Physics 2C: Fluids, Thermodynamics, Optics and Waves

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Additions to Syllabus:

Prof. office hours: Wed 2-3pm, 312 SERF bldg.

Tuesday lecture: start time 8-8:10am, HSS 22
(babysitter)

Muir campus

Things you need to know ....

Homeworks: (0%)
- Check the WWW page for assignments.
- Solutions posted ~ Wednesday's lecture
- Do the problems yourself!

Quizzes: (65%)
- every Friday, incl. this Friday
- best 5 count towards grade, no make-ups

Final Exam: (35%)
- Tues March 20, 11:30am
- inform me of conflicts asap!

"Rules"

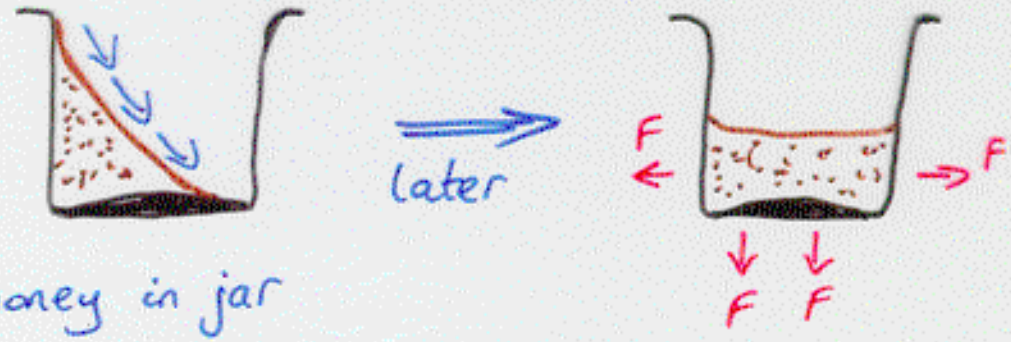
- All tests "closed book"
  - bring new, empty blue book to each quiz
- Lectures define course content, not textbook
- No, I don't "grade on a curve".

FLUIDS : stuff (matter) that flows!

(liquids and gases)

i.e. cannot sustain tangential (shear) forces

e.g.



honey in jar

- time taken ∝ viscosity
- conforms to container's shape
- – fluids do exert force ⊥ to boundaries (F)
- fluids "seek their own level" at equilibrium

Physical Properties

1. Density ρ ≡ mass / unit volume [kg/m³]

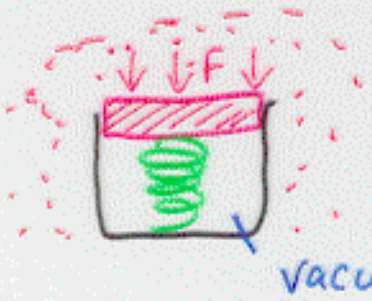
e.g. water has $\rho = 1000\ kg/m^3$

air in room ≈ $1.2\ kg/m^3$

Note: pump air into tire ⇒ tire gets heavier

Weight of air $mg = \rho V g$.

2. Pressure P = force / unit area



gas pressure on piston compresses spring

$P = F/A$

(Kinetic theory of gases will explain origin of force F).

Units: $1\ N/m^2 \equiv 1$ Pascal (Pa)

$1\ atm \approx 10^5\ Pa \approx 760$ torr ≈ 15 psi (Appendix D

mm Hg

Note:

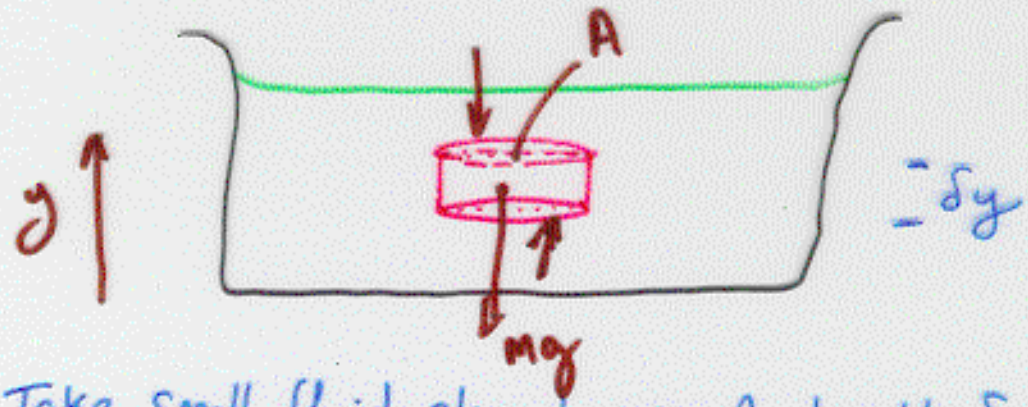
Gases – density ρ changes with pressure (and temperature)

e.g. can "squeeze" more air into constant-volume tire

Liquids – density ~ constant with pressure

"incompressible"

Fluids at Rest - Hydrostatic Pressure



Take small fluid element, area A, height δy

At eqm., weight of element supported by pressure difference.

Force on bottom of element = $P \cdot A$

top = $(P+\delta P) \cdot A$

So $P \cdot A = (P+\delta P) \cdot A + \underbrace{\rho \overbrace{A \delta y}^{\text{volume}} g}_{=\text{weight}}$

i.e. $\delta P = -\rho g \delta y$

$$\Rightarrow \frac{dP}{dy} = -\rho g \quad \text{(pressure gradient)}$$

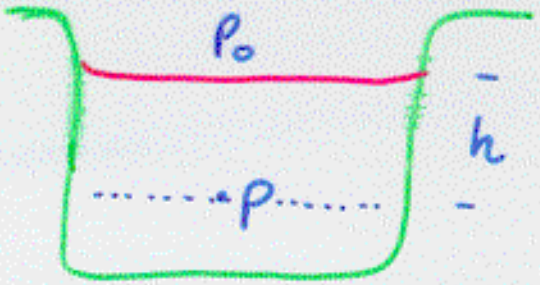
OR $$P_1 - P_2 = -\int_{y_1}^{y_2} \rho g \cdot dy$$

Pressure at any level y = weight of all the stuff above that level (at eqm.)

$$P_1 - P_2 = -\int \rho g \, dy$$

e.g. for incompressible liquids, ρ = constant

$\Rightarrow$ $P = P_0 + \rho g h$ at depth h :



P_0 = atm. pressure at surface = weight of air column

Example: For a human 2 m tall, show that the blood pressure difference between head and feet is approx. 2×10^4 Pa. Give 3 significant figures

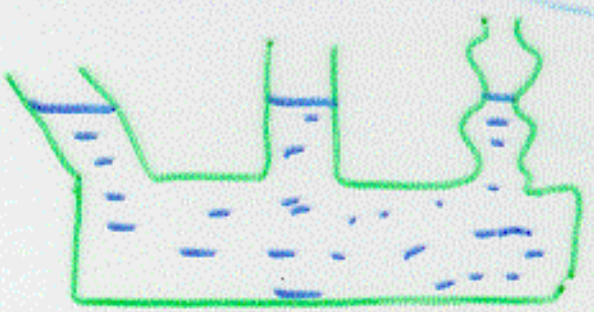
$\rho_{blood} = 1.1 \times 10^3 \text{ kg/m}^3$

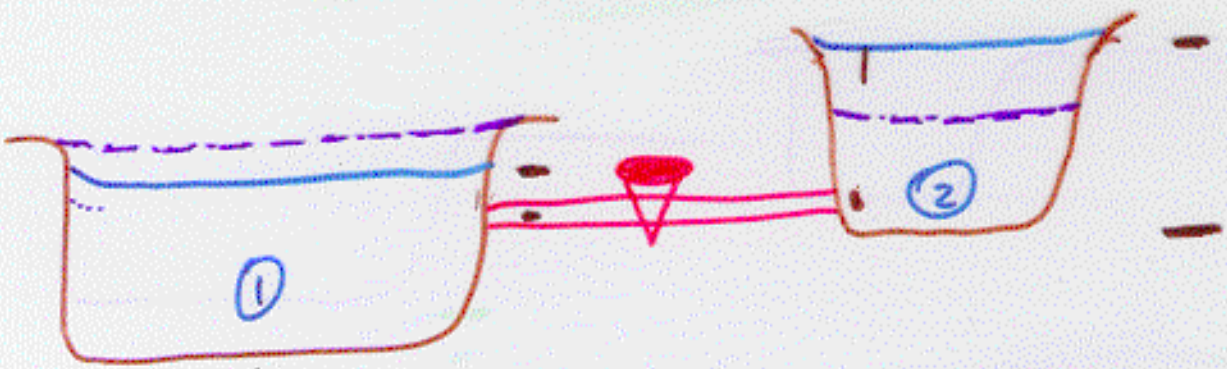
$g = 9.81 \text{ m/s}^2$

"Fluids seek their own level"

Reason : Pressure depends only on depth

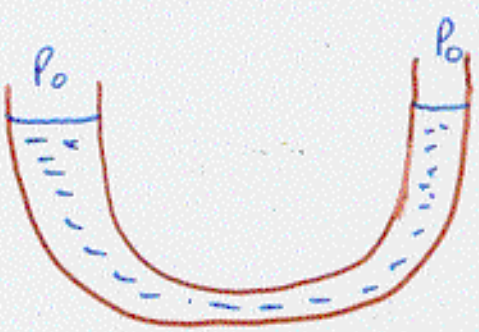
e.g.





Open valve in pipe : higher pressure in ② forces liquid from ② to ① until each end of pipe is at same pressure, i.e. same depth

c.f. "U-tube"



level does <u>not</u> depend on width of tube.