Lecture 1

Fluids at rest

Pascal

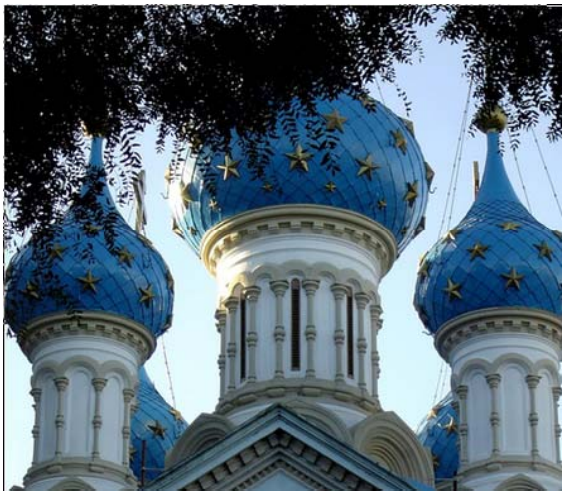
Physics 103 Spring 2012

Torricelli

http://web.njit.edu/~sirenko/Phys-103-2005/Phys-103-2012.htm

PRESSURE

$$p = \frac{F}{A} \quad \text{(pressure of uniform force on flat area),}$$



DENSITY and PRESSURE in FLUIDS

$$\rho = \frac{m}{V} \quad \text{(uniform density)},$$

TABLE 15-1 Some Densities

Material or Object	Density (kg/m^3)
Interstellar space	10^{-20}
Best laboratory vacuum	10^{-17}
Air: 20°C and 1 atm pressure	1.21
20°C and 50 atm	60.5
Styrofoam	1×10^2
Ice	0.917×10^3
Water: 20°C and 1 atm	0.998×10^3
20°C and 50 atm	1.000×10^3
Seawater: 20°C and 1 atm	1.024×10^3
Whole blood	1.060×10^3
Iron	7.9×10^3
Mercury (the metal)	13.6×10^3
Earth: average	5.5×10^3

Compressibility
Of liquids is very low

$$k = \frac{\Delta V / V}{\Delta P}$$

water has a compressibility of 4.5×10^{-10} Pa^{-1}.

Crystals

"…What do you know about crystals ?
"They make nice chandeliers !?.."

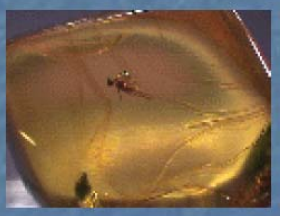
Superman Returns

- The habit of a crystal describes its overall shape
- These offer clues to how the atoms are arranged
- But, the growth (and shape) of crystals is also determined by a number of factors, including:
- (1) Temperature
- (2) Pressure
- (3) pH (acid or basic environment), etc
- So, scientists need another way to see how crystals form – the first way to do this is by x-ray diffraction (we will discuss this more in Chapter 2)
- Why do x-rays tell us about how the atoms are arranged?

Hexagonal beryl

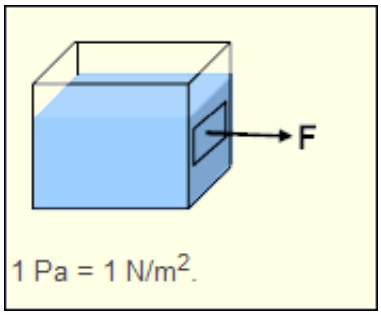
Monoclinic gypsum

Trigonal quartz



Amorphous amber (no underlying crystal symmetry)

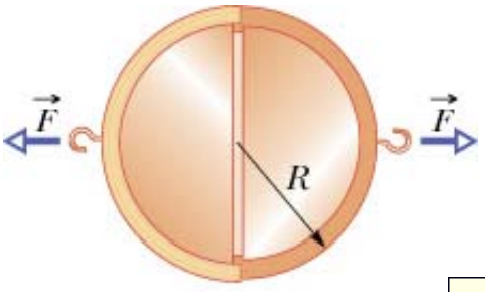
PRESSURE MEASUREMENT



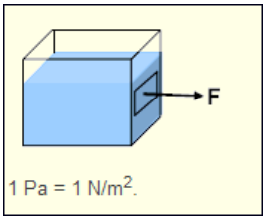
$$p = \frac{F}{A} \quad \text{(pressure of uniform force on flat area)},$$

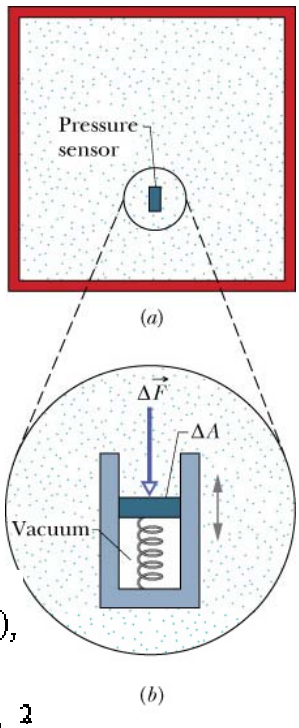
$$1 \text{ atm} = 1.01 \times 10^5 \text{ Pa} = 760 \text{ torr} = 14.7 \text{ lb/in.}^2.$$

PRESSURE MEASUREMENT



Magdeburg hemispheres





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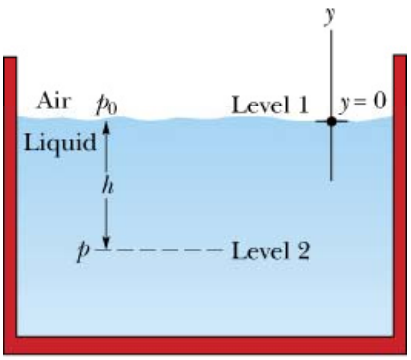
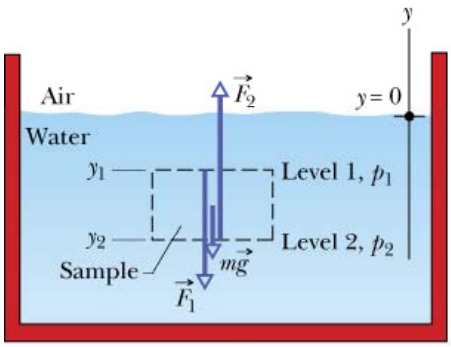
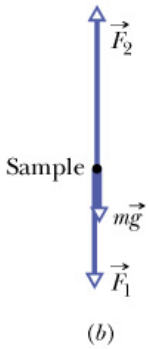




(a)

$$p = p_0 + \rho g h \quad \text{(pressure at depth } h\text{)}.$$

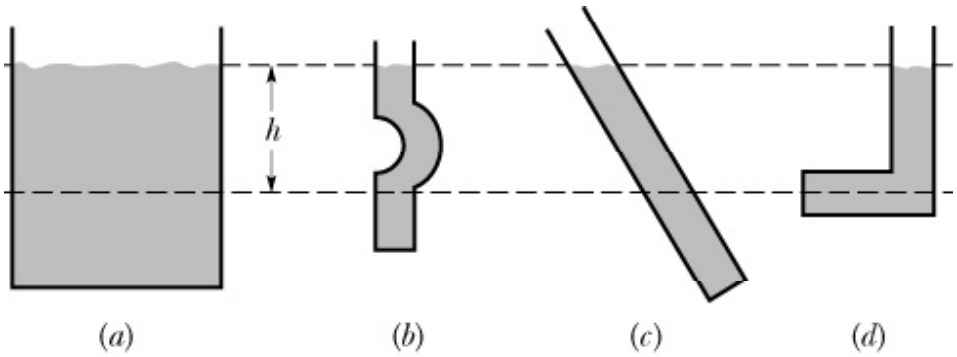
the pressure *increases* with depth below the air-water interface



(b)

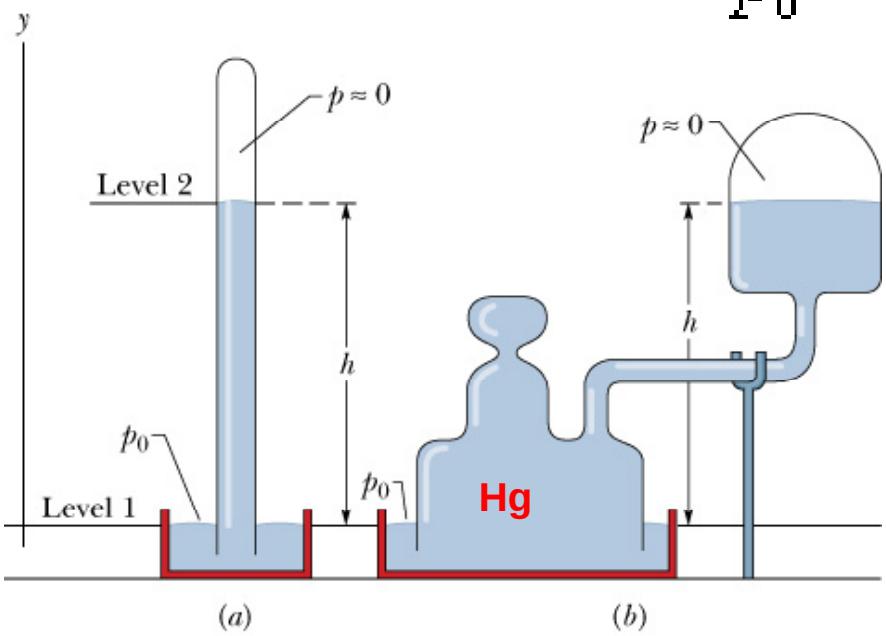
$$p_2 = p_1 + \rho g (y_1 - y_2).$$

QZ: The figure shows four containers of olive oil. Rank them according to the pressure at depth *h*, greatest first.

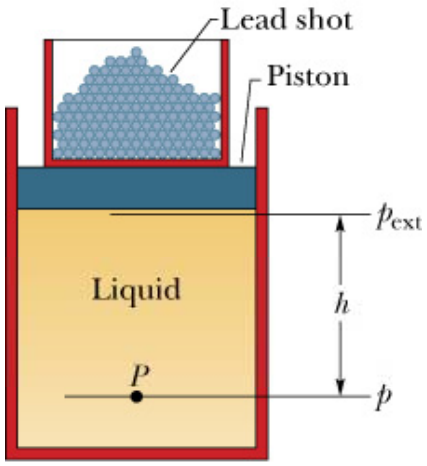


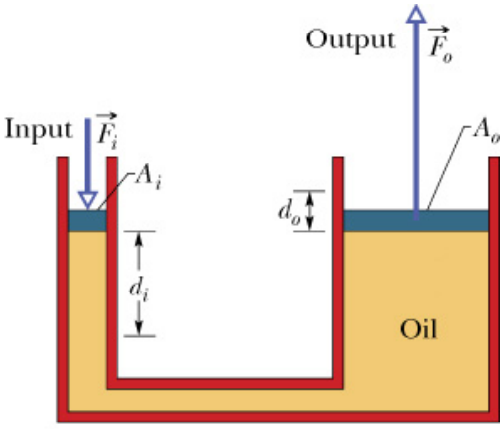
Measuring Pressure

$$p_0 = \rho g h.$$



Pascal's Principle

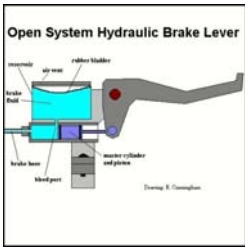


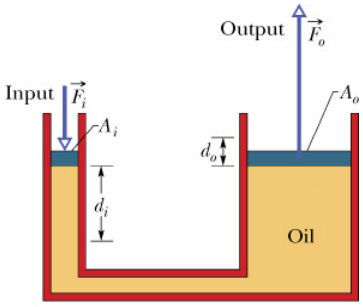


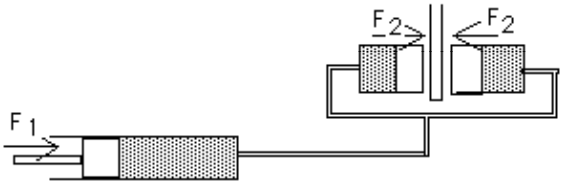
$$F_o = F_i \frac{A_o}{A_i}$$

With a hydraulic lever, a given force applied over a given distance can be transformed to a greater force applied over a smaller distance

Hydraulic Breaks







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With a hydraulic lever, a given force applied over a given distance can be transformed to a greater force applied over a smaller distance

FLUIDS at REST

The U-tube in Fig. 15-4 contains two liquids in static equilibrium: Water of density ρ_w ($= 998\ \text{kg/m}^3$) is in the right arm, and oil of unknown density ρ_x is in the left. Measurement gives $l = 135$ mm and $d = 12.3$ mm. What is the density of the oil?

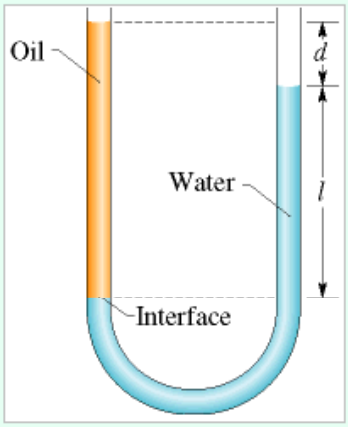


Fig. 15-4 Sample Problem 15-3 . The oil in the left arm stands higher than the water in the right arm because the oil is less dense than the water. Both fluid columns produce the same pressure P_{int} at the level of the interface.

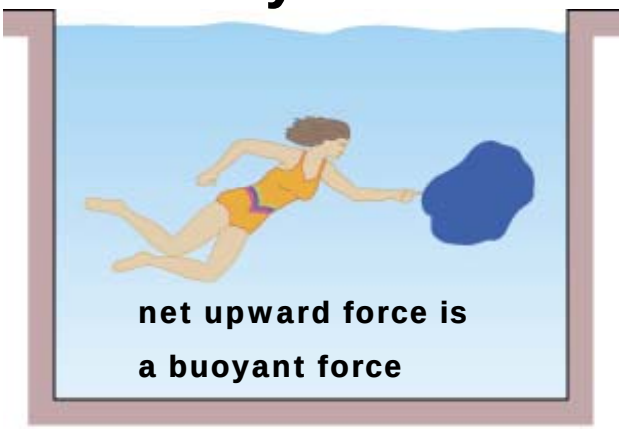
$$p_{int} = p_0 + \rho_w g l \qquad \text{(right arm)}.$$

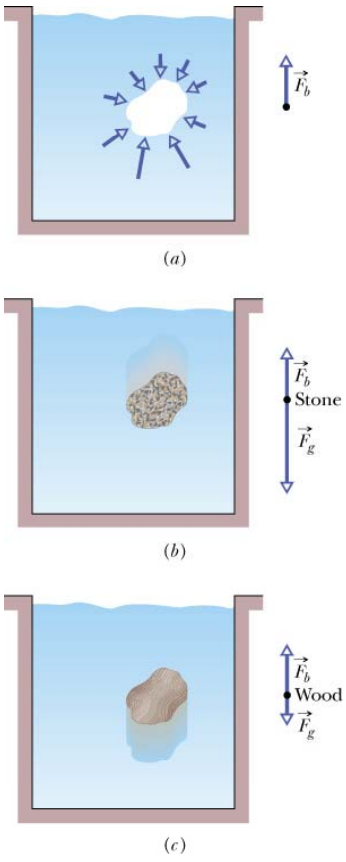
$$p_{int} = p_0 + \rho_x g (l + d) \qquad \text{(left arm)}.$$

$$p_x = \rho_w \frac{l}{l+d} = (998\ \text{kg/m}^3)\frac{135\ \text{mm}}{135\ \text{mm} + 12.3\ \text{mm}}$$

$$= 915\ \text{kg/m}^3.$$

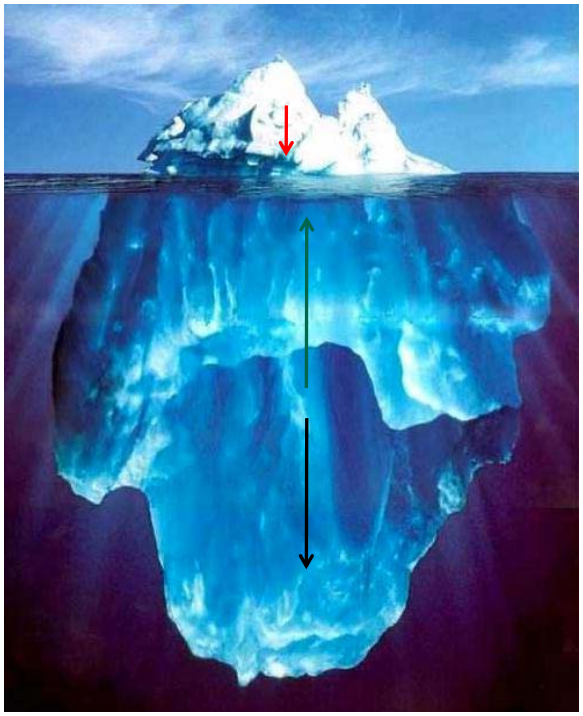
Buoyant force





When a body is fully or partially submerged in a fluid, a buoyant force F_b from the surrounding fluid acts on the body. The force is directed upward and has a magnitude equal to the weight $m_f g$ of the fluid that has been displaced by the body

Buoyant force



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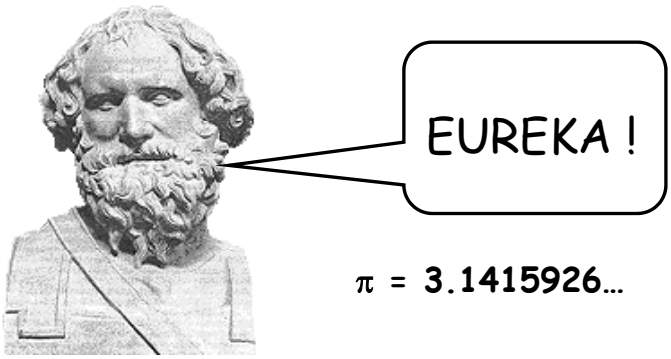
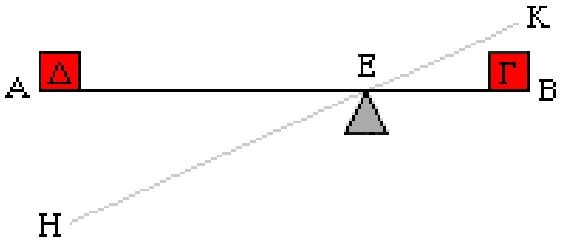
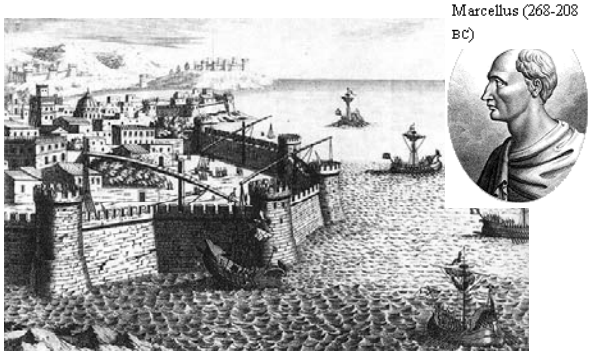


π = 3.1415926…

Archimedes
(287 BC - 211 BC)

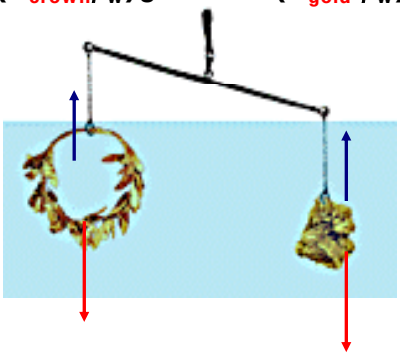




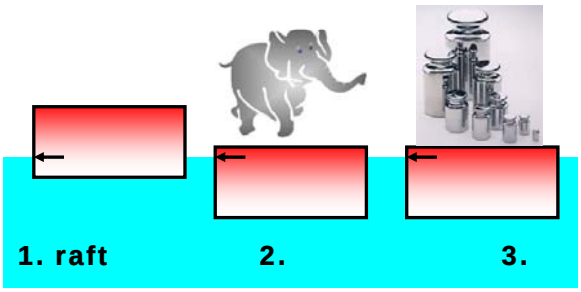
Marcellus (268-208 BC)

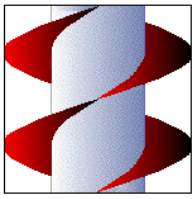
Hiero: "Is it really 100% gold ?"

$(V_{crown}\rho_w)g$ $(V_{gold}\rho_w)g$

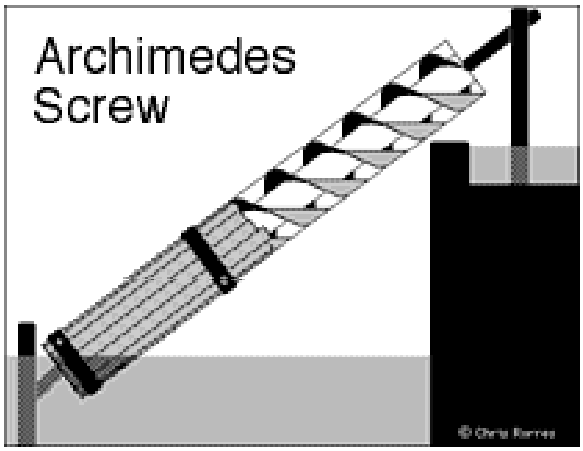


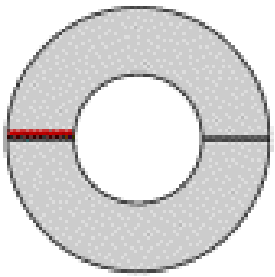
mg mg





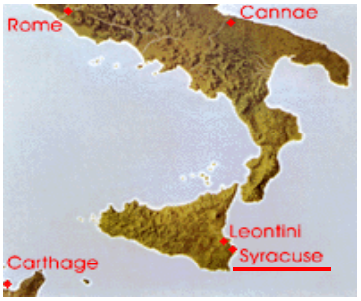
Archimedes Screw

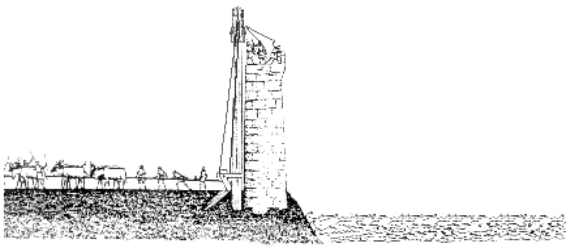


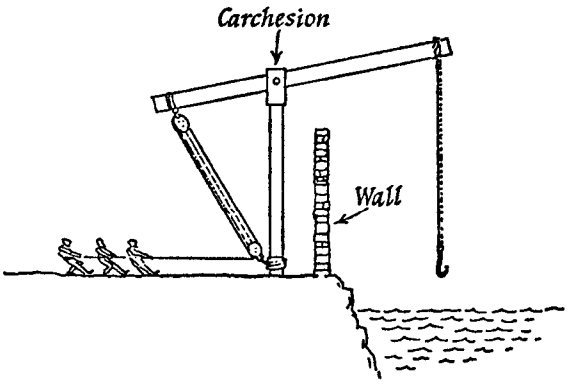


http://www.mcs.drexel.edu/~crorres/Archimedes/Claw/illustrations.html

Archimedes' Claw







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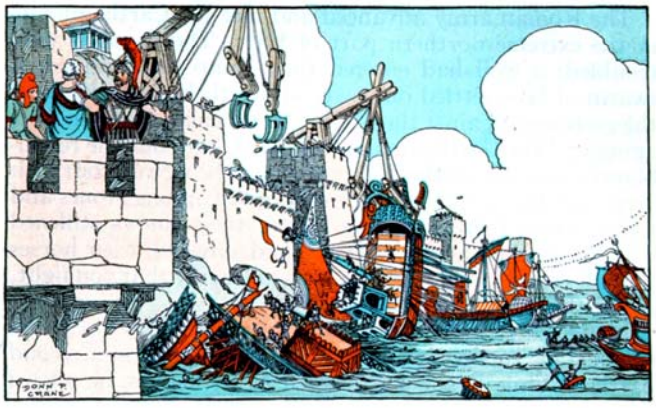

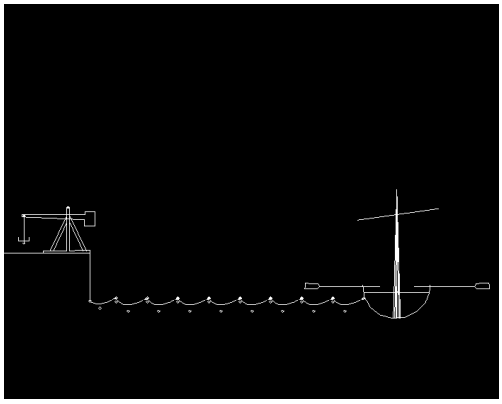

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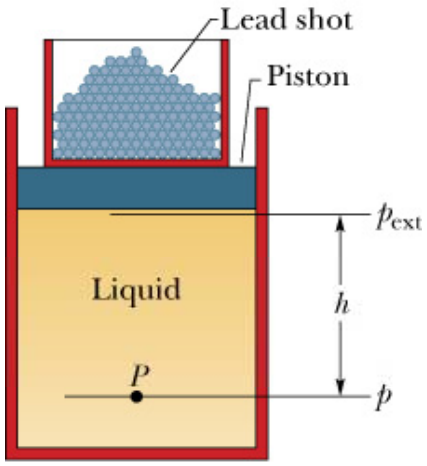
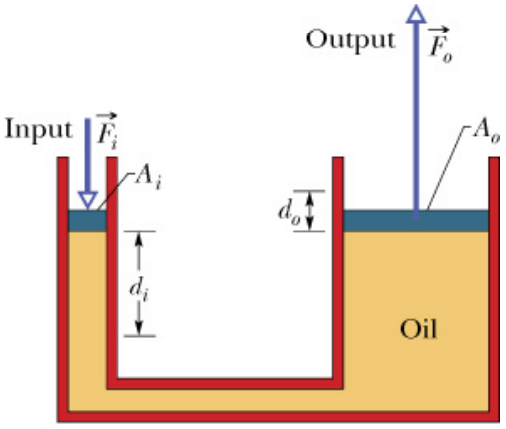
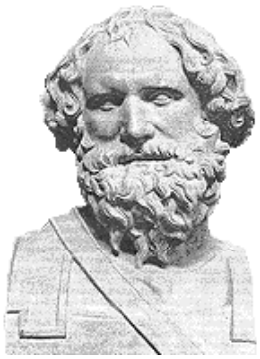
Pascal's Principle

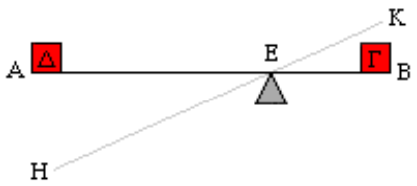




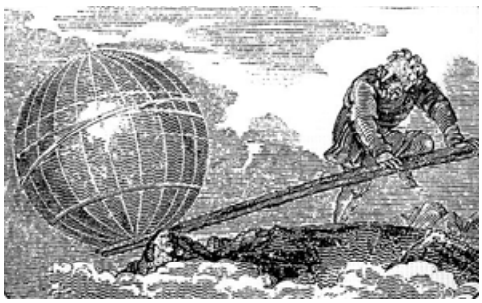
$$F_o = F_i \frac{A_o}{A_i}$$

With a hydraulic lever, a given force applied over a given distance can be transformed to a greater force applied over a smaller distance





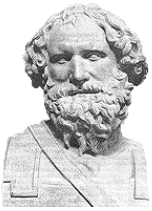
Archimedes
(287 BC - 211 BC)



GIVE ME A PLACE TO STAND AND I WILL MOVE THE EARTH

Give me a lever long enough and a place to stand, and I will move the world

Is it really possible ???



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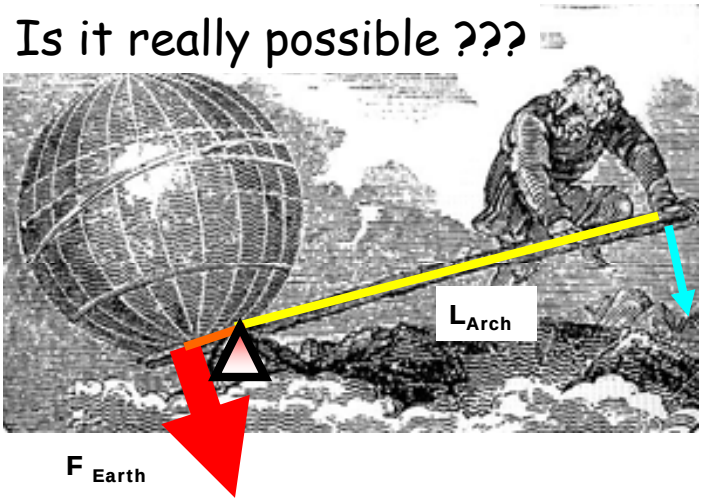
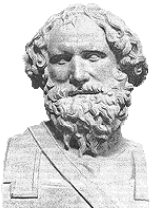


$F_{Earth} = 6\times10^{25}$ N ($M_{Earth} = 6\times10^{24}$ kg)

$F_{Arch} = 600$ N (60 kg)



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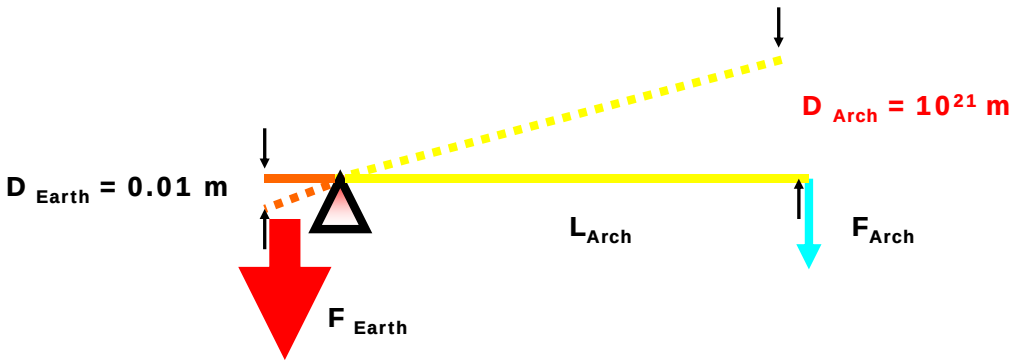


$F_{Arch} = 600$ N (60 kg)

$F_{Earth} = 6\times10^{25}$ N ($M_{Earth} = 6\times10^{24}$ kg)

$L_{Arch}/L_{Earth} = 1\times10^{23}$; ➔ $D_{Arch}/D_{Earth} = 1\times10^{23}$

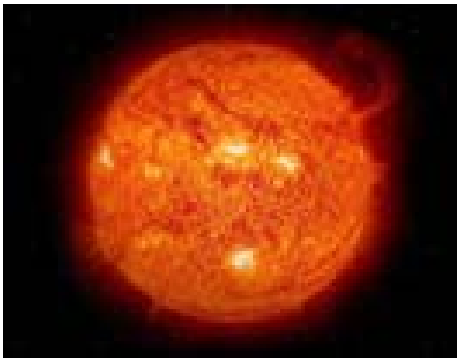
$D_{Arch} = 10^{21}$ m With the power of $P = 600 N\cdot m/s$, $t = 10^{21} s \cong 5\times10^{14}$ years

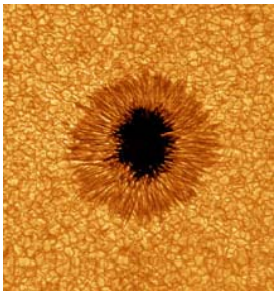
(people do not live that long)

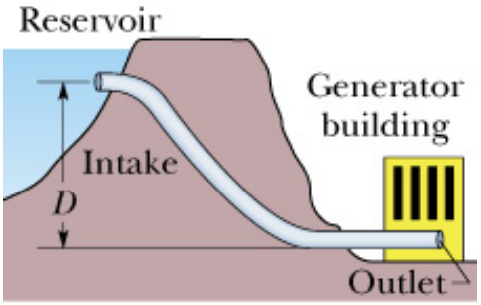
If Archimedes moves his arm with the speed of light, then

$D_{Arch} = 50$ m during 5×10^{9} years (life time of the Earth)

Perpetual Motion and "Free Energy"



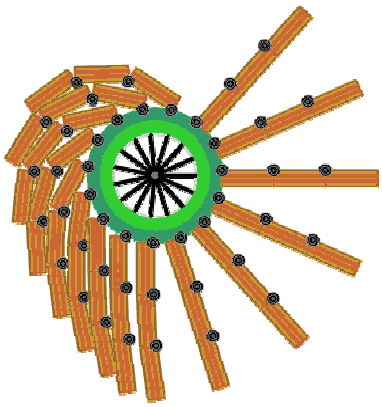


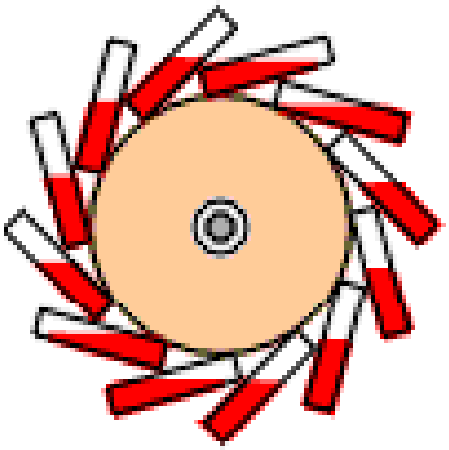


Perpetuum Mobile

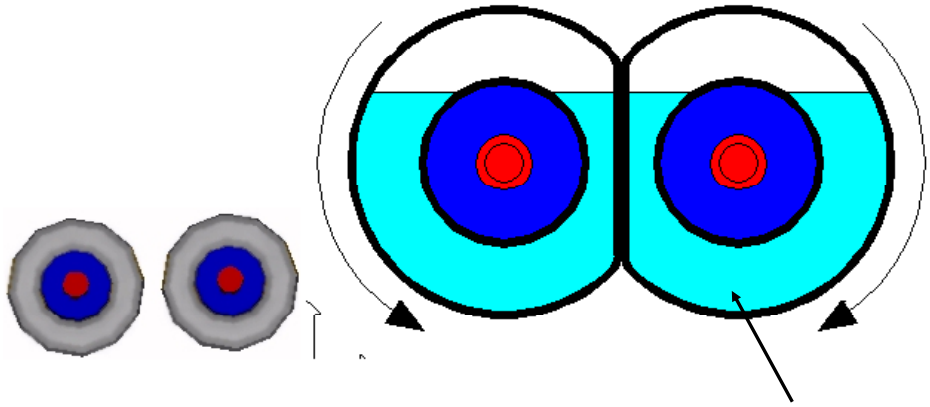
"Machine, which works itself forever"

English: Perpetual Motion





More Examples:

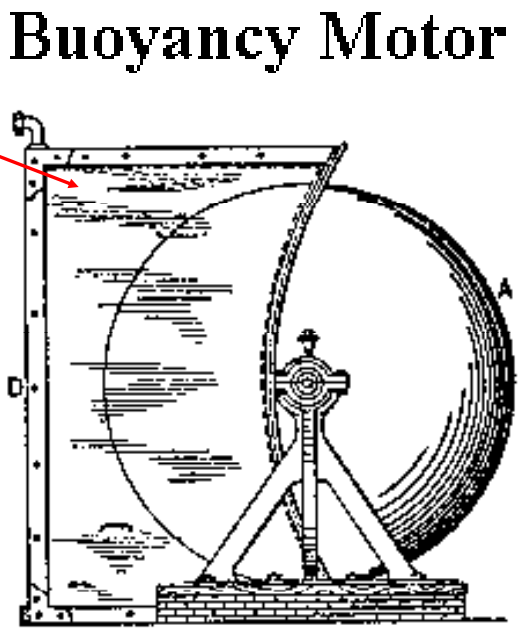


Put an innertube on a wheel. Fill it two thirds with wather. Put an axle through it so it can spin. Now make another one like it. Now hold the axels and push the wheel up against each other so that they can squeez each others wather to the outside. The results are that one side of each wheel is lighter than its other side. That is why the wheel spins.

More Examples:

Water

buoyant force of Archimedes' principle: "A body immersed in liquid experiences and upward buoyant force equal to the weight of the displaced liquid."



Lecture 1

Fluids at rest

http://web.njit.edu/~sirenko/Phys-103-2005/Phys-103-2011.htm

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