PHY 113 A General Physics I
9-9:50 AM MWF Olin 101

Plan for Lecture 32:
Review of Chapters 14, 19-22

1. **Advice about preparing for exam**
2. **Review of the physics of fluids and of thermodynamics**
3. **Example problems**

	11/02/2012	Exam	10-13,15		
23	11/05/2012	Fluid mechanics	14.1-14.4	14.8, 14.24	11/07/2012
24	11/07/2012	Fluid mechanics	14.5-14.7	14.39, 14.51	11/09/2012
25	11/09/2012	Temperature	19.1-19.5	19.1, 19.20	11/12/2012
26	11/12/2012	Heat	20.1-20.4	20.3, 20.14, 20.24	11/14/2012
27	11/14/2012	First law of thermodynamics	20.5-20.7	20.26, 20.35	11/16/2012
28	11/16/2012	Ideal gases	21.1-21.5	21.10, 21.19	11/19/2012
29	11/19/2012	Engines	22.1-22.8	22.3, 22.62	11/26/2012
	11/21/2012	*Thanksgiving Holiday*			
	11/23/2012	*Thanksgiving Holiday*			
	11/26/2012	Review	14,19-22		
	11/28/2012	Exam	14,19-22		
30	11/30/2012	Wave motion	16.1-16.6	16.5, 16.22	12/03/2012
31	12/03/2012	Sound & standing waves	17.1-18.8	17.35, 18.35	12/05/2012
	12/05/2012	Review	1-22		
	12/13/2012	Final Exam -- 9 AM			

Format of Wednesday's exam

What to bring:
1. **Clear, calm head**
2. **Equation sheet (turn in with exam)**
3. **Scientific calculator**
4. **Pencil or pen**

(Note: labtops, cellphones, and other electronic equipment must be off or in sleep mode.)

Timing:
May begin as early as 8 AM; must end ≤ 9:50 AM

Probable exam format
- **4 problems similar to homework and class examples; focus on Chapters 14 & 19-22 of your text.**
- **Full credit awarded on basis of analysis steps as well as final answer**

Examples of what to include on equation sheet

Given information on exam paper	Suitable for equation sheet
Universal or common constants (such as g, R, ..)	Basic physics equations from earlier Chapters: Newton's laws, energy, momentum,…
Particular constants (density of fluid, heat capacity of fluid, latent heat for phase change …)	Relationship between pressure and force; fluid density; pressure within fluids; buoyant force; Bernoulli's equation
Unit conversion factors such atm to Pa, Cal to J, ^oC to K, …	Concept of temperature and its measurement scales; ideal gas law
	Definition of thermodynamic heat and work; first law of thermodynamics
	Molecular model of ideal gas law; internal energy of ideal gas
	Thermodynamic cycles and their efficiency

General advice for preparing for exam

- **Prepare equation sheet, including basic equations* from each chapter**
- **Work example problems from class notes, textbook examples, webassign, other sources using your equation sheet**
- **During your review, you may develop new questions. Make an effort to get answers by consulting with your instructor, physics TA, etc.**

***Note: One of the challenges is to distinguish the basic equations/concepts from particular examples**

iclicker question:
Which of the following equations concerning the physics of fluids can be safely omitted from your equation sheet?

A. $\rho = \frac{M}{V}$

B. $P = \frac{|\mathbf{F}|}{A}$

C. $F_B = \rho_{fluid} V_{displaced} g$

D. $v_1 = \sqrt{\frac{2(P - P_0)}{\rho} + 2gh}$

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

Problem solving steps

1. Visualize problem – labeling variables
2. Determine which **basic physical principle(s)** apply
3. Write down the appropriate equations using the variables defined in step 1.
4. Check whether you have the correct amount of information to solve the problem (same number of knowns and unknowns). **Note: in some cases, there may be extra information not needed in the solution.**
5. Solve the equations.
6. Check whether your answer makes sense (units, order of magnitude, etc.).

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iclicker question:

A. I would like to have two extra review sessions one on Monday and one on Tuesday to go over the material
B. I would like to have one extra review session on Tuesday to go over the material
C. I would like to schedule individual or small group meetings in Olin 300 to go over the material
D. I am good

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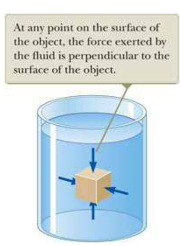
Review: Physics of fluids

Density of a fluid with mass M and volume V: $\rho = \frac{M}{V}$

Pressure exerted by force $\mathbf{F}$ on a surface of area A: $P = \frac{|\mathbf{F}|}{A}$



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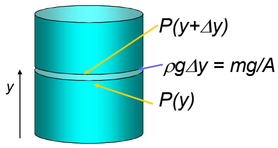
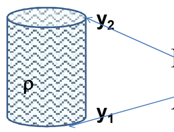
Review: Physics of fluids -- continued
Pressure exerted by fluid itself due to gravity:



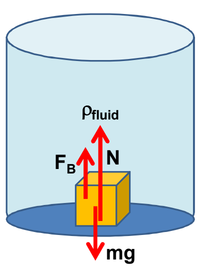
$$F(y) = F(y+\Delta y) + mg$$
$$\frac{F(y)}{A} = \frac{F(y+\Delta y)}{A} + \frac{mg}{A}$$
$$P(y) = P(y+\Delta y) + \rho g \Delta y$$
$$\lim_{\Delta y \to 0} \frac{P(y+\Delta y) - P(y)}{\Delta y} = \frac{dP}{dy}$$
$$\Rightarrow \frac{dP}{dy} = -\rho g$$



For incompressible fluid:
$$P(y_1) = P(y_2) + \rho g (y_2 - y_1)$$

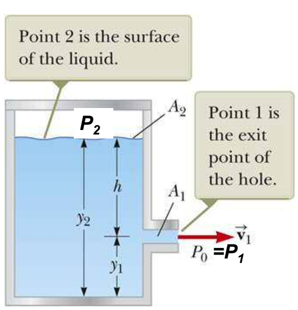
Review: Physics of fluids -- continued
Buoyant force

Buoyant force: $F_B = \rho_{\text{fluid}} g V_{displaced}$



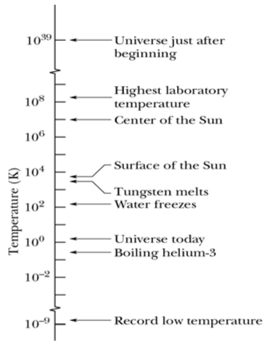
$$N + F_B - mg = 0$$

Review: Physics of fluids -- continued
Bernoulli's equation $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$
Continuity condition $A_1 v_1 = A_2 v_2$



Given $\rho, P_1, P_2, A_1, A_2, y_1, y_2$:
Solve for fluid velocity v_1

Review: Temperature -- notion of "absolute" Kelvin scale



$T_C = T_K - 273.15$

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Review: Ideal gas law

Effects of temperature on materials –ideal gas "law" (thanks to Robert Boyle (1627-1691), Jacques Charles (1746-1823), and Gay-Lussac (1778-1850)

$$PV = nRT$$

- 8.314 J/(mol K) (R)
- temperature in K (T)
- volume in m^3 (V)
- # of moles (n)
- pressure in Pascals (P)

1 mole corresponds to 6.022 x 10^{23} molecules

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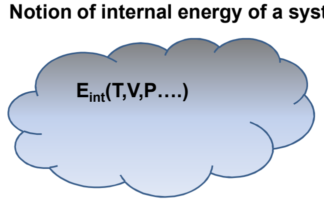
Review: Notion of internal energy of a system



The internal energy is a "state" property of the system, depending on the instantaneous parameters (such as T, P, V, etc.).

$$\Delta E_{\text{int}} = E_{\text{int}}(T_f, V_f, P_f) - E_{\text{int}}(T_i, V_i, P_i)$$

ΔE_{int} can also include phase change of a material (solid←→liquid, liquid←→gas, etc.)

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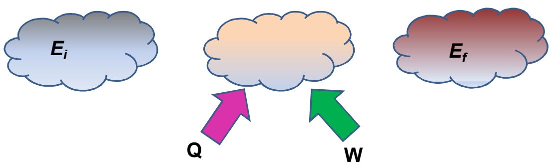
Review: First law of thermodynamics

$$\Delta E_{\text{int}} = Q + W$$



Q: heat added to system **W: work on system**

Review: First law of thermodynamics – continued

Examples with W=0 → $\Delta E_{\text{int}} = Q$

Changing temperature in a given phase

$$Q = m\int_{T_i}^{T_f} c\,dT = mc\left(T_f - T_i\right) \qquad c \equiv \text{heat capacity per unit mass}$$

Example, for water: $c = 4186\ \text{J/(kg}\cdot\text{K)}$

Changing phase at given temperature

$$Q = mL \qquad L \equiv \text{latent heat per unit mass}$$

Example, for ice melting at 273.15 K, $L = 333000$ J/kg

Review: First law of thermodynamics – continued

Work done on the system: $W = -\int_{V_i}^{V_f} P\,dV$

Examples for ideal gas $PV = nRT$:

At constant volume $(V_f = V_i)$ $\Rightarrow W = 0$

At constant pressure $(P_f = P_i)$ $\Rightarrow W = -P_i\left(V_f - V_i\right)$

At constant temperature $(T_f = T_i)$ $\Rightarrow W = -P_i V_i \ln\left(V_f / V_i\right)$

At adiabatic conditions $(Q = 0)$ $\Rightarrow W = -\frac{P_i V_i}{\gamma - 1}\left(1 - \left(\frac{V_i}{V_f}\right)^{\gamma-1}\right)$

Review: First law of thermodynamics – continued

E_{int} for ideal gas

$$E_{\text{int}} = \frac{1}{\gamma - 1} nRT$$

$$\gamma = \begin{cases} \frac{5}{3} & \text{for monoatomic} \\ \frac{7}{5} & \text{for diatomic} \\ \ldots\ldots\ldots\ldots\ldots\ldots & \end{cases}$$

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Review: First law of thermodynamics – continued

Translational kinetic energy for ideal gas molecules:

$$\left\langle \tfrac{1}{2} M v_i^2 \right\rangle = \frac{3}{2} RT$$

$$\left\langle v_i^2 \right\rangle = \sqrt{\frac{3RT}{M}}$$

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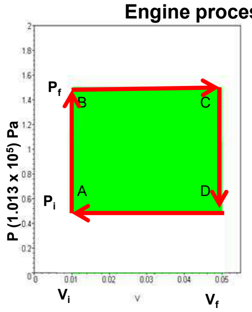
Review thermodynamic cycles for designing ideal engines and heat pumps

Engine process:



Work of engine : $W_{eng} = -W$

Heat input to system : $Q = |Q_{in}| - |Q_{out}|$

Efficiency : $\varepsilon \equiv \frac{W_{eng}}{Q_{in}}$

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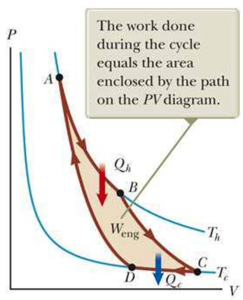
Review thermodynamic cycles -- Carnot cycle

A→B Isothermal at T_h
B→C Adiabatic
C→D Isothermal at T_c
D→A Adiabatic



Efficiency of Carnot cycle

$$\varepsilon = \frac{Q_{in} - |Q_{out}|}{Q_{in}} = 1 - \frac{|Q_{out}|}{Q_{in}}$$

$$\varepsilon = 1 - \frac{T_c}{T_h}$$

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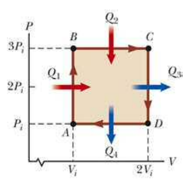
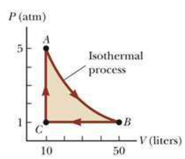
Review thermodynamic cycles – continued
Other examples of thermodynamic cycles





Thermodynamic work: W = –(shaded area)
For simple graph, can use geometry to calculate area; first law of thermo and ideal gas laws also apply.

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