Physics 7B-1 (A/B)
Professor Cebra
Winter 2010
Lecture 1

- Introduction:
  - Primary Instructors:
    - Daniel Cebra Lectures
    - Marcus Afshar D/L’s
  - More on Cebra
    - ‘84 B.S. University of Pennsylvania (Physics/Biology)
    - ‘90 Ph.D. Michigan State University (Nuclear Physics)
    - ‘92 Postdoc Lawrence Berkeley Labs (Rel. Heavy Ion)
    - ‘92-present Faculty at UCD

What is Physics 7? Where have we been and where are going?

3-quarter series of intro physics, typically taken by bio-sci majors

Subject matter

- **7A: Energy conservation and thermodynamics**
- **7B: Fluids, Circuits, Classical mechanics**
- **7C: Waves, Fields, E&M, Optics, and modern physics**

Lec Dates	Lecture Concepts
Lec1 06 Jan 07 Jan	Unit 5A – Fluid and Transport
Lec2 13 Jan 14 Jan	Unit 5B – Simple Circuits
Lec3 20 Jan 21 Jan	Unit 5C – Circuits II
Lec4 27 Jan 28 Jan	Unit 5D – Capacitance
Lec5 03 Feb 04 Feb	Unit 6A – Vectors
Lec6 10 Feb 11 Feb	Unit 7A – Projectile Motion
Lec7 17 Feb 18 Feb	Unit 7B – Momentum Conservation
Lec8 24 Feb 25 Feb	Unit 7C – Rotational Motion
Lec9 03 Mar 04 Mar	Unit 8A – Newton's Laws
Lec 10 10 Mar 11 Mar	Unit 8B – Simple Harmonic Motion
Final Exam	Wednesday 17-Mar-2010 3:30 to 5:30

Course Policies, Quizzes

There will be 8 quizzes (15 mins. each), one given at the *beginning* of EVERY lecture except for today and the last day of class in March. Quizzes cover any material covered in preceding DLs including FNT follow ups. For example, Quiz 1 (Jan. 13, 2010) will cover DL 1 and its FNTs that were followed up in DL 2 (in activities 5.1.4), but it will not cover the new material presented in DL 2 (in activity 5.1.5). On the quizzes, you are also responsible for the material covered in the reading assignments.
There will be *no make-up quizzes. Quizzes are closed book and closed-notes. Calculators are allowed for the quizzes; make sure you* have one and bring it to lecture.

Course Policy, Final Exam

The **final exam will be given on Wednesday, March 17, 3:30pm-5:30pm in various locations, TBA.** You **must take the final exam at this assigned time and day.** If you cannot take the final at this time, do not take Physics 7B this quarter. (Students sometimes have multiple finals on the same day as the scheduled Physics 7B final. This is never an excuse for changing the final time.)

Course Policies, Quiz and Final Grading

Your grade on every quiz or exam problem will be reported using a Rubric. The quiz questions will be graded by assigning a letter code that characterizes your response. A description of the meaning of the letter codes will be posted on the website when the quizzes are returned. The letter code is an indication of what you actually wrote down on paper during the quiz. It is not an indication of what you might have been thinking (but did not write down), nor does it ignore material you wrote down but changed your mind about later.

If, after carefully comparing what you actually wrote on your quiz question and the description of the letter codes, you believe the wrong letter code was assigned, you may request a reconsideration of the letter assigned to a particular response. To do this, fill out the quiz reevaluation form that you can get on our website and attach the **unaltered** quiz. Turn these in at the *second lecture following the return of the quizzes*

Course policy, Discussion Labs

Discussion/laboratory grading: The DL is central to the course.
If you fail DL, you will fail Physics 7B. Your DL Instructor will determine your DL grade based on your preparation (consistency in completing the out-of-class assignments) and participation in the DL. Your TA will discuss how this grade is determined. DL grades are:

HP High pass--increases your exam grade by 0.250 points (on the 4.5 scale).
MP Mid pass—increases your exam grade by 0.10 points.
P Pass--does not change your exam grade.
LP Low pass--decreases your exam grade by 0.250 points.
U Unsatisfactory--decreases your exam grade by 1.000 points
(i.e., a whole letter grade: "B-" to "C-", or "B" to "C", etc.).
F Fail the course.

DL Sections

Winter 2010 7B-1 (A/B) D/L Assignments & Job Responsibilities

1	WF	10:30-12:50	2317 EPS	Marcus Afshar
2	MW	2:10-4:30	2317 EPS	Aaron Hernley
3	MW	4:40-7:00	2317 EPS	Rylan Conway
4	MW	7:10-9:30	2317 EPS	Rylan Conway
5	MR	8:00-10:20	2317 EPS	Robert Lynch
6	TR	10:30-12:50	2317 EPS	Aaron Hernley
7	R	2:10-4:30	2317 EPS	Justin Dhooghe
7	M	10:30-12:50	2317 EPS	Justin Dhooghe
8	TR	4:40-7:00	2317 EPS	Britney Rutherford
9	TR	7:10-9:30	2317 EPS	Britney Rutherford
10	TF	8:00-10:20	2317 EPS	Emily Ricks
11	TF	2:10-4:30	2317 EPS	Justin Dhooghe

The first DLs meet today through Friday.
PTA numbers are issued only in DL.

	M	T	W	R	F
8	AB05 Robert	AB10 Emily	LecA Daniel	AB05 Robert	AB10 Emily
9			LecB Daniel		
10					
11	AB07 Justin	AB06 Aaron	AB01 Marcus	AB06 Aaron	AB01 Marcus
12					
1			TA Mtg		TA Mtg
2					
3	AB02 Aaron	AB11 Justin	AB02 Aaron	AB07 Justin	AB11 Justin
4					
5	AB03 Rylan	AB08 Britney	AB03 Rylan	AB08 Britney	
6					
7					
8	AB04 Rylan	AB09 Britney	AB04 Rylan	AB09 Britney	

	M	T	W	R	F
8	CD06 Miles		CD06 Miles	LecC Orpheus	
9				LecD Orpheus	
10	CD01 John	CD05 Robert		CD01 John	CD05 Robert
11					
12					
1	TA Mtg			TA Mtg	
2	CD07 Emily	CD02 Miles	CD07 Emily	CD02 Miles	
3					
4	CD08 McCullen	CD03 Ben	CD08 McCullen	CD03 Ben	
5					
6					
7	CD09 McCullen	CD04 Ben	CD09 McCullen	CD04 Ben	
8					

Course Policy, Academic Honesty

Suspicion of cheating of any form is always immediately reported to Student Judicial Affairs for appropriate action, which may involve failing Physics 7, suspension or expulsion from UCD.

Don’t risk your academic career by cheating!

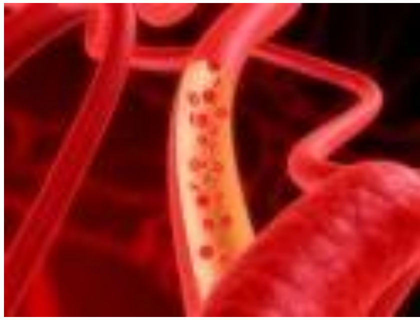
Chapter 5 – Flow, Transport and Change

- Models are idealized representations of nature.
- We will study three models:
  - Steady-state Energy Density Model
  - Linear Transport Model (Lecture 3)
  - Exponential Change Model (Lecture 4)
- We will use the SSED model to study:
  - Fluid systems (Lecture 1)
  - Electrical circuits (Lecture 2)

Fluid Systems

- What is a fluid?
  - Any thing that would spill if it were not in a container.
  - Liquids and gases – atoms are free to move
- How do we describe fluids?
  - Volume, pressure, temperature, flow rate, chemical composition, viscosity
- Assumptions:
  - Mass and energy are conserved, i.e. they are constant in time.
  - Mass density and energy density are constant, i.e. they are constant in space.
  - Flow is steady-state flow, i.e. the variables describing the fluid are fixed.
  - Fluid is incompressible, i.e. the mass density is fixed.

Examples of Fluid Systems



- Water in household plumbing
- Blood in arteries

- Air conditioning ducts
- Water in plant capillaries

- Coffee in a cup
- Water in a fountain

- Air in a musical instrument

Energy-Interaction Model

Remember the *Energy-Interaction Model* from Block 1 in Physics 7A?

For a Closed System, the sum of the changes in energy (ΔE) added to zero.

$$\Sigma \Delta E = 0$$

For an Open System, the sum of the changes in energy equaled the heat transferred (Q) and the work done (W).

$$\Sigma \Delta E = Q + W$$

Steady-State Energy Density Model

Now let's consider the *Steady-state Energy Density Model*. We need to get into unit of density → divide by the volume (V):

For an *Isolated* System, the sum of the changes in *energy density* ($\Delta E/V$) added to zero.

$$\Sigma \Delta E/V = 0$$

For a *non-isolated* System, the sum of the changes in energy density equaled the *heat energy density* and the *work energy density*.

$$\Sigma \Delta E/V = Q/V + W/V$$

Energy Density in a Fluid

So what is energy density in a fluid?

Energy has units of kgm^2/s^2

Energy density is E/V → $kgm^2/s^2\ /m^3 = kg/ms^2$

Pressure (P) is force per unit area → $kgm/s^2\ /m^2 = kg/ms^2$
→ **Pressure has units of energy density**.

Density (ρ) times gravity (g) times height → $(kg/m^3)(m/s^2)(m) = kg/ms^2$
→ ρgy is the *potential energy density*.

$\frac{1}{2}\rho v^2$ has units kg/ms^2
--> $\frac{1}{2}\rho v^2$ is the *kinetic energy density*.

Energy Systems

- What types of energy (energy systems) does a fluid possess?
  - Pressure
  - Kinetic Energy
  - Gravitational Potential Energy

$$\Delta E = 0 \quad \Rightarrow \quad \frac{\Delta E}{V} = 0 \quad \Rightarrow \quad \Delta P + \frac{\Delta PE}{V} + \frac{\Delta KE}{V} = 0$$

$$\Rightarrow \quad \Delta P + \rho g \Delta y + \frac{1}{2}\rho \Delta (v^2) = 0$$

Pressure

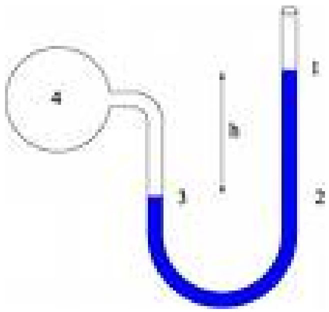
$$\Sigma \Delta E/V = 0$$

$$\Delta P + \rho g y + \tfrac{1}{2}\rho v^2 = 0$$

Now, let the fluid be static… not moving, v = 0

$$\Delta P + \rho g y + \tfrac{1}{2}\rho v^2 = 0$$

$$\Delta P + \rho g y = 0$$



DEMO: Manometer

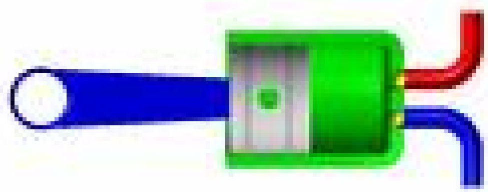
$1\ \text{Pa} = 1\ \text{N/m}^2 = 10^{-5}\ \text{bar} = 9.8692\times10^{-6}\ \text{atm}$

Atomospheric Pressure = 10^5 Pa = 760 mm Hg = 760 Torr

DEMO: Test Tube

Pressure and Force

Consider a Piston



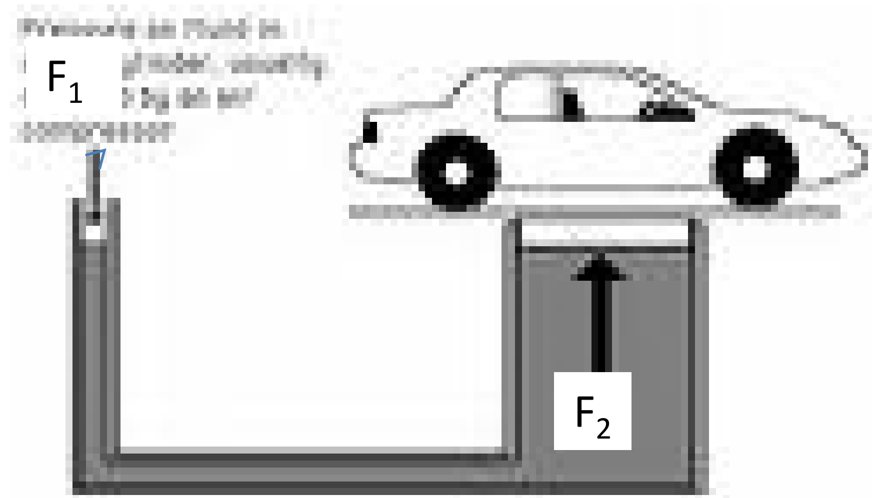
$dW = F\,dx = -PdV \qquad dV = -Adx$

$\rightarrow Fdx = PAdx \ \rightarrow F = PA$

Hydraulics

$P = F_1/A_1$

$F_2 = P\,A_2 = F_1A_2/A_1$



Dissapative Flow

How do we deal with frictional energy losses within the fluid (*dissipation*)?

We address this the same way we addresses frictional energy loss in the spring in the mass-spring system; we consider frictional losses to create thermal energy through heating.

$$\Delta P + \rho g y + \frac{1}{2} \rho v^2 + \Delta E_{th}/V = 0$$

But what did we really do about this with the spring? We decided that it would usually be really small.

Energy Input

- It is possible to add (or subtract) energy at any point in a fluid system.
  - A Pump: Adds energy

- In this case energy is no longer conserved:

$$\Delta E \neq 0$$

$$\frac{\Delta E}{V} = \frac{E_{Pump}}{V} \quad \Rightarrow \quad \Delta P + \rho g \Delta y + \frac{1}{2}\rho \Delta(v^2) = \frac{E_{Pump}}{V}$$

Resistance

- A fluid must flow through a pipe. This pipe-fluid interface causes another sort of frictional energy losses – *Resistance* (*R*)!
- We define the volumetric flow rate as the volume of fluid that passes through a given region of the pipe per unit time

V/t = current = I

Ohm's Law gives $\Delta E_R/V = IR$

For Laminar Flow, R is independent of I. Above a certain I, the flow becomes turbulant

$$\frac{\sum \Delta E_{External}}{V} = \frac{E_{Pump}}{V} - \mathrm{IR} \qquad \Rightarrow \qquad \Delta P + \rho g \Delta y + \frac{1}{2}\rho\Delta(v^2) = \frac{E_{Pump}}{V} - \mathrm{IR}$$

Power

- Power: Energy dissipated/used/produced per unit time.

$$P = \frac{E}{t}$$

- Each of the following has a power rating:
  - A pipe with friction dissipates energy.
  - A light bulb uses energy.
  - A battery produces energy.
- Do not confuse power (P) with Pressure (P)

Analyzing Fluid Systems

- Use conservation of mass and energy.
- Conservation of mass implies the continuity equation where *A* is the cross sectional area and *v* is the average velocity:

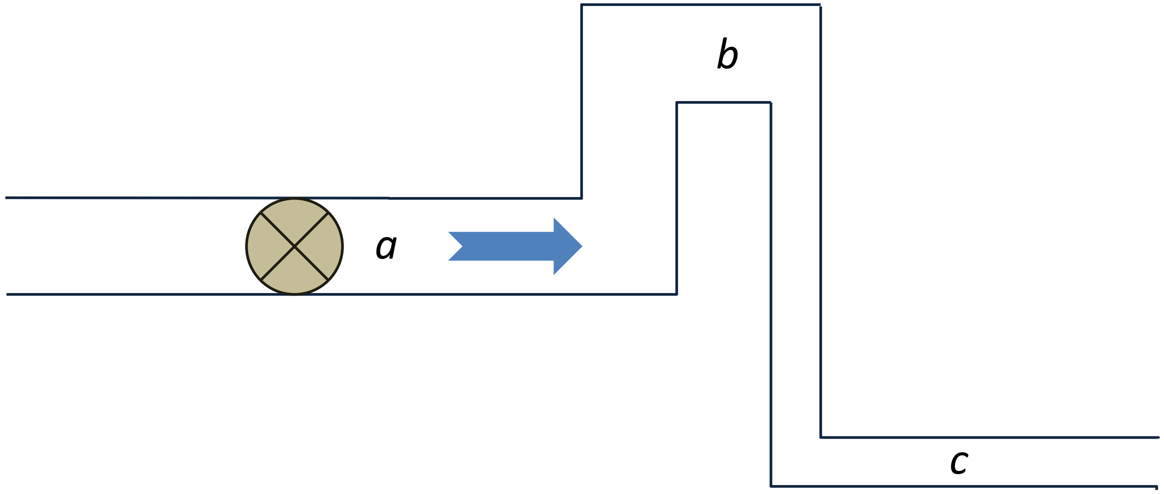
$$A_1 v_1 = A_2 v_2$$

- Conservation of energy implies the energy density equation:

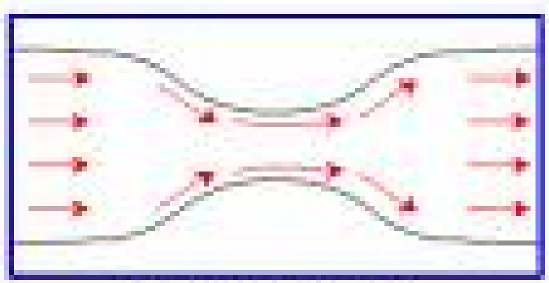
$$\Delta P + \rho g \Delta y + \frac{1}{2}\rho\Delta(v^2) = 0$$

Practice Problem

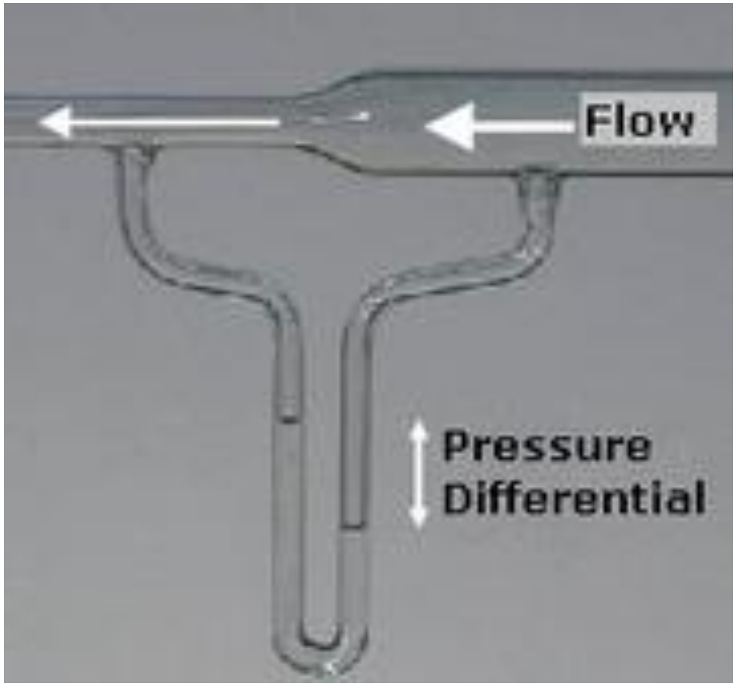
- Suppose there is no friction in the pipes, thickness of pipe at *b* is equal to that at *a*, and thickness of pipe at *c* is less than that at *a*.
  - Compare flow rate at *b* to *a*. Compare *c* to *a*.
  - Compare pressure at *b* to *a*. Compare *c* to *a*.



Bernoulli's Principle



The fluid velocity must increase through the constriction to satisfy the equation of continuity, while its pressure must decrease due to conservation of energy: the gain in kinetic energy is balanced by a drop in pressure or a pressure gradient force. An equation for the drop in pressure due to the Venturi effect may be derived from a combination of Bernoulli's principle and the equation of continuity.



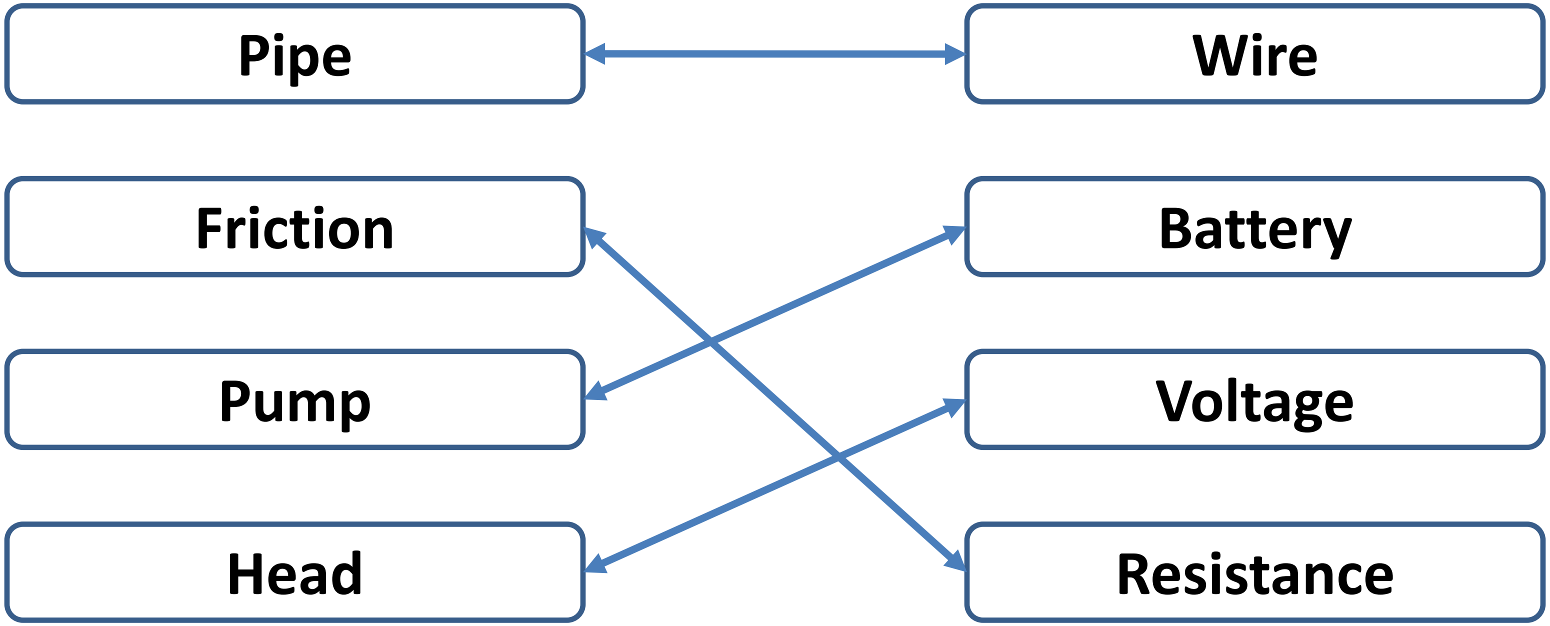
A flow of air into a Venturi meter. The kinetic energy increases at the expense of the fluid pressure, as shown by the difference in height of the two columns of water.

DEMO: Atomizer
DEMO: Floating balls

DEMO Venturi Tubes

Electrical Circuits

- Fluid systems consist of atoms in motion. Electrical circuits consist of electrons in motion. The two are analogous:



Announcements

- Buy text and DL handouts at MU bookstore.
  - Bring to DL every time.
- Buy PRS clicker at MU bookstore.
  - Bring to lecture every time.
- Read chapter 5, pages 1-23 by next Wednesday.
- Use Smartsite as course web site.
- Quiz 1 next week