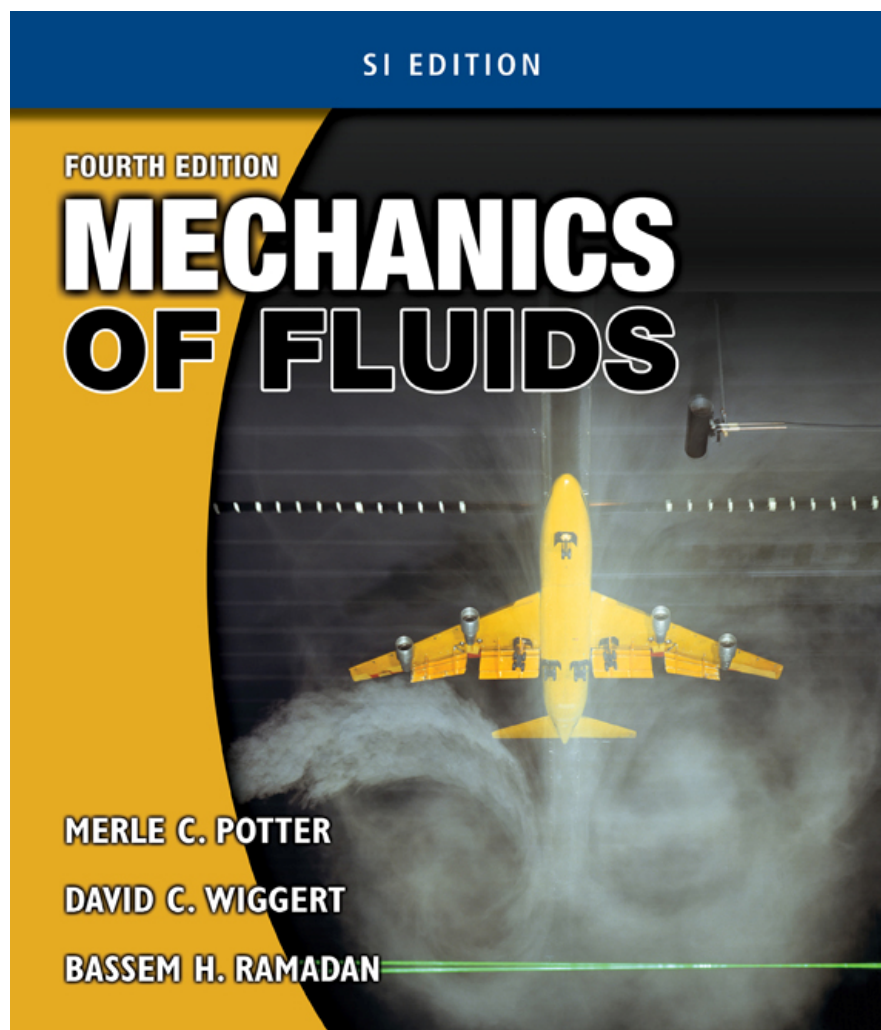


A STUDENT'S SOLUTIONS MANUAL TO ACCOMPANY
MECHANICS *of* FLUIDS,
4TH EDITION, SI

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DAVID C. WIGGERT
BASSEM H. RAMADAN



 **CENGAGE**
Learning®

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TO ACCOMPANY
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FOURTH EDITION, SI

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1.13 (D)	<p>Since a dog's whistle produces sound waves at a high frequency, the speed of sound is $c = \sqrt{RT} = \sqrt{287 \text{ J/kg} \cdot \text{K} \times 323 \text{ K}} = \underline{304 \text{ m/s}}$</p> <p>where we used $\text{J/kg} = \text{m}^2/\text{s}^2$.</p>
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Dimensions, Units, and Physical Quantities

1.16	<p>a) density = $\frac{M}{L^3} = \frac{FT^2/L}{L^3} = FT^2/L^4$</p> <p>c) power = $F \times \text{velocity} = F \times L/T = FL/T$</p> <p>e) mass flux = $\frac{M/T}{A} = \frac{FT^2/L}{L^2T} = FT/L^3$</p>
1.18	<p>b) $N = [C] \text{ kg} \quad \therefore [C] = \text{N/kg} = (\text{kg} \cdot \text{m/s}^2)/\text{kg} = \text{m/s}^2$</p>
1.20	<p>$\text{kg} \frac{\text{m}}{\text{s}^2} + c \frac{\text{m}}{\text{s}} + km = f$. Since all terms must have the same dimensions (units) we require:</p> <p>$[c] = \text{kg/s}$, $[k] = \text{kg/s}^2 = \text{N} \cdot \text{s}^2 / \text{m} \cdot \text{s}^2 = \text{N/m}$, $[f] = \text{kg} \cdot \text{m/s}^2 = \text{N}$</p> <p>Note: we could express the units on c as $[c] = \text{kg/s} = \text{N} \cdot \text{s}^2 / \text{m} \cdot \text{s} = \underline{\text{N} \cdot \text{s/m}}$</p>
1.22	<p>a) $1.25 \times 10^8 \text{ N}$ c) $6.7 \times 10^8 \text{ Pa}$ e) $5.2 \times 10^{-2} \text{ m}^2$</p>
1.24	<p>a) $20 \text{ cm/hr} = 20 \frac{\text{cm}}{\text{hr}} \times \frac{\text{m}}{100 \text{ cm}} \times \frac{\text{hr}}{3600 \text{ s}} = 5.556 \times 10^{-5} \text{ m/s}$</p> <p>c) $500 \text{ hp} = 500 \text{ hp} \times \frac{745.7 \text{ W}}{\text{hp}} = 37,285 \text{ W}$</p> <p>e) $2000 \text{ kN/cm}^2 = 2000 \frac{\text{kN}}{\text{cm}^2} \times \left(\frac{100 \text{ cm}}{\text{m}} \right)^2 = 2 \times 10^{10} \text{ N/m}^2$</p>
1.26	<p>The mass is the same on the earth and the moon, so we calculate the mass, then calculate the weight on the moon:</p> <p>$m = 27 \text{ kg} \quad \therefore W_{\text{moon}} = (27 \text{ kg}) \times (1.63) = \underline{44.01 \text{ N}}$</p>

CHAPTER 2

Fluid Statics

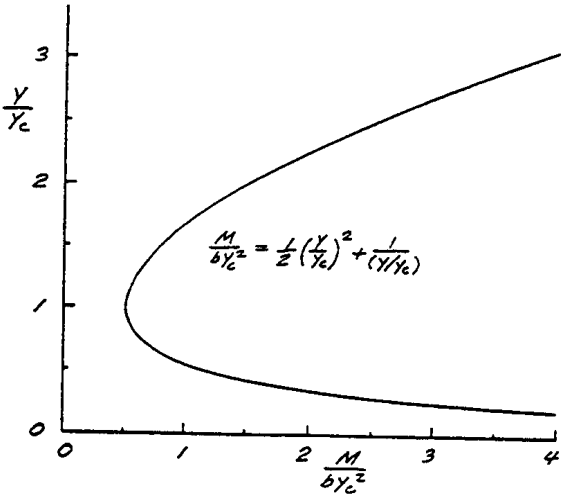
FE-type Exam Review Problems: Problems 2-1 to 2-9

2.1 (C)	<p>The pressure can be calculated using: $p = \gamma_{Hg} h$ where h is the height of mercury.</p> $p = \gamma_{Hg} h = (13.6 \times 9810 \text{ N/m}^3) \times (28.5 \times 0.0254) = 96,600 \text{ Pa} = \underline{96.6 \text{ kPa}}$
2.2 (D)	<p>Since the pressure varies in a vertical direction, then:</p> $p = p_0 - \rho g h = 84,000 \text{ Pa} - 1.00 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 \times 4000 \text{ m} = \underline{44.76 \text{ kPa}}$
2.3 (C)	$p_w = p_{atm} + \gamma_m h_m - \gamma_{water} h_w = 0 + 30,000 \times 0.3 - 9810 \times 0.1 = 8020 \text{ Pa} = 8.02 \text{ kPa}$ <p>This is the gage pressure since we used $p_{atm} = 0$.</p>
2.4 (A)	<p>Initially, the pressure in the air is</p> $p_{Air,1} = -\gamma H = -(13.6 \times 9810) \times 0.16 = -21,350 \text{ Pa.}$ <p>After the pressure is increased we have:</p> $p_{Air,2} = -21,350 + 10,000 = -11,350 = -13.6 \times 9810 H_2.$ $\therefore H_2 = 0.0851 \text{ m} = 8.51 \text{ cm}$
2.5 (B)	<p>The moment of force P with respect to the hinge, must balance the moment of the hydrostatic force F with respect to the hinge, that is: $(2 \times \frac{5}{3}) \times P = F \times d$</p> $F = \gamma \bar{h} A = 9.81 \text{ kN/m}^3 \times 1 \text{ m} \times (2 \times \frac{5}{3} \times 3 \text{ m}^2) \therefore F = 98.1 \text{ kN}$ <p>The location of F is at</p> $y_p = \bar{y} + \frac{\bar{I}}{\bar{y} A} = 1.67 + \frac{3(3.33)^3 / 12}{1.67(3.33 \times 3)} = 2.22 \text{ m} \Rightarrow d = 3.33 - 2.22 = 1.11 \text{ m}$ $3.33 \times P = 98.1 \times 1.11 \therefore P = 32.7 \text{ kN}$
2.6 (A)	<p>The gate opens when the center of pressure is at the hinge:</p> $\bar{y} = \frac{1.2 + h}{2} + 5. \quad y_p = \bar{y} + \frac{\bar{I}}{A \bar{y}} = \frac{11.2 + h}{2} + \frac{b(1.2 + h)^3 / 12}{(1.2 + h)b(11.2 + h) / 2} = 5 + 1.2$ <p>This can be solved by trial-and-error, or we can simply substitute one of the answers into the equation and check to see if it is correct. This yields $h = 1.08 \text{ m}$.</p>

7.76	$\bar{u} = \Sigma u_i / 11 = \underline{16.2 \text{ m/s}} \quad \bar{v} = \Sigma v_i / 11 = \underline{-1.6 \text{ m/s}} \quad u' = u - \bar{u} \quad v' = v - \bar{v}$ <table><tr><td>t</td><td>0</td><td>0.01</td><td>0.02</td><td>0.03</td><td>0.04</td><td>0.05</td><td>0.06</td><td>0.07</td><td>0.08</td><td>0.09</td><td>0.1</td></tr><tr><td>u'</td><td>-0.1</td><td>9.5</td><td>-5.6</td><td>1.1</td><td>-11</td><td>-6</td><td>0.9</td><td>12.4</td><td>-9.5</td><td>3</td><td>5.4</td></tr><tr><td>u'^2</td><td>0.01</td><td>90.2</td><td>31.4</td><td>1.2</td><td>121</td><td>36</td><td>0.81</td><td>153.8</td><td>90.2</td><td>9</td><td>29.2</td></tr><tr><td>v'</td><td>3.2</td><td>-3.8</td><td>-7</td><td>5.1</td><td>5.7</td><td>-4.4</td><td>0.2</td><td>8.3</td><td>-3.6</td><td>-6.6</td><td>3.1</td></tr><tr><td>v'^2</td><td>10.2</td><td>14.4</td><td>49</td><td>26</td><td>32.5</td><td>19.4</td><td>0.04</td><td>68.9</td><td>13.0</td><td>43.6</td><td>9.6</td></tr><tr><td>$u'v'$</td><td>-0.32</td><td>-36.1</td><td>39.2</td><td>5.6</td><td>-62.7</td><td>26.4</td><td>0.2</td><td>102.9</td><td>34.2</td><td>-19.8</td><td>16.7</td></tr></table> $\overline{u'^2} = \underline{51.2 \text{ m}^2/\text{s}^2} \quad \overline{v'^2} = \underline{26.1 \text{ m}^2/\text{s}^2} \quad \overline{u'v'} = \underline{9.7 \text{ m}^2/\text{s}^2}$	t	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	u'	-0.1	9.5	-5.6	1.1	-11	-6	0.9	12.4	-9.5	3	5.4	u'^2	0.01	90.2	31.4	1.2	121	36	0.81	153.8	90.2	9	29.2	v'	3.2	-3.8	-7	5.1	5.7	-4.4	0.2	8.3	-3.6	-6.6	3.1	v'^2	10.2	14.4	49	26	32.5	19.4	0.04	68.9	13.0	43.6	9.6	$u'v'$	-0.32	-36.1	39.2	5.6	-62.7	26.4	0.2	102.9	34.2	-19.8	16.7
t	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1																																																														
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7.78	$\eta = -\frac{\overline{u'v'}}{d\bar{u}/dy} = -\frac{-2.52}{(23-18.2)/0.03} = \underline{0.016 \text{ m}^2/\text{s}}$ $K_{uv} = \frac{\overline{u'v'}}{\sqrt{\overline{u'^2}}\sqrt{\overline{v'^2}}} = \frac{-2.52}{\sqrt{29}\sqrt{14}} = \underline{-0.125}$ $\ell_m = \sqrt{\eta/\partial\bar{u}/\partial y} = \sqrt{0.016/(23-18.2)/0.03} = 0.01 \text{ m or } \underline{1 \text{ cm}}$																																																																								
7.80	<p>b) $\text{Re} = \frac{0.2 \times 0.2}{10^{-6}} = 40,000, \quad \frac{e}{D} = 0.0013$</p> <p>From the Moody diagram, this is in the transition zone where δ_ν may be near, in magnitude, to e. The pipe is <u>rough</u>.</p>																																																																								
7.82	<p>b) With $\text{Re} = 40,000, e/D = 0.0013$ the Moody diagram gives $f = 0.026$. Then</p> $\tau_0 = \frac{0.026}{8} 1000 \times 0.2^2 = 0.130 \text{ Pa} \quad u_\tau = \sqrt{0.130/1000} = 0.01140 \text{ m/s}$ <p>Eq. 7.6.17: $u_{\max} = u_\tau \left(2.44 \ln \frac{r_o}{e} + 8.5 \right)$</p> $= 0.0114 \left(2.44 \ln \frac{0.1}{0.00026} + 8.5 \right) = \underline{0.262 \text{ m/s}}$																																																																								
7.84	$V = \frac{Q}{A} = \frac{70 \times 10^{-3}}{\pi \times (0.6)^2} = 6.2 \text{ m/s} \quad \text{Re} = \frac{VD}{\nu} = \frac{6.2 \times 0.12}{1.007 \times 10^{-6}} = 7.4 \times 10^5$ <p>From Table 7.1, $n \cong 8.5$. From Eq. 7.6.20</p> $u_{\max} = \frac{(n+1)(2n+1)}{2n^2} \times V = \frac{9.5 \times 18}{2 \times 8.5^2} \times 6.2 = \underline{7.34 \text{ m/s}}$																																																																								

<p>10.28</p>	<p>(a) $B' = 1 \text{ m}, H' = 0.36 \text{ m} \Rightarrow B = \frac{B'}{0.3048} = 3.281$ and $H = \frac{H'}{0.3048} = 1.18$</p> <p>$Q = 0.11BH^{(1.522B)^{0.026}} = 0.11 \times (3.281)(1.18)^{(1.522 \times 3.281)^{0.026}} = \underline{0.42 \text{ m}^3/\text{s}}$</p> <p>(b) $H'(\text{m})$ 0.15 0.2 0.25 0.30 0.35 0.4 0.45</p> <p>$Q \text{ m}^3/\text{s}$ 0.17 0.23 0.29 0.35 0.41 0.47 0.53</p>
<p>10.30</p>	<p>$Q_1 = b \left(\frac{2}{3} \sqrt{\frac{2}{3}g} \right) (y_1 - h)^{3/2}, Q_2 = b \left(\frac{2}{3} \sqrt{\frac{2}{3}g} \right) (y_2 - h)^{3/2}$</p> <p>given Q_1, y_1, Q_2, y_2, solve for b and h</p> <p>$\frac{y_1 - h}{y_2 - h} = \left(\frac{Q_1}{Q_2} \right)^{2/3}$ or $h = \frac{y_1 - y_2 (Q_1/Q_2)^{2/3}}{1 - (Q_1/Q_2)^{2/3}}$</p> <p>(a) $h = \frac{1.05 - 1.75(0.15/30)^{2/3}}{1 - (0.15/30)^{2/3}} = \underline{1.03 \text{ m}}$</p> <p>$\therefore b = \frac{Q_2}{\frac{2}{3} \left(\sqrt{\frac{2}{3}g} \right) (y_2 - h)^{3/2}} = \frac{30}{\frac{2}{3} \left(\sqrt{\frac{2}{3} \times 9.81} \right) (1.75 - 1.03)^{3/2}} = \underline{28.8 \text{ m}}$</p>

Momentum Concepts

<p>10.32</p>	<div style="display: flex; align-items: center;"> <div style="flex: 1;"> $M = b \left(\frac{y^2}{2} + \frac{q^2}{gy} \right)$ $\frac{M}{by_c^2} = \frac{1}{2} \left(\frac{y}{y_c} \right)^2 + \frac{q^2}{gy_c^2 y}$ $= \frac{1}{2} \left(\frac{y}{y_c} \right)^2 + \frac{q^2}{gy_c^3 (y/y_c)}$ <p>But $q^2/gy_c^3 = 1$</p> $\therefore \frac{M}{by_c^2} = \frac{1}{2} \left(\frac{y}{y_c} \right)^2 + \frac{1}{(y/y_c)}$ </div> <div style="flex: 1; text-align: center;">  </div> </div>
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