

Answers to Selected Even-Numbered Homework Problems

Chapter 1

- 1.2** (a) MLT^{-1} ; (b) ML^4L^{-2} ; (c) MT^{-2}
1.4 (a) FLT^{-2} ; (b) $FL^{-1}T^{-1}$; (c) $FL^{-3}T$
1.10 (a) FL^{-1} ; (b) FL^{-3} ; FL
1.12 LT^{-1} ; $F^0L^0T^0$; LT^{-1}
1.14 Yes
1.16 $1/2$, $-1/2$
1.18 Dimensionless
1.20 $7,200\text{ m}^3/\text{s}$
1.22 acceleration $\times$ time/velocity $= (LT^{-2})(T)/(LT^{-1}) = L^0T^0$
 frequency $\times$ time $= (T^{-1})(T) = T^0$
 (velocity) 2 /length $\times$ acceleration $= (LT^{-1})^2/(L)(LT^{-2}) = L^0T^0$
 force $\times$ time/momentum $= (F)(T)/(MLT^{-1}) = (F)(T)/(FT^2L^{-1})(LT^{-1}) = F^0L^0T^0$
 density $\times$ velocity $\times$ length/dynamic viscosity $= (ML^{-3})(LT^{-1})(L)/(ML^{-1}T^{-1}) = M^0L^0T^0$
1.26 (a) 3580 N; (b) 598.6 N
1.30 1.36
1.34 9770 N/m^3 ; 996 kg/m^3 ; 0.996
1.36 $3,290\text{ N/m}^3$
1.40 64°C
1.42 Oxygen
1.44 1.26 m^3
1.46 58 kPa
1.50 893 l/s
1.54 $0.277\text{ N} \cdot \text{s}/\text{m}^2$
1.56 $2.05 \times 10^{-5}\text{ N} \cdot \text{s}/\text{m}^2$
1.58 (a) No; (b) Not correct
1.60 184
1.62 $C = 1.43 \times 10^{-6}\text{ kg}/(\text{m} \cdot \text{s} \cdot \text{K}^{1/2})$; 107 K
1.64 $5.76 \times 10^{-4}\text{ N} \cdot \text{s}/\text{m}^2$
1.66 $0.300\text{ N} \cdot \text{s}/\text{m}^2$
1.68 non-Newtonian
1.70 286 N
1.72 0.0883 m/s
1.74 0.19 m/s
1.76 151 s^{-1} ; $33,333\text{ m}^{-2}\text{s}^{-1}$
1.78 $1.22 \times 10^{-3}\text{ N} \cdot \text{s}/\text{m}$
1.80 (a) $1.182\text{ m}^2/\text{rev}$; (b) $0.225\text{ N} \cdot \text{s}/\text{m}^2$
1.86 2.73 MPa
1.88 2.02 GPa
1.92 719 kPa (gage)

- 1.94** 2.88 kg/m^3
1.96 2.18 kg/m^3 ; 154°C
1.98 718.6 kPa
1.100 1.06
1.102 14.1%
1.106 13 kPa (abs)
1.108 5.81 kPa (abs)
1.110 0.060 N/m
1.112 538 Pa
1.114 97.9 Pa
1.116 (a) $\theta = 24.5^\circ$
1.118 0.00156 m; Yes.
1.120 3.00 mm
1.122 7.49 mm

Chapter 2

- 2.2** 59.2 kPa
2.6 2.39 kPa
2.8 404 kPa
2.10 (a) $p = -E_v \ln(1 - \rho_0 gh/E_v)$; (b) 61.4 MPa; (c) 60.6 MPa
2.12 $p = Kh^2/2 + \gamma_0 h$
2.18 464 mm
2.20 63.5%
2.24 8,794 m
2.26 443 m
2.28 60 kPa
2.32 99.35 kPa (abs)
2.34 (a) 5.6 m; (b) 60.76 kPa; (c) 150.3 kPa
2.36 0.095 m
2.38 1.91 m
2.40 -3.32 kPa
2.42 (a) 1.22 m; (b) 0.63 m
2.44 0.43 m
2.46 (a) 26.9 kPa; (b) 0.202 m
2.48 16.99 kg/m^3
2.50 94.9 kPa
2.54 6.56 m
2.56 27.52 kPa
2.58 0.100 m
2.60 28.68
2.62 0.212 m
2.64 0.089 m (down)

ANS-2 Answers to Selected Even-Numbered Homework Problems

- 2.66** $\ell = [d + 11.31 - (d^2 + 18.61d + 128)^{1/2}]/2$
2.68 159,493.6 N
2.70 $p(\text{kPa}) = 1.85 \theta$
2.73 0.00802 N
2.75 89.62 kN
2.78 37,166 N
2.80 107 kPa
2.82 7.11 m; No
2.86 $F_B = \gamma \pi R^3/4$
2.88 (a) 3.6 m; (b) 48 kN; (c) 0 kN
2.90 373 kN
2.92 314 kN; 497 kN
2.94 7 kN
2.98 1.02 m
2.100 (a) 2.11 m; (b) 941 kN
2.102 4519 N
2.104 426 kN, 2.46 m below surface
2.106 1.4 m
2.108 0.146
2.114 392 kN; 437 kN; Yes
2.116 135.4 N; 2574 N; 2.29 kN/m²
2.118 34.32×10^9 N acting 124 m above base
2.120 64.4 kN
2.122 24.527 kPa
2.124 203 kN down
2.126 3370 lb; 882 lb
2.128 485 kN
2.132 0.37 m; no change
2.134 3,423,630 N; 1,367,452 N
2.136 236 kN
2.140 536 N
2.142 18.9 kPa; 0.208 m³
2.144 2932 N upward; $l = 1.9$ m to right of point A
2.146 89.5%
2.148 2.63 m/s²
2.150 3374 N/m²; 253 N downward
2.152 30°
2.154 $h = a\ell/g$
2.156 6.04 rad/s
2.158 1.7 m
2.160 28.8 kPa
3.36 58.8 kN/m²
3.40 9.34 N/s
3.42 0.334×10^{-3} m³/s
3.44 15.4 m
3.46 (a) 0.069 m; 0.452 kN/m²
3.48 2.45×10^5 kN/m³; 5.50×10^{-6} m³/s
3.50 0.92 m
3.52 0.0156 m³/s for any D
3.54 1.97 m; B above A
3.56 $D = D_1/[1 - (\pi^2 g D_1^4 z/8Q^2)^{1/4}]$
3.58 0.94 m
3.60 2.94 m
3.62 2.13×10^{-3} m³/s, 23,520 N/m², 22,932 N/m², 588 N/m²
3.64 (a) 1.1 m; (b) 11.0 m/s; -462 kN/m²
3.66 135 kPa (gage)
3.68 6.26 m
3.70 (a) 1.06×10^{-3} ; (b) 3.02×10^{-3} ; 0.118
3.72 29.5 Pa
3.74 0 (gage); 0.146 m
3.76 (a) 0.0696 m³/s; (b) 0.574 m
3.78 $H/H_0 = 1/(1 + cx/L)^{1/2}$, where $c = 2\gamma_{\text{H}_2\text{O}} d_{\text{max}}/\rho V_0^2$
3.80 0.0132 m³/s
3.82 6.84 cm
3.84 4
3.86 89.1 kPa
3.88 0.607 ft³/s; (b) 21.3 ft
3.90 3.52×10^{-3} m³/s
3.92 0.131 m
3.94 $R = 0.998 z^{1/4}$
3.100 404.5 kPa
3.102 252 kPa; 114 kPa
3.104 9.10×10^{-3} m³/s; 57.9 kPa
3.106 81.1 m³/s; 59.1 m³/s; 62.3 m³/s
3.108 155 N/m²
3.112 1.336 m; 0.188 m
3.116 6.10×10^{-3} m³/s
3.118 0.026 m
3.120 1.73 m²/s
3.122 25.4 m; 6.51 m; -9.59 m

Chapter 3

- 3.2** 13.7 m/s
3.4 -30.0 kPa/m
3.6 -18.797 kPa/m; 0.795 kPa/m
3.8 (a) $-2\rho a^2 V_0^2 [1 - (a/x)^2]/x^3$
 (b) $p_0 + \rho V_0^2 [(a/x)^2 - (a/x)^4/2]$
3.12 12.0 kPa; -20.1 kPa
3.14 (a) 500 N/m³; (b) 1311 N/m³
3.20 3.21 N/m²
3.24 0.57 kN/m²; 61.7 m/s
3.28 46.5 m/s
3.32 2.0 m/s
3.34 13.9 m

Chapter 4

- 4.2** $\sqrt{9y^2 + 12y + 68}$ m/s
4.4 $x = y + y^2/2$
4.8 $x = -2, y = 2$
4.10 Everywhere; $x^2 + y^2 = \text{constant}$
4.14 $x = -h (u_0/v_0) \ln (1 - y/h)$
4.18 10, 9, 6, 4 ft/s
4.20 $2c^2x^3; 2c^2y^3; x = y = 0$
4.22 $4x\hat{i} + y\hat{j} + z\hat{k}$
4.24 (a) 2 m/s²; (b) negative
4.26 10 m/s²
4.28 -5.12×10^{10} m/s²; -5.21×10^9
4.32 720 m/s²; 1440 m/s²; 2160 m/s²

- 4.34 -10.7 m/s^2 ; 1.01
 4.36 $(225x + 150) \text{ m/s}^2$; 0; 150 m/s^2 ; 375 m/s^2
 4.42 2.42 m/s
 4.46 8860 m/s^2 ; 7440 m/s^2
 4.48 3 m/s^2 ; 6 m/s^2 , $3\hat{s} + 6\hat{n} \text{ m/s}^2$
 4.50 $a_x = 2c^2x(x^2 + y^2)$; $a_y = 2c^2y(x^2 + y^2)$
 4.52 3.20 m/s^2 ; 1.48 m/s^2
 4.54 -67.4 m/s^2 ; -8.42 m/s^2 ; -2.5 m/s^2
 4.56 157.5° F/s
 4.58 -28.4° C/s ; -25.1° C/s
 4.60 (a) 200° C/s ; 100° C/s
 4.62 $5.0 \text{ m}^3/\text{s}$ for each line
 4.64 $2.7 \text{ m}^3/\text{s}$
 4.68 (b) $2 V_0 \hbar b/3$
 4.72 (a) 3000 kg/s ; (b) $3.00 \text{ m}^3/\text{s}$

Chapter 5

- 5.2 20 m/s
 5.4 282.95 kg/s
 5.6 0.028 m
 5.8 1.28 m/s
 5.10 314 m/s
 5.12 -0.0189 kg/s
 5.14 0.202 kg/m^3
 5.16 $1.00 \text{ m}^3/\text{s}$
 5.18 150 liters/s
 5.20 1.1 m/s
 5.22 0.711 ; 0.791 ; 0.837 ; 0.866
 5.24 (a) 6280 kg/s
 5.26 (a) 0.1 kg/s
 (b) $0.16 \text{ kg/m}^3 \cdot \text{s}$
 5.28 1260 min
 5.30 14.8 m/s
 5.32 (a) 58 L/min ; (b) 232 L/min
 5.34 120 N
 5.36 $2.66 \times 10^{-4} \text{ m}^3/\text{s}$
 5.38 64.6 N
 5.40 $0.2 \text{ m}^3/\text{s}$
 5.42 2207 N
 5.44 14 N
 5.46 (a) 6.26 m/s ; (b) 392 N ; (c) 675 N
 5.48 0 N
 5.50 482 N downward
 5.52 85.1 kN
 5.54 $85.1 \text{ m}^3/\text{s}$
 5.56 16.7 N
 5.58 (a) $T_1 = W_1 - 40.9 \text{ N}$; (b) $W_2 + 73.6 \text{ N}$
 5.60 -185 kN ; 45.8 kN
 5.62 44082 N/m ; 18580.6 N/m
 5.64 29.3 kN
 5.66 12.9 kN
 5.68 66.6 N
 5.70 74 N
 5.72 non-uniform = $(4/3)$ uniform
 5.74 (a) 753 N ; (b) 613 N
 5.76 (b) 1020 N
 5.78 40610 N
 5.80 78.5 kN
 5.88 (a) $231 \text{ N} \cdot \text{m}$, 185 rad/s ; (b) $200 \text{ N} \cdot \text{m}$, 160 rad/s ;
 (c) $116 \text{ N} \cdot \text{m}$, 92.5 rad/s
 5.90 30.13 kW
 5.92 (a) 43 deg ; (b) $73.4 \text{ N} \cdot \text{m/s}$
 5.94 $-3.3 \text{ N} \cdot \text{m/kg}$
 5.96 $-280.8 \text{ N} \cdot \text{m/kg}$
 5.100 0.32 ft ; right to left
 5.102 $0.042 \text{ m}^3/\text{s}$
 5.104 $4.5 \times 10^{-3} \text{ m}^3/\text{s}$
 5.106 $364.7 \text{ N} \cdot \text{m/kg}$
 5.108 $86.2 \text{ N} \cdot \text{m/kg}$; $18 \text{ N} \cdot \text{m/kg}$
 5.110 227 m
 5.112 $2.22 \times 10^6 \text{ W}$
 5.114 $3910.2 \text{ N} \cdot \text{m/s}$
 5.116 Will work for $p_2 = 200 \text{ kPa}$; will not work for
 $p_2 = 300 \text{ kPa}$
 5.118 $0.052 \text{ m}^3/\text{s}$
 5.120 $147.2 \text{ N} \cdot \text{m/kg}$; $1471 \text{ N} \cdot \text{m/s} = 1.5 \text{ W}$
 5.122 (a) 2.999 kW ; (b) 2.98 m
 5.124 0.58
 5.126 1.78 kW
 5.128 (a) 0.9 ; (b) 5 N
 5.132 0.81 m
 5.134 (a) 17.2 deg , 4.29 m/s ; $558 \text{ N} \cdot \text{m/s}$
 5.136 (a) $0.95 \text{ N} \cdot \text{m/kg}$; (b) $0.68 \text{ N} \cdot \text{m/kg}$
 5.138 $11.6 \text{ N} \cdot \text{m/kg}$; 0.796
 5.140 $16.5 \text{ N} \cdot \text{m/kg}$; 0.85

Chapter 6

- 6.2 $2x, 4xt^2, -2y, 4yt^2$; $V = 0$; $\mathbf{a} = 1.2 - 1.2\hat{j} \text{ m/s}^2$;
 $a = 1.69 \text{ m/s}^2$
 6.4 (a) 0; (b) $\boldsymbol{\omega} = -(y/2 + z)\hat{i} + (5z/2)\hat{j} - (y/2)\hat{k}$;
 No
 6.6 $\zeta = 3xy^2\hat{k}$; No
 6.8 $u = -\frac{3}{2}x^2 + \frac{x^3}{3} + f(y)$
 6.10 $\dot{\gamma} = -\frac{-r_0\omega}{r_0 - r_i}$
 6.12 No
 6.14 (a) 2.24 m/s , -63.4 deg , $x = y = 0$; (b) 4.12
 m/s , 76.0 deg , none
 6.16 No
 6.18 Second one
 6.22 $v = \frac{-y^2}{2x} + f(x)$
 6.24 $v_\theta = -4r\theta - 9r^2 \cos \theta + f(r)$
 6.26 (a) $\psi = \frac{-Ar^2}{2} + C$; (b) $\psi = -A \ln r + C$
 6.30 $19.6y - 100 \text{ kPa}$, where y is m
 6.34 $\psi = 0.6x - 1.2y + C$; $\phi = -1.2x - 0.6y + C$
 6.36 $\phi = A \ln r + Br \cos \theta + C$; $\theta = \pi$, $r = A/B$
 6.38 37 kPa
 6.40 (a) Yes; (b) Yes, $\phi = 0.2(x + y) + C$; (c) 0

ANS-4 Answers to Selected Even-Numbered Homework Problems

- 6.42 (a) $\phi = U(0.866x + 0.500y)$;
 $\psi = U(0.866y - 0.500x)$; (b) $\frac{\partial p}{\partial y} = -\gamma$
- 6.46 -7.10 kPa
- 6.48 $\psi = 5x^2y - 5y^3/3 + C$
- 6.50 27 m
- 6.52 0.9 m
- 6.54 (a) $1.60 \times 10^3/r^3$ kPa/m; (b) 184 kPa
- 6.56 0.00239 m to the right of slit
- 6.60 130 km/h, 86.7 km/h, 65 km/h
- 6.62 $h^2 = m/2\pi A$
- 6.64 $\sin \theta = (\Gamma/2\pi rU) \ln(r/4)$
- 6.66 (b) 0 ; 68.2 mph
- 6.68 8.49×10^{-4} m/s
- 6.74 $(2/3)^{1/2}$
- 6.76 10
- 6.80 0.014 pa
- 6.84 $\tau_{xy} = 30\mu xy$; $\tau_{yz} = \tau_{xz} = 0$
- 6.86 (a) $\partial v/\partial y = -2x$; (b) $a = 2x^3\hat{i}$;
(c) $\partial p/\partial y = 2\mu - 2\rho x^3$
- 6.88 0.225 m/s
- 6.90 $q = -2\rho gh^3/3\mu$
- 6.92 (a) $u = Uy/b$; (b) $Ub/2$
- 6.94 $u = [(U_1 + U_2)/b]y - U_2$
- 6.96 $y/b = 1/3$
- 6.98 $v_\theta = R^2\omega/r$
- 6.100 (a) $\mathcal{F} = 2\pi r_0^3 \mu \omega \ell / (r_0 - r_i)$; (b) $\dot{\gamma} = -U/b$
- 6.102 57.1 N/m³; 0.252 m/s
- 6.106 Δp (nonuniform)/ Δp (uniform) = 3.52
- 6.108 $V_0 = (\Delta p/\ell)[2r_i^2 \ln(r_i/r_0) - (r_i^2 - r_0^2)]/4\mu$

Chapter 7

- 7.6 (a) 103 m/s; (b) 444 m/s
- 7.8 $q/(b^{3/2}g^{1/2}) = \phi(H/b, \mu/b^{3/2}g^{1/2}\rho)$
- 7.10 $Q/A^{5/4}g^{1/2} = \phi(\epsilon/A^{1/2}, S_0)$
- 7.12 $\omega \ell^{1/2}/g^{1/2} = \phi(h/\ell)$
- 7.14 $Q/d^{5/2}g^{1/2} = \phi(\rho_g/\rho_a, h/d)$
- 7.16 $\delta/d = \phi(\ell/d, \rho V^2/E, \mu V/dE)$
- 7.18 $h/\ell = \phi(\sigma/\ell^2 g\rho)$
- 7.20 $h/D = \phi(\sigma/\gamma D^2)$
- 7.22 $\Delta p \propto 1/D^2$ (for a given velocity)
- 7.26 $t\sqrt{g/d} = \phi(\nabla/d^3, \rho\sqrt{g}d^{3/2}/\mu)$
- 7.28 (a) $VD\sqrt{\rho/\eta W} = \phi(b/d, d/D)$;
(b) $V = \sqrt{2\eta Wb/\pi\rho dD^2}$
- 7.30 5.49×10^7 ; 1.84 ; 1.41 ; 409×10^{-3}
- 7.32 $\Delta p/\rho V_1^2 = -1.2747(A_1/A_2)^2 + 1.1754(A_1/A_2)$
 -0.0137 ; 313.85 N/m²
- 7.34 $\Delta p/(\rho V^2) = 14.178(D/d)^{0.3697}$
- 7.36 (a) $H/b = \phi(h/b, \ell/b)$;
(b) $H/b = 0.0833(h/b)^{-1.00}$
- 7.38 (a) Correct; (b) $t = 1.36 \mu$
- 7.40 (a) $-1/2$; (b) Yes
- 7.42 (a) $\theta = 5.98 \omega \mu$ 7.88
- 7.44 11.0 m/s
- 7.46 Colder
- 7.48 Double pressure

- 7.50 0.019 m/s
- 7.52 129 m/s
- 7.54 1712 m/s; No
- 7.56 1170 km/hr
- 7.58 187 mph
- 7.60 (a) 7.2 km/h; (b) 2.4 m
- 7.62 0.125 ; 0.0625
- 7.64 (a) $h/H = \phi(d/H, b/H, \rho g/H_s, V/\sqrt{gH})$;
(b) 33.9 km/h
- 7.66 112.1 N
- 7.68 50.2 kPa (abs)
- 7.70 (a) $\Delta p/\rho c^2 = \phi(E/\rho c^2 d^3)$
- 7.72 (a) $V_{0m} t_m/D_m = V_0 t/D$, $\omega_m t_m = \omega t$,
 $\rho_m V_{0m} D_m/\mu_m = \rho V_0 D/\mu$, $D \Delta p_\ell/\rho V_0^2 =$
 $D_m \Delta p_{\ell m}/\rho_m V_{0m}^2$; (b) 160 rad/s
- 7.74 150 km/h to 725 km/h
- 7.76 (a) 0.1 kg/m³; (b) 2.8 m/s; (c) 1.90 Hz
- 7.78 (a) 2.91 m/s; (b) 2.61 N
- 7.80 (a) 400 N; (b) 7220 W
- 7.82 (a) $V\ell^2/Q = \phi(\ell_i/\ell, Q^2/\ell^5 g, \rho Q/\ell\mu)$; no
(b) 0.410 gpm; 2.46 in.
- 7.84 (a) $nD/V = \phi(VD/\nu)$; (b) Yes; (c) 2.26 m/s
- 7.86 (a) $V_m/U_m = V/U$, $V_m D_m/\nu_{sm} = VD/\nu_s$,
 $V_m^2/g_m D_m = V^2/gD$, $(\rho - \rho_s)_m/\rho_m = (\rho - \rho_s)/\rho$;
(b) No
- 7.88 0.132 m; 0.08 m³/s
- 7.92 (a) $d^2 y^*/dx^{*2} = (P\ell^2/EI)(x^* - 1)$
- 7.94 $\partial u^*/\partial t^* = (X/\rho h\omega^2) \cos t^* + (\mu/\rho h^2\omega)\partial^2 u^*/\partial y^{*2}$

Chapter 8

- 8.2 Turbulent
- 8.4 1.01 m
- 8.6 4.95×10^{-6} m³/s at 20°C
- 8.8 3 m; 8.83 N/m²
- 8.10 2 m/s; 1 m/s; 1.26×10^{-3} m³/s
- 8.12 0.0073 kN/m²; 0.0028 kN/m², 0
- 8.14 (b) to (a)
- 8.16 0.354 D
- 8.18 3.43 m; 166 kPa
- 8.20 $z = 1 + e^{-(t/2.7 \times 10^5)} s$, where t is seconds
- 8.22 1.89 m/s; 7.42×10^{-3} m³/s
- 8.24 (a) 4.2×10^{-4} m³/s; 3.9×10^{-4} m³/s
- 8.26 8.88×10^{-8} m³/s
- 8.28 2.4×10^{-4} m³/s
- 8.30 (a) $0.707 R$; (b) $0.750 R$
- 8.34 3.2×10^{-5} m
- 8.36 B to A; A to pump
- 8.38 (a) 1.5462 kN/m²; (b) 7.4 kN/m²; (c) -4.3 kN/m²
- 8.40 2.04×10^{-3} W
- 8.42 0.025
- 8.44 0.0261
- 8.46 3.704 kN/m²
- 8.48 0.0404
- 8.50 19.6 m
- 8.52 0.00396 m
- 8.54 (a) 0.168 m; (b) 1.12 m; (c) 0.08 m

- 8.56** 46.7
8.58 39.7 kPa; 93.0 kPa
8.60 73.7
8.62 4.49 N/m^2
8.64 9
8.66 Disagree
8.68 1.54 kPa
8.70 0.188 m
8.72 33.07 N/m^2
8.74 42.19 m; 42.27 m
8.76 26.5 m
8.78 4.998 kPa
8.80 $18.34 \text{ kN} \cdot \text{m/s}$
8.82 135.94 kN/m^2
8.84 4.9 m
8.86 330 kPa
8.88 379 kW
8.90 $5.46 \times 10^{-4} \text{ m}^3/\text{s}$
8.92 $1.7046 \times 10^{-3} \text{ m}^3/\text{s}$
8.94 $1.7046 \times 10^{-3} \text{ m}^3/\text{s}$
8.96 120 kW
8.98 $1.37 \times 10^{-3} \text{ m}^3/\text{s}$
8.100 0.144 m
8.102 0.648 m
8.104 0.0354
8.106 0.0445 m
8.108 $0.00273 \text{ m}^3/\text{s}$
8.112 $0.0180 \text{ m}^3/\text{s}$
8.114 $0.0284 \text{ m}^3/\text{s}$; $0.0143 \text{ m}^3/\text{s}$; $0.0141 \text{ m}^3/\text{s}$
8.118 $18.0 \text{ m}^3/\text{s}$
8.120 32.4 kPa
8.122 $0.013 \text{ m}^3/\text{s}$
8.124 $0.0221 \text{ m}^3/\text{s}$
8.126 $0.00359 \text{ m}^3/\text{s}$
8.128 $0.00317 \text{ m}^3/\text{s}$
8.130 0.296 m

Chapter 9

- 9.2** (a) 0.06 ($\rho U^2/2$); (b) 2.40
9.4 No
9.6 5.43 kN
9.8 0.142
9.12 1.12 m; $7.92 \times 10^{-3} \text{ m}$
9.14 $6.65 \times 10^{-6} \text{ m}^2/\text{s}$
9.16 7.3×10^{-6}
9.20 $d = 0.3 + 0.00849\sqrt{x} \text{ m}$ where x is m
9.22 (a) 0.052 m; (b) 0.041 m
9.26 0.052 m; 0.041 m
9.28 (b) $\delta/x = 5.48/\sqrt{Re_x}$
9.30 (b) $\delta = 5.83\sqrt{vx/U}$
9.34 0.707
9.36 470.46 N
9.38 44.7 kN
9.40 1.4; upright
9.42 85.4 kW
9.44 $8.08 \times 10^4 \text{ N}$; 33.3%

- 9.46** $2.83 \mathcal{D}_U$; $0.354 \mathcal{D}_U$
9.52 $0.0438 \text{ N} \cdot \text{m}$
9.54 1.06 m/s
9.58 (a) 171.6 m/s ; (b) 36.4 m/s ; (c) 4.1 m/s
9.60 133 N
9.62 24.3 m/s
9.64 $7080 \text{ N} \cdot \text{m}$
9.68 42 m/s
9.70 1609 N
9.72 1462.4 W
9.74 0.28 m/s in water; 8.92 m/s in air
9.76 (a) 2.44 m/s ; (b) 2.13 m/s
9.78 5.31 m/s
9.80 6.14 N; 614 N
9.82 7220 m/s^2
9.84 9.65 lb/ft^2
9.86 (a) 4.31 MN; (b) 4.17 MN
9.88 53.5 kW; 4.46 kW
9.92 3
9.94 4.35%
9.96 12.5 m/s
9.98 2,2977 W
9.100 (a) 11.2 w; (b) 24,347 w
9.102 0.34; 0.98
9.104 48,483.2 w
9.106 22.1%
9.108 1.72 U
9.110 0.206
9.114 Yes
9.116 0.476, 0.405, 0.420, 0.472
9.118 5.72%
9.122 28.4%

Chapter 10

- 10.2** Subcritical
10.4 Subcritical; 1.04 m
10.8 1.67 m
10.10 2.80 m/s
10.12 52.4 m/s
10.14 616 km/hr
10.16 2.45 m or 0.388 m
10.18 $y = 1.732 \text{ m}$ or $y = 0.38 \text{ m}$
10.20 $y_2 = 0.69$ and $z_2 = 0.129 \text{ m}$
10.24 $y_2 = 0.5428 \text{ m}$
10.26 0.2032 m
10.30 0.6 m or 1.0399 m; 0.6 m or 0.39 m
10.34 0.000551
10.36 188.1 m
10.38 3.49 N/m^2
10.42 (a) 90.47 N/m^2 ; (b) 0.047; (c) 0.636
10.44 7.41 min
10.46 23.7%
10.48 1.72 m/s
10.50 Yes
10.52 $40.9 \text{ m}^3/\text{s}$
10.54 2.5 m/s

ANS-6 Answers to Selected Even-Numbered Homework Problems

- 10.56** 1.86 m/s
10.58 5.1 m
10.60 $18.2 \text{ m}^3/\text{s}$
10.64 $3.27 \text{ m}^3/\text{s}$
10.66 1.19 m
10.68 0.841 m
10.70 0.861 m
10.72 Each requires the same.
10.74 Not possible
10.76 1.6 m
10.78 2.59 m
10.80 10.66 m
10.82 1.22 m
10.84 1.8 m
10.86 0.0022
10.88 0.000764
10.90 0.00025
10.92 0.00942 m
10.94 1.68 m
10.96 401 kW
10.100 $84.5 \text{ m}^3/\text{s}$
10.102 0.0378 m
10.104 0.06; 0.000249
10.106 0.652 m; 2.61 m
10.108 $0.116 \text{ m}^3/\text{s}$
10.110 1.4 m
10.112 9 s
10.118 $0.350 \text{ m}^2/\text{s}$

Chapter 11

- 11.4** (a) 71,700 J/kg; (b) 100,000 J/kg;
(c) $-1.58 \text{ kg}/\text{m}^3$; (d) $396 \text{ J}/\text{kg} \cdot \text{K}$
11.8 $-5.08 \times 10^6 \text{ N} \cdot \text{m}/\text{kg}$; $-7.16 \times 10^6 \text{ N} \cdot \text{m}/\text{kg}$;
 $-1.40 \times 10^4 \text{ N} \cdot \text{m}/\text{kg}$
11.10 234 K
11.12 339 K; $121 \text{ J}/\text{kg} \cdot \text{K}$
11.16 5300 m/s; 1470 m/s; 340 m/s
11.18 (a) 343 m/s; (b) 265 m/s; (c) 1005 m/s
11.20 (a) 102 m/s; (b) 392 m/s
11.22 0.0167 m; 1.67
11.24 16 cm
11.28 (a) 2.08; (b) 694.7 m/s
11.30 Convenient reference property at every location in
as specific isentropic flow.
11.32 1.34 kg/s
11.34 (a) 0.99988; (b) 0.998; (c) 0.99496 (d) 0.7008
267 m/s; 0.725; 285 m/s; 0.78; 283 m/s; 0.89
11.38 0.65 kg/s; 2.6 kJ/kg
11.42 0.36 m^2 ; 23 kPa; 113 k
11.44 (a) 0.483%; (b) 1.43%; (c) 0.445%; (d) 0.0163%
11.50 69.6 kPa
11.52 (a) 1.70 kg/s; (b) 1.52 kg/s

- 11.54** 135 kPa
11.58 404 kPa; 83 k; 31 m/s
11.64 0.475; 899 k; 936.5 k; 2121.8 kPa; 2472 kPa;
438.5 m/s
11.66 1.25; 380 m/s
11.68 (a) 0.94; 4 kPa; (b) 0.8; 17 kPa; (c) 0.47; 50 kPa
11.70 0.62; 0.213; 0.16
11.72 $T_{0.1} = 15^\circ\text{C} = 288 \text{ K}$; $P_{0.1} = 101.3 \text{ kPa}$;
 $T_1 = (0.56)(288 \text{ K}) = 161 \text{ K}$;
 $P_1 = (0.13)(101.3 \text{ kPa}) = 13.2 \text{ kPa}$;
 $V_1 = Ma_1 \sqrt{Rt_1} = (2.0)(\sqrt{286.9 \text{ J}/\text{kg} \cdot \text{K}})$
 $(161 \text{ K})(1.4) = 509 \text{ m/s}$; $T_{0.1x} = (288 \text{ K})$
 $(1/0.79)(0.91) = 332 \text{ K}$; $P_{0.1x} = (101.3 \text{ kPa})$
 $(1/1.5)(1.12) = 75.6 \text{ kPa}$; $T_x = (0.69)(332 \text{ K}) =$
229 K; $P_x = (0.27)(75.6 \text{ kPa}) = 20 \text{ kPa}$;
 $P_y = (2.5)(20 \text{ kPa}) = 50 \text{ kPa}$; $T_y = (1.3)(229 \text{ K}) =$
298 K; $V_y = (455 \text{ m/s})/1.9 = 239 \text{ m/s}$;
 $T_{0.1y} = T_{0.1x} = 332 \text{ K}$; $T_{0.1a} = T_{0.1x}/0.79 =$
 $288 \text{ K}/0.79 = 365 \text{ K} = T_{0.2}$; $P_{0.1a} = P_{0.1}/1.5 =$
 $101.3 \text{ kPa}/1.5 = 68 \text{ kPa} = P_{0.2}$; $P_a = 13.2$
 $\text{kPa}/0.36 = 36.7 \text{ kPa} = P_2$; $T_a = 161 \text{ K}/0.53 = 304$
 $\text{K} = T_2$; $V_a = 509 \text{ m/s}/1.45 = 351 \text{ m/s} = V_2$

Chapter 12

- 12.2** 55.4 deg
12.4 $520.2 \text{ N}/\text{m}^2$
12.8 $-71 \text{ ft} \cdot \text{lb}/\text{slug}$
12.10 (b) fan; (c) $161 \text{ m}^2/\text{s}^2$
12.12 $1406 \text{ N} \cdot \text{m}/\text{s}$
12.14 $1197 \text{ N} \cdot \text{m}$
12.16 16.7 m
12.18 404 L/min
12.20 (a) 1.68 m; (b) -0.6 m
12.22 (a) 2.07 kW; (b) 12.6 m
12.26 1400 gal/min
12.28 598 L/min; Yes
12.30 6585 L/min; Yes
12.34 $0.0328 \text{ m}^3/\text{s}$; 8.00 m
12.36 Yes
12.38 4 kL/min; 240 m
12.40 Centrifugal
12.42 1894 rpm
12.44 (a) 5.5 m; mixed-flow
12.48 (a) $-15.6 \text{ m}^2/\text{s}^2$; (b) $-15.6 \text{ m}^2/\text{s}^2$
12.50 $-21,208 \text{ W}$
12.52 $16.6 \text{ m}^2/\text{s}^2$; 0.849
12.54 $0.188 \text{ N} \cdot \text{m}$; 28.23 W
12.56 816 kW pump
12.58 23,200 kW
12.60 26,600 N; 37.6 m/s; 707 kg/s
12.64 70 m
12.68 impulse