FAFF36 Medicinsk Fysik

Energi

Arbete

$$W = \int_{x_1}^{x_2} \overline{F} \cdot \mathrm{d}\overline{x}$$

Translationsenergi

$$W_\mathrm{k} = \frac{1}{2} \cdot m \cdot v^2 = \frac{p^2}{2 \cdot m}$$

Rotationsenergi

$$W_\mathrm{r} = \frac{1}{2} \cdot I \cdot \omega^2 = \frac{L^2}{2 \cdot I}$$

Potentiell energi

$$W_\mathrm{p} = m \cdot g \cdot h$$

Effekt

$$P = \frac{\mathrm{d}W}{\mathrm{d}t}$$

Vindens effekt

$$P_v = \frac{1}{2} \cdot \rho \cdot A \cdot v^3$$

Vattenkraftverk

$$P_p = \frac{dW_p}{dt} = \rho \cdot \frac{dV}{dt} \cdot g \cdot h$$

Tryck

$$p = \frac{\mathrm{d}F}{\mathrm{d}A}$$

Barometerformeln

$$p = p_0 + \rho \cdot g \cdot h$$

Lufttrycket

$$p = p_0 \cdot e^{-[M \cdot g/(R \cdot T)] \cdot y}$$

Hydromekanik

Massflöde

$$\Phi_m = \frac{dm}{dt} = \rho \cdot A \cdot v$$

Kontinuitetsekvationen

$$\rho_1 \cdot A_1 \cdot v_1 = \rho_2 \cdot A_2 \cdot v_2$$

Bernoullis ekvation

$$p_1 + \frac{1}{2} \cdot \rho \cdot v_1^{\,2} + \rho \cdot g \cdot y_1 = p_2 + \frac{1}{2} \cdot \rho \cdot v_2^{\,2} + \rho \cdot g \cdot y_2$$

Viskositet

$$F = \eta \cdot \frac{A \cdot v}{y}$$

Värme

Temperaturförändring

$$\mathrm{d}Q = m \cdot c \cdot \mathrm{d}T$$

$$Q = m \cdot c \cdot \Delta T$$

Fasövergång

$$Q = m \cdot L$$

Gaser

Allmänna gaslagen

$$p \cdot V = n \cdot R \cdot T$$

$$R = 8{,}314\ 51\ \mathrm{J/(mol \cdot K)}$$

$$p \cdot V = N \cdot k \cdot T$$

$$k = 1{,}380\ 658 \cdot 10^{-23}\ \mathrm{J/K}$$

Molmassa

$$M = \frac{m}{n}$$

Massdensitet

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

Partikeldensitet

$$n_0 = \frac{N}{V}$$

Volymandel

$$C_{V_i} = \frac{V_i}{V}$$

Massandel

$$C_{m_i} = \frac{m_i}{m}$$

Termodynamik

Arbete

$$W = \int_{V_1}^{V_2} p \cdot \mathrm{d}V$$

Inre energiändring

$$\Delta U = n \cdot C_V \cdot \Delta T$$

1:a Huvudsatsen

$$Q = \Delta U + W$$

Värmekapacitet

$$C = M \cdot c$$

$$C_\mathrm{V} = \frac{f}{2} \cdot \mathrm{R}$$

$$C_\mathrm{p} = C_\mathrm{V} + \mathrm{R}$$

$$\gamma = \frac{c_\mathrm{p}}{c_\mathrm{V}} = \frac{C_\mathrm{p}}{C_\mathrm{V}}$$

Adiabatisk process (Poissons ekvation)

$$p_1 \cdot V_1^{\gamma} = p_2 \cdot V_2^{\gamma}$$

$$T_1 \cdot V_1^{\gamma-1} = T_2 \cdot V_2^{\gamma-1}$$

$$T_1 \cdot p_1^{-(\gamma-1)/\gamma} = T_2 \cdot p_2^{-(\gamma-1)/\gamma}$$

Kretsprocesser

$$e = \frac{W}{Q_\mathrm{H}} \quad \text{(verkningsgrad)}$$

$$e = \frac{Q_\mathrm{H}}{W} \quad \text{(värmefaktor)}$$

$$e = \frac{Q_\mathrm{C}}{W} \quad \text{(köldfaktor)}$$

Carnot/Stirlingprocesserna

$$e = \frac{T_H - T_C}{T_H} \quad \text{(verkningsgrad)}$$

$$e = \frac{T_H}{T_H - T_C} \quad \text{(värmefaktor)}$$

$$e = \frac{T_C}{T_H - T_C} \quad \text{(köldfaktor)}$$

Sammanfattning av 1:a huvudsatsen

$$\Delta Q = \Delta U + W$$

Process	Definition	ΔQ	ΔU	W
Isobar	$\Delta p = 0$	$n \cdot C_\mathrm{p} \cdot \Delta T$	$n \cdot C_\mathrm{V} \cdot \Delta T$	$p \cdot \Delta V$
Isokor	$\Delta V = 0$	$n \cdot C_\mathrm{V} \cdot \Delta T$	$n \cdot C_\mathrm{V} \cdot \Delta T$	0
Isoterm	$\Delta T = 0$	W	0	$n \cdot R \cdot T \cdot \ln(V_2/V_1)$
Adiabat	$\Delta Q = 0$	0	$n \cdot C_\mathrm{V} \cdot \Delta T$	$- n \cdot C_\mathrm{V} \cdot \Delta T$

Värmetransport

Värmeeffekt

$$H = \frac{\mathrm{d}Q}{\mathrm{d}t}$$

Fouriers lag (värmeledning)

$$H = -k \cdot A \cdot \frac{\mathrm{d}T}{\mathrm{d}x}$$

Linjär värmeleding

$$H = -k \cdot A \cdot \frac{\Delta T}{\Delta x}$$

Radiell värmeledning

$$H = -k \cdot 2 \cdot \pi \cdot L \cdot \frac{(T_2 - T_1)}{\ln \frac{r_2}{r_1}}$$

Newtons avkylningslag (värmeövergång)

$$H = -h \cdot A \cdot \left(T_S - T_\infty\right)$$

Stefan Bolzmanns lag (värmestrålning)

$$H = \varepsilon \cdot \sigma \cdot A \cdot T^4$$

$$\sigma = 5{,}6705 \cdot 10^{-8}\ \mathrm{W/(m^2 \cdot K^4)}$$

Ljus

Fotonens energi

$$E = h \cdot f$$

$$h = 6{,}626\,076 \cdot 10^{-34}\ \mathrm{J \cdot s}$$

Intensitet

$$I = \frac{P}{A}$$

Stefan Bolzmanns lag (värmestrålning)

$$P = H = \varepsilon \cdot \sigma \cdot A \cdot T^4$$

$$\sigma = 5{,}6705 \cdot 10^{-8}\ \mathrm{W/(m^2 \cdot K^4)}$$

Strålning

Energi och massa

$$E = m \cdot c^2$$

Bindningsenergi

$$B = \left(Z \cdot m(^1\mathrm{H}) + N \cdot m_n - m(^A\mathrm{X})\right) \cdot c^2$$

$$1\ \mathrm{u} = 931{,}502\ \mathrm{MeV/c^2}$$

Alfasönderfall (α-sönderfall)

$$Q = \left(m({}^{A}_{Z}\mathrm{M}) - m({}^{A-4}_{Z-2}\mathrm{D}) - m(\alpha)\right) \cdot c^2$$

$$E_k(\alpha) = \frac{Q}{1 + \frac{m(\alpha)}{m({}^{A-4}_{Z-2}D)}}$$

Betasönderfall (β-sönderfall)

$$Q_{\beta^-} = \left(m({}^{A}_{Z}\mathrm{M}) - m({}^{A}_{Z+1}\mathrm{D})\right) \cdot c^2$$

$$Q_{\beta^+} = \left(m({}^{A}_{Z}\mathrm{M}) - m({}^{A}_{Z-1}\mathrm{D}) - 2m_e\right) \cdot c^2$$

$$Q_{\varepsilon} = \left(m({}^{A}_{Z}\mathrm{M}) - m({}^{A}_{Z-1}\mathrm{D})\right) \cdot c^2$$

Sönderfall

$$N(t) = N_0 \cdot e^{-\lambda \cdot t}$$

Aktivitet

$$A = \left|\frac{\mathrm{d}N}{\mathrm{d}t}\right| = \lambda \cdot N(t) = A_0 \cdot e^{-\lambda \cdot t}$$

Växelverkan

Alfapartiklarnas växelverkan

$$Q = E_k \cdot \frac{4 \cdot m_e}{M}$$

Fotonens växelverkan

$$I(x) = I_0 \cdot e^{-\mu \cdot x}$$

Prefix	**Beteckning**	**Storlek**
yetta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hekto	h	10^{2}
deka	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
mikro	µ	10^{-6}
nano	n	10^{-9}
piko	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

Luft och vatten

Vatten	Densitet (vid 20 °C)	0,998 kg/dm^3
	Smältvärme	334 kJ/kg
	Ångbildningsvärme	2260 kJ/kg
	Värmekapacitivitet	4,18 kJ/(kg·K)
Luft	Densitet (vid 0 °C och $1{,}013\cdot10^5$ Pa)	1,293 kg/m^3
	Värmekapacitivitet (vid 0 °C), c_p	1,00 kJ/(kg·K)
	c_p/c_V (vid 0 °C)	1,40

Ytor och volymer

	Area	Volym
Cirkel	$\pi\cdot r^2$	
Klot	$4\cdot\pi\cdot r^2$	$4\cdot\pi\cdot r^3/3$

Energienheter inom fysiken

J	kWh	eV	kcal
1	$0{,}277778 \times 10^{-6}$	$6{,}2418 \times 10^{18}$	$0{,}238846 \times 10^{-3}$
$3{,}6 \times 10^{6}$	1	$22{,}471 \times 10^{24}$	859,845
$1{,}6021 \times 10^{-19}$	$44{,}503 \times 10^{-27}$	1	$38{,}266 \times 10^{-24}$
$4{,}1868 \times 10^{3}$	$1{,}163 \times 10^{-3}$	$2{,}6132 \times 10^{22}$	1

Tryckenheter

Pa	bar	torr	atm
1	10×10^{-6}	$7{,}50062 \times 10^{-3}$	$9{,}86923 \times 10^{-6}$
100×10^{3}	1	750,062	0,986923
133,322	$1{,}33322 \times 10^{-3}$	1	$1{,}31579 \times 10^{-3}$
$101{,}325 \times 10^{3}$	1,01325	760	1

Exempel: Trycket 1 atm = $101{,}325\cdot10^3$ Pa = 1,01325 bar = 760 torr.

Tissue optical properties:

$I(z) = I_0 e^{-\mu_{eff} \cdot z}$ the Beer-Lambertian law

$\mu_t = \mu_a + \mu_s$ total attenuation coefficient

$\mu_{a,tissue} = \sum_i conc_i \cdot \mu_{a,i}$

R

$\mu_s' = \mu_s(1-g)$ reduced scattering coefficient

$\mu_s' = a_R \left(\frac{\lambda}{\lambda_0}\right)^{-4} + a_M \left(\frac{\lambda}{\lambda_0}\right)^{-b}$

$\mu_{eff} = \sqrt{\frac{\mu_a}{D}}$ effective attenuation coefficient

$D = \frac{1}{3\mu_s'}$ diffusion coefficient

The time-dependent diffusion equation:

$$\frac{1}{c}\frac{\partial}{\partial t}\phi(\mathbf{r},t) - D\nabla^2\phi(\mathbf{r},t) + \mu_a\phi(\mathbf{r},t) = S(\mathbf{r},t)$$

The steady state diffusion equation:

$$\nabla^2\phi(\mathbf{r}) - \mu_{eff}{}^2\phi(\mathbf{r}) = S(\mathbf{r})$$

Fluence rate for a point source in an infinite medium:

$$\phi(\mathbf{r}) = \phi(\mathbf{r}=\mathbf{0})\frac{1}{|\mathbf{r}|}\exp(-\mu_{eff}\cdot|\mathbf{r}|) = \frac{P\mu_{eff}{}^2}{4\pi\mu_a}\frac{1}{|\mathbf{r}|}\exp(-\mu_{eff}\cdot|\mathbf{r}|)$$

Diffuse reflectance from semi-infinite medium and transmittance from slab:

$$R_d(r) = \frac{P}{4\pi}\left[\frac{z_0(1+\mu_{eff}r_1)exp(-\mu_{eff}r_1)}{r_1^3} - \frac{(z_0+2z_b)(1+\mu_{eff}r_2)exp(-\mu_{eff}r_2)}{r_2^3}\right]$$

$$T_d(r) = \frac{P}{4\pi}\sum_{i=-n}^{n}\left[\frac{(d-z_{+,i})(1+\mu_{eff}r_{+,i})exp(-\mu_{eff}r_{+,i})}{r_{+,i}^3} - \frac{(d-z_{-,i})(1+\mu_{eff}r_{-,i})exp(-\mu_{eff}r_{-,i})}{r_{-,i}^3}\right],$$

with $z_{+,i}$ being the z-coordinate of the i:th positive source: $z_{+,i} = z_0 + 2id$, and $z_{-,i}$ being the z-coordinate for the i:th negative mirror source: $z_{-,i} = -z_0 + 2id$, while $r_{+,i} = \sqrt{r^2 + (d - z_{+,i})^2}$) and $r_{-,i} = \sqrt{r^2 + (d - z_{-,i})^2}$ are the distances from the sources to the detection position, respectively.

$$\rho c\frac{\partial T}{\partial t} = \nabla(k\nabla T) + q_\mathrm{s} + q_\mathrm{p} + q_\mathrm{m}$$

The Bioheat equation:

$$\Delta T = \frac{Q}{4\pi\alpha t}e^{-\frac{r^2}{4\alpha t}}$$

$A = \phi\mu_a\tau \qquad \Delta T = \frac{A}{C\rho}$

Oxygenering

$$\boldsymbol{Sat} = \frac{[\boldsymbol{HbO_2}]}{[\boldsymbol{Hb}]+[\boldsymbol{HbO_2}]}$$

Periodiska systemet

Grupp**

Period	1 IA 1A																	18 vIIIA 8A
1	1 H 1.008	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
			3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 ------- -------	9 VIII --- 8	10 ---- -------	11 IB 1B	12 IIB 2B						
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 190.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac~ (227)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 --- ()	111 --- ()	112 --- ()		114 --- ()		116 --- ()		118 --- ()

Lanthanide Series*	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinide Series~	90 Th 232.0	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)