17.5/20

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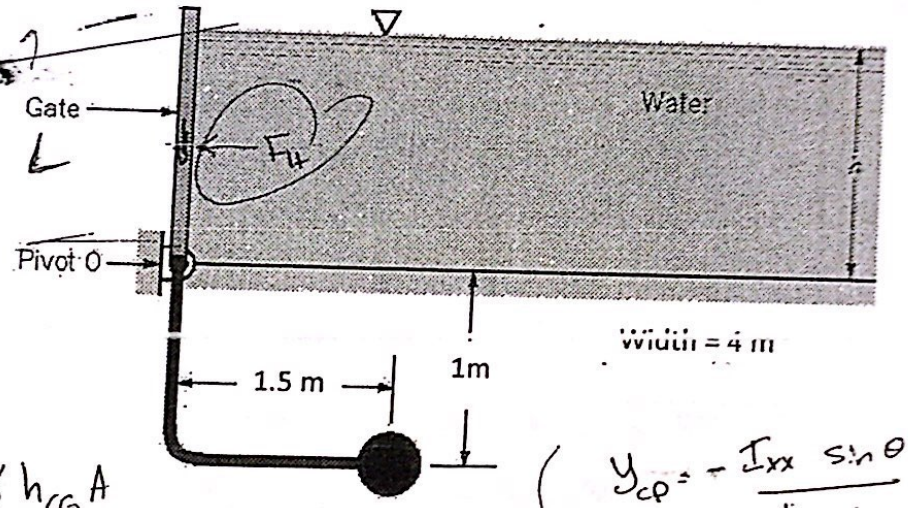
Fluid Mechanics – First Exam November 6th, 2012

Answer All Questions on same sheets

Question 1:

The mass-less, *4 m* wide gate shown in the figure below pivots about the frictionless hinge *O*. It is held in place by the *1000 N* counterweight, *W*.

For such configuration, determine the water depth, *h*?



$h_{cg} = \frac{h}{2}$

$F_H = \gamma h_{cg} A$

$F_H = 9790\, h_{cg} (4h)$

$F_H = 39160\, h_{cg} h$

$F_H = 39160 \left(\frac{h}{2}\right) h \Rightarrow F_H = 19580 h^2$

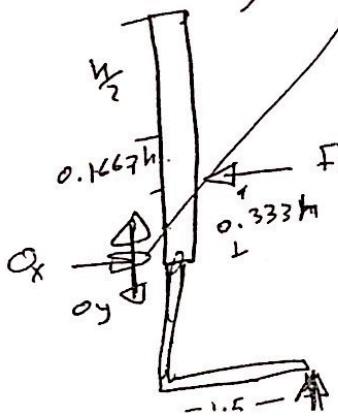
$y_{cp} = \frac{-I_{xx} \sin\theta}{h_{cg} A}$

$y_{cp} = \frac{-\frac{1}{12}(4)h^3 \sin 90}{h_{cg}(4h)}$

$y_{cp} = \frac{-0.0833\, h^2}{h_{cg}}$

$y_{cp} = \frac{-0.0833\, h^2}{\frac{h}{2}}$

$y_{cp} = -0.1667 h$



$\sum M_O = 0$

$1000(1.5) = 19580 h^2 (0.333h)$

$1500 = 6520.14 h^3$

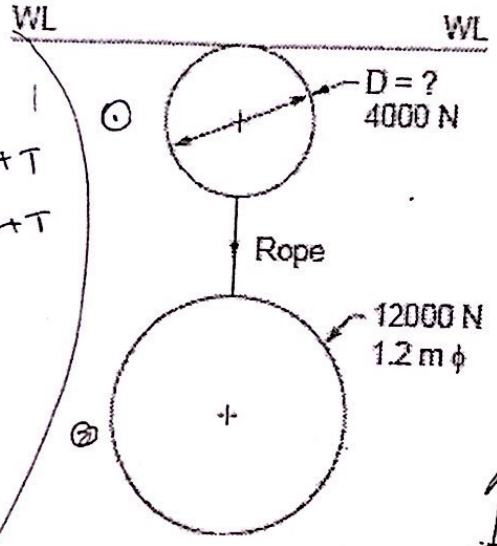
$h = 0.613$ m

Question 2:

Two spheres, one heavier and weighing ***12000 N*** and of diameter ***1.2 m*** and the other lighter and weighing ***4000 N***, are tied with a rope and placed in water. It was found that the spheres floated vertically with the lighter sphere just submerging.

Determine:

a) The diameter of the lighter sphere?
b) The tension in the rope?



$F_B = W + T$

ρg Volume $= 4000 + T$

9790 (Volume displaced) $= 4000 + T$

Volume $= 0.408$

$\frac{4}{3} r^3 \pi = 0.408$

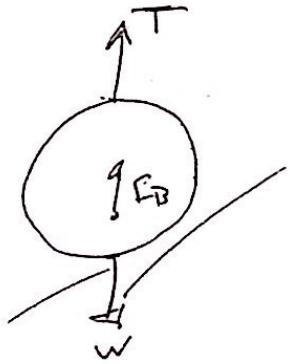
$r = 0.46$ m

$d = 2 * r$

$d = 0.921$ m (4000 N)

$d = 1.2$

$r = 0.6$



$W = F_B + \text{Tension}$

$12000 = \gamma$ (Volume displaced) $+ \text{Tension}$

$12000 = 9790 \left(\frac{4}{3} \pi r^3\right) + \text{Tension}$

$12000 = 8853.3 + \text{Tension}$

b) **Tension = 3146.7 N**

+ or Heavier

$F_B = W + \text{Tension}$

9790 (Volume disp.) $= 4000 + 3146.7$

$V = 0.73$

$\frac{4}{3} \pi r^3 = 0.73 \Rightarrow r = 0.558$

$d = 2 * r = 1.12$ m

1 bar = 100 000 Pa

Volume = $\frac{4}{3} r^3 \pi$

Pressure

Question 3:

i. A balloon is filled with 6 kg of hydrogen at 2 bar and 20°C. What will be the diameter of the balloon when it reaches an altitude where the pressure and temperature are 0.2 bar and –60° C. Assume that the pressure and temperature inside are the same as that at the outside at this altitude. Take $R_{hydrogen}$= 4157 J/kg.K, and assume it an ideal gas.

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$P = \rho R T$ | $\rho = \frac{m}{V}$

~~mass 6kg~~

$2 * 10^5 = \rho * 4157 * 293$

$\rho = 0.1642$

$\rho = \frac{m}{\text{Volume}} \Rightarrow \text{Volume} = \frac{m}{\rho}$

$\text{Volume} = \frac{6}{0.164}$

$\text{Volume} = 36.54\ m^3$

and when the temp. – 60° C.
and the Pressure = 0.2 bar
it is diameter will be

Temp.= 273 – 60 = 213 Kelvin

Pressure = 0.2 (10^5) = 20 000 Pa

$P = \rho R T$

$\rho = \frac{P}{RT} \Rightarrow \frac{20\,000}{4157 * 213}$

$\rho = 0.0225$

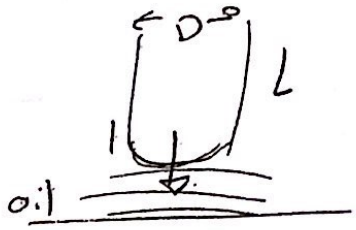
$\rho = \frac{m}{V} \Rightarrow V = \frac{m}{\rho} = \frac{6}{0.022}$

$V = 265.63\ m^3$

$V = \frac{4}{3} r^3 \pi$ (balloon)

$\frac{(265.63)^3}{4\pi} = r^3$

$r = 3.988$ m



ii. **Determine the resistance offered to the downward sliding** of a shaft of ***400 mm*** diameter and ***0.1 m*** length by the oil film between the shaft and a bearing of internal diameter ***402 mm***. The kinematic viscosity is ***2.4×10^{-4} m^2/s*** and density is ***900 kg/m^3***. The shaft is to move centrally and axially at a constant velocity of ***0.1 m/s***.

2.5

$$\tau = \mu \frac{du}{dh}$$

$$\frac{F_{shear}}{A} = \mu \frac{du}{dh}$$

$$A = \pi D H$$

$$A = \pi (400 * 10^{-3})(0.1)$$

$$A = 0.1256\ m^2$$

$$\frac{F}{0.1256} = 2.4 * 10^{-4} * \frac{0.1}{0.402}$$

$$\tau = \mu \frac{u}{h}$$

$$= 2.4 * 10^{-4} * 0.1$$

$$\tau \left(\frac{F}{A}\right) = 5.97 * 10^{-5}$$

$$\frac{F}{0.1256} = 5.97 * 10^{-5}$$

$$F = 7.498 * 10^{-6}\ N$$