The Final Exam Schedule is Now Final!

PHYS 1020: Monday, December 17, 6 - 9 pm
Frank Kennedy Brown & Gold Gyms
The whole course
30 multiple choice questions
Formula sheet provided

Seating (from exam listing on Aurora)

Brown Gym

A - SIM

Gold Gym

SIN - Z

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

11	M	12	**Remembrance Day**			Experiment 4: Centripetal Force
	W	14	28	Chapter 11 exclude 11.11	Fluids	
	F	16	29			
12	M	19	30	Chapter 12 sections 1 - 8	Temperature and heat (some small sections, notably thermal stress will be omitted)	Tutorial and Test 4 (chapters 8, 9, 10)
	W	21	31			
	F	23	32			
13	M	26	33	Chapter 13	Transfer of Heat -- Self study only. **Required for last lab.** This chapter **IS** examinable on the final.	Experiment 5: Thermal Conductivity of an Insulator
	W	28	34	Chapter 14	The Ideal Gas Law & Kinetic Theory	
	F	30	35			
14	M	**Dec 3**	36			No lab or tutorial
	W	5	37	**Last Day of Classes**		

Week of November 19
Tutorial & Test 4: chapters 8, 9, 10
Week of November 26
Experiment 5: Thermal conductivity

Simple Pendulum

The restoring force along the arc s along which the mass moves is:

$F = -mg\sin\theta \simeq -mg\theta$ for small angles

and $\theta = \frac{s}{L}$ radians

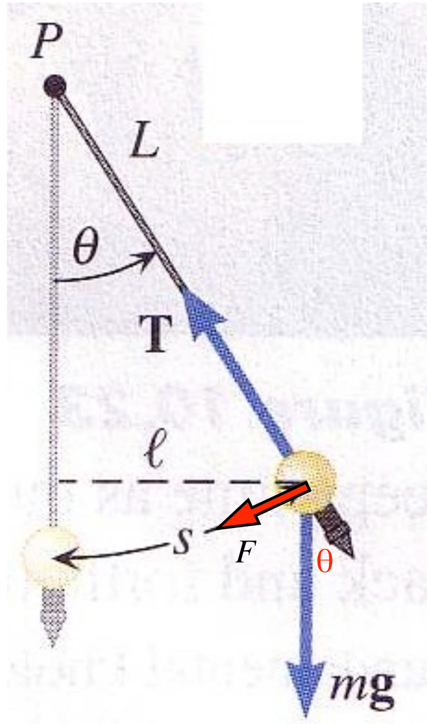
So, $F = -\left(\frac{mg}{L}\right)s$

Force pulls mass back to θ = 0

This is of the same form as for a mass on a spring:

F = -kx, with s taking the place of x and with an effective spring constant:

k = mg/L $\quad \rightarrow T = 2\pi\sqrt{\frac{L}{g}}$



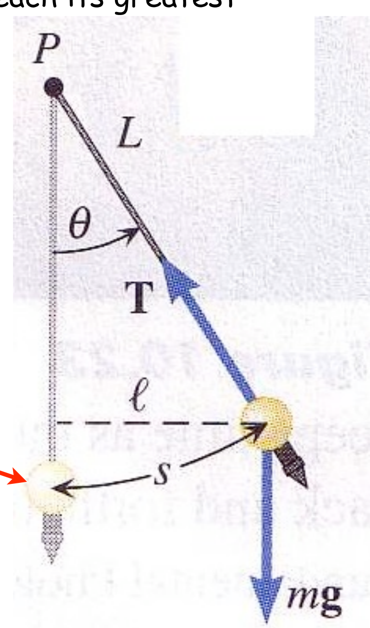
10.40: A pendulum consists of a ball on the end of a string 0.65 m long. The ball is pulled to one side through a small angle and released. How long does it take the ball to reach its greatest speed?

Conservation of mechanical energy:

$PE_o + KE_o = PE + KE$, or

$PE_o + 0 = 0 + KE$

At lowest point, PE = 0, so KE = maximum value



Time to reach lowest point is T/4:

$$t = \frac{1}{4} \times 2\pi\sqrt{\frac{L}{g}} = 0.40 \text{ s}$$

10.-/42: A pendulum clock acts as a simple pendulum of length 1 m. It keeps accurate time at a location where the acceleration due to gravity is 9.83 m/s^2. What must be the length of the pendulum to keep accurate time if the local acceleration due to gravity is 9.78 m/s^2?

$$\text{Period, } T = 2\pi\sqrt{\frac{L}{g}}$$

For a fixed period, L/g = constant.

$$\text{So, } \frac{L_1}{g_1} = \frac{L_2}{g_2} \text{ to keep time}$$

$$L_2 = L_1 \times \frac{g_2}{g_1} = (1\text{ m}) \times \frac{9.78}{9.83}$$

$$L_2 = 0.995\text{ m}$$

Simple Harmonic Motion

- The restoring force has the form: F = –kx
- The motion is: x = A cos(ωt), or x = A sin(ωt)
- The angular frequency is: $\omega = \sqrt{\frac{k}{m}}$

$$\omega = 2\pi f = 2\pi/T \qquad T = 2\pi\sqrt{\frac{m}{k}}$$

- Simple pendulum, motion simple harmonic, with k = mg/L:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Chapter 11: Fluids

- Density
- Pressure, variation of pressure with depth in a fluid
- Pascal's Principle
- Archimedes' Principle
- Fluids in motion -
  - equation of continuity
  - Bernoulli's equation
- Leave out 11.11, viscous flow

Density

The density of a gas, liquid or solid is its mass divided by its volume:

$$\text{Density, } \rho = \frac{\text{mass}}{\text{volume}} = \frac{m}{V} \ (\text{kg/m}^3)$$

Specific gravity is the density of a substance relative to water:

$$\text{Specific gravity } = \frac{\text{Density of substance}}{\text{Density of water at } 4^\circ \text{ C}} = \frac{\text{Density of substance}}{1000 \text{ kg/m}^3}$$

$$\text{Mass, } m = \rho V$$

Table 11.1 Mass Densities[a] of Common Substances

Substance	Mass Density ρ (kg/m^3)
Solids	
Aluminum	2700
Brass	8470
Concrete	2200
Copper	8890
Diamond	3520
Gold	19 300
Ice	917
Iron (steel)	7860
Lead	11 300
Quartz	2660
Silver	10 500
Wood (yellow pine)	550
Liquids	
Blood (whole, 37 °C)	1060
Ethyl alcohol	806
Mercury	13 600
Oil (hydraulic)	800
Water (4 °C)	1.000×10^3
Gases	
Air	1.29
Carbon dioxide	1.98
Helium	0.179
Hydrogen	0.0899
Nitrogen	1.25
Oxygen	1.43

[a] Unless otherwise noted, densities are given at 0 °C and 1 atm pressure.

11.92/6: A chunk of concrete of mass 33 kg has a hollow spherical cavity inside. The volume of the chunk is 0.025 m^3. What is the radius of the spherical cavity? The density of concrete is 2,200 kg/m^3.

If the mass of the chunk is 33 kg, then its volume should be,
V = m/ ρ :

V = (33 kg) / (2,200 kg/m^3) = 0.015 m^3.

Its actual volume is 0.025 m^3, so the volume of the spherical cavity is 0.025 – 0.015 = 0.010 m^3.

Volume of a sphere: $V = \frac{4}{3}\pi r^3$

$$\text{So, } r = \left[\frac{3V}{4\pi}\right]^{1/3} = \left[\frac{3 \times 0.01}{4\pi}\right]^{1/3} = 0.134 \text{ m}$$

11.9: An antifreeze solution is made by mixing ethylene glycol (density = 1116 kg/m^3) with water. The specific gravity of the solution is 1.073. Find the percentage of ethylene glycol by volume.

Density of the antifreeze = 1.073 × 1000 = 1073 kg/m^3.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{m_1 + m_2}{V_1 + V_2} = \frac{\rho_1 V_1 + \rho_2 V_2}{V_1 + V_2}$$

$$\rho_1 = 1116 \text{ kg/m}^3 \text{ (ethylene glycol)}$$
$$\rho_2 = 1000 \text{ kg/m}^3 \text{ (water)}$$

$$\text{Put } \frac{V_1}{V_1 + V_2} = \alpha, \text{ then } \frac{V_2}{V_1 + V_2} = 1 - \alpha$$

α = fraction of ethylene glycol by volume

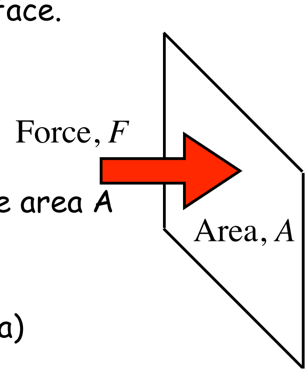
$$\text{Density of antifreeze} = \rho_1 \alpha + \rho_2 (1 - \alpha) = 1073 \text{ kg/m}^3$$

$$\text{So, } 1116\alpha + 1000(1 - \alpha) = 1073$$

$$\rightarrow \alpha = 0.629, \text{ i.e. 62.9 percent ethylene glycol by volume}$$

Pressure

Pressure is the force exerted by a fluid on its surroundings.
The force is measured per unit area of surface.

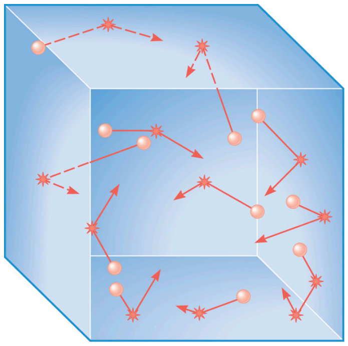


The pressure exerted by the force F on the area A perpendicular to the force is:

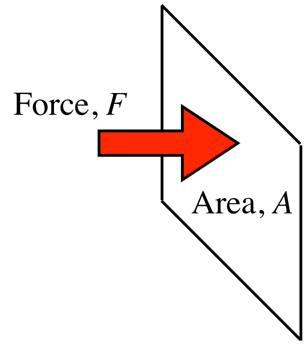
P = F/A, Units: 1 N/m^2 = 1 Pascal (Pa)

Normal atmospheric pressure is 1.013 × 10^5 Pa = 101.3 kPa.

Pressure is exerted equally in all directions.



Pressure



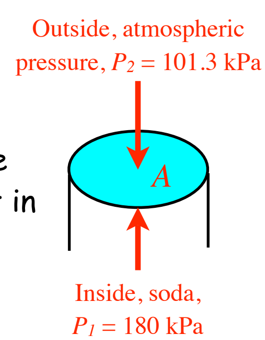
Pressure is due to the impact of molecules with the surface – the molecules of the fluid carry momentum and exert an impulse on the surface when they bounce from it.

The resulting force is equal to the rate of change of momentum of the molecules as they bounce from the surface.

The total force on a surface is proportional to its area.

11.12/10: A bottle of soda has a screw cap. The absolute pressure inside the bottle is 180 kPa.

If the cap has an area 4.1×10^{-4} m^2, calculate the force exerted on the cap by the screw thread that keeps it in place.



Inside the bottle: P_1 = 180 kPa → outward force on cap = P_1A

Outside the bottle: P_2 = 101.3 kPa → inward force on cap = P_2A

The net outward force on the cap is $F = (P_1 - P_2)A$

$F = [(180 - 101.3) \times 1000\text{ Pa}] \times (4.1\times10^{-4}\text{ m}^2) = 32.3\text{ N}$

The thread exerts an inward force of 32.3 N

11.11: An airtight box has a removable lid of area 0.013 m^2 and negligible weight. The air is removed from the box and the box is taken up a mountain where the air pressure outside the box is 85 kPa. What force is needed to remove the lid?

There is zero pressure inside the box and 85 kPa outside, so there is a force pushing the lid onto the box.

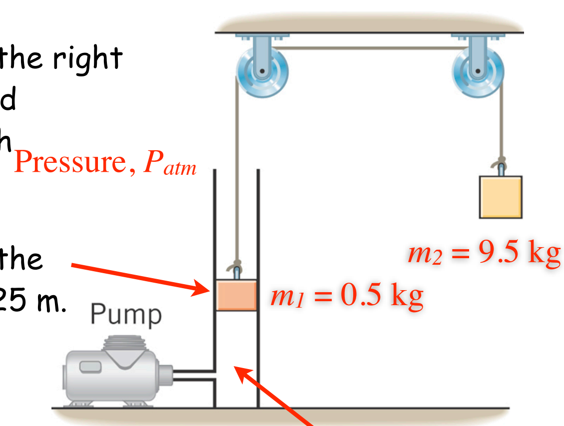
The force is F = PA = (85,000 Pa)(0.013 m^2) = 1105 N

If instead the airtight box contained air at normal atmospheric pressure, 101.3 kPa, there would be a net outward force on the lid, as the pressure inside would be greater than the pressure on the outside.

The outward force would be $(P_{in} - P_{out})A$ = (101,300 - 85,000)(0.013 m^2)

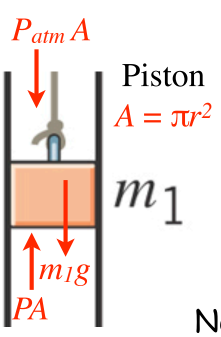
F = 212 N, outwards.

11.18/95: Given that the block at the right falls 1.25 m from rest in 3.3 s, find the pressure in the cylinder, which is held constant by the pump. Ignore friction.



The radius of the piston is r = 0.025 m.

Constant pressure, P < P_{atm}

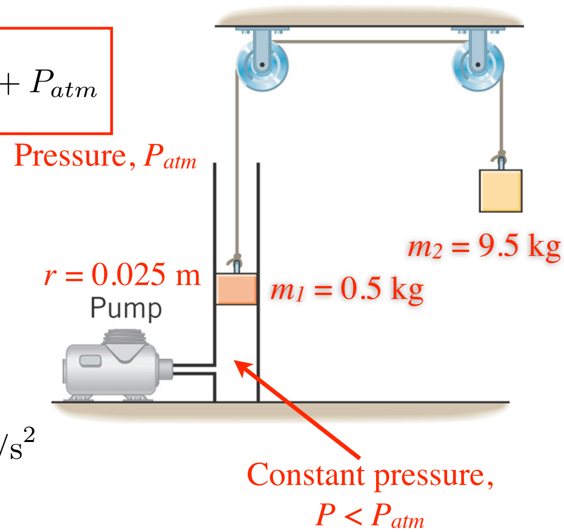


Net force accelerating the two masses:

$$F = (m_2 - m_1)g + (P - P_{atm})A = (m_1 + m_2)a$$

$$\rightarrow P = \frac{(m_1 + m_2)a - (m_2 - m_1)g}{A} + P_{atm}$$

$$P = \frac{(m_1 + m_2)a - (m_2 - m_1)g}{\pi r^2} + P_{atm}$$



Block at the right falls 1.25 m from rest in 3.3 s.

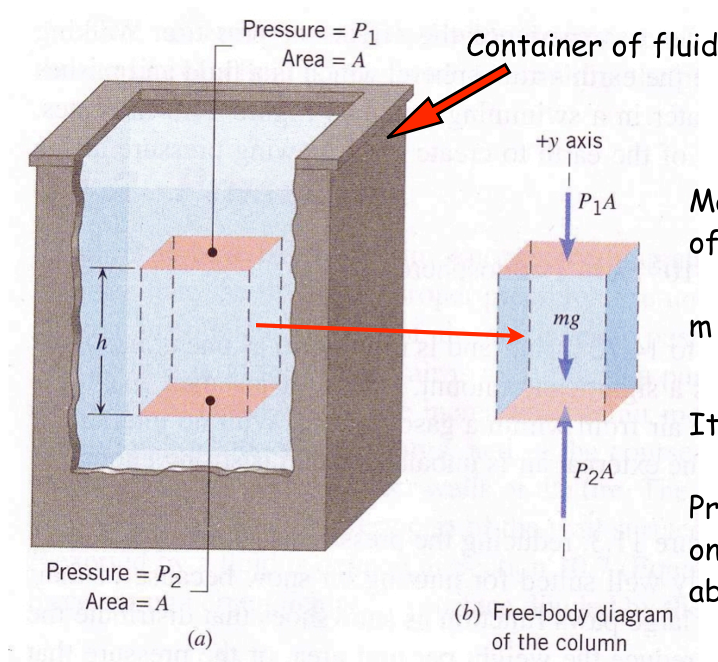
Acceleration of the block:

$$s = \frac{1}{2}at^2$$

$$\text{So, } a = \frac{2s}{t^2} = \frac{2 \times 1.25}{3.3^2} = 0.23 \text{ m/s}^2$$

$$\begin{aligned} P &= \frac{(0.5 + 9.5) \times 0.23 - (9.5 - 0.5)g}{\pi \times 0.025^2} + P_{atm} \\ &= -43,749 + P_{atm} \\ P &= 57.6 \text{ kPa} \end{aligned}$$

Variation of Pressure with Depth



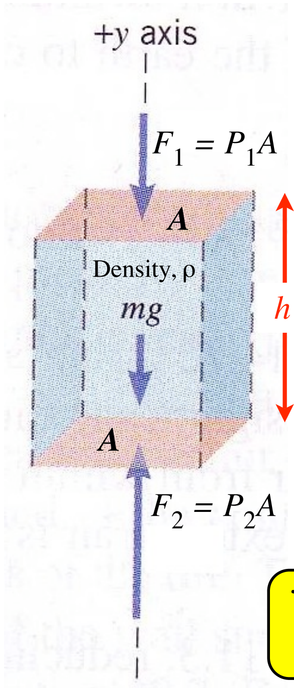
Mass of small column of fluid is:

m = ρ V = ρ Ah

It is in equilibrium

Pressure forces act on the column from above and from below

Variation of Pressure with Depth



For the column of fluid to be in equilibrium:

$$-mg - F_1 + F_2 = 0$$

$$\text{So,} \ -mg - P_1A + P_2A = 0$$

$$\text{or,} \ P_2 = P_1 + \frac{mg}{A}$$

The mass of the column of fluid is:

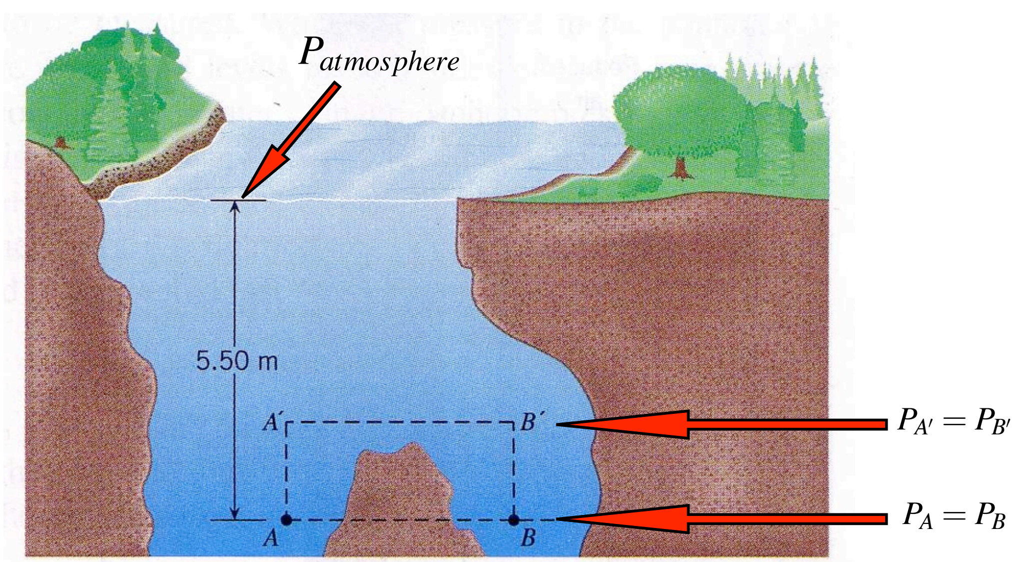
$$m = \rho V = \rho A h$$

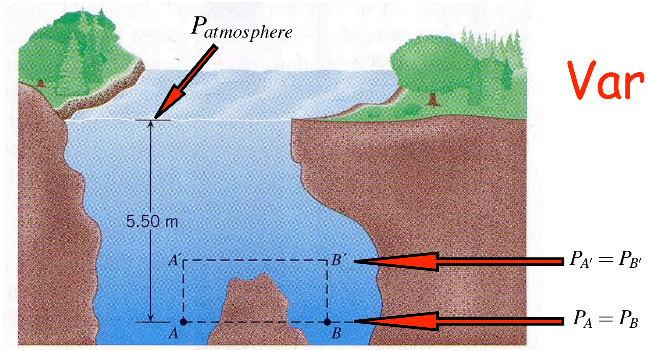
$$\text{Therefore,} \ P_2 = P_1 + \rho g h$$

The pressure is the same at all points at the same depth

Variation of Pressure with Depth

The pressure is the same at all points at the same depth





Variation of Pressure with Depth

Both A and B are 5.5 m below the surface of the water.

$$P_A = P_B = P_{atmosphere} + \rho g h$$

$$= P_{atmosphere} + (1000 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(5.5 \text{ m})$$

$$= P_{atmosphere} + 53,900 \text{ Pa}$$

Standard atmospheric pressure is 101.3 kPa,

so P_A = 1.53 atmospheres (i.e., 1.53 × $P_{atmosphere}$)