 Name: SOLUTIONS

CE 3305 Engineering Fluid Mechanics
Exercise Set 9
Spring 2014

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TEXAS TECH UNIVERSITY
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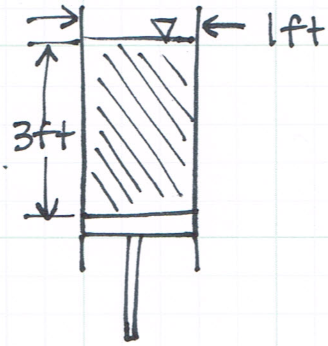
ASCE STUDENT CHAPTER

NAME SOLUTION DATE 24 Feb 14
COURSE CE 3305 SHEET 1 OF 3

4.38) If the piston and water ($\rho = 62.4$ lbm/ft^3) are accelerated upward at a rate of 0.4g, what will be the pressure at a depth of 2ft in the water column?

SKETCH:



KNOWN:

$\gamma = 62.4\ \text{lbm}/\text{ft}^3$ $z = 3\text{ft}$

$a = 0.4g$

UNKNOWN:

$P_a = ?$

GOVERNING EQN:

$$\rho a_\ell = -\frac{d}{d\ell}(p + \gamma z)$$

SOLUTION:

$$\rho(0.4g) = -\frac{\partial p}{\partial \ell} - \gamma\frac{\partial z}{\partial \ell}$$

$$\frac{\gamma}{\cancel{g}}(0.4\cancel{g}) = -\frac{\partial P}{\partial \ell} - \gamma(3)$$

$$\frac{dP}{\partial \ell} = -\gamma(0.4 + 3) = -3.4\gamma$$

Pressure decreases upward at a rate of 3.4γ. Pressure at the top is atmospheric.

@ depth 3ft:

$$P_2 = (3.4\gamma)(3') = 10.2\gamma$$
$$= 10.2'\left(\frac{62.4\ \text{lbm}}{\text{ft}^3}\right)$$
$$= 636.48\ \text{lbm}$$

4.41) Water ($\rho = 1000\,kg/m^3$) is accelerated from rest in a horizontal pipe that is 80m long and 30 cm in diameter. If the acceleration rate (toward the downstream end) is $5\,m/s^2$, what is the pressure at the upstream end if pressure at the downstream end is 90 kPa gage?

KNOWN:

$L = 80\,m$ $\quad \rho = 1000\,kg/m^3$

$D = 30\,cm$ $\quad P_{downstream} = 90\,kPa$

$a_s = 5\,m/s^2$

UNKNOWN:

$P_{upstream} = ?$

GOVERNING EQN:

$$\frac{\partial P}{\partial s} = -\rho a_s$$

SOLUTION:

$$\frac{\partial P}{\partial s} = -\rho a_s$$

$$= -1000\frac{kg}{m^3}\left(\frac{5m}{s^2}\right) = -5000\,N/m^3$$

$$\frac{P_{down} - P_{up}}{\Delta s} = \frac{\partial p}{\partial s}$$

$$P_{up} = 90{,}000\,Pa + (5000\,N/m^3)(80\,m)$$

$$= 490{,}000\,Pa \text{ gage}$$

$$\boxed{P_{upstream} = 490\,kPa \text{ gage}}$$

4.44) If the velocity varies linerally with distance through this water nozzle, what is the pressure gradient, dp/dx, halfway through the nozzle?

KNOWN:

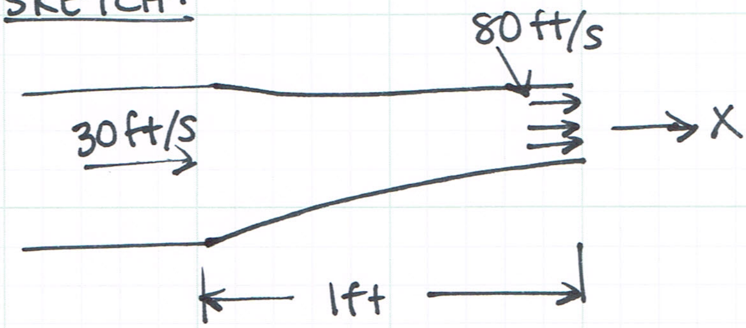
$\rho = 62.4\ \text{lbm}/\text{ft}^3$

$L = 1\text{ft}$

$V_1 = 30\text{ft/s}$

$V_2 = 80\text{ft/s}$

SKETCH:



UNKNOWN:

$\frac{dp}{dx}$ in (psf/ft)

GOVERNING EQN:

$$\frac{\partial}{\partial x}(p + \gamma z) = \rho a_x$$

SOLUTION:

$z = \text{constant}\ \therefore$

$$\frac{\partial p}{\partial x} = -\rho a_x$$

$$a_x = a_{convective} = V\frac{dV}{dx}$$

$$\frac{dV}{dx} = \frac{\left(80\frac{ft}{s} - 30\frac{ft}{s}\right)}{1ft} = 50\,s^{-1}$$

$$V_{mid} = \frac{(80ft/s + 30ft/s)}{2} = 55ft/s$$

$$a_x = V_{mid}\frac{dV}{dx} = 55\frac{ft}{s} \times \frac{50}{s} = 2750\ ft/s^2$$

$$\frac{dp}{dx} = -62.4\frac{lbm}{ft^3}\left(2750\frac{ft}{s^2}\right)$$

$$\boxed{\frac{dp}{dx} = -5{,}330\ psf/ft}$$