Physics 2c Lecture 9

Recap of Entropy

First part of chapter 18:

Hydrostatic Equilibrium

Measuring Pressure

Pascal's Law

Archimedes Principle

Defining Entropy

Macroscopic Definition of entropy difference:

$$\Delta S = \int_1^2 \left(\frac{dQ}{T} \right)$$

integral may go **via any reversible process.**

Microscopic Definition of entropy:

$$S = k \ln \Omega$$

Ω = number of microscopic states/macroscopic state

Entropy in a cyclic process

Entropy = measure of likelihood of a macroscopic state.

Reversible cyclic process by definition returns to the same macroscopic state.

=> Entropy of the system is the same at the beginning and end of a cyclical reversible macroscopic process.

Entropy is a "state variable"

Entropy & 2nd law of thermo

No process is possible in which the total entropy decreases, after all systems taking part in the process are included.

The entropy of the universe can only increase!

Macroscopically, the universe changes towards more likely outcomes.

Why does my bedroom strive towards the disorderly state?

Because there are many more ways of being disorderly than orderly!

Aside on next Monday's Quiz

- The quiz will cover:
  - entropy, and related topics.
  - The first "half" of chapter 18. I.e. anything to do with hydrostatics, but nothing to do with dynamics.
    - All the material of today's lecture will be covered in quiz on Monday.
    - Material introduced only tomorrow will not be on the quiz!

Chapter 18 Fluid “dynamics”

Today we will cover “static” situations.
Tomorrow we cover flows.

Hydrostatic Equilibrium

$P = F/A$ or dF/dA

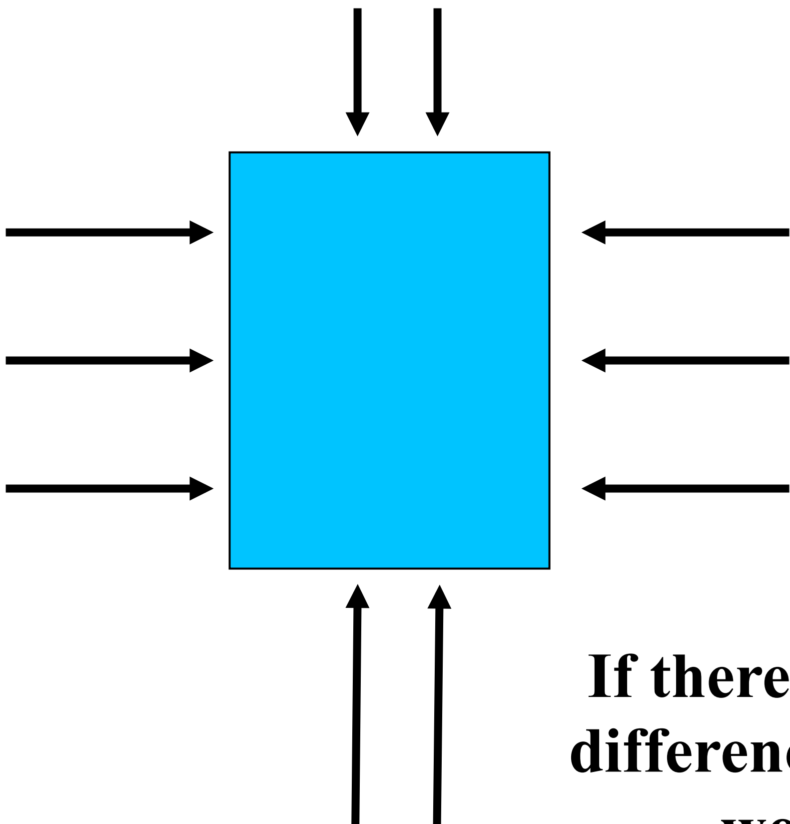
Fluid at rest => net force everywhere = 0 => P=const

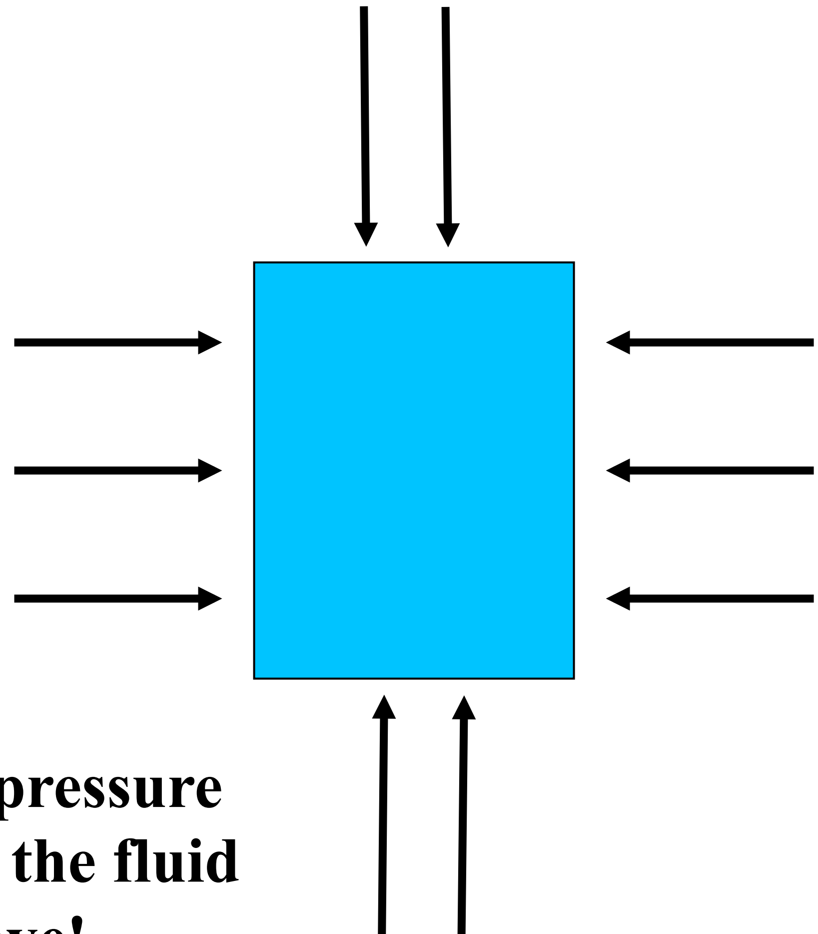
Hydrostatic Equilibrium

Pressure is constant everywhere in the fluid.

Example: Hydrostatic Equilibrium with gravity

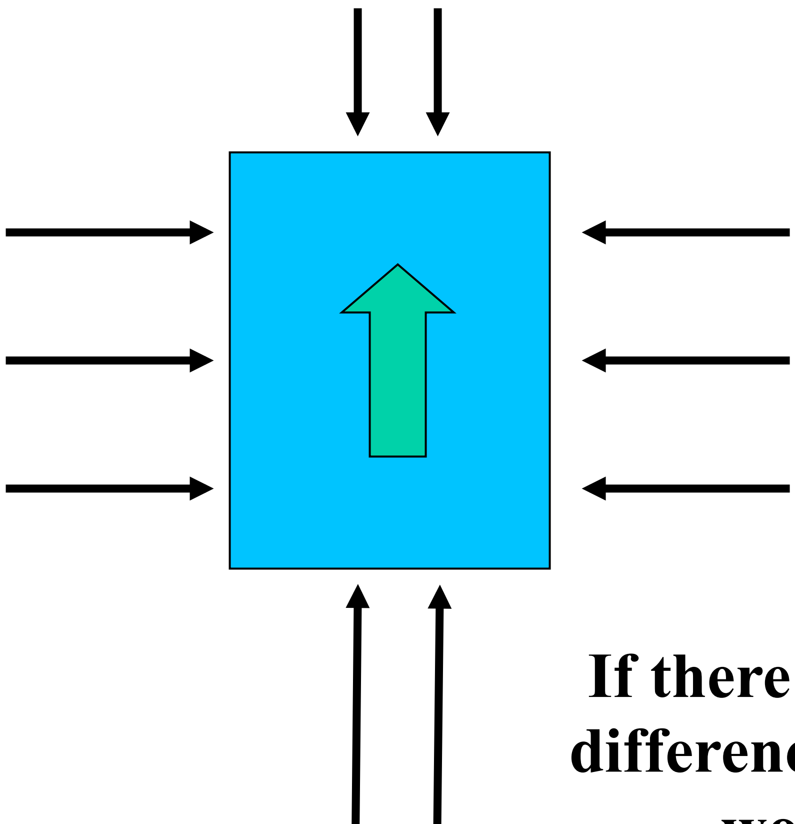
What do I mean by this?

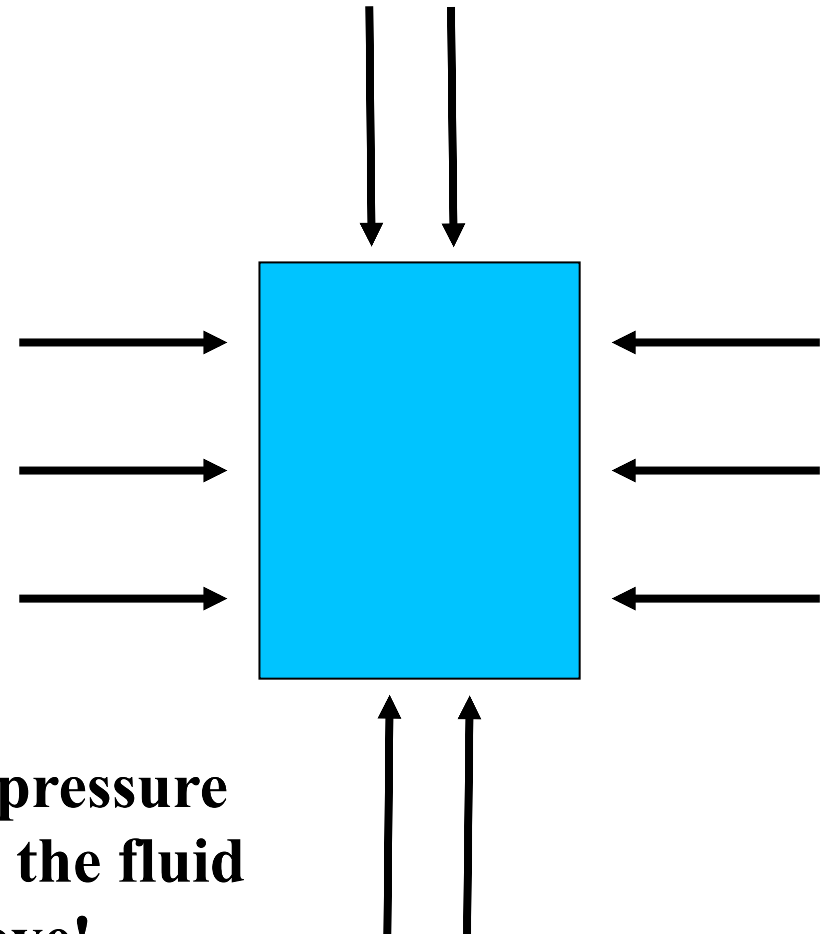




If there was a pressure difference then the fluid would move!

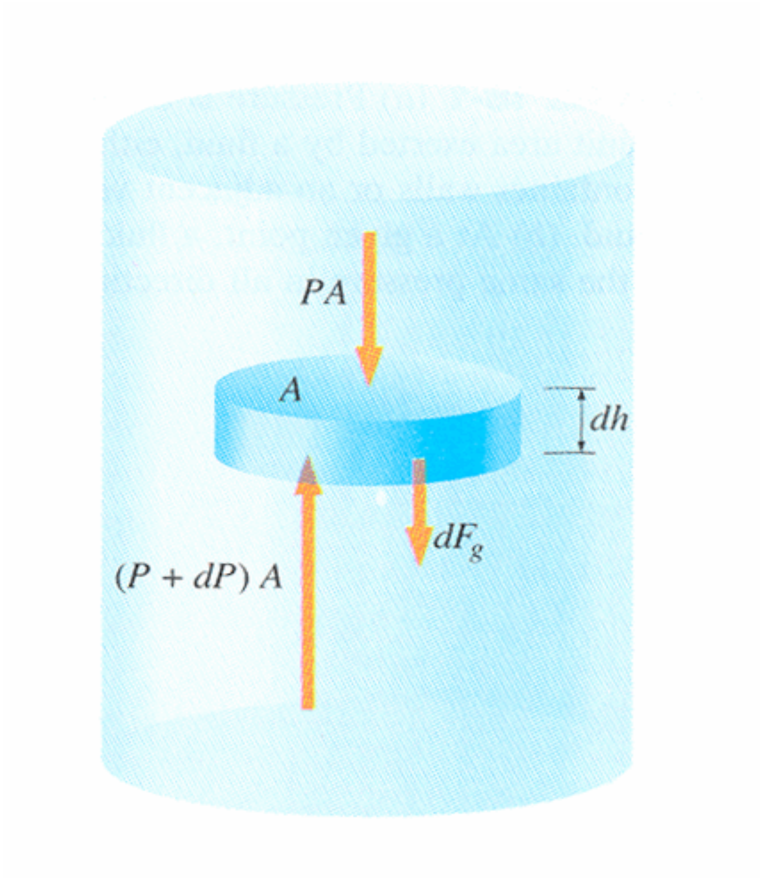
What do I mean by this?





If there was a pressure difference then the fluid would move!

Hydrostatics & Gravity



Net force due to pressure:
$dF_{press} = (P+dP)A - PA = A\,dP$

Force due to gravity and mass dm:
$dF_{grav} = -g\,dm = -g\,\rho\,A\,dh$

Hydrostatic Eq. Requires:
dFpress + dFgrav = 0
=> $dP/dh = g\,\rho$

$$P = P_0 + g\,\rho\,h$$

Applications:

Sensation in your ears when diving to the bottom of a deep swimming pool.

Barometer

limits of water pumps based on suction

Barometer

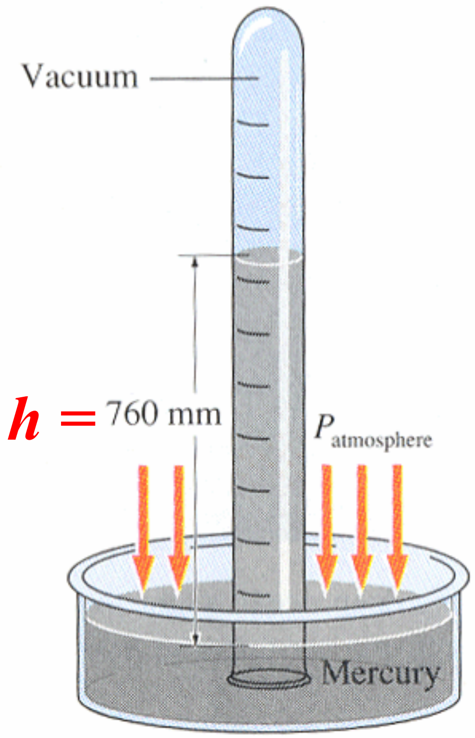


FIGURE 18-6 A mercury barometer. Normal air pressure supports a mercury column 760 mm high.

$$P = g\,\rho\,h$$

How deep a well can a suction pump empty out?

- (a) 1m
- (b) 10m
- (c) 100m
- (d) 1km

- ***$P = 1atm = 10^5\ N/m^2$***
- ***$g = 10\ m/s^2$***
- ***$\rho = 1000\ kg/m^3$***

Answer: 10m

- P= $g \rho h$ => $h = P/(g\rho)$
- $P = 1atm = 10^5\ N/m^2$
- $g = 10\ m/s^2$
- $\rho = 1000\ kg/m^3$

Pascal's Law & Hydraulic Lift

A pressure increase anywhere in the fluid is felt throughout the fluid.

How can you use this to lift a car with your bare hands?

Example 18-3

Example 18-3

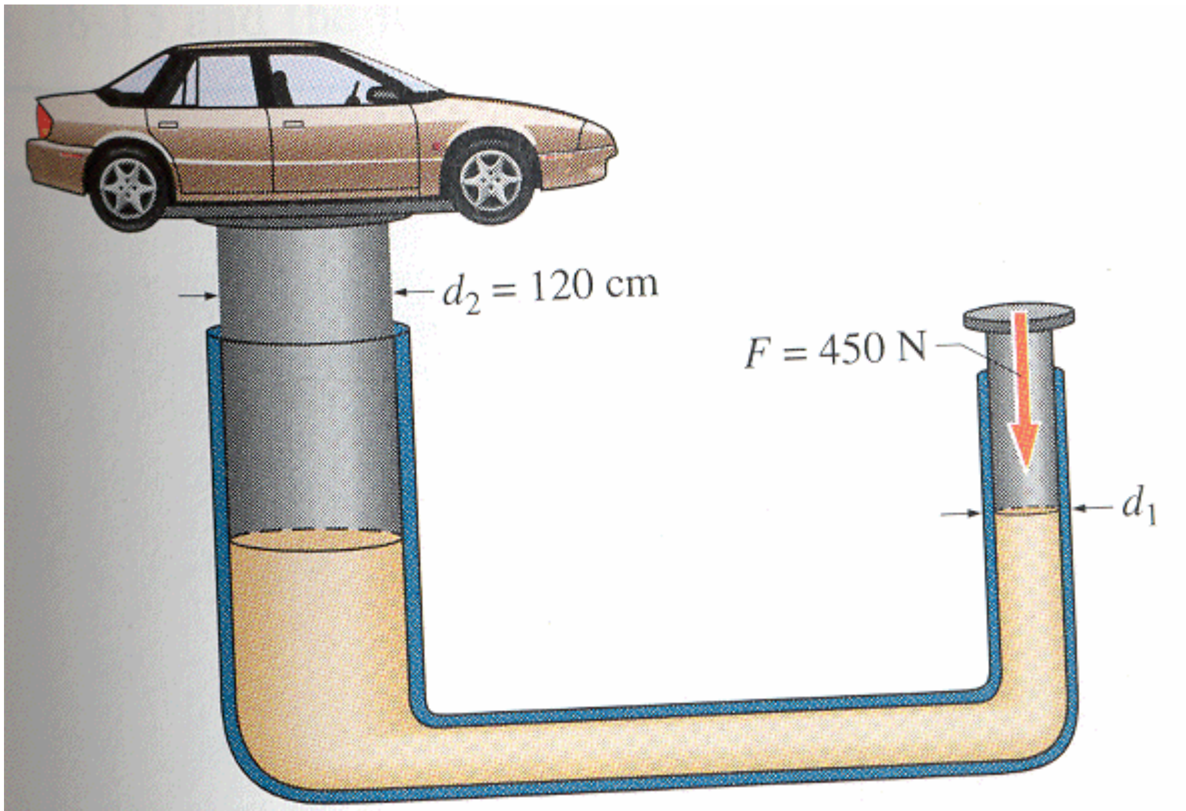
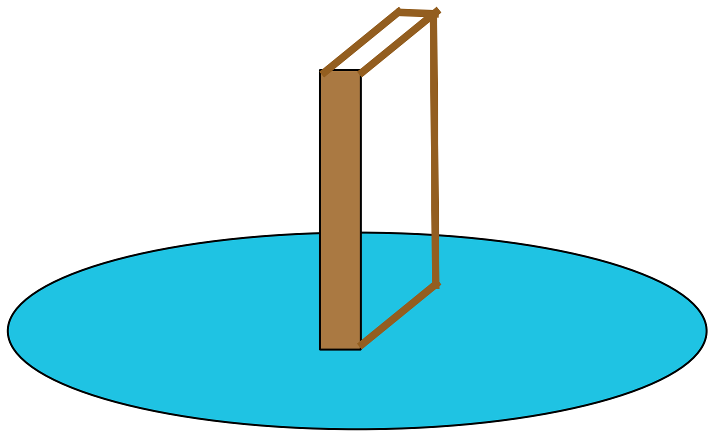


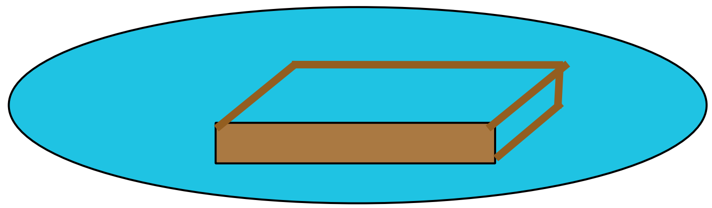
FIGURE 18-9 A hydraulic lift (Example 18-3).

P=F/A

Smaller A requires smaller F to achieve the same P.

Floating a wooden board in a shallow pool





You stick the board in with it's small side, and it doesn't float.

You stick the board in with it's large side, and it does float.

Why ?

Archimedes Principle

The buoyant force on an object is equal to the weight of the fluid displaced by the object.

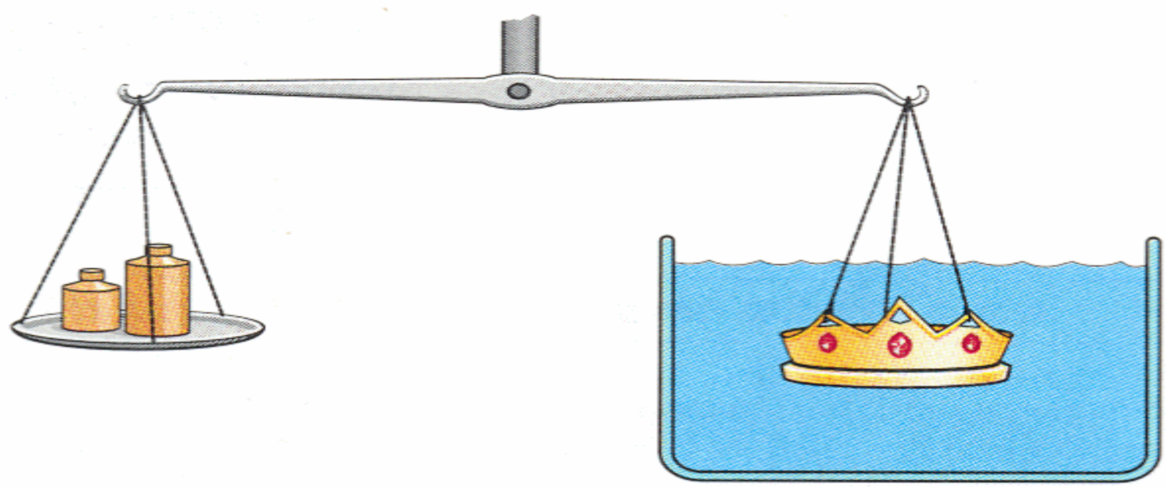


FIGURE 18-14 Archimedes purportedly verified that the king's crown was pure gold by finding its apparent weight when submerged in water.

Measuring ρ of the crown

1. Measure weight outside of water: Wout
2. Measure weight inside the water: Win
3. Ignoring buoyancy in air:

$$\frac{Wout}{Wout - Win} = \rho_{crown} / \rho_{water}$$

$$W_{out} = g\rho_{crown}V$$

$$W_{in} = g(\rho_{crown} - \rho_{water})V$$

$$W_{out} - W_{in} = g\rho_{water}V$$

Application ships floating

- This is the basic principle why ships float.
- It’s why a loaded ship sinks deeper into the water than an unloaded ship.
- It allows you to calculate the maximum weight a ship can carry.

⇒ lot’s of opportunities to make up quiz questions !!!

Application dead sea

The dead sea has a very high salt concentration.
This increases the density.
As a result, people float more easily in the dead sea.