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# Reference Tables for Physical Setting/PHYSICS

## 2002 Edition

## List of Physical Constants

| Name | Symbol | Value |
|---|---|---|
| Universal gravitational constant | $G$ | $6.67 \times 10^{-11}$ N•m$^2$/kg$^2$ |
| Acceleration due to gravity | $g$ | 9.81 m/s$^2$ |
| Speed of light in a vacuum | $c$ | $3.00 \times 10^8$ m/s |
| Speed of sound in air at STP | | $3.31 \times 10^2$ m/s |
| Mass of Earth | | $5.98 \times 10^{24}$ kg |
| Mass of the Moon | | $7.35 \times 10^{22}$ kg |
| Mean radius of Earth | | $6.37 \times 10^6$ m |
| Mean radius of the Moon | | $1.74 \times 10^6$ m |
| Mean distance—Earth to the Moon | | $3.84 \times 10^8$ m |
| Mean distance—Earth to the Sun | | $1.50 \times 10^{11}$ m |
| Electrostatic constant | $k$ | $8.99 \times 10^9$ N•m$^2$/C$^2$ |
| 1 elementary charge | $e$ | $1.60 \times 10^{-19}$ C |
| 1 coulomb (C) | | $6.25 \times 10^{18}$ elementary charges |
| 1 electronvolt (eV) | | $1.60 \times 10^{-19}$ J |
| Planck's constant | $h$ | $6.63 \times 10^{-34}$ J•s |
| 1 universal mass unit (u) | | $9.31 \times 10^2$ MeV |
| Rest mass of the electron | $m_e$ | $9.11 \times 10^{-31}$ kg |
| Rest mass of the proton | $m_p$ | $1.67 \times 10^{-27}$ kg |
| Rest mass of the neutron | $m_n$ | $1.67 \times 10^{-27}$ kg |

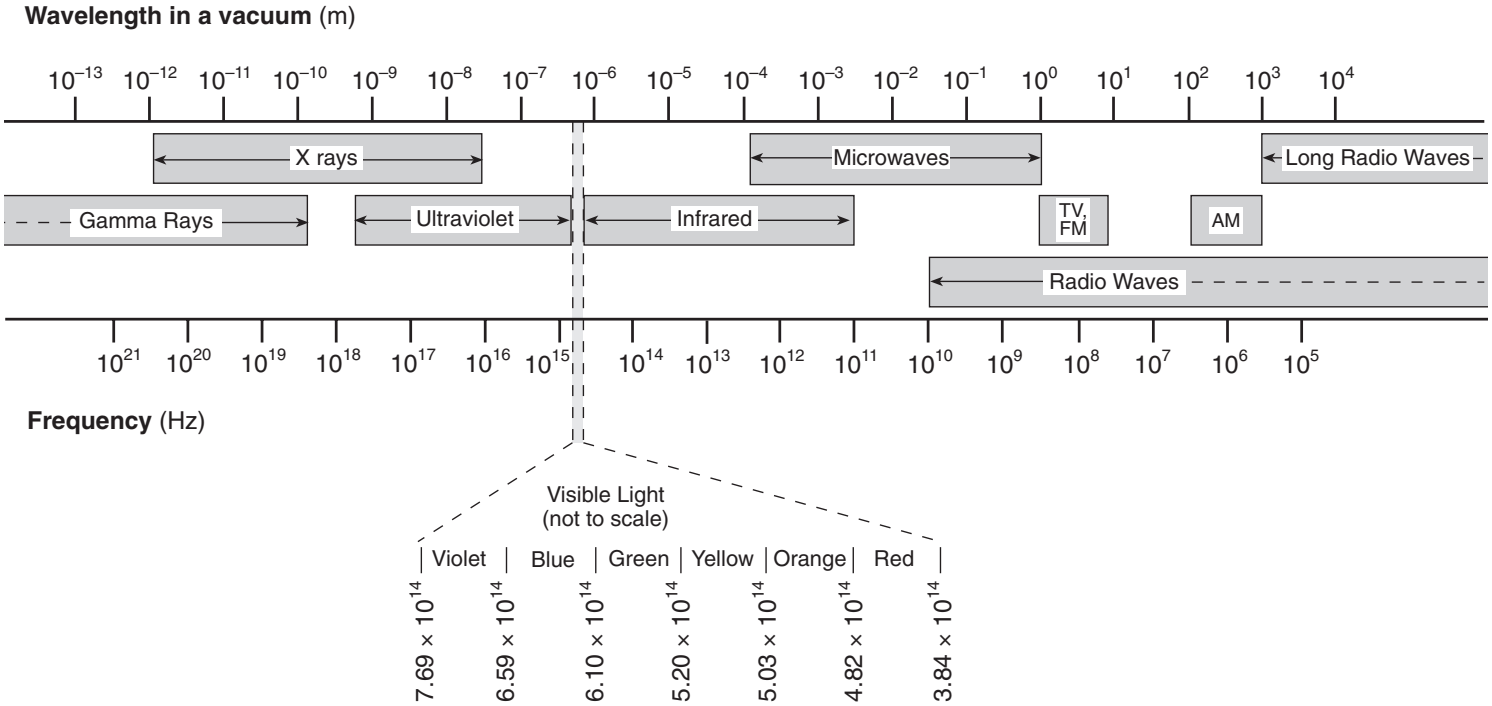
## Prefixes for Powers of 10

| Prefix | Symbol | Notation |
|---|---|---|
| tera | T | $10^{12}$ |
| giga | G | $10^9$ |
| mega | M | $10^6$ |
| kilo | k | $10^3$ |
| deci | d | $10^{-1}$ |
| centi | c | $10^{-2}$ |
| milli | m | $10^{-3}$ |
| micro | μ | $10^{-6}$ |
| nano | n | $10^{-9}$ |
| pico | p | $10^{-12}$ |

## Approximate Coefficients of Friction

| | Kinetic | Static |
|---|---|---|
| Rubber on concrete (dry) | 0.68 | 0.90 |
| Rubber on concrete (wet) | 0.58 | |
| Rubber on asphalt (dry) | 0.67 | 0.85 |
| Rubber on asphalt (wet) | 0.53 | |
| Rubber on ice | 0.15 | |
| Waxed ski on snow | 0.05 | 0.14 |
| Wood on wood | 0.30 | 0.42 |
| Steel on steel | 0.57 | 0.74 |
| Copper on steel | 0.36 | 0.53 |
| Teflon on Teflon | 0.04 | |

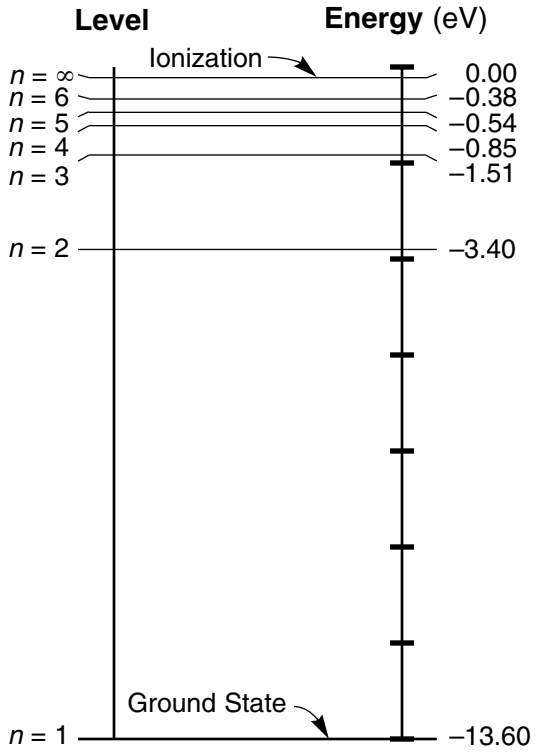
# The Electromagnetic Spectrum




| Absolute Indices of Refraction ($f = 5.09 \times 10^{14}$ Hz) | |
|---|---|
| Air | 1.00 |
| Corn oil | 1.47 |
| Diamond | 2.42 |
| Ethyl alcohol | 1.36 |
| Glass, crown | 1.52 |
| Glass, flint | 1.66 |
| Glycerol | 1.47 |
| Lucite | 1.50 |
| Quartz, fused | 1.46 |
| Sodium chloride | 1.54 |
| Water | 1.33 |
| Zircon | 1.92 |

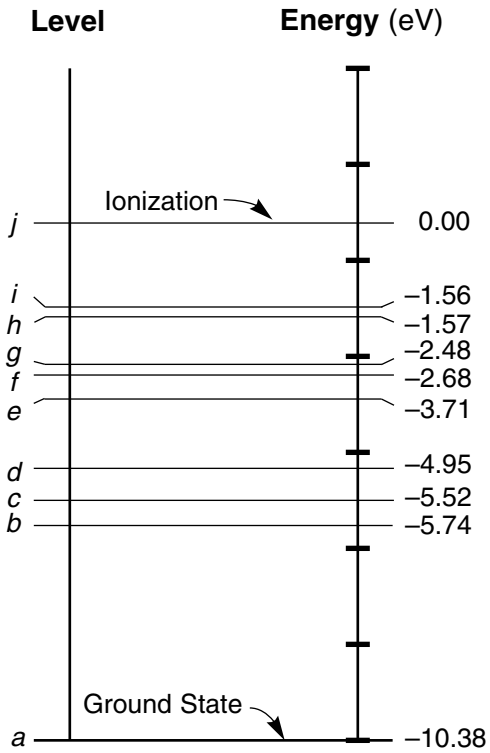
# Energy Level Diagrams

## Hydrogen




**Energy Levels for the Hydrogen Atom**

## Mercury




**A Few Energy Levels for the Mercury Atom**

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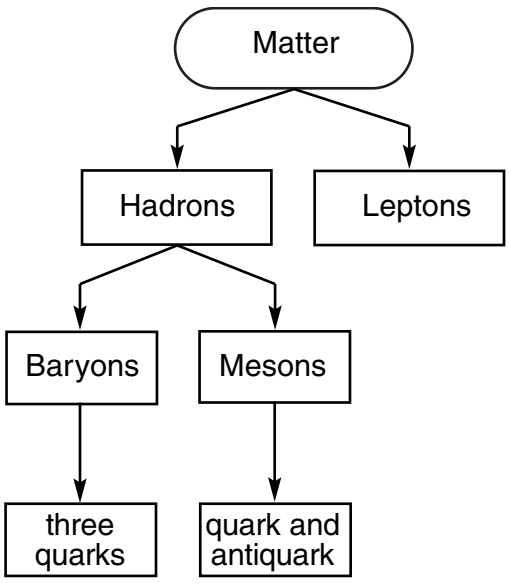
## Classification of Matter




## Particles of the Standard Model

### Quarks

| | | | |
|---|---|---|---|
| Name | up | charm | top |
| Symbol | $u$ | $c$ | $t$ |
| Charge | $+\frac{2}{3}$ e | $+\frac{2}{3}$ e | $+\frac{2}{3}$ e |
| | down | strange | bottom |
| | $d$ | $s$ | $b$ |
| | $-\frac{1}{3}$ e | $-\frac{1}{3}$ e | $-\frac{1}{3}$ e |

### Leptons

| | | |
|---|---|---|
| electron | muon | tau |
| e | μ | τ |
| –1e | –1e | –1e |
| electron neutrino | muon neutrino | tau neutrino |
| $\nu_e$ | $\nu_\mu$ | $\nu_\tau$ |
| 0 | 0 | 0 |

**Note:** For each particle, there is a corresponding antiparticle with a charge opposite that of its associated particle.

## Electricity

$$F_e = \frac{kq_1q_2}{r^2}$$

$$E = \frac{F_e}{q}$$

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

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

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

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

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

$$W = Pt = VIt = I^2Rt = \frac{V^2t}{R}$$

$A$ = cross-sectional area
$E$ = electric field strength
$F_e$ = electrostatic force
$I$ = current
$k$ = electrostatic constant
$L$ = length of conductor
$P$ = electrical power
$q$ = charge
$R$ = resistance
$R_{eq}$= equivalent resistance
$r$ = distance between centers
$t$ = time
$V$ = potential difference
$W$ = work (electrical energy)
$\Delta$ = change
$\rho$ = resistivity

### Series Circuits

$$I = I_1 = I_2 = I_3 = \ldots$$

$$V = V_1 + V_2 + V_3 + \ldots$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

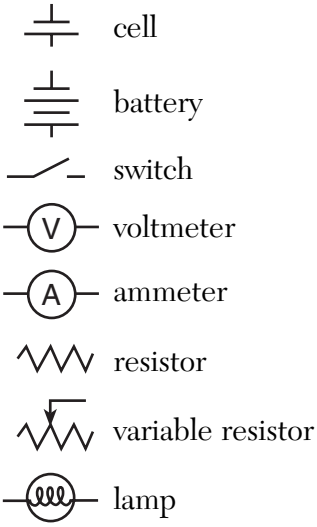
### Parallel Circuits

$$I = I_1 + I_2 + I_3 + \ldots$$

$$V = V_1 = V_2 = V_3 = \ldots$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

## Circuit Symbols




cell
battery
switch
voltmeter
ammeter
resistor
variable resistor
lamp

| Resistivities at 20°C | |
|---|---|
| **Material** | **Resistivity** ($\Omega$•m) |
| Aluminum | $2.82 \times 10^{-8}$ |
| Copper | $1.72 \times 10^{-8}$ |
| Gold | $2.44 \times 10^{-8}$ |
| Nichrome | $150. \times 10^{-8}$ |
| Silver | $1.59 \times 10^{-8}$ |
| Tungsten | $5.60 \times 10^{-8}$ |

## Waves and Optics

$v = f\lambda$

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

$\theta_i = \theta_r$

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

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

$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$c$ = speed of light in a vacuum
$f$ = frequency
$n$ = absolute index of refraction
$T$ = period
$v$ = velocity
$\lambda$ = wavelength
$\theta$ = angle
$\theta_i$ = angle of incidence
$\theta_r$ = angle of reflection

## Modern Physics

$E_{photon} = hf = \frac{hc}{\lambda}$

$E_{photon} = E_i - E_f$

$E = mc^2$

$c$ = speed of light in a vacuum
$E$ = energy
$f$ = frequency
$h$ = Planck's constant
$m$ = mass
$\lambda$ = wavelength

## Geometry and Trigonometry

**Rectangle**

$A = bh$

**Triangle**

$A = \frac{1}{2}bh$

**Circle**

$A = \pi r^2$
$C = 2\pi r$

**Right Triangle**

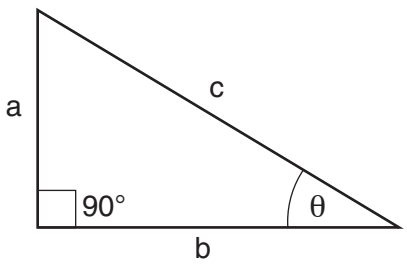
$c^2 = a^2 + b^2$

$\sin \theta = \frac{a}{c}$

$\cos \theta = \frac{b}{c}$

$\tan \theta = \frac{a}{b}$

$A$ = area
$b$ = base
$C$ = circumference
$h$ = height
$r$ = radius



## Mechanics

$$\bar{v} = \frac{d}{t}$$

$$a = \frac{\Delta v}{t}$$

$$v_f = v_i + at$$

$$d = v_i t + \tfrac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2ad$$

$$A_y = A \sin \theta$$

$$A_x = A \cos \theta$$

$$a = \frac{F_{net}}{m}$$

$$F_f = \mu F_N$$

$$F_g = \frac{G m_1 m_2}{r^2}$$

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

$$p = mv$$

$$p_{before} = p_{after}$$

$$J = Ft = \Delta p$$

$$F_s = kx$$

$$PE_s = \tfrac{1}{2} k x^2$$

$$F_c = m a_c$$

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

$$\Delta PE = mg\Delta h$$

$$KE = \tfrac{1}{2} m v^2$$

$$W = Fd = \Delta E_T$$

$$E_T = PE + KE + Q$$

$$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$$

$a$ = acceleration

$a_c$ = centripetal acceleration

$A$ = any vector quantity

$d$ = displacement/distance

$E_T$ = total energy

$F$ = force

$F_c$ = centripetal force

$F_f$ = force of friction

$F_g$ = weight/force due to gravity

$F_N$ = normal force

$F_{net}$ = net force

$F_s$ = force on a spring

$g$ = acceleration due to gravity or gravitational field strength

$G$ = universal gravitational constant

$h$ = height

$J$ = impulse

$k$ = spring constant

$KE$ = kinetic energy

$m$ = mass

$p$ = momentum

$P$ = power

$PE$ = potential energy

$PE_s$ = potential energy stored in a spring

$Q$ = internal energy

$r$ = radius/distance between centers

$t$ = time interval

$v$ = velocity/speed

$\bar{v}$ = average velocity/average speed

$W$ = work

$x$ = change in spring length from the equilibrium position

$\Delta$ = change

$\theta$ = angle

$\mu$ = coefficient of friction