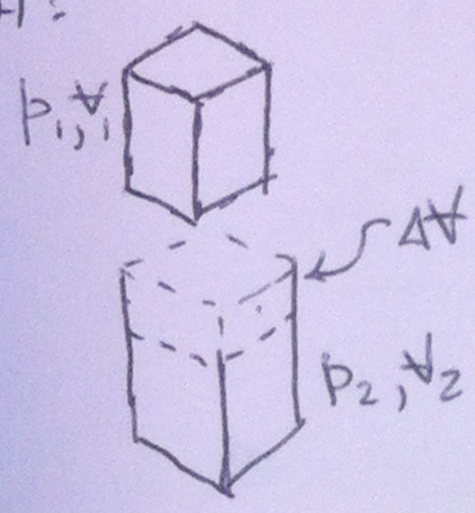
CE 3305 Engineering Fluid Mechanics
Exercise Set 2
Summer 2015 – GERMANY

1. (Problem 2.13 pg 55) Calculate the pressure increase (Δp) required to reduce the volume of a mass of water by 2-percent (2 %)

SKETCH:



$p_1 + \Delta p$, $\forall_1 - \Delta\forall = \forall_2$

$\Delta\forall = 0.02\forall_1$

KNOWN: $\Delta\forall$ = ↓ by 2%

UNKNOWN: Δp

SOLUTION: USE COMPRESSIBILITY EQUATION

$$E = -\Delta p \cdot \frac{\forall}{\Delta\forall} \quad ; \; E = 2.2\text{-}10^9 \text{ Pa from table A.5}$$

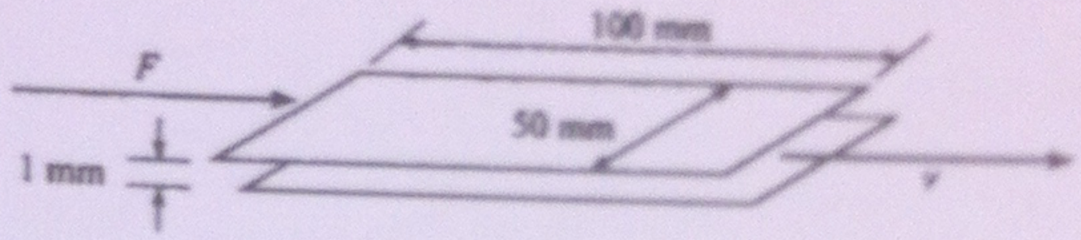
$$\Delta p = -E\,\frac{\Delta\forall}{\forall} = -2.2\times10^9 \text{Pa}\,\frac{(-0.02\cancel{\forall})}{\cancel{\forall}} = 4.4\cdot10^7 \text{ Pa}$$

$\therefore \Delta p = 44$ MPa INCREASE IS REQUIRED PRESSURE

DISCUSSION: • USE COMPRESSIBILITY AS EQUATION OF STATE
• NEARLY 40 ATMOSPHERES TO CHANGE BY ONLY 2%.

CE 3305 Fluid Mechanics; Exercise Set 2 Name SOLUTION

2. (Problem 2.35 pg 56) Figure 1 is a schematic of a sliding plate viscometer used to measure the viscosity of a fluid. The top plate is moving to the right with a constant velocity of 10 meters per second in response to a force of 3 Newtons. What is the viscosity of the fluid?[1]



PROBLEM 2.35

Figure 1: Sliding Plate Viscometer

KNOWN: $A = 50 \times 100$ mm ; $\Delta y = 1$ mm ; $N = 10$ m/s ; $F = 3$N

UNKNOWN: Fluid Viscosity

SOLUTION: USE DEFN. VISCOSITY ; USE DEFN. SHEAR

$$\tau = \mu \frac{dV}{dy} \quad ; \quad \tau = \frac{F}{A}$$

$$\tau = \frac{3\,N}{50mm \times 100mm} = \frac{600\,N}{m^2}$$

$$\mu = \frac{\tau}{\left(\frac{dV}{dy}\right)} = \frac{\frac{600\,N}{m^2}}{\left(\frac{10m/s}{1mm}\right)\left(\frac{1000mm}{1m}\right)} = 6 \cdot 10^{-2} \frac{N \cdot s}{m^2}$$

DISCUSSION: • UNITS VARY IN SCALE, NEED TO EXPRESS IN USEFUL UNITS. HENCE UNIT CONVERSIONS
• EVALUATE dV/dy AT ENDPOINTS SO THAT $\frac{dV}{dy} \approx \frac{\Delta V}{\Delta y}$

[1] Assume a linear velocity distribution.