Physics formula sheet

Mechanics

Equations of motion $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

$\vec{s} = \vec{v} \cdot t$ $\vec{v} = \vec{a} \cdot t$ $\vec{s} = \frac{1}{2} \cdot \vec{a} \cdot t^2$

Forces $\vec{F} = m \cdot \vec{a}$ $F_f = \mu \cdot F_n$ $\vec{F}_G = m \cdot \vec{g}$ $F_{spring} = k \cdot y$

Moment of force (Torque) $M = F \cdot r$

Air resistance $F_L = \frac{1}{2} \cdot c_W \cdot \rho_{Luft} \cdot A \cdot v^2$

Density $\rho = \frac{m}{V}$

Pressure, buoyancy $p = \frac{F_\perp}{A}$ $p = \rho_{liquid} \cdot g \cdot h$ $F_B = \rho_{liquid} \cdot g \cdot V_{immersed}$

Work $W = \vec{F} \cdot \vec{s}$

$W_{accelerating} = \frac{1}{2} \cdot m \cdot v^2$ $W_{lifting} = m \cdot g \cdot h$ $W_{extending\ a\ spring} = \frac{1}{2} \cdot k \cdot y^2$

Energy $E_k = \frac{1}{2} \cdot m \cdot v^2$ $E_{p(gravitational)} = m \cdot g \cdot h$ $E_{p(elastic)} = \frac{1}{2} \cdot k \cdot y^2$

Power, efficiency $P = \frac{W}{t}$ $\eta = \frac{E_{useful}}{E_{consumed}} = \frac{P_{useful}}{P_{consumed}}$

Uniform circular motion $f = \frac{1}{T}$ $\omega = \frac{\Delta \varphi}{\Delta t} = \frac{2\pi}{T} = 2\pi \cdot f$ $\left|\vec{v}\right| = \omega \cdot r = \frac{2\pi \cdot r}{T}$

$a_Z = \omega^2 \cdot r = \frac{v^2}{r}$ $F_Z = m \cdot \omega^2 \cdot r = \frac{m \cdot v^2}{r}$

Gravitation $F_G = G \cdot \frac{m_1 \cdot m_2}{r^2}$

Optics

Reflection $\Theta_{incidence} = \Theta_{reflection}$

Refraction $n_{medium} = \frac{c_{vacuum}}{c_{medium}}$ $n_1 \cdot \sin(\Theta_1) = n_2 \cdot \sin(\Theta_2)$ $c_2 \cdot \sin(\Theta_1) = c_1 \cdot \sin(\Theta_2)$

$\Theta_{critical} = \arcsin\left(\frac{c_{slower}}{c_{faster}}\right) = \arcsin\left(\frac{n_{lower}}{n_{higher}}\right)$

Magnification, Thin lens equation $m = \frac{h_i}{h_o} = \frac{d_i}{d_o}$ $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Refractive power $P = \frac{1}{f}$ f in meters

Heat and thermo

Temperature, Thermal expansion	$°C + 273 \rightarrow K$	$\Delta\ell = \alpha \cdot \ell_0 \cdot \Delta T$	$\Delta V = \gamma \cdot V_0 \cdot \Delta T$
Internal energy	$\Delta U = Q + W$	$\Delta U = c \cdot m \cdot \Delta T$	
Latent heat	$Q = L_f \cdot m$	$Q = L_v \cdot m$	

Mathematics

Trigonometry $\sin\alpha = \frac{\text{Opposite}}{\text{Hypotenuse}}$ $\cos\alpha = \frac{\text{Adjacent}}{\text{Hypotenuse}}$ $\tan\alpha = \frac{\text{Opposite}}{\text{Adjacent}}$

Circle — Circumference $u = 2\pi \cdot r$ — Area $A = \pi \cdot r^2$

Sphere — Surface area $S = 4\pi \cdot r^2$ — Volume $V = \frac{4\pi}{3} \cdot r^3$

Physical constants

Universal Gravitational Constant	$G = 6.67 \cdot 10^{-11}\ \frac{N \cdot m^2}{kg^2}$
mass of the Earth	$m_{Earth} = 5.972 \cdot 10^{24}$ kg
radius of the Earth	$r_{Earth} = 6.371 \cdot 10^{6}$ m
distance between the centers of Sun and Earth	$r_{Sun\text{-}Earth} = 1.496 \cdot 10^{11}$ m
orbital period of the Earth	$T_{Earth} = 365.26$ d
distance between the centers of Earth and Moon	$r_{Earth\text{-}Moon} = 3.844 \cdot 10^{8}$ m
mass of the Moon	$m_{Moon} = 7.346 \cdot 10^{22}$ kg
radius of the Moon	$r_{Moon} = 1.737 \cdot 10^{6}$ m
orbital period of the Moon	$T_{Moon} = 27.32$ d
mass of the Sun	$m_{Sun} = 1.99 \cdot 10^{30}$ kg
radius of the Sun	$r_{Sun} = 6.960 \cdot 10^{8}$ m

Acceleration of free fall in $\frac{m}{s^2}$:

Earth (north pole)	9.83	Earth (Europe)	9.81	Earth (equator)	9.78
Moon	1.62	Venus	8.83	Mars	3.73
Jupiter	23.1	Mercury	3.70	Sun	274
Saturn	9.0	Uranus	8.7	Neptune	11.0

Coefficient of static friction		**coefficient of kinetic friction**		**coefficient of rolling resistance**	
steel on steel	0.78	steel on steel	0.42	steel on steel	0.0015
tyre on asphalt	0.85	tyre on asphalt	0.65	tyre on asphalt	0.008
steel on ice	0.027	steel on ice	0.014		
wood on stone	0.7	wood on stone	0.3		
wood on wood	0.4	wood on wood	0.3		
glass on glass	0.94	glass on glass	0.40		

Drag coefficients (air resistance)

Person (erect)	0.78	sphere	0.47
Passenger car (closed)	0.36	hollow cone, $\alpha = 30°$	0.34
Motorcycle	0.7	hollow cone, $\alpha = 60°$	0.51
Truck	0.6 - 1.5	circular disc	1.11
Bicycle incl. person	1	Square plate	1.10
Parachute	1.4	cube	1.05
Aerofoil	0.05	cube	0.80

Speed of light in $\frac{\mathbf{m}}{\mathbf{s}}$

vacuum	$2.998 \cdot 10^8$	water	$2.25 \cdot 10^8$	ice	$1.90 \cdot 10^8$
air	$2.997 \cdot 10^8$	diamond	$1.24 \cdot 10^8$	PMMA (Plexiglass)	$2.01 \cdot 10^8$

Indices of refraction

ethanol	1.36	water	1.33	salt	1.54
methanol	1.33	diamond	2.42	window glass	1.52

Thermodynamic properties of solids, liquids and gases

Solids	density in $\frac{kg}{m^3}$	coefficient of linear expansion in $\frac{1}{K}$	specific heat (capacity) in $\frac{J}{kg \cdot K}$	melting point in °C	latent heat of fusion in $\frac{J}{kg}$
aluminium	$2.70 \cdot 10^3$	$23.8 \cdot 10^{-6}$	$0.896 \cdot 10^3$	660	$3.97 \cdot 10^5$
concrete	$2.2 \cdot 10^3$	$12 \cdot 10^{-6}$	$0.879 \cdot 10^3$	–	–
lead	$11.34 \cdot 10^3$	$31.3 \cdot 10^{-6}$	$0.129 \cdot 10^3$	327	$0.23 \cdot 10^5$
ice	$0.917 \cdot 10^3$	$37 \cdot 10^{-6}$	$2.09 \cdot 10^3$	0	$3.34 \cdot 10^5$
iron	$7.86 \cdot 10^3$	$12 \cdot 10^{-6}$	$0.450 \cdot 10^3$	1535	$2.77 \cdot 10^5$
glass	$2.5 \cdot 10^3$	$8.5 \cdot 10^{-6}$	$0.84 \cdot 10^3$	815	–
gold	$19.29 \cdot 10^3$	$14 \cdot 10^{-6}$	$0.129 \cdot 10^3$	1063	$0.64 \cdot 10^5$
wood	$0.4 – 0.8 \cdot 10^3$	$5 – 8 \cdot 10^{-6}$	$1.7 – 2.1 \cdot 10^3$	–	–
constantan	$8.9 \cdot 10^3$	$15.2 \cdot 10^{-6}$	$0.41 \cdot 10^3$	1280	–
cork	$0.3 \cdot 10^3$	$1 \cdot 10^{-6}$	$1.88 \cdot 10^3$	–	–
copper	$8.92 \cdot 10^3$	$16.8 \cdot 10^{-6}$	$0.383 \cdot 10^3$	1083	$2.05 \cdot 10^5$
brass	$8.47 \cdot 10^3$	$18 \cdot 10^{-6}$	$0.380 \cdot 10^3$	905	$1.6 \cdot 10^5$
magnesium	$1.74 \cdot 10^3$	$26 \cdot 10^{-6}$	$1.02 \cdot 10^3$	650	$3.70 \cdot 10^5$
natrium	$0.97 \cdot 10^3$	$70 \cdot 10^{-6}$	$1.22 \cdot 10^3$	97,8	$1.13 \cdot 10^5$
platinum	$21.4 \cdot 10^3$	$9.0 \cdot 10^{-6}$	$0.133 \cdot 10^3$	1769	$1.11 \cdot 10^5$
porcelain	$2.3 \cdot 10^3$	$4.0 \cdot 10^{-6}$	$0.846 \cdot 10^3$	–	–
silver	$10.51 \cdot 10^3$	$19.7 \cdot 10^{-6}$	$0.235 \cdot 10^3$	960.5	$1.05 \cdot 10^5$
steel	$7.9 \cdot 10^3$	$13.0 \cdot 10^{-6}$	$0.47 \cdot 10^3$	ca 1500	$2.7 \cdot 10^5$
styrofoam	17	$50 – 80 \cdot 10^{-6}$	$1.25 \cdot 10^3$	–	–
tungsten	$19.3 \cdot 10^3$	$4.3 \cdot 10^{-6}$	$0.134 \cdot 10^3$	3390	$1.91 \cdot 10^5$
zinc	$7.14 \cdot 10^3$	$26 \cdot 10^{-6}$	$0.385 \cdot 10^3$	419.5	$1.11 \cdot 10^5$

Liquids	density at 20 °C in $\frac{kg}{m^3}$	coefficient of volume expansion in $\frac{1}{K}$	specific heat (capacity) in $\frac{J}{kg \cdot K}$	boiling point at 1.013 bar in °C	latent heat of vaporization in $\frac{J}{kg}$
alcohol (ethanol)	$0.789 \cdot 10^3$	$1.10 \cdot 10^{-3}$	$2.43 \cdot 10^3$	78.3	$0.840 \cdot 10^6$
gasoline	$0.741 \cdot 10^3$	$1.06 \cdot 10^{-3}$	$2.02 \cdot 10^3$	–	–
benzene	$0.879 \cdot 10^3$	$1.23 \cdot 10^{-3}$	$1.725 \cdot 10^3$	80.1	$0.394 \cdot 10^6$
diethyl ether	$0.716 \cdot 10^3$	$1.62 \cdot 10^{-3}$	$2.310 \cdot 10^3$	34.5	$0.384 \cdot 10^6$
glycerol	$1.26 \cdot 10^3$	$0.49 \cdot 10^{-3}$	$2.39 \cdot 10^3$	290.5	$0.854 \cdot 10^6$
sea water	$1.03 \cdot 10^3$	$0.25 \cdot 10^{-3}$	$3.99 \cdot 10^3$	100.1	–
olive oil	$0.92 \cdot 10^3$	$0.72 \cdot 10^{-3}$	$1.97 \cdot 10^3$	300	–
petroleum	$0.85 \cdot 10^3$	$0.96 \cdot 10^{-3}$	$2.1 \cdot 10^3$	150-300	–
mercury	$13.55 \cdot 10^3$	$0.182 \cdot 10^{-3}$	$0.139 \cdot 10^3$	357	$0.285 \cdot 10^6$
water	$0.998 \cdot 10^3$	$0.207 \cdot 10^{-3}$	$4.182 \cdot 10^3$	100.0	$2.257 \cdot 10^6$

Gases	density at 0 °C and 1.013 bar in $\frac{kg}{m^3}$		specific heat in $\frac{J}{kg \cdot K}$ (at constant pressure)	boiling point at 1.013 bar in °C	
ammonia	0.771		$2.160 \cdot 10^3$	- 33.4	
chlorine	3.21		$0.74 \cdot 10^3$	- 34.1	
helium	0.179		$5.23 \cdot 10^3$	-269	
isobutane	2.6956		$1.698 \cdot 10^3$	-11.7	
carbon dioxide	1.98		$0.837 \cdot 10^3$	- 78.5	
air	1.293		$1.005 \cdot 10^3$	-191	
propane	2.01		$1.67 \cdot 10^3$	-42	
oxygen	1.43		$0.917 \cdot 10^3$	-183	
nitrogen	1.250		$1.038 \cdot 10^3$	-196	
water vapor (steam) 100 °C, 1.013 bar	0.6		$1.863 \cdot 10^3$	100	
hydrogen	0.0899		$14.32 \cdot 10^3$	-253	