5. DROPED PAPER

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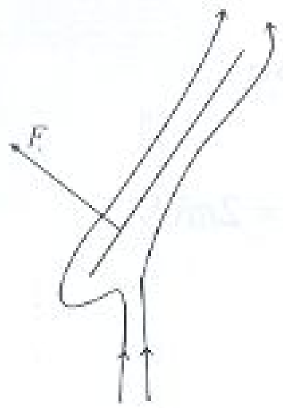
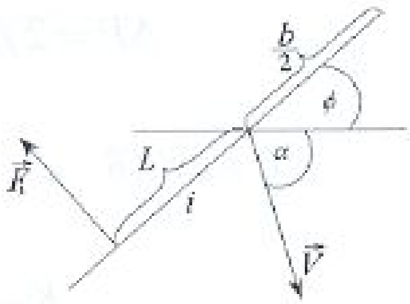
School № 42 named after I.N. Vekua



pic.1



pic.2

$Re \sim 10^3$

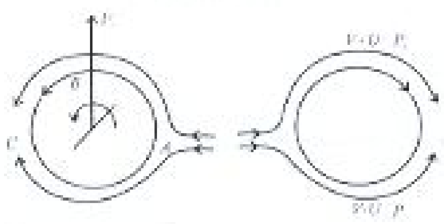
$$F_1 = 0{,}13\rho V^2 S \sin i \qquad \sin i = \sin(\alpha - \varphi)$$

$$L = 0{,}3b(1 - \sin i) \qquad tg\alpha = \frac{\dot{y}}{\dot{x}}$$

$$M_o = F_1 L$$

$$M_o = I\ddot{\varphi} \qquad I = \frac{mb^2}{12}$$

F_1 is force caused by air when paper moves with velocity V. F_1 makes moment M_0 with respect to c.m. of paper and paper begins rotation. ρ - density of air, S-square of paper, I - inertial moment with respect to longest axis, m is mass of paper and b-width of paper. L,φ,α are shown on pic.2



When paper rotates because of air friction air rotates around paper and as a result of this event we have two flows: rotating and blowing ones.

At the ABC airflow intensive each other at the AC break each other ABC is longer than AC so rotation conserves Because of velocity difference according the Bernoulli rule appears difference of pressure U is velocity of rotating Forces caused by difference of pressure are expressed below
In simple model we have:

$$P_1 = P_0 - \frac{\rho(U-V)^2}{2} \qquad P_2 = P_0 - \frac{\rho(U+V)^2}{2}$$

$$\Delta P = 2\rho UV \qquad F = \Delta PS$$

$$F = \rho KVR \quad \text{where} \quad K = 2\pi RU$$

$$K = \sum_{ACA} \Delta\vec{r}\vec{V} = \oint_{ACA} \vec{V}d\vec{r}$$

force caused by rotation is following:

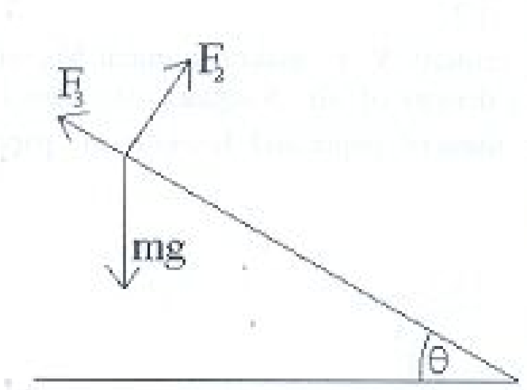
$F_2 = \rho KVl \qquad K = \mu\pi b^2\omega$ ω - an angular velocity of paper

$F_3 = \eta l_1 V$ viscosity force η -viscosity of air

$m\vec{a} = m\vec{g} + \vec{F}_1 + \vec{F}_2 + \vec{F}_3$ Newton's second law

When air surrounds paper F_1 disappears and we have no moment.

Steady motion



Steady motion trajectory of a paper is line which makes angle θ with respect to the horizontal. Steady condition means balance of all forces Condition of balance is expressed below and we get dependence of steady angle on different parameters.

$$F_3 = mg\sin\theta$$

$$F_2 = mg\cos\theta$$

$$tg\theta = \frac{F_3}{F_2} = \frac{\eta l_1}{\mu\pi b^2 \omega l\rho}$$