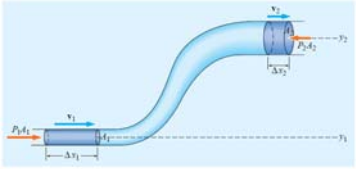
7.2 Fluid Dynamics

Fluid dynamics
Bernoulli equation
Venturi effects
Windmills

Bernoulli's Equation
Conservation of Energy in a flow tube



The change in Energy of mass m in going from 1 to 2 is equal to the Work done on the mass by external pressure.

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

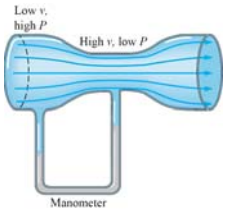
$$P + \frac{1}{2}\rho v^2 + \rho g y = \text{Constant}$$

Venturi flow

When fluid flows faster through a flow tube the pressure is decreased.

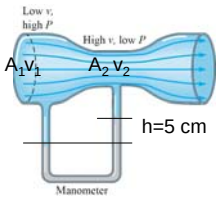
$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

The high pressure does work to increase the kinetic energy.



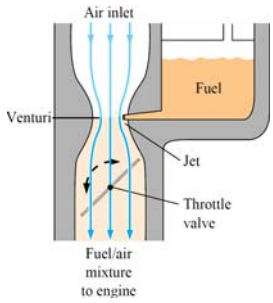
Venturi flowmeter

Air flows through a Venturi flowmeter having a tube with a diameter d_1 that has a constriction where the diameter is reduced by a factor of 2. A U-tube containing water connects the two regions. What is the velocity v_1 if the difference in the water between the two arms of the U-tube is 5.0 cm.

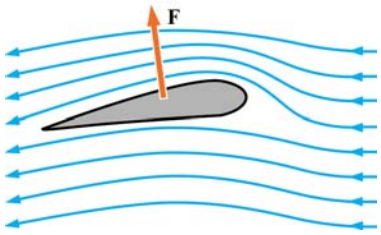


Carburator

Low pressure draws liquid into the airstream at the constriction.



Airflow over airplane wing

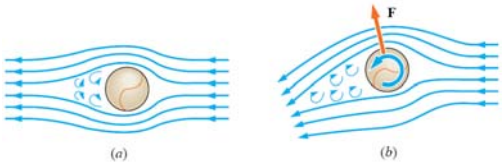


Higher velocity – lower pressure contributes to lift on the airplane wing.

Airplane lift

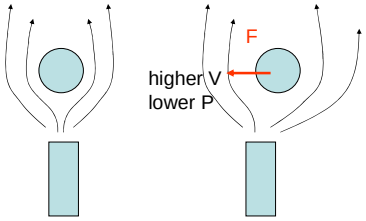
An airplane flies on a level path. There is a pressure difference of 500 Pa between the upper and lower surfaces of the wings. The area of each wing surface is about 100 m^2. The air moves below the wings at a speed of 80.5 m/s. Estimate the weight of the plane and the air speed above the wings.

Curve ball



Under spin-The higher air velocity above the ball contributes to the lift of the ball

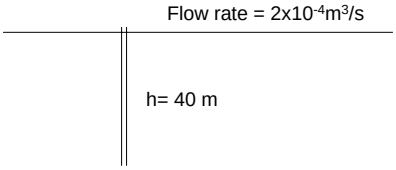
Aerodynamic stability



A ball suspended in an air stream is stable.

Pumping water

The volume flow rate of the water supplied by a well is $2x10^{-4}$ m^3/s. The well is 40 m deep. (a) What is the power output of the pump? (b) Find the pressure difference the pump must maintain. (c) Can the pump be at the top of the well or must it be at the bottom?



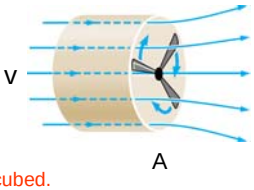
Wind power

Kinetic energy in moving air

KE= ½ mv^2

$m=\rho Av\Delta t$

Power $=KE/\Delta t = ½\ \rho Av^3$



power depends on velocity cubed.

Windmill

A windmill with a radius of 30m is powered by average wind speed of 10 m/s. If the windmill extracts kinetic energy from the wind with an efficiency of 50% how much power can it provide.

$$P = e\left(\frac{1}{2}\rho_{air} A v^3\right) = e\frac{1}{2}\rho_{air}\frac{\pi d^2}{4}v^3$$

$P = 0.5(0.5)(1.2)\pi(30)^2 10^3 = 8.5x10^5\,W = 0.85MW$

Tehachapi windmills

http://www.youtube.com/watch?v=-Uevs4Ak9S4&NR=1

http://maps.google.com/maps?hl=en&tab=wl