Pregled formula iz *Fizike 1* i *Fizike 2*

FER/fizika

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1 Kinematika čestice

Položaj $\vec{r}[t]$, brzina $\vec{v}[t]$ i akceleracija $\vec{a}[t]$:

$$\vec{v}[t] = \frac{\mathrm{d}}{\mathrm{d}t}\vec{r}[t] \qquad \vec{r}[t] = \vec{r}[t_0] + \int_{t_0}^{t} \vec{v}[t']\,\mathrm{d}t'$$

$$\vec{a}[t] = \frac{\mathrm{d}}{\mathrm{d}t}\vec{v}[t] \qquad \vec{v}[t] = \vec{v}[t_0] + \int_{t_0}^{t} \vec{a}[t']\,\mathrm{d}t'$$

Gibanje stalnom brzinom $\vec{v}$:

$$\vec{r}[t] = \vec{r}[t_0] + \vec{v}(t - t_0)$$

Gibanje stalnom akceleracijom $\vec{a}$:

$$\vec{v}[t] = \vec{v}[t_0] + \vec{a}(t - t_0)$$

$$\vec{r}[t] = \vec{r}[t_0] + \vec{v}[t_0](t - t_0) + \frac{\vec{a}}{2}(t - t_0)^2$$

Kosi hitac uz $\vec{a} = -g\,\hat{\jmath}$ u $z = 0$ ravnini:

$$\vec{r}[0] = 0 \qquad \vec{v}[0] = v_0(\cos\alpha\,\hat{\imath} + \sin\alpha\,\hat{\jmath})$$

$$\vec{v}[t] = v_0\cos\alpha\,\hat{\imath} + (v_0\sin\alpha - gt)\,\hat{\jmath}$$

$$\vec{r}[t] = v_0 t\cos\alpha\,\hat{\imath} + \left(v_0 t\sin\alpha - \frac{g}{2}t^2\right)\hat{\jmath}$$

$$y[x] = x\,\mathrm{tg}\,\alpha - \frac{gx^2}{2v_0^2}(1 + \mathrm{tg}^2\alpha)$$

Gibanje po kružnici polumjera r u $z = 0$ ravnini:

$$\vec{r}[t] = r\,(\cos\varphi[t]\,\hat{\imath} + \sin\varphi[t]\,\hat{\jmath})$$

$$\vec{v}[t] = r\omega[t](-\sin\varphi[r]\,\hat{\imath} + \cos\varphi[t]\,\hat{\jmath}) \qquad \omega[t] = \frac{\mathrm{d}}{\mathrm{d}t}\varphi[t]$$

$$\vec{a}[t] = -(\omega[t])^2\,\vec{r}[t] + \frac{\alpha[t]}{\omega[t]}\vec{v}[t] \qquad \alpha[t] = \frac{\mathrm{d}}{\mathrm{d}t}\omega[t]$$

uz definiciju $\vec{\omega} = \omega\,\hat{k}$, $\vec{\alpha} = \alpha\,\hat{k}$ i $\vec{a} = \vec{a}_{\mathrm{rad.}} + \vec{a}_{\mathrm{tang.}}$:

$$\vec{v} = \vec{\omega}\times\vec{r} \qquad \vec{a}_{\mathrm{rad.}} = \vec{\omega}\times\vec{v} \qquad \vec{a}_{\mathrm{tang.}} = \vec{\alpha}\times\vec{r}$$

Kruženje stalnom kutnom brzinom ω:

$$\varphi[t] = \varphi[t_0] + \omega(t - t_0)$$

Kruženje stalnom kutnom akceleracijom α:

$$\omega[t] = \omega[t_0] + \alpha(t - t_0)$$

$$\varphi[t] = \varphi[t_0] + \omega[t_0](t - t_0) + \frac{\alpha}{2}(t - t_0)^2$$

2 Dinamika čestice

Količina gibanja i kinetička energija:

$$\vec{p} = m\vec{v} \qquad E_{\mathrm{kin.}} = \frac{mv^2}{2}$$

Jednadžba gibanja:

$$\frac{\mathrm{d}}{\mathrm{d}t}\vec{p} = \vec{F}$$

$$\vec{F} = m\vec{a} \qquad (m = \mathrm{konst.})$$

Impuls sile:

$$\vec{I} = \int_{t_1}^{t_2} \vec{F}[t]\,\mathrm{d}t = \vec{p}[t_2] - \vec{p}[t_1]$$

Kutna količina gibanja i moment sile:

$$\vec{L} = \vec{r}\times\vec{p} \qquad \vec{M} = \frac{\mathrm{d}}{\mathrm{d}t}\vec{L} = \vec{r}\times\vec{F}$$

Rad, kinetička energija, snaga:

$$\mathrm{d}W = \vec{F}\cdot\mathrm{d}\vec{r} \qquad W_{12} = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F}[\vec{r}]\cdot\mathrm{d}\vec{r}$$

$$\Delta W = \Delta E_{\mathrm{kin.}} \qquad P = \frac{\mathrm{d}W}{\mathrm{d}t} = \vec{F}\cdot\vec{v}$$

Konzervativne sile ($\oint \vec{F}[\vec{r}]\cdot\mathrm{d}\vec{r} = 0$), potencijalna energija:

$$E_{\mathrm{pot.}}[\vec{r}] = E_{\mathrm{pot.}}[\vec{r}_0] - \int_{\vec{r}_0}^{\vec{r}} \vec{F}[\vec{r}\,']\cdot\mathrm{d}\vec{r}\,'$$

$$\vec{F}[\vec{r}] = -\nabla E_{\mathrm{pot.}}[\vec{r}]$$

$$\Delta E_{\mathrm{kin.}} + \Delta E_{\mathrm{pot.}} = 0$$

sila opruge: $F[x] = -kx \qquad E_{\mathrm{pot.}}[x] = \frac{1}{2}kx^2$

sila teža: $\vec{G} = -mg\,\hat{\jmath} \qquad E_{\mathrm{pot.}}[y] = mgy$

Nekonzervativne sile ($\oint \vec{F}[\vec{r}]\cdot\mathrm{d}\vec{r} \neq 0$):

trenje klizanja: $F = \mu N$

Centripetalna sila:

$$\vec{F}_{\mathrm{CP}} = m\vec{a}_{\mathrm{rad.}} = -m\omega^2\vec{r} \qquad F_{\mathrm{CP}} = \frac{mv^2}{r}$$

3 Sudar dviju čestica

Veličine označene s $'$ odnose se na stanje nakon sudara:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

$$E_{\text{kin.}} = \frac{m_1v_1^2 + m_2v_2^2}{2} \qquad E'_{\text{kin.}} = \frac{m_1{v_1'}^2 + m_2{v_2'}^2}{2}$$

$$\text{koeficijent restitucije:} \quad k = \frac{|\vec{v}_1' - \vec{v}_2'|}{|\vec{v}_1 - \vec{v}_2|}$$

$$Q = E'_{\text{kin.}} - E_{\text{kin.}} = -(1-k^2)\frac{m_1m_2|\vec{v}_1 - \vec{v}_2|^2}{2(m_1+m_2)}$$

Savršeno neelastični sudar ($k = 0$):

$$\vec{v}_1' = \vec{v}_2' = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2}$$

Savršeno elastični čeoni sudar ($k = 1$):

$$\vec{v}_1' = \frac{(m_1 - m_2)\vec{v}_1 + 2m_2\vec{v}_2}{m_1+m_2}$$

$$\vec{v}_2' = \frac{(m_2 - m_1)\vec{v}_2 + 2m_1\vec{v}_1}{m_1+m_2}$$

Općenit čeoni sudar, $\vec{v}_2' - \vec{v}_1' = -k(\vec{v}_2 - \vec{v}_1)$:

$$\vec{v}_1' = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2} - k\,\frac{m_2(\vec{v}_1 - \vec{v}_2)}{m_1+m_2}$$

$$\vec{v}_2' = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2} - k\,\frac{m_1(\vec{v}_2 - \vec{v}_1)}{m_1+m_2}$$

4 Sustav čestica

Masa i centar mase sustava, $i = 1, \ldots, N$:

$$m = \sum_i m_i \qquad \vec{r}_{\text{cm}} = \frac{1}{m}\sum_i m_i\vec{r}_i$$

$$\vec{v}_{\text{cm}} = \frac{\mathrm{d}}{\mathrm{d}t}\vec{r}_{\text{cm}} \qquad \vec{a}_{\text{cm}} = \frac{\mathrm{d}}{\mathrm{d}t}\vec{v}_{\text{cm}}$$

Količina gibanja sustava:

$$\vec{p} = \sum_i \vec{p}_i = m\vec{v}_{\text{cm}} \qquad \frac{\mathrm{d}}{\mathrm{d}t}\vec{p} = m\vec{a}_{\text{cm}} = \sum_i \vec{F}_i = \vec{F}$$

Kutna količina gibanja sustava:

$$\vec{L} = \sum_i \vec{L}_i \qquad \frac{\mathrm{d}}{\mathrm{d}t}\vec{L} = \sum_i \vec{M}_i = \vec{M}$$

Kinetička energija sustava:

$$E_{\text{kin.}} = \frac{1}{2}\sum_i m_iv_i^2 = \frac{1}{2}mv_{\text{cm}}^2 + \frac{1}{2}\sum_i m_i|\vec{v}_i - \vec{v}_{\text{cm}}|^2$$

5 Kruto tijelo

Vrtnja oko čvrste osi (s je udaljenost od osi):

$$I_z = \sum_i m_is_i^2 \qquad s = \sqrt{x^2+y^2}$$

$$\text{teorem o paralelnim osima:} \quad I_z = I_{\text{cm}} + md^2$$

$$\text{teorem o okomitim osima:} \quad I_z = I_x + I_y$$

$$L_z = I_z\omega \qquad \frac{\mathrm{d}}{\mathrm{d}t}L_z = I_z\alpha = M_z$$

$$E_{\text{kin.}} = \frac{1}{2}I_z\omega^2 \qquad P = M_z\omega \qquad \mathrm{d}W = M_z\,\mathrm{d}\varphi$$

Vrtnja uz translaciju:

$$E_{\text{kin.}} = \frac{1}{2}mv_{\text{cm}}^2 + \frac{1}{2}I_{\text{cm}}\omega^2$$

Vrtnja tijela oko glavne osi (osi simetrije):

$$\vec{L} = I_{\text{cm}}\vec{\omega}$$

Momenti tromosti I_{cm} u odnosu na os kroz centar mase nekih simetričnih tijela:

Tanki prsten, os $\perp$ na ravninu prstena:	mR^2
Okrugla ploča, os $\perp$ na ravninu ploče:	$\frac{1}{2}mR^2$
Šuplji valjak, os simetrije:	$\frac{1}{2}m(R_1^2 + R_2^2)$
Homogena kugla:	$\frac{2}{5}mR^2$
Tanka šuplja kugla (sfera):	$\frac{2}{3}mR^2$
Tanki štap duljine L, os $\perp$ na štap:	$\frac{1}{12}mL^2$

6 Gravitacija

Sila na česticu 1:

$$\vec{F}_{12} = -G_{\text{N}}\frac{m_1m_2}{r_{12}^2}\hat{r}_{12} \qquad \vec{r}_{12} = \vec{r}_2 - \vec{r}_1$$

Gravitacijsko polje i potencijal:

$$\vec{g}[\vec{r}] = -G_{\text{N}}\sum_i \frac{m_i(\vec{r} - \vec{r}_i)}{|\vec{r} - \vec{r}_i|^3} \qquad \vec{F}[\vec{r}] = m\vec{g}[\vec{r}]$$

$$\phi[\vec{r}] = -G_{\text{N}}\sum_i \frac{m_i}{|\vec{r} - \vec{r}_i|} \qquad E_{\text{pot.}}[\vec{r}] = m\phi[\vec{r}]$$

$$\vec{g}[\vec{r}] = -\nabla\phi[\vec{r}] \qquad \vec{F}[\vec{r}] = -\nabla E_{\text{pot.}}[\vec{r}]$$

7 Neinercijski sustavi

Galileijeve transformacije (S' se giba brzinom v u smjeru x-osi):

$$x' = x - vt \qquad y' = y \qquad z' = z \qquad t' = t$$

$$v_x' = v_x - v \qquad v_y' = v_y \qquad v_z' = v_z$$

Jednadžba gibanja (S' ubrzava akceleracijom $\vec{a}_0$ u odnosu na inercijski sustav S):

$$m\vec{a} = \vec{F} \qquad m\vec{a}' = \vec{F} + \vec{F}_{\text{I}}' \qquad \vec{F}_{\text{I}}' = -m\vec{a}_0$$

Centrifugalna i Coriolisova sila:

$$\vec{F}_{\text{CF}}' = m\omega^2\vec{r} \qquad \vec{F}_{\text{COR}}' = 2m\vec{v}' \times \vec{\omega}$$

8 Relativistička mehanika

Lorentzove transformacije (S' se giba brzinom v u smjeru x-osi, $\beta = v/c$):

$$x' = \frac{x - vt}{\sqrt{1-\beta^2}} \qquad y' = y \qquad z' = z \qquad t' = \frac{t - vx/c^2}{\sqrt{1-\beta^2}}$$

kontrakcija duljine: $\Delta x = \Delta x_0 \sqrt{1-\beta^2}$

dilatacija vremena: $\Delta t = \dfrac{\Delta t_0}{\sqrt{1-\beta^2}}$

Transformacija brzine:

$$u'_x = \frac{u_x - v}{1 - vu_x/c^2} \qquad u'_{y,z} = \frac{u_{y,z}\sqrt{1-\beta^2}}{1 - vu_x/c^2}$$

Količina gibanja i energija čestice:

$$\vec{p} = \gamma m \vec{v} \qquad E = \gamma mc^2 = mc^2 + E_{\text{kin.}}$$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \qquad \beta = \frac{v}{c}$$

$$E^2 = (pc)^2 + (mc^2)^2$$

9 Statika fluida

Tlak, uvjet ravnoteže fluida, uzgon:

$$p = \frac{dF}{dA} \qquad dp = -\rho g\, dh \qquad dF_U = \rho g\, dV$$

Hidrostatski tlak na dubini d ($\rho =$ konst.):

$$p[d] = p_0 + \rho g d$$

Izotermna atmosfera ($p/\rho \propto T =$ konst.):

$$p[h] = p_0 \exp\left[-\frac{\rho_0}{p_0} g h\right]$$

Površinska napetost:

$$\sigma = \frac{dW}{dS} = \frac{dF}{d\ell} \qquad \Delta p = \sigma \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Kapilarna elevacija:

$$h = \frac{2\sigma \cos\theta}{\rho g r}$$

10 Dinamika fluida

Jednadžba kontinuiteta, Bernoullijeva jednadžba:

$$q_v = \frac{dV}{dt} = Sv = \text{konst.} \qquad p + \rho g h + \frac{\rho v^2}{2} = \text{konst.}$$

Viskozno trenje, Reynoldsov broj:

$$F_{TR} = \eta S \frac{dv}{dz} \qquad \text{Re} = \frac{\rho v \ell}{\eta}$$

Poiseuilleov zakon:

$$v[r] = \frac{p_1 - p_2}{4\eta\ell}\left(R^2 - r^2\right) \qquad q_v = \frac{\pi(p_1 - p_2)}{8\eta\ell} R^4$$

Stokesov zakon:

$$F_{\text{otpor}} = 6\pi\eta R v$$

Turbulentno strujanje:

$$F_{\text{otpor}} = \frac{1}{2} C_0 S \rho v^2$$

11 Toplina i temperatura

Toplinsko rastezanje:

$$\ell = \ell_0(1 + \alpha\,\Delta T) \qquad \alpha = \frac{d\ell}{\ell_0\, dT}$$

$$V = V_0(1 + \gamma\,\Delta T) \qquad \gamma = \frac{dV}{V_0\, dT} \simeq 3\alpha$$

Jednadžba stanja idealnog plina:

$$pV = NkT = nRT = \frac{m}{M} RT$$

Vođenje topline ($\Delta T = T_2 - T_1 > 0$):

$$Q = \lambda \frac{\Delta T}{\Delta x} S t \qquad \Phi = \frac{dQ}{dt} = \lambda \frac{\Delta T}{\Delta x} S = \frac{\Delta T}{R} \qquad R = \frac{\Delta x}{\lambda S}$$

12 Termodinamika

Prvi zakon:

$$d'Q = dU + d'W \qquad d'W = p\, dV$$

Toplinski kapaciteti:

$$C_p = \frac{1}{n}\left(\frac{dQ}{dT}\right)_{p=\text{konst.}} \qquad C_V = \frac{1}{n}\left(\frac{dQ}{dT}\right)_{V=\text{konst.}}$$

$$C_p - C_V = R \qquad \kappa = \frac{C_p}{C_V} \qquad c_p = \frac{C_p}{M} \qquad c_V = \frac{C_V}{M}$$

Adijabatski proces ($d'Q = 0$):

$$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{\kappa} \qquad \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\kappa-1} = \left(\frac{p_1}{p_2}\right)^{(\kappa-1)/\kappa}$$

$$W_{12} = \frac{nR}{\kappa - 1}(T_1 - T_2) = \frac{p_1 V_1}{\kappa - 1}\left(1 - \frac{T_2}{T_1}\right)$$

Izotermni proces ($T =$ konst.):

$$W_{12} = nRT \ln\frac{V_2}{V_1} = nRT \ln\frac{p_1}{p_2}$$

Carnotov kružni proces ($T_1 > T_2$):

$$W = Q_1 + Q_2 = |Q_1| - |Q_2| = Q_1\left(1 - \frac{T_2}{T_1}\right)$$

$$\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$$

Entropija:

$$dS = \frac{d'Q}{T} \qquad S_2 - S_1 = \int_1^2 \frac{d'Q}{T}$$

13 Kinetička teorija

Tlak, unutarnja energija i toplinski kapacitet idealnog plina:

$$p = \frac{Nm}{3V}\overline{v^2} = \frac{2N}{3V}\overline{E_{\text{kin.}}}$$

$$\overline{E_{\text{kin.}}} = \frac{i}{2}kT \qquad U = \frac{i}{2}NkT = \frac{i}{2}nRT$$

$$C_p = \frac{i+2}{2}R \qquad C_V = \frac{i}{2}R \qquad \kappa = \frac{i+2}{i}$$

Maxwellova raspodjela:

$$N_v = \frac{\mathrm{d}N}{\mathrm{d}v} = \frac{4N}{\sqrt{\pi}}\left(\frac{m}{2kT}\right)^{3/2} v^2 \exp\left[-\frac{mv^2}{2kT}\right]$$

$$v_{\max} = \sqrt{\frac{2RT}{M}} \qquad \overline{v} = \sqrt{\frac{8RT}{\pi M}} \qquad \sqrt{\overline{v^2}} = \sqrt{\frac{3RT}{M}}$$

Maxwell–Boltzmannova raspodjela:

$$N_E = \frac{\mathrm{d}N}{\mathrm{d}E} = \frac{2N}{\sqrt{\pi k^3 T^3}}\sqrt{E}\exp\left[-\frac{E}{kT}\right]$$

$$E_{\max} = \frac{kT}{2} \qquad \overline{E} = \frac{3}{2}kT$$

14 Elastičnost

Modul elastičnosti i gustoća energije:

vlak: $$E = \frac{\sigma}{\delta_L} = \frac{F/S_0}{\Delta L/L_0} \qquad u = \frac{E}{2}\delta_L^2 = \frac{\sigma^2}{2E}$$

tlak: $$B = -\frac{p}{\delta_V} = -\frac{F/S_0}{\Delta V/V_0} \qquad u = \frac{B}{2}\delta_V^2 = \frac{p^2}{2B}$$

smik: $$G = \frac{\sigma}{\delta_\phi} = \frac{F/S}{\Delta\phi} \qquad u = \frac{G}{2}\delta_\phi^2 = \frac{\sigma^2}{2G}$$

Poissonov omjer:

$$\mu = -\frac{\delta_{L\perp\sigma}}{\delta_{L\parallel\sigma}} \qquad E = 3B(1-2\mu)$$

Konstanta torzije šipke:

$$D = \frac{\mathrm{d}M}{\mathrm{d}\varphi} = G\frac{R^4\pi}{2L}$$

15 Titranje

Jednostavno harmoničko titranje, $ma = -kx$:

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}x[t] + \omega_0^2 x[t] = 0 \qquad \omega_0^2 = \frac{k}{m}$$

$$x[t] = A\cos[\omega_0 t + \phi] \qquad \omega_0 = 2\pi f = 2\pi/T$$

$$A = \sqrt{x[0]^2 + v[0]^2/\omega_0^2}$$

$$\cos\phi = \frac{x[0]}{A} \qquad \sin\phi = -\frac{v[0]}{A\omega_0}$$

$$E = \frac{1}{2}kA^2 = \frac{1}{2}m\omega_0^2 A^2$$

Matematičko, fizičko i torziono njihalo:

$$\omega^2_{\text{mat.}} = \frac{g}{\ell} \qquad \omega^2_{\text{fiz.}} = \frac{mg\ell_{\text{cm}}}{I_{\text{cm}} + m\ell^2_{\text{cm}}} = \frac{g}{\ell_{\text{red.}}} \qquad \omega^2_{\text{torz.}} = \frac{D}{I}$$

Prigušeno titranje, $ma = -kx - bv$, $\delta < \omega_0$:

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}x[t] + 2\delta\frac{\mathrm{d}}{\mathrm{d}t}x[t] + \omega_0^2 x[t] = 0 \qquad \omega_0^2 = \frac{k}{m} \qquad 2\delta = \frac{b}{m}$$

$$x[t] = A\mathrm{e}^{-\delta t}\cos[\omega t + \phi] \qquad \omega = \sqrt{\omega_0^2 - \delta^2} = 2\pi f = 2\pi/T$$

$$\lambda = \delta T = \frac{2\pi\delta}{\omega} \qquad Q = \frac{\omega}{2\delta}$$

Kritično prigušenje, $\delta = \omega_0$:

$$x[t] = \mathrm{e}^{-\delta t}\Big(x[0] + \big(v[0] + x[0]\delta\big)t\Big)$$

Aperiodičko prigušenje, $\delta > \omega_0$, $q = \sqrt{\delta^2 - \omega_0^2}$:

$$x[t] = \mathrm{e}^{-\delta t}\Big(x[0]\mathrm{ch}[qt] + \frac{v[0] + x[0]\delta}{q}\mathrm{sh}[qt]\Big)$$

Prisilno titranje, $ma = -kx - bv + F_{\mathrm{p}}\cos[\omega t]$:

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}x[t] + 2\delta\frac{\mathrm{d}}{\mathrm{d}t}x[t] + \omega_0^2 x[t] = f_{\mathrm{p}}\cos[\omega t]$$

$$\omega_0^2 = k/m \qquad 2\delta = b/m \qquad f_{\mathrm{p}} = F_{\mathrm{p}}/m$$

partikularno rješenje: $x[t] = A\cos[\omega t + \phi]$

$$A = \frac{f_{\mathrm{p}}}{\sqrt{\left(\omega_0^2 - \omega^2\right)^2 + 4\delta^2\omega^2}} \qquad \mathrm{tg}\,\phi = \frac{2\delta\omega}{\omega_0^2 - \omega^2}$$

rezonancija amplitude: $\omega_{\text{rez.}} = \sqrt{\omega_0^2 - 2\delta^2}$

16 Mehanički valovi

Valna jednadžba ($y[x,t]$ je pomak iz ravnoteže):

$$\frac{\partial^2}{\partial x^2}y[x,t] - \frac{1}{v^2}\frac{\partial^2}{\partial t^2}y[x,t] = 0$$

opće rješenje: $y[x,t] = f[x \pm vt]$

Harmonički val:

$$y[x,t] = A\cos[kx \pm \omega t + \phi]$$

$$\omega = 2\pi f = \frac{2\pi}{T} = kv = \frac{2\pi}{\lambda}v$$

Stojni val:

$$y[x,t] = A\cos[kx + \phi_1]\cos[\omega t + \phi_2]$$

Rubni uvjeti na stojni val u točkama razmaknutim L:

čvrst–čvrst ili slob.–slob.: $\lambda_n = 2L/n, \quad n = 1, 2, \ldots$

čvrst–slob.: $\lambda_n = 4L/(2n-1), \quad n = 1, 2, \ldots$

Brzina i srednja snaga transverzalnog vala na užetu:

$$v^2 = \frac{F}{\mu} \qquad \overline{P} = \frac{\mu}{2}\omega^2 A^2 v$$

Brzina zvuka longitudinalnog vala (zvuka) u tankom štapu, tekućini i plinu:

$$v^2_{\text{štap}} = \frac{E}{\rho} \qquad v^2_{\text{tek.}} = \frac{B}{\rho} \qquad v^2_{\text{plin}} = \frac{\kappa p}{\rho} = \frac{\kappa RT}{M}$$

Srednja snaga i intenzitet zvuka:

$$\overline{P} = \frac{\rho}{2}\omega^2 A^2 S v \qquad I = \frac{\overline{P}}{S} = \frac{(\Delta p_{\max})^2}{2v\rho}$$

Razina jakosti buke:

$$L = 10\log_{10}\frac{I}{I_0} \qquad I_0 = 10^{-12}\,\mathrm{W\,m^{-2}}$$

Dopplerov efekt:

$$f_{\mathrm{p}} = f_{\mathrm{i}}\frac{v_{\mathrm{z}} - \hat{r}_{\mathrm{ip}}\cdot\vec{v}_{\mathrm{p}}}{v_{\mathrm{z}} - \hat{r}_{\mathrm{ip}}\cdot\vec{v}_{\mathrm{i}}} \qquad \vec{r}_{\mathrm{ip}} = \vec{r}_{\mathrm{p}} - \vec{r}_{\mathrm{i}}$$

17 Elektromagnetizam

Lorentzova sila:

$$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$$

Elektrostatika (Coulombovo polje):

$$\vec{E}[\vec{r}] = \frac{1}{4\pi\epsilon_0}\sum_i \frac{q_i(\vec{r}-\vec{r}_i)}{|\vec{r}-\vec{r}_i|^3} = \frac{1}{4\pi\epsilon_0}\int \frac{\rho[\vec{r}\,'](\vec{r}-\vec{r}\,')}{|\vec{r}-\vec{r}\,'|^3}\,\mathrm{d}V'$$

$$\Phi[\vec{r}] = \frac{1}{4\pi\epsilon_0}\sum_i \frac{q_i}{|\vec{r}-\vec{r}_i|} \qquad \vec{E}[\vec{r}] = -\nabla\Phi[\vec{r}]$$

Magnetostatika (Biot–Savartov zakon, $I = \mathrm{d}q/\mathrm{d}t$):

$$\vec{B}[\vec{r}] = \frac{\mu_0}{4\pi}\int \frac{I'\,\mathrm{d}\vec{r}\,'\times(\vec{r}-\vec{r}\,')}{|\vec{r}-\vec{r}\,'|^3}$$

Maxwellove jednadžbe u integralnom obliku:

Gaussov zakon za $\vec{E}$ i $\vec{B}$ ($S = \partial V$):

$$\oint_S \vec{E}\cdot\mathrm{d}\vec{S} = \frac{1}{\epsilon_0}\int_V \rho\,\mathrm{d}V \qquad \oint_S \vec{B}\cdot\mathrm{d}\vec{S} = 0$$

Faradayev zakon indukcije ($C = \partial S$):

$$\oint_C \vec{E}\cdot\mathrm{d}\vec{r} = -\frac{\partial}{\partial t}\int_S \vec{B}\cdot\mathrm{d}\vec{S}$$

Ampère–Maxwellov zakon ($C = \partial S$):

$$\oint_C \vec{B}\cdot\mathrm{d}\vec{r} = \mu_0\int_S \vec{J}\cdot\mathrm{d}\vec{S} + \mu_0\epsilon_0\frac{\partial}{\partial t}\int_S \vec{E}\cdot\mathrm{d}\vec{S}$$

Maxwellove jednadžbe u diferencijalnom obliku:

$$\nabla\cdot\vec{E} = \frac{\rho}{\epsilon_0} \qquad \nabla\cdot\vec{B} = 0$$

$$\nabla\times\vec{E} = -\frac{\partial}{\partial t}\vec{B}$$

$$\nabla\times\vec{B} = \mu_0\vec{J} + \mu_0\epsilon_0\frac{\partial}{\partial t}\vec{E}$$

Valna jednadžba za $\vec{E}$ i $\vec{B}$:

$$\Delta\vec{E} - \mu_0\epsilon_0\frac{\partial^2}{\partial t^2}\vec{E} = 0 \qquad \Delta\vec{B} - \mu_0\epsilon_0\frac{\partial^2}{\partial t^2}\vec{B} = 0$$

Ravni val, $c = 1/\sqrt{\mu_0\epsilon_0}$, $\omega = |\vec{k}|c$:

$$\vec{E}[\vec{r},t] = \vec{E}_0\cos[\vec{k}\cdot\vec{r} - \omega t + \phi] \qquad \vec{E}_0\cdot\vec{k} = 0$$

$$\vec{B}[\vec{r},t] = \vec{B}_0\cos[\vec{k}\cdot\vec{r} - \omega t + \phi] \qquad \vec{B}_0 = \hat{k}\times(\vec{E}_0/c)$$

Poyntingov vektor i gustoća energije:

$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B} \qquad u = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{1}{\mu_0}B^2\right)$$

$$\frac{\partial}{\partial t}u + \nabla\cdot\vec{S} = -\vec{J}\cdot\vec{E}$$

Polja uz polarizaciju i magnetizaciju medija:

$$\vec{D} = \epsilon_0\vec{E} + \vec{P} \qquad \vec{H} = \frac{1}{\mu_0}\vec{B} - \vec{M}$$

$$\vec{P} = \epsilon_0\chi_{\mathrm{e}}\vec{E} \qquad \vec{D} = \epsilon\vec{E} \qquad \epsilon = \epsilon_0\epsilon_{\mathrm{r}} = \epsilon_0(1+\chi_{\mathrm{e}})$$

$$\vec{M} = \chi_{\mathrm{m}}\vec{H} \qquad \vec{H} = \frac{1}{\mu}\vec{B} \qquad \mu = \mu_0\mu_{\mathrm{r}} = \mu_0(1+\chi_{\mathrm{m}})$$

18 Fotometrija i geom. optika

Svjetlosni tok i osvijetljenost površine:

$$\mathrm{d}\Phi = I_\Omega\,\mathrm{d}\Omega \qquad E = \frac{\mathrm{d}\Phi}{\mathrm{d}S} = \frac{I_\Omega}{r^2}\cos\beta$$

Zakon loma:

$$n = \frac{c}{v} = \sqrt{\mu_{\mathrm{r}}\epsilon_{\mathrm{r}}} \qquad \frac{\sin\alpha}{\sin\alpha'} = \frac{n'}{n} \qquad \sin\alpha_{\mathrm{g}} = \frac{n'}{n}$$

Paralelni pomak Δ pri prolasku kroz planparalelnu ploču debljine d indeksa loma n' (u sredstvu n):

$$\Delta = d\sin\alpha\left(1 - \frac{\cos\alpha}{\sqrt{(n'/n)^2 - \sin^2\alpha}}\right)$$

Kut devijacije δ pri prolasku kroz prizmu vršnog kuta A indeksa loma n' (u sredstvu n):

$$\frac{\sin\alpha_1}{\sin\alpha_1'} = \frac{n'}{n} = \frac{\sin\alpha_2}{\sin\alpha_2'} \qquad \alpha_1' + \alpha_2' = A$$

$$\delta = (\alpha_1 - \alpha_1') + (\alpha_2 - \alpha_2') = \alpha_1 + \alpha_2 - A$$

minimum devijacije (pri $\alpha_1 = \alpha_2$):

$$n\sin[(\delta_{\min} + A)/2] = n'\sin[A/2]$$

Sferno zrcalo:

$$\frac{1}{a}+\frac{1}{b}=\frac{2}{R}=\frac{1}{f} \qquad m=-\frac{b}{a}$$

Sferni dioptar:

$$\frac{n}{a}+\frac{n'}{b}=\frac{n'-n}{R} \qquad m=-\frac{nb}{n'a}$$

Tanka leća (u sredstvu indeksa loma n):

$$\frac{1}{a}+\frac{1}{b}=\frac{n'-n}{n}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=\frac{1}{f}=J \qquad m=-\frac{b}{a}$$

19 Fizikalna optika

Duljina optičkog puta svjetlosti:

$$\mathrm{d}s=c\,\mathrm{d}t=nv\,\mathrm{d}t=n\,\mathrm{d}r$$

Interferencija dvaju točkastih koherentnih izvora:

konstruktivna: $\delta=s_2-s_1=m\lambda,\quad m=0,\pm1,\pm2,\dots$

destruktivna: $\delta=(m+1/2)\,\lambda,\quad m=0,\pm1,\pm2,\dots$

Listić debljine d u zraku, reflektirana svjetlost:

maksimum: $2d\sqrt{n^2-\sin^2\alpha}=(m+1/2)\lambda$

Newtonovi kolobari, $h\simeq r^2/(2R)$, reflektirana svjetlost:

maksimum: $r=\sqrt{R\,(m+1/2)\,\lambda}$

minimum: $r=\sqrt{Rm\lambda},\quad m=0,1,2,\dots$

Dva točkasta izvora razmaknuta za d (Youngov pokus):

maksimum: $\delta=d\sin\alpha\simeq d\frac{y}{D}=m\lambda,\quad m=0,\pm1,\dots$

N točkastih izvora na međusobnom razmaku d:

$$I[\alpha]=I_0\frac{\sin^2\left[N\frac{\pi d}{\lambda}\sin\alpha\right]}{\sin^2\left[\frac{\pi d}{\lambda}\sin\alpha\right]}$$

glavni maks. $I[\alpha]$: $\sin\alpha=\frac{\lambda}{d}m,\quad m=0,\pm1,\pm2,\dots$

minimum $I[\alpha]$: $\sin\alpha=\frac{\lambda}{Nd}m',\quad m'\neq mZ$

razlučivanje: $\frac{\lambda}{\Delta\lambda}=mN$, disperzija: $\frac{\mathrm{d}\alpha}{\mathrm{d}\lambda}=\frac{m}{d\cos\alpha}$

Difrakcija na pukotini širine a:

$$I[\alpha]=I_0\frac{\sin^2\left[\frac{\pi a}{\lambda}\sin\alpha\right]}{\left(\frac{\pi a}{\lambda}\sin\alpha\right)^2}$$

minimum $I[\alpha]$: $\sin\alpha=\frac{\lambda}{a}m\quad m=\pm1,\pm2,\dots$

N pukotina širine a na međusobnom razmaku d:

$$I[\alpha]=I_0\frac{\sin^2\left[\frac{\pi a}{\lambda}\sin\alpha\right]}{\left(\frac{\pi a}{\lambda}\sin\alpha\right)^2}\frac{\sin^2\left[N\frac{\pi d}{\lambda}\sin\alpha\right]}{\sin^2\left[\frac{\pi d}{\lambda}\sin\alpha\right]}$$

Polarizacija svjetlosti:

Malusov zakon: $I[\theta]=I_0\cos^2\theta$

Brewsterov kut: $\mathrm{tg}\,\alpha_{\mathrm{B}}=\frac{n'}{n}$

20 Kvantna priroda svjetlosti

Planckova relacija:

$$E=\hbar\omega=hf=hc/\lambda$$

Zakon zračenja crnog tijela, $\mathrm{d}P=I\,\mathrm{d}S$:

$$\mathrm{d}I=I_\lambda\,\mathrm{d}\lambda \qquad I_\lambda[\lambda,T]=\frac{2\pi hc^2}{\lambda^5}\frac{1}{\exp\left[hc/\lambda kT\right]-1}$$

$$\mathrm{d}I=I_f\,\mathrm{d}f \qquad I_f[f,T]=\frac{2\pi hf^3}{c^2}\frac{1}{\exp\left[hf/kT\right]-1}$$

$$I=\int_0^\infty I_\lambda\,\mathrm{d}\lambda=\int_0^\infty I_f\,\mathrm{d}f=\frac{2\pi^5k^4}{15c^2h^3}T^4=\sigma T^4$$

Stefan–Boltzmannov zakon: $P=S\sigma T^4$

Wienov zakon: $\lambda_{\mathrm{max}}T\simeq 2.898\times10^{-3}\ \mathrm{m\,K}$

Fotoelektrični efekt, $E_{\mathrm{fot.}}=\hbar\omega=hf=hc/\lambda$:

$$\frac{m_ev_e^2}{2}\leq E_{\mathrm{fot.}}-W_{\mathrm{izlaz}}$$

Comptonovo raspršenje, $p_{\mathrm{fot.}}=E_{\mathrm{fot.}}/c$:

$$hf+m_ec^2=hf'+\gamma_e'm_ec^2 \qquad \gamma_e'=1/\sqrt{1-(v_e'/c)^2}$$

$$\frac{hf}{c}=\frac{hf'}{c}\cos\theta_{\mathrm{fot.}}'+\gamma_e'm_ev_e'\cos\theta_e'$$

$$0=\frac{hf'}{c}\sin\theta_{\mathrm{fot.}}'-\gamma_e'm_ev_e'\sin\theta_e'$$

$$\Delta\lambda=\lambda'-\lambda=\frac{c}{f'}-\frac{c}{f}=\frac{h}{m_ec}(1-\cos\theta_{\mathrm{fot.}}')$$

21 Struktura atoma

Bohrov model, $L_n=n\hbar=nh/(2\pi)$, $n=1,2,\dots$:

$$r_n=\frac{\epsilon_0h^2}{\pi m_eZe^2}n^2 \qquad E_n=-\frac{E_{\mathrm{I}}}{n^2} \qquad E_{\mathrm{I}}=\frac{m_eZ^2e^4}{8\epsilon_0^2h^2}$$

$$E_{\mathrm{fot.}}=\hbar\omega_{mn}=hf_{mn}=\frac{hc}{\lambda_{mn}}=|E_m-E_n|$$

Vodik: $\frac{1}{\lambda_{mn}}=R_\infty\left|\frac{1}{n^2}-\frac{1}{m^2}\right| \qquad R_\infty=\frac{m_ee^4}{8\epsilon_0^2h^3c}$

Moseleyev zakon:

K–serija: $f=cR\left(1-\frac{1}{n^2}\right)(Z-a)^2 \qquad a\simeq1$

L–serija: $f=cR\left(\frac{1}{2^2}-\frac{1}{n^2}\right)(Z-a)^2 \qquad a\simeq7.4$

Braggov zakon:

$$2d\sin\theta=m\lambda \qquad m=1,2,3,\dots$$

De Broglieva relacija:

$$\lambda=\frac{h}{p} \qquad p=\frac{h}{\lambda}=\hbar k=\gamma mv$$

22 Atomska jezgra

Defekt mase ($m[^A_Z\mathrm{X}]$ je masa jezgre $^A_Z\mathrm{X}$, $m^*[^A_Z\mathrm{X}]$ je masa atoma $^A_Z\mathrm{X}$):

$$\begin{aligned}\Delta m &= Zm_p + (A-Z)m_n - m[^A_Z\mathrm{X}] \\ &= Zm[^1\mathrm{H}] + (A-Z)m_n - m^*[^A_Z\mathrm{X}]\end{aligned}$$

Energija vezanja: $E_\mathrm{b} = \Delta m\, c^2$

Zakon radioaktivnog raspada i aktivnost:

$$N[t] = N[t_0]\mathrm{e}^{-\lambda(t-t_0)} \qquad A[t] = -\frac{\mathrm{d}}{\mathrm{d}t}N[t] = \lambda N[t]$$

$$T_{1/2} = \frac{\ln 2}{\lambda} \qquad \tau = \frac{1}{\lambda}$$

Nuklearne reakcije, $\mathrm{a} + \mathrm{X} \to \mathrm{Y} + \mathrm{b}$:

$$Q = (m_\mathrm{X} + m_\mathrm{a})c^2 - (m_\mathrm{Y} + m_\mathrm{b})c^2$$

A Trigonometrijski identiteti

Eulerova formula ($\mathrm{i}^2 = -1$):

$$\mathrm{e}^{\mathrm{i}\phi} = \cos\phi + \mathrm{i}\,\sin\phi$$

Adicione formule:

$$\sin[\alpha \pm \beta] = \sin\alpha\,\cos\beta \pm \cos\alpha\,\sin\beta$$

$$\cos[\alpha \pm \beta] = \cos\alpha\,\cos\beta \mp \sin\alpha\,\sin\beta$$

Funkcije dvostrukog i polovice kuta:

$$\sin[2\alpha] = 2\sin\alpha\,\cos\alpha$$

$$\cos[2\alpha] = \cos^2\alpha - \sin^2\alpha = 1 - 2\sin^2\alpha = 2\cos^2\alpha - 1$$

$$\sin\frac{\alpha}{2} = \pm\sqrt{\frac{1-\cos\alpha}{2}} \qquad \cos\frac{\alpha}{2} = \pm\sqrt{\frac{1+\cos\alpha}{2}}$$

Kvadrat funkcije:

$$\sin^2\alpha = (1-\cos[2\alpha])/2 \qquad \cos^2\alpha = (1+\cos[2\alpha])/2$$

Zbroj, razlika i produkt funkcija:

$$\sin\alpha + \sin\beta = 2\sin[(\alpha+\beta)/2]\cos[(\alpha-\beta)/2]$$

$$\sin\alpha - \sin\beta = 2\cos[(\alpha+\beta)/2]\sin[(\alpha-\beta)/2]$$

$$\cos\alpha + \cos\beta = 2\cos[(\alpha+\beta)/2]\cos[(\alpha-\beta)/2]$$

$$\cos\alpha - \cos\beta = 2\sin[(\alpha+\beta)/2]\sin[(\beta-\alpha)/2]$$

$$\sin\alpha\sin\beta = (\cos[\alpha-\beta] - \cos[\alpha+\beta])/2$$

$$\cos\alpha\cos\beta = (\cos[\alpha-\beta] + \cos[\alpha+\beta])/2$$

$$\sin\alpha\cos\beta = (\sin[\alpha-\beta] + \sin[\alpha+\beta])/2$$

Veza s hiperbolnim funkcijama:

$$\mathrm{sh}\,x = \frac{\mathrm{e}^x - \mathrm{e}^{-x}}{2} = -\mathrm{i}\,\sin[\mathrm{i}x] \qquad \mathrm{i}\,\sin x = \mathrm{sh}[\mathrm{i}x]$$

$$\mathrm{ch}\,x = \frac{\mathrm{e}^x + \mathrm{e}^{-x}}{2} = \cos[\mathrm{i}x] \qquad \cos x = \mathrm{ch}[\mathrm{i}x]$$

B Vektori

Vektor, modul vektora, jedinični vektor:

$$\vec{a} = a_x\,\hat{\imath} + a_y\,\hat{\jmath} + a_z\,\hat{k}$$

$$a = |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2} \qquad \hat{a} = \vec{a}/a$$

Skalarno množenje:

$$\vec{a}\cdot\vec{b} = ab\cos\theta = \vec{b}\cdot\vec{a} = a_x b_x + a_y b_y + a_z b_z$$

$$|\vec{a}| = \sqrt{\vec{a}\cdot\vec{a}} \qquad |\vec{a}\pm\vec{b}| = \sqrt{a^2 \pm 2ab\cos\theta + b^2}$$

komponenta $\vec{a}$ u smjeru $\hat{n}$: $\vec{a}_\parallel = (\vec{a}\cdot\hat{n})\,\hat{n}$

komponenta $\vec{a}$ okomita na $\hat{n}$: $\vec{a}_\perp = \vec{a} - \vec{a}_\parallel$

Vektorsko množenje:

$$\vec{a}\times\vec{b} = ab\sin\theta\,\hat{n} \quad \text{(smjer } \hat{n} \text{ pravilom “desne ruke”)}$$

$$\vec{a}\times\vec{b} = -\vec{b}\times\vec{a} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix}$$

Identiteti sa skalarnim i vektorskim množenjem:

$$\vec{a}\cdot(\vec{b}\times\vec{c}) = \vec{b}\cdot(\vec{c}\times\vec{a}) = \vec{c}\cdot(\vec{a}\times\vec{b})$$

$$\vec{a}\times(\vec{b}\times\vec{c}) = (\vec{a}\cdot\vec{c})\,\vec{b} - (\vec{a}\cdot\vec{b})\,\vec{c}$$

Gradijent skalarnog polja $\phi[\vec{r}]$:

$$\nabla\phi[\vec{r}] = \frac{\partial\phi[\vec{r}]}{\partial x}\,\hat{\imath} + \frac{\partial\phi[\vec{r}]}{\partial y}\,\hat{\jmath} + \frac{\partial\phi[\vec{r}]}{\partial z}\,\hat{k}$$

Teorem o gradijentu:

$$\int_{\vec{r}_1}^{\vec{r}_2} (\nabla\phi[\vec{r}])\cdot\mathrm{d}\vec{r} = \phi[\vec{r}_2] - \phi[\vec{r}_1]$$

Divergencija vektorskog polja $\vec{A}[\vec{r}]$:

$$\nabla\cdot\vec{A}[\vec{r}] = \frac{\partial A_x[\vec{r}]}{\partial x} + \frac{\partial A_y[\vec{r}]}{\partial y} + \frac{\partial A_z[\vec{r}]}{\partial z}$$

Teorem o divergenciji (Gaussov teorem):

$$\int_V (\nabla\cdot\vec{A}[\vec{r}])\,\mathrm{d}V = \oint_{S=\partial V} \vec{A}[\vec{r}]\cdot\mathrm{d}\vec{S}$$

Rotacija vektorskog polja $\vec{A}[\vec{r}]$:

$$\nabla\times\vec{A}[\vec{r}] = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ A_x[\vec{r}] & A_y[\vec{r}] & A_z[\vec{r}] \end{vmatrix}$$

Teorem o rotaciji (Stokesov teorem):

$$\int_S (\nabla\times\vec{A}[\vec{r}])\cdot\mathrm{d}\vec{S} = \oint_{C=\partial S} \vec{A}[\vec{r}]\cdot\mathrm{d}\vec{r}$$

Laplaceov operator $\Delta = \nabla\cdot\nabla$:

$$\Delta\phi[\vec{r}] = \nabla\cdot\nabla\phi[\vec{r}] = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2}$$

$$\Delta\vec{A} = \Delta A_x[\vec{r}]\,\hat{\imath} + \Delta A_y[\vec{r}]\,\hat{\jmath} + \Delta A_z[\vec{r}]\,\hat{k}$$

Identiteti s operatorima ∇ i Δ:

$$\nabla\times\nabla\phi = 0 \qquad \nabla\cdot(\nabla\times\vec{a}) = 0$$

$$\nabla\times(\nabla\times\vec{a}) = \nabla(\nabla\cdot\vec{a}) - \Delta\vec{a}$$

$$\nabla(\vec{a}\cdot\vec{b}) = (\vec{a}\cdot\nabla)\vec{b} + (\vec{b}\cdot\nabla)\vec{a} + \vec{a}\times(\nabla\times\vec{b}) + \vec{b}\times(\nabla\times\vec{a})$$

$$\nabla\times(\vec{a}\times\vec{b}) = \vec{a}(\nabla\cdot\vec{b}) - \vec{b}(\nabla\cdot\vec{a}) + (\vec{b}\cdot\nabla)\vec{a} - (\vec{a}\cdot\nabla)\vec{b}$$

$$\nabla\cdot(\vec{a}\times\vec{b}) = \vec{b}\cdot(\nabla\times\vec{a}) - \vec{a}\cdot(\nabla\times\vec{b})$$

C Fizičke konstante

Naziv:	*Simbol (definicija):*	*Približna vrijednost:*
Standardna akceleracija gravitacije	g	$9.806\ \mathrm{m\,s^{-2}}$
Gravitacijska konstanta	G_N	$6.674 \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$
Brzina svjetlosti u vakuumu	c	$2.998 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Elementarni električni naboj	e	$1.602 \times 10^{-19}\ \mathrm{C}$
Permeabilnost vakuuma	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N\,A^{-2}}$	$1.257 \times 10^{-6}\ \mathrm{N\,A^{-2}}$
Permitivnost vakuuma	$\epsilon_0 = 1/(\mu_0 c^2)$	$8.854 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
Boltzmannova konstanta	k	$1.381 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
		$8.617 \times 10^{-5}\ \mathrm{eV\,K^{-1}}$
Avogadrova konstanta	$N_A = (1\ \mathrm{g})/(u\ \mathrm{mol})$	$6.022 \times 10^{23}\ \mathrm{mol^{-1}}$
Opća plinska konstanta	$R = kN_A$	$8.314\ \mathrm{J\,mol^{-1}\,K^{-1}}$
Molarni volumen (STP)	$V_0 = kN_A(273.15\,\mathrm{K})/(101\,325\,\mathrm{Pa})$	$22.41 \times 10^{-3}\ \mathrm{m^3\,mol^{-1}}$
Planckova konstanta	h	$6.626 \times 10^{-34}\ \mathrm{J\,s}$
Reducirana Planckova konstanta	$\hbar = h/(2\pi)$	$1.055 \times 10^{-34}\ \mathrm{J\,s}$
		$6.582 \times 10^{-22}\ \mathrm{MeV\,s}$
Comptonova valna duljina elektrona	$\lambda_e = h/(m_e c)$	$2.426 \times 10^{-12}\ \mathrm{m}$
Stefan–Boltzmannova konstanta	$\sigma = 2\pi^5 k^4/(15 c^2 h^3)$	$5.670 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$
Bohrov polumjer	$a_0 = r_1 = \epsilon_0 h^2/(\pi m_e e^2)$	$5.292 \times 10^{-11}\ \mathrm{m}$
Rydbergova konstanta	$R_\infty = m_e e^4/(8\epsilon_0^2 h^3 c)$	$1.097 \times 10^{7}\ \mathrm{m^{-1}}$
Masa elektrona	m_e	$9.109\,38 \times 10^{-31}\ \mathrm{kg}$
		$510.999\ \mathrm{keV}/c^2$
Masa protona	m_p	$1.672\,62 \times 10^{-27}\ \mathrm{kg}$
		$938.272\ \mathrm{MeV}/c^2$
Masa neutrona	m_n	$1.674\,93 \times 10^{-27}\ \mathrm{kg}$
		$939.566\ \mathrm{MeV}/c^2$
Atomska jedinica mase	$u = m^*[^{12}\mathrm{C}]/12$	$1.660\,54 \times 10^{-27}\ \mathrm{kg}$
		$931.494\ \mathrm{MeV}/c^2$

$T_0 = 0\ ^\circ\mathrm{C} = 273.15\ \mathrm{K}$ $\quad p_0 = 1\ \mathrm{atm} = 101\,325\ \mathrm{Pa}$ $\quad 1/(4\pi\epsilon_0) = 8.988 \times 10^{9}\ \mathrm{m^2\,N\,C^{-2}}$ $\quad \mu_0/(4\pi) = 10^{7}\ \mathrm{s^2\,N\,C^{-2}}$

$1\ \mathrm{eV} = 1.602 \times 10^{-19}\ \mathrm{J}$ $\quad 1\ \mathrm{eV}/c^2 = 1.782 \times 10^{-36}\ \mathrm{kg}$ $\quad hc = 1240\ \mathrm{eV\,nm}$ $\quad \hbar c = 197.3\ \mathrm{eV\,nm}$