Florida International University
Department of Civil and Environmental Engineering

CWR 3201 Fluid Mechanics
Fall 2018
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Homework Assignment 3 Solutions

*Mechanics of Fluids (**Fifth edition**), by M.C. Potter, D.C. Wiggert and B.H. Ramadan.*

1. 3.18 (same number in *Fourth edition*)

   a) $\cos\alpha = \frac{V\cdot\hat{\imath}}{\|V\|} = \frac{[(1+2)\hat{\imath}+2\hat{\jmath}]\cdot\hat{\imath}}{\sqrt{3^2+2^2}} = 0.832$

   $$\alpha = 33.69\ deg$$

   To calculate the normal: $V \cdot \hat{n} = 0$

   $$(3\hat{\imath}+2\hat{\jmath})\cdot\left(n_x\hat{\imath}+n_y\hat{\jmath}\right)=0$$

   $$3n_x+2n_y=0$$

   $$Unit\ vector: n_x^2+n_y^2=1$$

   Solving system of equations gives: $\hat{n} = \frac{1}{\sqrt{13}}(2\hat{\imath}-3\hat{\jmath})$

   Part b and c are the same steps except V is given as different equations

2. 3.19 (same number in *Fourth edition*)

a) $V \times dr = 0$

$$[(x+2)\hat{\imath}+xt\hat{\jmath}]\times(dx\hat{\imath}+dy\hat{\jmath})=0$$

$(x+2)dy - xtdx = 0$ OR $t\frac{xdx}{x+2} = dy$

$$Integrate: t\int\frac{xdx}{x+2} = \int dy$$

$$t[x-2ln|x+2|] = y + C$$

Plug in streamline point values to solve for coefficient C: $2(1-2ln3) = -2 + C$

$$C = 0.8028$$

Equation of the streamline: $t[x-2ln|x+2|] = y + 0.8028$

Part b and c are the same steps but different equations to integrate

3. 3.28

   a. Along the center of the pipe r=0 cm:

   $$u = 2(1-0)\left(1-e^{-\frac{t}{10}}\right) = 2\frac{m}{s}\ when\ t=\infty$$

   $$a_x = \frac{\partial u}{\partial t} = 2(1-0)\left(\frac{1}{10}\right)e^{-\frac{t}{10}} = 0.2\frac{m}{s^2}\ at\ t=0$$

b. At r = 0.5 cm: $u = 2\left(1-\frac{0.5^2}{2^2}\right)\left(1-e^{-\frac{t}{10}}\right) = 1.875\,\frac{m}{s}\, when\ t = \infty$

$$a_x = \frac{\partial u}{\partial t} = 2\left(1-\frac{0.5^2}{2^2}\right)\left(\frac{1}{10}\right)e^{-\frac{t}{10}} = 0.1875\,\frac{m}{s^2}\, at\ t = 0$$

c. Along the wall, r = 2 cm (entirety of the tube): $u = 2\left(1-\frac{2^2}{2^2}\right)\left(1-e^{-\frac{t}{10}}\right) =$ $0\,\frac{m}{s}\, when\ t = all\ time$

$$a_x = \frac{\partial u}{\partial t} = 2\left(1-\frac{2^2}{2^2}\right)\left(\frac{1}{10}\right)e^{-\frac{t}{10}} = 0\,\frac{m}{s^2}\, at\ t = all\ time$$

4. 3.35

$$\mathbf{A} = \mathbf{a} + \frac{d^2\mathbf{S}}{dt^2} + 2\mathbf{\Omega}\times\mathbf{V} + \mathbf{\Omega}\times(\mathbf{\Omega}\times\mathbf{r}) + \frac{d\mathbf{\Omega}}{dt}\times\mathbf{r} \qquad (3.2.12)$$

acceleration of reference frame	Coriolis acceleration	normal acceleration	angular acceleration

a. $A = 2(20\hat{k}\times 12\hat{\imath}) + 20\hat{k}\times(20\hat{k}\times 4.5\hat{\imath}) = 480\,\hat{\jmath} - 1800\hat{\imath}\ ft/s^2$

b. $A = 2(20\hat{k}\times -60cos30\hat{\jmath}) + 20\hat{k}\times(20\hat{k}\times 4.5\hat{\imath}) = 278\hat{\imath}\ ft/s^2$

5. 3.45

Reynolds Number: $Re = \frac{VL}{\upsilon} = \frac{(\frac{2m}{s})(0.015\ m)}{(0.77x10^{-6})} = 38961$ Turbulent