# TEORIJA LETA I – FORMULE

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| $\tau = \mu \cdot \frac{\mathrm{d}\alpha}{\mathrm{d}t} = \mu \cdot \frac{\mathrm{d}u}{\mathrm{d}y}$ | viskoznost fluida | $T[\mathrm{K}] = t[^\circ\mathrm{C}] + 273{,}15$ | $\delta\vec{F} = p \cdot \delta\vec{S}$ | $p = \rho \cdot g \cdot h = \gamma \cdot h$ | $\rho = \frac{m}{\mathcal{V}}$ | $v_s = \frac{1}{\rho}$ |

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| $\rho = \frac{p}{R \cdot T}$ | jednadžba stanja idealnog plina | $\rho_r = \frac{\rho}{\rho_{ref}}$ | relativna gustoća | $R = 287{,}053\ \mathrm{J/(kg \cdot K)}$ | $\mu = 1{,}7894 \cdot 10^{-5}$ Pa·s | za zrak pri ISA/SL |

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| $\nu = \frac{\mu}{\rho}$ [m²/s] | kinematička viskoznost | $\mu = 2{,}417 \cdot 10^{-7} \cdot T^{0{,}76}$ [Pa·s] | eksponencijalni zakon | $\mu = 1{,}458 \cdot 10^{-6} \frac{T^{1{,}5}}{T + 110{,}4}$ | Sutherlandov zakon |

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| $E = -\mathcal{V}\frac{\mathrm{d}p}{\mathrm{d}\mathcal{V}}$ | modul elastičnosti fluida | $\frac{\mathrm{d}\rho}{\rho} = \frac{\mathrm{d}p}{E}$ | $E = \rho \cdot a^2$ | $Ma = \frac{V}{a}$ | Machov broj | $a = \sqrt{\kappa \cdot R \cdot T}$ | brzina zvuka | $\kappa = 1{,}4$ | za zrak |

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| $c_v = \left(\frac{\mathrm{d}q}{\mathrm{d}T}\right)_{v=const}$ | $c_p = \left(\frac{\mathrm{d}q}{\mathrm{d}T}\right)_{p=const}$ | spec. topline pri konstantnom volumenu ili tlaku [J/(kg·K)] | $R = c_p - c_v$ | $\kappa = \frac{c_p}{c_v}$ | $c_p = \frac{\kappa \cdot R}{\kappa - 1}$ | $c_v = \frac{R}{\kappa - 1}$ |

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| $u = c_v \cdot T$ [J/kg] | unutrašnja energija | $h = u + p \cdot v = c_p \cdot T$ [J/kg] | entalpija | $\mathrm{d}s = \frac{\mathrm{d}q_{rev}}{T}$ | entropija [J/(kg·K)] | $H = \frac{R_0}{R_0 + h} \cdot h$ |

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| $s_2 - s_1 = c_p \cdot \ln\frac{T_2}{T_1} - R \cdot \ln\frac{p_2}{p_1} = c_v \cdot \ln\frac{T_2}{T_1} + R \cdot \ln\frac{\rho_2}{\rho_1}$ | $p_a = p_z + p_p$ | Daltonov zakon | $\rho_{vz} = \rho_z + \rho_p$ | $\varphi = \frac{\rho_p}{\rho_{p\max}} = \frac{p_p}{p_{pz}}$ | rel. vlaž. |

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| $\frac{\mathrm{d}p}{\mathrm{d}h} = -\rho \cdot g$ | osnova diferencijalna jednadžba aerostatike | $F_Z = \rho \cdot g \cdot \mathcal{V}$ | sila aerostatskog uzgona | $g = g_n \cdot \left(\frac{R_0}{R_0 + h}\right)^2$ | $\rho_{vz} = \frac{p_a}{R \cdot T} - \frac{\varphi \cdot p_z}{T}\left(\frac{1}{R} - \frac{1}{R_p}\right)$ |

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| $T = T_n - 6{,}5 \cdot 10^{-3} \cdot H$ | $p = p_n \cdot \left(1 - 2{,}256 \cdot 10^{-5} \cdot H\right)^{5{,}256}$ | $\rho = \rho_n \cdot \left(1 - 2{,}256 \cdot 10^{-5} \cdot H\right)^{4{,}256}$ | promjena temperature, tlaka i gustoće zraka u troposferi |
| $T = 216{,}65\ \mathrm{K} = \mathrm{const.}$ | $p = 0{,}22336 \cdot p_n \cdot e^{-1{,}577 \cdot 10^{-4}(H - 11000)}$ | $\rho = 0{,}29708 \cdot \rho_n \cdot e^{-1{,}577 \cdot 10^{-4}(H - 11000)}$ | temperatura, tlak i gustoća u donjem sloju stratosfere |

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| $\dot{m} = \frac{\Delta m}{\Delta t} = \rho VA$ | $Q = \frac{\Delta \mathcal{V}}{\Delta t} = VA$ | maseni i volumenski protok | $\dot{m} = const.$ | jednadžba kontinuiteta | $p + \frac{1}{2}\rho V^2 + \rho g z = const.$ | Bernoullijeva jednadžba |

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| $\frac{\partial}{\partial t}\int_{\mathcal{V}} \rho \vec{V} d\mathcal{V} + \int_S \left(\rho \vec{V} \cdot d\vec{S}\right) \cdot \vec{V} = \int_{\mathcal{V}} \rho \vec{f} d\mathcal{V} - \int_S p d\vec{S} + \vec{F}_{visk} + \vec{F}_{kont} + \vec{F}_{osl}$ | jednadžba održanja količine gibanja | $V_e = V\sqrt{\frac{\rho}{\rho_n}}$ | ekvivalentna brzina | |

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| $\alpha_a = \alpha - \alpha_{z0}$ | $\lambda = \frac{c(s)}{c(0)}$ | $\mathrm{AR} = \frac{b^2}{S}$ | $Z' = c_z \frac{1}{2}\rho_\infty V_\infty^2 A$ | $X' = c_x \frac{1}{2}\rho_\infty V_\infty^2 A$ | $M'_{PB} = c_{MPB} \frac{1}{2}\rho_\infty V_\infty^2 Ac$ | $q_\infty = \frac{1}{2}\rho_\infty V_\infty^2$ |

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| $C_p = \frac{p - p_\infty}{q_\infty} = 1 - \left(\frac{V}{V_\infty}\right)^2$ | $c_{M\xi} = c_{MAC} + \left(c_z \cos\alpha + c_x \sin\alpha\right)\left(\bar{\xi} - \bar{\xi}_{AC}\right)$ | $\bar{\xi} = \frac{\xi}{c}$ | $c_{MPB} = -\xi_{CP}\left(c_z \cos\alpha + c_x \sin\alpha\right)$ |

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| $u = \frac{\partial\phi}{\partial x} = \frac{\partial\psi}{\partial y}$ | $v = \frac{\partial\phi}{\partial y} = -\frac{\partial\psi}{\partial x}$ | $w = \phi + i\psi$ | $z = x + iy = re^{i\theta}$ | $r = \sqrt{x^2 + y^2}$ | $e^{i\theta} = \cos\theta + i\sin\theta$ | $\theta = \mathrm{arctg}\,\frac{y}{x}$ |

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| $\bar{V} = \frac{\mathrm{d}w}{\mathrm{d}z} = u - iv$ | kompleksna brzina | $F'_a = \rho_\infty V_\infty \Gamma b$ | teorem Joukowskog | $c_z = 2\pi\alpha_a$ | $\mathrm{d}\vec{V} = \frac{\Gamma}{4\pi}\frac{\mathrm{d}\vec{y} \times \vec{r}}{\lvert r\rvert^3}$ | Biot – Savartov zakon | |

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| $-\frac{1}{2\pi}\int_0^c \frac{\gamma(x)\mathrm{d}x}{x_0 - x} + V_\infty \sin\left[\alpha - \mathrm{arctg}\left(\frac{\mathrm{d}z}{\mathrm{d}x}\right)_0\right] = 0$ | osnovna jednadžba tankog aeroprofila | $c_z = 2\pi\alpha$ | $c_{MPB} = -\frac{\pi}{2}\alpha$ | $\bar{x}_{CP} = \bar{x}_{AC} = \frac{1}{4}$ | simetrični aeroprofil |

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| $A_0 = \alpha - \frac{1}{\pi}\int_0^\pi \frac{\mathrm{d}z}{\mathrm{d}x}\mathrm{d}\theta$ | $A_n = \frac{2}{\pi}\int_0^\pi \frac{\mathrm{d}z}{\mathrm{d}x}\cos(n\theta)\mathrm{d}\theta$ | $c_z = 2A_0\pi + A_1\pi$ | $\alpha_{z0} = \frac{1}{\pi}\int_0^\pi \frac{\mathrm{d}z}{\mathrm{d}x}(1 - \cos\theta)\mathrm{d}\theta$ | $c_{MPB} = -\frac{\pi}{2}\left(A_0 + A_1 - \frac{A_2}{2}\right)$ |

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| $\bar{x}_{CP} = \frac{1}{4} - \frac{\pi}{4}(A_2 - A_1)\frac{1}{c_z}$ | $c_{Mx} = -\frac{c_z}{4} - \frac{\pi}{4}(A_1 - A_2) + \frac{x}{c}c_z$ | $c_{MAC} = -\frac{\pi}{4}(A_1 - A_2)$ | $\bar{x}_{AC} = \frac{1}{4}$ | $c_z = 2\pi\alpha_a$ | zakrivljeni aeroprofil |

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| $Re = \frac{\rho V x}{\mu} = \frac{Vx}{\nu}$ | $Z = C_z \frac{1}{2}\rho_\infty V_\infty^2 A$ | $X = C_x \frac{1}{2}\rho_\infty V_\infty^2 A$ | |

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| $\alpha_i = \mathrm{tg}^{-1}\frac{w_{y0}}{V_\infty} \approx \frac{w_{y0}}{V_\infty}$ | $\alpha_a = \alpha_0 - \alpha_i$ | $\alpha_a = \alpha - \alpha_{z0}$ | $C_{xi} = \frac{C_z^2}{\pi \mathrm{AR}}$ | $\alpha_i = \frac{C_z}{\pi \mathrm{AR}}$ | $m = \frac{m_0}{1+\frac{m_0}{\pi \mathrm{AR}}}$ | eliptično krilo |

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| $\mathrm{AR} = \frac{b^2}{S}$ | aspektni odnos | $C_z = m\alpha_a$ | $C_{xi} = \frac{C_z^2}{\pi \mathrm{AR}}(1+\delta)$ | $\delta = \sum_{n=2}^{N} n\left(\frac{A_n}{A_1}\right)^2$ | $e = \frac{1}{1+\delta}$ | $C_{xi} = \frac{C_z^2}{\pi\, e\mathrm{AR}}$ | za krila drugih oblika |

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| $\alpha_a = \alpha_0 + \frac{C_z}{\pi \mathrm{AR}}(1+\tau)$ | $\alpha_1 = \alpha_2 + \frac{C_z}{\pi}\left(\frac{1+\tau_1}{\mathrm{AR}_1} + \frac{1+\tau_2}{\mathrm{AR}_2}\right)$ | $Z = C_z \frac{1}{2}\rho_\infty V_\infty^2 A$ | $X = C_x \frac{1}{2}\rho_\infty V_\infty^2 A$ | $M = C_M \frac{1}{2}\rho_\infty V_\infty^2 A c$ |

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| $M_{AC,K} = C_{MAC,K}\frac{\rho V_\infty^2}{2} S c_a$ | $x_{CP,K} = \frac{-M_{RC}}{Z}$ | $M_{RC} = M_{AC,K} - Z x_{AC,K}$ | $x_{AC,K} = -\frac{(\mathrm{d}M_{RC}/\mathrm{d}\alpha)}{(\mathrm{d}Z/\mathrm{d}\alpha)}$ | $x_{AC,K} = \frac{b}{6}\frac{1+2\lambda}{1+\lambda}\mathrm{tg}\Lambda$ |

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| $\delta = 5{,}0\sqrt{\frac{\nu x}{U}}$ | $\overline{C}_{fl} = 1{,}328\sqrt{\frac{\nu}{Ul}}$ | $X_{fl} = \overline{C}_f \frac{\rho U^2}{2} A$ | laminarni granični sloj | $Re_{krl} = 5 \cdot 10^5$ | $Re_{kr} = \frac{\rho V x_{kr}}{\mu}$ | tranzicija laminarnog u turbulentni granični sloj |

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| $\delta = 0{,}371 x^{0,8}\left(\frac{\nu}{U}\right)^{0,2}$ | $\overline{C}_{ft} = 0{,}074\frac{1}{Re^{0,2}}$ | $\overline{C}_{ft} = \frac{0{,}455}{(\log Re)^{2,58}}$ za $Re > 10^7$ | $X_{ft} = \overline{C}_f \frac{\rho U^2}{2} A$ | turbulentni granični sloj |

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| $\overline{C}_{ftl} = \frac{0{,}074}{Re^{0,2}} - \frac{1700}{Re}$ | $\overline{C}_{ftl} = \frac{0{,}455}{(\log Re)^{2,58}} - \frac{1700}{Re}$ za $Re > 10^7$ | laminarno-turbulentni granični sloj | $C_{fstl} = \frac{C_{fnestl}}{\left(1+0{,}144 Ma_\infty^2\right)^{0,65}}$ | |

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| $X_{uk} = X_0 + X_l$ | $X_0 = X_{0,f} + X_{0,p}$ | $X_l = X_{l,f} + X_{l,i}$ | $X_{uk} = \sum_{j=1}^{n} X_j$ | $X_j = C_{xj}\frac{1}{2}\rho V_\infty^2 A_{ref}$ | $X_{uk} = C_{xuk}\frac{1}{2}\rho V_\infty^2 A_{ref}$ |

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| $C_{xuk} = K_0 + K_1 C_z^2$ | polara zrakoplova | | | | |

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| $\tau = \frac{\partial C_L/\partial \delta_f}{\partial C_L/\partial \alpha_u} = \frac{\partial \alpha_u}{\partial \delta_f}$ | djelotvornost upravljačke površine | $L = C_L q_\infty S_{up}$ | $H = C_h q_\infty S_f c_f$ | $M = C_M q_\infty S_{up} c$ | aerodin. karakteristike upravljačkih površina |

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| $Ma = \frac{V}{a}$ | $a = \sqrt{\kappa R T} = \sqrt{\frac{\kappa p}{\rho}}$ | $c_p T + \frac{V^2}{2} = const.$ | $\frac{a^2}{\kappa - 1}T + \frac{V^2}{2} = const.$ | Bernoulli-Lagrangeova jednadžba | $\frac{p}{\rho^\kappa} = const.$ |

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| $C_p = \frac{p - p_\infty}{0{,}5\rho_\infty V_\infty^2} = \frac{2}{\kappa Ma_\infty^2}\left(\frac{p}{p_\infty} - 1\right)$ | $C_p \cong -\frac{2\hat{u}}{V_\infty}$ | $C_p = \frac{C_{p,nestl}}{\beta} = \frac{C_{p,nestl}}{\sqrt{1 - Ma_\infty^2}}$ | $C_z = \frac{C_{z,nestl}}{\sqrt{1 - Ma_\infty^2}}$ | $C_M = \frac{C_{M,nestl}}{\sqrt{1 - Ma_\infty^2}}$ |

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| $x_{CP} = x_{CP,nestl}$ | $x_{AC} = x_{AC,nestl}$ | $C_{p,kr} = \frac{2}{\kappa Ma_{\infty,kr}^2}\left\{\left[\frac{2 + (\kappa - 1)Ma_{\infty,kr}^2}{\kappa + 1}\right]^{\frac{\kappa}{\kappa - 1}} - 1\right\}$ | $Ma_{\infty,kr} = \frac{V_{\infty,kr}}{a}$ | |

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| $V_0 = \sqrt{V^2 + V_t^2}$ | $V_t = r\varpi = 2\pi r n$ | $\alpha_a = \beta - \phi$ | $H = 2\pi\, r\mathrm{tg}\beta$ | $H_a = 2\pi\, r\mathrm{tg}\phi = \frac{V}{n}$ | $S_k = H - H_a$ | $\sigma_p = \frac{mc}{2\pi\, r}$ |

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| $A_p = \frac{D^2\pi}{4}$ | $F_v = \rho A_p\left(V + \frac{\Delta V_u}{2}\right)\Delta V_u = \dot{m}\Delta V_u$ | $P_u = \dot{m}V\Delta V_u\left(1 + \frac{\Delta V_u}{2V}\right)$ | $P_k = F_v V = \dot{m}V\Delta V_u$ | $\eta_i = \frac{P_k}{P_u} = \frac{1}{1 + \Delta V_u/(2V)}$ |

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| $\mathrm{tg}\phi = \frac{V}{V_t} = \frac{V}{2\pi\, rn}$ | $J = \frac{V}{nD}$ | $F_v = C_T \cdot \rho \cdot n^2 \cdot D^4$ | $P_u = C_p \cdot \rho \cdot n^3 \cdot D^5$ | $\eta_e = \frac{\mathrm{tg}\phi}{\mathrm{tg}(\phi + \gamma)}$ | $\eta = \frac{P_k}{P_u} = \eta(J, \beta)$ | |

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| $\gamma = \frac{\delta X}{\delta Z} = \frac{c_x}{c_z}$ | $C_s = \frac{V/(nD)}{C_P^{0,2}} = V\left(\frac{\rho}{P_u n^2}\right)^{0,2}$ | $V_{0P} = \sqrt{V^2 + (D\pi n)^2}$ | $Ma_{0P} = Ma\sqrt{1 + \left(\frac{\pi}{J}\right)^2}$ | $\vec{M}_3 = (I_1\vec{\varpi}_1) \times \vec{\varpi}_2$ | |

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| $\frac{l_{m1}}{l_{o1}} = \frac{l_{m2}}{l_{o2}} = \ldots = k_g = \mathrm{const.}$ | $\frac{V_{m1}}{V_{o1}} = \frac{V_{m2}}{V_{o2}} = \ldots = k_k = \mathrm{const.}$ | $\frac{F_{in,m1}}{F_{in,o1}} = \frac{F_{in,m2}}{F_{in,o2}} = \frac{F_{\mu,m1}}{F_{\mu,o1}} = \frac{F_{\mu,m2}}{F_{\mu,o2}} = \frac{F_{p,m1}}{F_{p,o1}} = \ldots = k_F = \mathrm{const.}$ |

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| $Re = \frac{\rho V x}{\mu} = \frac{Vx}{\nu}$ | $Ma = \frac{V}{a}$ | $Fr = \frac{V^2}{gl}$ | $Eu = \frac{\Delta p}{\rho V^2} = \frac{C_p}{2}$ | $St = \frac{lf}{V_\infty}$ | $I_t = \frac{\sqrt{\overline{V'^2}}}{\overline{V}_\infty}$ | $\varepsilon_t = \frac{\sqrt{\overline{u'^2}}}{\overline{V}_\infty}$ | |

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| $Re_m = Re_o$ | $Ma_m = Ma_o$ | $Fr_m = Fr_o$ | $Eu_m = Eu_o$ | $St_m = St_o$ | $I_{t,m} = I_{t,o}$ | $\varepsilon_{t,m} = \varepsilon_{t,o}$ | |