EXPERIMENTAL PHYSICS 1

EXERCISE 11
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Problem 1: Stokes Friction $\mathbf{2+2\ Points}$

A sphere with a radius of 1.5 cm and a mass of 10g is released at the bottom of a very long tube which is filled with oil (density $\rho = 850\,\frac{\mathrm{kg}}{\mathrm{m}^3}$, viscosity $\eta = 0.081\,\frac{\mathrm{kg}}{\mathrm{m\cdot s}}$).

a. What is the sphere's acceleration when it is released?
b. What is the maximum speed the sphere will reach after a while?

Problem 2: Sinking Sphere $\mathbf{(3+1+4+2\ Points)}$

A steel sphere (radius r) is immersed in water (viscosity η) and held at rest. At $t = 0$ the sphere is released and starts to sink.

a. Sketch and calculate the forces acting on the sphere right at the beginning of the decent.
b. Sketch the forces acting on the sphere after it sunk for a quite a large distance.
c. Calculate the speed $v(t)$ of the sphere as a function of time by integration of the equation of motion.
d. After which time has the speed reached its $(1 - 1/e \approx 0.6321)$ of the terminal speed?

$\rho_{\text{steel}} = 8000\,\mathrm{kg/m^3}$, $\rho_{\text{water}} = 1000\,\mathrm{kg/m^3}$, $r = 2\,\mathrm{mm}$, $\eta = 1\,\mathrm{mPa\,s}$

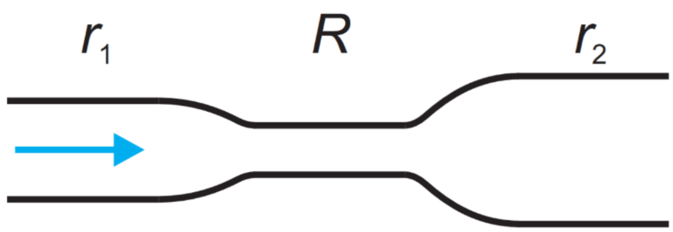
Problem 3: Beer keg **$(2 + 2 + 4 + 1$ Points$)$**

A large keg of height H and cross-sectional area A_1 is filled with root beer. The top is open to the atmosphere. There is a spigot opening of area A_2, which is much smaller than A_1, at the bottom of the keg.

a) Show that when the height of the root beer is h, the speed of the root beer leaving the spigot is approximately $\sqrt{2gh}$
b) Show that if $A_2 \ll A_1$, the rate of change of the height h of the root beer is given by $\frac{dh}{dt} = -\frac{A_2}{A_1} \cdot \sqrt{2gh}$.
c) Find h as a function of time if $h = H$ at $t = 0$.
d) Find the total time needed to drain the keg if $H = 2.00\ \mathrm{m}$, $A_1 = 0.8\ \mathrm{m}^2$, and $A_2 = 1 \cdot 10^{-4} A_1$. Assume laminar non viscous flow.

Problem 4: Pipe with changing radius **$(5$ Points$)$**

In the image below you can see water flowing from left to right through a pipe with changing cross section. The radius r_1 of the left pipe section is twice the radius of the narrowed section: $2R = r_1$. The radius of the right section is $r_2 = 3R$. Furthermore, in the middle narrow section the water flows with a velocity of $v = 0.5\frac{\mathrm{m}}{\mathrm{s}}$. Calculate the energy that is needed to move $0.4\ \mathrm{m}^3$ water from the segment on the left-hand side to the segment right-hand side.



Task to think about:

What is the role of turbolence in swimming? How can you swim without turbolence?

You put a race car on smaller tires and remove the rear wing. Will it be faster?