Phys 103,Spring 2023

Common Exam 1 – Wednesday, February 15, 4:15 – 5:45 pm

7 multiple choice questions , 1 point each and 4 open-ended questions, 2 points each

Chapter 9 sect. 5&6, Chapter 10 sect. 1 – 10, Chapter 13 sect 1-8

Stress (σ) is the force per unit area

$$\sigma = F/A$$

Strain (ε) is a measure of the amount of deformation

$$\varepsilon = (\Delta L/L)$$

Stress directly proportional to the strain.

$$\sigma = E\,\varepsilon$$

E – Modulus of elasticity (Young's modulus)

$$\frac{F}{A} = E\frac{\Delta L}{L_o}$$

How large a force is necessary to stretch a 2.0-mm-diameter steel wire ($E = 2.0 \times 10^{11}$ N/m^2) by 1.0%?

$$\frac{F}{A} = E\frac{\Delta L}{L_o}$$

$\varepsilon = \frac{\Delta L}{L_o}$ = 1.0% = 0.01   r = 1 mm= 0.001m

*F=EA*0.01 =2x10^9^*π*0.001^2^*0.01 = 6300 N*

$F = EA \cdot 0.01 = 2\times10^{9} \cdot \pi \cdot 0.001^{2} \cdot 0.01 = 6300\ N$

A nylon string on a tennis racket is under a tension of 300 N. If its diameter is 1 mm, by how much is it lengthened from its original length of 30 cm? *Use* $E_{Nylon} = 5.0*10^9\ N/m^2$.

$$\frac{F}{A} = E\frac{\Delta L}{L_o}$$

$$\Delta L = \frac{F*L_o}{A*E} = \frac{300*0.3}{7.85x10^{-7}*5x10^9} = 0.023\text{m}$$

$$A = \pi r^2 = 3.14*0.0005^2 = 7.85\text{x}10^{-7}\text{m}^2$$

Pressure is defined as the force per unit area. $\mathbf{P} = \frac{F}{A}$

The units of pressure in the SI system are pascals:

1 Pa=1 N/m^2 1atm = 1.013x10^5 Pa

Hydrostatic pressure = **ρgh** – ***gauge pressure***

Absolute pressure $\mathbf{p_{ab} = p_{atm} + \rho g h}$

Buoyant force $\mathbf{F_B = \rho g V}$ Floating $\mathbf{mg = \rho g V}$

Pascal's Principle: $\frac{F_L}{A_L} = \frac{F_s}{A_s}$

Continuity equation: $A_1 v_1 = A_1 v_1$

Bernoulli's equation: $\mathbf{p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2}$

When a box rests on a round sheet of wood on the ground, it exerts an average pressure p on the wood. If the wood is replaced by a sheet that has half the diameter of the original piece, what is the new average pressure?

$R_2 = ½R_1$ $A_2 = \pi(R_2)^2 = \pi(½R_1)^2 = \pi¼(R_1)^2 = ¼A_1$

$$p_2 = \frac{F}{A_2} = \frac{F}{¼A_1} = 4\frac{F}{A_1} = 4p$$

A) 4p
B) 2p
C) p
D) p/2
E) p/4

Crew members attempt to escape from a damaged submarine 80 m below the surface. What force must they apply to a pop-out hatch of radius of 18 cm to push it out? Assume the density of ocean water 1025 kg/m^3.

$F = pA = (\rho g h)\, \pi r^2 = 1025 kg/m^3 \cdot 9.8 m/s^2 \cdot 80\ m * \pi(0.18m)^2$

82 kN

A block of wood has density 0.50 g/cm^3 and volume of 3000cm^3. It floats in a container of oil (the oil's density is 0.75 g/cm^3). What volume of oil does the wood displace?

$mg=F_B$ $\rho_w V_w g=\rho_{oil} V_{dis} g$ $\rho_w V_w=\rho_{oil} V_{dis}$

$$V_{disp} = \frac{0.5*3000}{0.75} = 2000\ cm^3$$

As a rock sinks deeper and deeper into water of constant density, what happens to the buoyant force on it if it started above the surface of the water?

A) The buoyant force keeps increasing steadily.

B) The buoyant force remains constant.

C) The buoyant force first increases and then remains constant.

D) The buoyant force steadily decreases.

E) None of the above

A 10 kg iron block (density = 7900 kg/m^3) is hanging from the rope. What is the tension in the rope if the block is immersed in a water.

$T + F_b - mg = 0$

$T = mg - F_b$

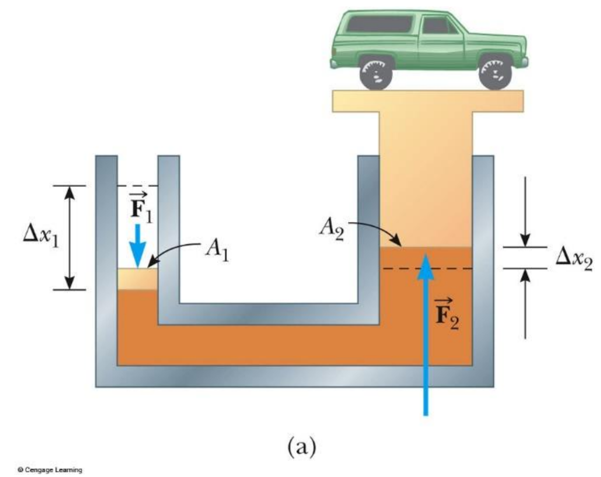
$F_B = \rho g V$ $V = m/\rho = 10 kg/7900 kg/m^3 = 0.0012 m^3$

$T = 98 N - 1000*9.8*0.0012 = 98 N - 12.4 N =$

$86 N$

In a hydraulic garage lift, the small piston has a radius of 5.0 cm and the large piston has a radius of 15 cm. What force must be applied on the small piston in order to lift a car weighing 20,000 N on the large piston? Assume the pistons each have negligible weight.

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$



$$F_1 = \frac{A_1 F_2}{A_2} = \frac{\pi r^2 F_2}{\pi R^2} = \frac{5^2 * 20000}{15^2} = 2200\text{N}$$

A 5/8-in (inside) diameter garden hose is used to fill a round swimming pool 6.1 m in diameter. How long will it take to fill the pool to a depth of 1.4 m if water flows from the hose at a speed of 4.0 m/s?

$$Av=\frac{volume}{time}$$ ***r = 5/16inx2.54 cm/in=0.79 cm***

volume = πR²d = π(3.05m)²1.4m =40.8m³

$$t=\frac{volume}{\pi r^2 v}=\frac{40.8m^3}{\pi(0.0079m)^2 4m/s}$$ ***= 51558 s =14.3 h***

If wind (density of air =1.29 kg/m^3) blows at 30 m/s parallel to a flat roof having an area of 475 m^2, what is the force exerted on the roof?

$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$$

$$p_1 - p_2 = \frac{1}{2}\rho(v_2^2 - v_1^2) = \frac{1}{2}\cdot 1.29\text{kg/m}^3(30^2 - 0)$$

$$= 580.5 \text{ Pa}$$

$$F = (p_1 - p_2)A = 580.5\text{Pa} * 475 \text{ m}^2 =$$

$2.76\text{x}10^5$ N, up

When you blow some air above a paper strip, the paper rises. This happens because

A) the air above the paper moves faster and the pressure is higher.

B) the air above the paper moves faster and the pressure is lower.

C) the air above the paper moves faster and the pressure remains constant.

D) the air above the paper moves slower and the pressure is higher.

E) the air above the paper moves slower and the pressure is lower.

In a section of horizontal pipe with a diameter of 3.0 cm, the pressure is 100 kPa and water is flowing with a speed of 1.5 m/s. The pipe narrows to 2.0 cm. What is the pressure in the narrower region? Treat the water as an ideal incompressible fluid.

$$A_1v_1 = A_2v_2 \quad v_2 = \frac{A_1v_2}{A_1} = \frac{\pi r^2 v_1}{\pi R^2} = \frac{1.5^2 * 1.5}{1^2} = 3.4 m/s$$

$$p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$$

$$p_2 = p_1 + ½\rho(v_1 - v_2^2)$$

$$p_2 = 1x10^5 Pa + ½ 1000 kg/m^3 * (1.5^2 - 3.4^2) = 95kPa$$

Converting Among Temperature Scales

$$T_C = T_K - 273.15$$

$$T_F = \frac{9}{5}T_C + 32$$

$$T_C = \frac{5}{9}\left(T_F - 32\right)$$

$$\Delta T_F = \frac{9}{5}\Delta T_C$$

Linear , Area and Volume Expantion

- $$\Delta L = L_0 \alpha \Delta T$$

$$\Delta A = A - A_o = \gamma A_o \Delta t,$$

$$\gamma = 2\alpha$$

$$\Delta V = \beta V_o \Delta t$$

$$\text{for solids}, \beta = 3\alpha$$

The temperature of the iron cube, 5 cm on edge, should be changed by what amount for the volume of the cube to increase by 0.35 cm^3. (The coefficient of linear expansion of iron is 1.2 x 10^{-5} per ^0C)

$0.35cm^3 = (5cm)^3 (3\alpha)\Delta T$ solve for ΔT

$$\Delta T = \frac{0.35}{125 * 3 * 1.2x10^{-5}} = 78^0C$$

For mercury to expand its volume by 2 % , what change in temperature is necessary? (β = $180 \times 10^{-6}/^{0}C$).

$$\mathbf{\Delta V = V_o \beta \Delta T} \qquad \frac{\Delta V}{V_o} = \mathbf{0.02}$$

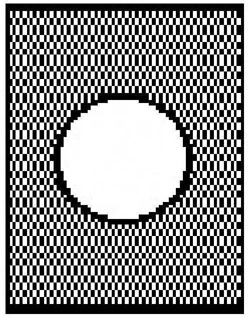
$$\frac{\Delta V}{V_o} = \beta \Delta T$$

$$\Delta T = \frac{0.02}{\beta} = \frac{0.02}{1.8x10^{-4}} = 111^{0}\mathrm{C}$$

A horizontal steel-beam is rigidly connected to two vertical steel girders. If the beam was installed when the temperature was 15^0C, what stress is developed in the beam when the temperature increases to 45^0C? b. Will it fracture? The Young's modulus for the steel is 200×10^9Pa and the ultimate strength of the steel is 1.70×10^8 Pa, $\alpha = 12 \times 10^{-6}/^0C$

$\sigma = E\alpha\Delta T = 2 \times 10^{11} * 12 \times 10^{-6} * (45 - 15) = 7.2 \times 10^7$Pa

Consider a flat steel plate with a hole through its center as shown in the figure. When the temperature of the plate is increased, the hole will



A) expand only if it takes up more than half the plate's surface area.
B) contract if it takes up less than half the plate's surface area.
C) always contract as the plate expands into it.
D) always expand with the plate.
E) remain the same size as the plate expands around it.

pV=nRT

R=8.31J/mol·K

$$n = \frac{mass}{molecular\ mass}$$

Avogadro number =6.023x10^{23}/mol

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

(a) Approximately how many moles of argon (atomic mass is 40 g/mol) are needed to fill the space between two panes of glass in a window, if the absolute gas pressure is 2 atm., the volume of the space is 0.2 m^3 , and the temperature is 30^0C? (1atm=$1.013x10^5$Pa)
(b) What is the mass of the argon ? ©How many argon atoms are in the space between two panes of glass?

pV = nRT   T = 273+30^0C = 303 K

p = $2x1.013x10^5$Pa =$2.023x10^5$Pa

solve for n; (a) n = $\frac{2.023x10^5*0.2}{8.31*303} = 16\, mole$

(b) m = n* atomic mass =16*40 g/mol=640 g

© N = n*$6.023x10^{23}$ = $9.6x10^{24}$

A tire is filled with air at 18^0C to an absolute pressure of 220 kPa. If the tire reaches a temperature of 42^0C what will the new absolute pressure be inside it?

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

volume- constant

$$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

$$p_2 = \frac{p_1 T_2}{T_1} = \frac{2.2x10^5(273 + 42)}{273 + 18} = 2.38x10^5 Pa$$

A air bubble at the bottom of a lake 41 m deep has a volume of 1 cm^3. If the temperature at the bottom is 5.0^0C and at the top is 18.0^0C, what is the volume of the bubble just before it reaches the surface? ($p_{at} = 1.013x10^5$Pa, $\rho = 1000 kg/m^3$)

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$V_1 = 1\ cm^3$

$p_1 = 1.013x10^5 + 1000*9.8*41 = 5.05x10^5 Pa$,

$T_1 = 273+5 = 278K$

$p_2 = 1.013x10^5 Pa$, $T_2 = 273+18 = 291K$

$$\boldsymbol{V_2 = \frac{p_1V_1T_2}{p_2T_1} = \frac{5.05x10^5 Pa 1cm^3 291K}{1.013x10^5\ Pa 278K}} = \mathbf{5.22\ cm^3}$$