2 × 10-3 m = 5.2 millimetres = 5.2 mm

See also the log tables on page 45

**Try to identify the name or the term using the clues below**

|  |  |
| --- | --- |
|  | 1 x 1012 firmas |
|  | 2 x 1012 bulls |
|  | 1 x 109 lows |
|  | 2 x 106 phones  |
|  | 1 x 103 manjaros |
|  | 1 x 103 whales  |
|  | 2 x 103  mockingbirds |
|  | 1 x 10 -3 pedes |
|  | 1 x 10-3 nnium |
|  | 1 x 10-3 taries |
|  | 2 x 10-6 scopes  |
|  | 3 x 10-6 phones |
|  | 1 x 10-12 boos  |

Answers

1. 1 terra firma
2. 1 terabull
3. 1 gigalow
4. 2 megaphones
5. 1 kilomanjaro
6. 1 kilowhale
7. 2 kilomockingbird
8. 1 millipede
9. 1 millennium (so 1 nnium = 106 years)
10. 1 military
11. 2 microscopes
12. 3 microphones
13. 1 picaboo

*Question: What is the unit for the level of beauty required to launch a single ship?*

*Answer: The milliHelen*



## SYMBOLS UNITS AND EQUATIONS

*‘Maths is what you have left when you start with something interesting and take away the units.’*

**Be familiar with the log tables**

The **Prefixes**used in SI units are on page 45.

The **Fundamental Physical constants** are given on pages 46 - 47.

For Physics use the **Periodic Table** on page 79 and the first table on page 82.

**Well I still get full marks for a maths question if I don’t write down the formula?**

Yes, students will be awarded full marks for formula and for substitution if they only present the correctly substituted formula.

However there is a much greater risk of making an error in substitution if the student hasn't the original formula written down and that results in zero marks.

This error is quite common.

Best practise: write down the formula!!

**Note:**

All ***units*** are spelled out using lower case, e.g. newtons, joules, volts, kilogram.

*S****ymbols of units***that derive from *the name of a physicist* are all uppercase e.g. J, V etc. while symbols for all other units remain lowercase, e.g. the symbol for the kilogram is kg.

http://physics.nist.gov/cuu/Units/checklist.html

http://physics.nist.gov/cuu/pdf/typefaces.pdf

**(If typing these at any stage, note that both variables and constants should be italicised:**

***v* = *u* + *at* rather than v = u + at.)**

**Check that you know these by covering over all but the first column.**

Let me know if I’ve missed any.

### Mechanics

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Quantity** |  | **Symbol** |  | **Unit** |  | **Symbol** |  | **Equation** |
|  |  |  |  |  |  |  |  |  |
| Area |  | *a* |  | metres squared |  | m2 |  |  |
|  |  |  |  |  |  |  |  |  |
| Volume |  | *v* |  | metres cubed |  | m3 |  |  |
|  |  |  |  |  |  |  |  |  |
| Mass |  | *m* |  | kilogram |  | kg |  |  |
|  |  |  |  |  |  |  |  |  |
| Density |  | *ρ* |  | kilogram per metre cubed |  | kg m-3 |  | **ρ = m/v** |
|  |  |  |  |  |  |  |  |  |
| Displacement |  | *s* |  | metre |  | m |  |  |
|  |  |  |  |  |  |  |  |  |
| Velocity |  | *v* |  | metre per second |  | m s-1 |  | **v = d/t** |
|  |  |  |  |  |  |  |  |  |
| Acceleration |  | *a* |  | metre per second squared |  | m s-2 |  |  |
|  |  |  |  |  |  |  |  |  |
| Force |  | *F* |  | newton |  | N |  | **F = ma** |
|  |  |  |  |  |  |  |  |  |
| Momentum |  | *ρ* |  |  |  | kg m s-1 |  | **ρ = mv** |
|  |  |  |  |  |  |  |  |  |
| Pressure |  | *p* |  | pascal |  | Pa |  | **p = F/a** |
|  |  |  |  |  |  |  |  |  |
| Moment of a force |  |  |  | newton metre |  | N m |  |  |
|  |  |  |  |  |  |  |  |  |
| Torque (couple) |  | *T* |  | newton metre |  | N m |  | **T = F x d** |
|  |  |  |  |  |  |  |  |  |
| Energy |  | *E / Q / W* |  | joule |  | J |  |  |
|  |  |  |  |  |  |  |  |  |
| Work |  | *w* |  | joule |  | J |  | **W = F s** |
|  |  |  |  |  |  |  |  |  |
| Power |  | *p* |  | watt |  | W |  | **P = W/t** |
|  |  |  |  |  |  |  |  |  |
| Angle |  | θ (“theta”) |  | radian |  | rad |  |  |
|  |  |  |  |  |  |  |  |  |
| Angular velocity |  | ω (“omega”) |  | radian per second |  | rad/sec |  | **ω = θ/t** |

### Heat and Temperature

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Quantity** |  | **Symbol** |  | **Unit** |  | **Symbol** |  | **Equation** |
|  |  |  |  |  |  |  |  |  |
| Heat Capacity |  | C |  | joule per kelvin |  | J/K |  | **Q = c (△θ)** |
|  |  |  |  |  |  |  |  |  |
| Specific Heat Capacity |  | c |  |  |  | J/kg/K |  | **Q = mc△θ** |
|  |  |  |  |  |  |  |  |  |
| Latent Heat |  | l |  | joule per kilogram |  | J/kg |  | **Q = ml** |

### Waves, Sound and Light

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Quantity** |  | **Symbol** |  | **Unit** |  | **Symbol** |  | **Equation** |
|  |  |  |  |  |  |  |  |  |
| Frequency |  | f |  | hertz |  | Hz |  |  |
|  |  |  |  |  |  |  |  |  |
| Wavelength |  | λ (“lamda”) |  | metres |  | m |  |  |
|  |  |  |  |  |  |  |  |  |
| Velocity |  | v (or c for light) |  | metre per second |  | m/s |  | **v = f λ** |
|  |  |  |  |  |  |  |  |  |
| Intensity |  | I |  | watts per metre squared |  | W/m2 |  | **S.I. = P/A** |
|  |  |  |  |  |  |  |  |  |
| Sound Intensity Level |  |  |  | decibels |  | dB |  |  |

### Electricity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Quantity** |  | **Symbol** |  | **Unit** |  | **Symbol** |  | **Equation** |
|  |  |  |  |  |  |  |  |  |
| Charge |  | Q |  | coulomb |  | C |  |  |
|  |  |  |  |  |  |  |  |  |
| Electric Field Strength |  | E |  | newtons per coulomb |  | N/C |  | **E = F/Q** |
|  |  |  |  |  |  |  |  |  |
| Potential Difference(“voltage”) |  | V |  | volts |  | V |  | **W = V Q** |
|  |  |  |  |  |  |  |  |  |
| Capacitance |  | C |  | farads |  | F |  | **C = Q/V** |
|  |  |  |  |  |  |  |  |  |
| Current |  | I |  | amperes (amps) |  | A |  | **I = Q/t** |
|  |  |  |  |  |  |  |  |  |
| Power |  | P |  | watt |  | W |  | **P = VI** |
|  |  |  |  |  |  |  |  |  |
| Resistance |  | R |  | ohm |  | Ω |  | R = V/I |
|  |  |  |  |  |  |  |  |  |
| Resistivity |  | ρ |  | ohm-metre |  | Ω m |  | **ρ = RA /l** |
|  |  |  |  |  |  |  |  |  |
| Magnetic Flux Density |  | B |  | tesla |  | T |  | **F = BIL** |
|  |  |  |  |  |  |  |  |  |
| Magnetic Flux |  | φ Psi (“sigh”) |  | weber |  | W |  | **φ = BA** |
|  |  |  |  |  |  |  |  |  |
| Half-Life |  | T1/2 |  | second |  |  |  | **T1/2 = 0.693/λ** |

## EQUATIONS

Many of the maths questions on the Leaving Cert Physics paper rely on you being able to quickly recall short equations.

And yes these are all in the log tables, but if you are looking for an *A* or *B* grade then you don’t have time to go searching.

The variables have deliberately not been arranged in the order in which they would appear in the formula (because that would just be too easy).

To test yourself, cover the third column and see if you can come up with the relevant equation given the information in the second column.

If you come across any equations which I have omitted, please let me know and I will update the list.

Hangman takes on a new dimension if you can include equations by allowing spaces for division, power s (e.g. ^2) etc.

### Mechanics

|  |  |  |
| --- | --- | --- |
|  | **Variables** | **Equation** |
|  |  |  |
| **Equations of Motion** |  | v = u + ats = ut + ½ at2v2 = u2 + 2as |
|  |  |  |
| **Force, Mass and Momentum** | acceleration, force, mass | F = ma |
|  |  |  |
|  | weight , mass | W = mg |
|  |  |  |
|  | velocity, mass, momentum | ρ = mv |
|  |  |  |
| **Conservation of Momentum** |  | m1 u1 + m2 u2 = m1 v3 + m2 v4 |
|  |  |  |
| **Pressure** | area, pressure, force | P = F/A |
|  |  |  |
|  | density, height, pressure | P = ρgh |
|  |  |  |
| **Boyle’s Law** |  | P1V1= P2V2 |
|  |  |  |
| **Newton’s Law of Gravitation** | gravitational force between two masses |  |
| ***g* at different heights** | acceleration due to gravity and distance above a planet | g = GM/ d2 |
|  |  |  |
| **Moment of a force** | distance, moment, force | Moment = Force x distance |
|  |  |  |
| **Torque** | force, distance, torque | T = F x d (between forces) |
|  |  |  |
| **Work, Energy** | force, work, displacement | W = F s |
|  |  |  |
| **Kinetic Energy** | velocity, mass energy | Ek = ½ mv2 |
|  |  |  |
| **Potential Energy** | height, mass, energy | Ep = mgh |
|  |  |  |
|  |  |  |
| **Conservation of Energy** |  | mgh = ½ mv2 |
|  |  |  |
| **Power** | time, power work | P = W/t |
|  |  |  |
|  |  |  |
| **Percentage Efficiency** |  | Power Out / Power In x 100/1 |
|  |  |  |
| **Circular Motion** | time, angular velocity, theta | ω = θ/t |
|  |  |  |
|  | linear velocity, angular velocity, radius | v = rω |
|  |  |  |
|  | acceleration,angular velocity, radius,  | a = rω2 |
|  |  |  |
|  | linear velocity, radius, acceleration | a = v2/r |
|  |  |  |
|  | force, angular velocity, radius, mass | F = mrω2 |
|  |  |  |
|  | mass, linear velocity, radius, force, | F = mv2/r |
|  |  |  |
|  | mass of planet, acceleration due to gravity, radius of satellite | g = GM/R2 |
|  |  |  |
|  | mass of a planet, radius,periodic tiime |  |
|  |  |  |
| **Hooke’s Law** | extension, restoring force | F = -k s |
|  |  |  |
| **S.H.M.** | acceleration and displacement | a = -ω2 s |
|  |  |  |
|  | periodic time and angular velocity | T = 2π/ω |
|  |  |  |
|  | frequency and periodic time | T = 1/f |
|  |  |  |
| **Simple Pendulum** |  | T = 2π √ l/g |

### Waves, Sound, Light

|  |  |  |
| --- | --- | --- |
| **Mirrors** | image distance, magnification, Object distance |  |
|  |  |  |
|  | image height, magnification, object height |  |
|  |  |  |
|  | image distance, magnification, object distance |  |
|  |  |  |
| **Refraction** |  |  |
|  |  |  |
|  | real and apparent depth |  |
|  |  |  |
|  | reversing direction and critical angle |  |
|  |  |  |
|  | refractive index and speeds |  |
|  |  |  |
|  | refractive index and critical angle |  |
| **Lenses** | image distance, mag, object distance |  |
|  |  |  |
|  | image height, mag, object height |  |
|  |  |  |
|  | image distance, magnification, object distance |  |
|  | power, focal length | $$P= \frac{1}{f}$$ |
|  |  |  |
|  | Addition of powers | PTotal = P1 + P2 |
|  |  |  |
| **Waves** | Wavelength, velocity, frequency | v = f λ |
|  |  |  |
| **Doppler Effect** |  |  |
|  |  |  |
|  | Area, Power, Solar Intensity | S.I. = Power / Area |
|  |  |  |
|  | Tension, Frequency, Length |  |
|  |  |  |
| **Wavelength of light** |  | nλ = d Sin θ |
|  |  |  |
| **Diffraction Grating Formula** | Distance between slits on a diffraction grating | d = 1/n |

### Electricity

|  |  |  |
| --- | --- | --- |
|  | **Variables** | **Equation** |
| **Static Electricity** | Coulomb’s Law | F =   |
|  |  |  |
|  | Relative Permittivity | ε = εr εo |
|  |  |  |
|  | Electric Field Intensity | E = F/Q |
|  |  |  |
|  | Electric Field Strength | E = F =  |
|  |  |  |
| **Potential Difference** | Charge, Voltage, Work | W = QV |
|  |  |  |
| **Capacitance** | Charge, Potential difference, Capacitance | C= Q/V |
|  |  |  |
|  | Area, Capacitance Distance | C = εA/d |
|  |  |  |
|  | Work/energy, Voltage Capacitance | W = ½ CV2 |
|  |  |  |
|  | Current, Charge, Time | I = Q/t Q = It |
|  |  |  |
|  | Power, Current, Voltage | P = VI |
|  |  |  |
| Ohm’s Law |  |  V = IR |
|  |  |  |
|  | Resistivity | R = ρl/A |
|  |  |  |
|  | Wheatstone Bridge |  |
|  |  |  |
|  | Current, TimeEnergy, Resistance, | Heat = I2Rt |
|  |  |  |
| Joule’s Law | Current, Power, Res | Power = I2R |
|  |  |  |
|  | Current, Length,Force, Mag field density | F = BIL |
|  |  |  |
|  | Force, Charge, velocity,Mag field density, | F = Bqv |
|  |  |  |
|  | Magnetic Flux Density,Area, Magnetic Flux | φ = *BA* |
|  |  |  |
|  | Induced emf | E = - N (dφ/dt) |
|  |  |  |
|  | Vrms, Maximum voltage | Vrms= Vmax/(√2) |
|  |  |  |
|  | Irms, Maximum current | Irms = Imax/(√2) |
|  |  |  |
| Transformer |  |  |

### Modern Physics

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Variables** | **Equation** | **Year** |
|  |  |  |  |
| Force on an electron |  | mv2/r = Bev |  |
|  |  |  |  |
|  | Potential energy andKinetic energy of electron | eV = ½ mv2 |  |
|  |  |  |  |
| Photoelectric Effect |  | hf = φ + ½mv2 |  |
|  |  |  |  |
|  | Frequency,Energy of a photon | E = hf |  |
|  |  |  |  |
|  | Wavelength,Energy of a photon | E = hc/λ |  |
|  |  |  |  |
|  | Decay rate,Decay constantNumber of atoms | dn/dt = λ N |  |
|  |  |  |  |
|  | Half life,Decay constant | T1/2 = 0.693/λ |  |
|  |  |  |  |
|  | Energy,Mass | E = mc2 |  |
|  |  |  |  |
|  |  |  +  →  + K.E. |  |
|  |  |  |  |
| Pair Production |  | γ rays → e- + e+ + K.E. |  |
|  |  |  |  |
| Particle Annihilation |  | e- + e+ → 2γ + K.E. |  |

## FORMULAE NOT IN TABLE BOOK OR ARE IN A NON-STANDARD FORM

### Mechanics

|  |  |  |
| --- | --- | --- |
| **Boyle’s Law** | Volume of gas and Pressure | pV= k OR p1V1= p2V2 |
| **Conservation of Energy** | Gravitational Potential Energy and Kinetic Energy |   |
| **Weight** | Given  |   |
| **Gravity & Circular Motion** | Velocity, radius of orbit and mass of central body |   |
| **Components of a Vector**  | Horizontal  and vertical  |

### Waves, Sound, Light

|  |  |  |
| --- | --- | --- |
| **Mirrors & Lenses** | Magnification, Image height, Object height(or size in any direction) |  |
| **Refraction** | Real and apparent depth |   |
|  | Reversing direction and refractive indices  |   |
| **Sound Intensity** | Sound Intensity, Area, Power |  Intensity, I = Power / Area |
| **Dedibels** | Decibels and sound intensity |  Double I = an increase of 3 dB |
| **Speed of sound** | Standing wave in tube closed at one end |   |
| **Grating Formula** | Distance between slits on a diffraction grating |  d = 1/n |

### Electricity

|  |  |  |
| --- | --- | --- |
| **Static Electricity** | Relative Permittivity |  ε = εr εo |
|  | Electric Field Strength (Due to *Q*) |  E =  |
| **Current/Charge** | Current, Charge, Time | Q = It OR I = Q/t  |
| **Joule’s Law** | Power, Current, Resistance |  () |
| **Magnetic Induction** | Induced E.M.F. in a coil with N turns |   |
| **Transformer** | Power in = Power out |  $V\_{in}I\_{in}=V\_{out}I\_{out}$ |

### Modern Physics

|  |  |  |
| --- | --- | --- |
| **Force on an electron** | Electron moving in a magnetic field moves in a circle |  |
| **Ek of an electron** | Kinetic energy of electron (*V* is voltage) |  |
| **Half life** | Half-life, Decay constant | T1/2 = 0.693/λ |
| **Walton** | Split nucleus and release energy |  +  →  + K.E. |
| **Pair Production** | Photon to particles (Note: *one* photon) | γ photon → e– + e+ + K.E. |
| **Particle Annihilation** | Particles to photons (Note: *two* photons) | e- + e+ → 2γ photons + K.E. |
|  |  |  |