

APPENDIX 2

Answers to Problems

Chapter 1

1. $6.277 \text{ m}^3/\text{s}$.
2. 9.15 m/s ; 5.33 atmospheres .
3. 551 rev/min , $1:10.8$; $0.8865 \text{ m}^3/\text{s}$; 17.85 MN .
4. $4,035 \text{ rev/min}$; 31.22 kg/s .

Chapter 2

1. 88.1 per cent .
2. (1) 703.1 K ; (2) 751.9 K ; (3) 669 K .
3. (1) 500 K , $0.313 \text{ m}^3/\text{kg}$; (2) 1.045 .
4. 49.2 kg/s ; 24 mm .
5. (1) 620 kPa , 274°C ; 240 kPa , 201°C ; 85 kPa , 126°C ; 26 kPa , $q = 0.988$; 7 kPa , $q = 0 - 95$; (2) 0.619 , 0.655 , 0.699 , 0.721 , 0.750 ; (3) 0.739 , 0.724 ; (4) 1.075 .

Chapter 3

1. 49.8 deg .
2. 0.767 ; $C_D = 0.048$, $C_L = 2.245$.
3. -1.17 deg ., 9.5 deg , 1.11 .
4. (1) 53 deg and 29.5 deg ; (2) 0.962 ; (3) 2.079 kN/m^2 .
5. (a) $s/l = 1.0$, $\alpha'_2 = 24.8 \text{ deg}$; (b) $C_L = 0.82$.
6. (b) 57.8 deg ; (c) (1) 3.579 kPa ; (2) 0.96 ; (3) 0.0218 , 1.075 .
7. (a) $\alpha_1 = 73.2^\circ$, $\alpha_2 = 68.1^\circ$, (b) (1) $C_L = 0.696$, (2) $\eta_D = 0.8824$

Chapter 4

2. (a) 88 per cent ; (b) 86.17 per cent , (c) 1170.6 K
3. $\alpha_2 = 70 \text{ deg}$., $\beta_2 = 7.02 \text{ deg}$., $\alpha_3 = 18.4 \text{ deg}$., $\beta_3 = 50.37 \text{ deg}$.
4. 22.62 kJ/kg ; 420 kPa , 177°C .
5. 90.2 per cent .
6. (1) 1.50 ; (2) 39.9 deg , 59 deg ; (3) 0.25 ; (4) 90.5 and 81.6 per cent .
7. (1) 488 m/s ; (2) 266.1 m/s ; (3) 0.83 ; (4) 0.128 .
8. (1) 213.9 m/s ; (2) 0.10 , 2.664 ; (3) 0.872 ; (4) 269°C , 0.90 Mpa .
9. (a) (1) 601.9 m/s ; (2) 282.8 m/s ; (3) 79.8 per cent . (b) 89.23 per cent .
10. (b) (1) 130.9 kJ/kg ; (2) 301.6 m/s ; (3) 707.6 K (c) (1) $10,200 \text{ rev/min}$; (2) 0.565 m
(3) 0.845 .
11. (2) 0.2166 m^2 ; (3) $8,740 \text{ rev/min}$. (4) 450.7 m/s , 0.846 .

Chapter 5

1. 14 stages.
2. 30.35°C.
3. 132.1 m/s, 56.1 kg/s; 10.0 MW.
4. 86.5 per cent; 9.27 MW.
5. 0.59, 0.415.
6. 33.5 deg, 8.5 deg, 52.9 deg; 0.827; 34.5 deg, 0.997.
7. 56.9 deg, 41 deg; 21.8 deg.
8. (1) 229.3 m/s; (2) 23.47 kg/s, 15,796 rev/min; (3) 33.614 kJ/kg; (4) 84.7 per cent; (5) 5.856 stages, 0.789 MW; (6) With six stages and the same loading, the pressure ratio is then 6.209. However, to maintain a pressure ratio of 6.0, the specific work must be decreased to 32.81 kJ/kg which requires an absolute flow angle α_m to change from 30° to 30.26°. With five stages and a pressure ratio of six the weight and cost would be lower but the stage loading would increase to 39.37 kJ/kg which would require α_m to be changed to 28.08 deg.
9. (a) 16.22 deg., 22.08 deg., 33.79 deg. (b) 467.2 Pa, 7.42 m/s.
10. (1) $\beta_1 = 70.79^\circ$, $\beta_2 = 68.24$ deg.; (2) 83.96 per cent; (3) 399.3 Pa; (4) 7.144 cm.
11. (1) 141.1 Pa, 0.588; (2) 60.48 Pa; (3) 70.14 per cent.

Chapter 6

1. 55 and 47 deg. 2. 0.602, 1.38, -0.08 (i.e. implies large losses near hub)
4. 70.7 m/s. 5. Work done is constant at all radii;

$$c_{x1}^2 = k_1 - 2a^2[r^2 - 2(b/a) \ln r]$$

$$c_{x2}^2 = k_2 - 2a^2[r^2 + 2(b/a) \ln r]$$

$$\beta_1 = 43.2 \text{ deg}, \beta_2 = 10.4 \text{ deg}.$$

6. (1) 469.3 m/s; (2) 0.798; (3) 0.079; (4) 3.244 MW; (5) 911.6 K, 897 K.
7. (1) 62 deg; (2) 55.3 and 1.5 deg; (3) 45.2 and 66 deg, (4) -0.175, 0.477.
8. See "*Solutions Manual*".

Chapter 7

1. (1) 27.9 m/s; (2) 882 rev/min, 0.604 m; (3) 182 W; (4) 0.333 (rad)
2. 579 kW; 169 mm; 5.273.
3. 0.8778; 5.62 kg/s.
4. 24,430 rev/min; 0.203 m, 0.5844.
5. 0.7324, 90.84 per cent.
6. (1) 542.5 kW; (2) 536 and 519 kPa; (3) 608.2 and 244 kPa, 1.22, 193.2 m/s; (4) 0.899; (5) 0.22; (6) 31,770 rev/min.
7. (1) 29.4 dm³/s; (2) 0.781; (3) 77.7 deg; (4) 7.8 kW.
8. (1) 14.11 cm; (2) 2.635 m; (3) 0.7664; (4) 17.73 m; (5) 13.8 kW; $\sigma_S = 0.722$, $\sigma_B = 0.752$.
9. (a) See text. (b) (1) 32,214 rev/min; (2) 5.246 kg/s; (c) (1) 1.254 MW; (2) 6.997.

Chapter 8

1. 587.4 m/s, 73.88 deg.
2. (1) 203.8 kPa, 977 K; (2) 0.40 m, 28,046 rev/min; (3) 1 MW.
3. (1) 90.54 per cent; (2) 0.2694 m; (3) 0.05316, 0.2009.
4. 1594 K.
5. (1) $2.159 \text{ m}^3/\text{s}$, 500 kW; (2) 0.0814 m and 0.1826 m; (3) 77 deg, 0.0995.
6. (a) 1.089 kg/s , 23,356 rev/min; (b) 9.063×10^5 , 1.879×10^6 .
7. (1) 81.82 per cent; (2) 890 K, 184.3 kPa; (3) 1.206 cm; (4) 196.3 m/s; (5) 0.492; (6) $r_{s3} = 6.59 \text{ cm}$, $r_{h3} = 2.636 \text{ cm}$.
8. (1) 308.24 m/s; (2) 56.42 kPa, 915.4 K; (3) 113.2 m/s, 0.2765 kg/s; (4) 5.472 cm; (5) 28.34 deg; (6) 0.7385 rad.

Chapter 9

1. (1) 224 kW; (2) $0.2162 \text{ m}^3/\text{s}$; (3) 6.423
2. (a) 2.138 m; (2) For $d = 2.2 \text{ m}$, (1) 17.32 m; (2) 59.87 m/s, 40.3 MW
3. (1) 378.7 rev/min; (2) 6.906 MW, 0.252 (rad); (3) 0.793; (4) 3
4. Head loss in pipeline is 17.8 m. (1) 672.2 rev/min; (2) 84.5 per cent; (3) 6.735 MW; (4) 2.59 per cent.
5. (1) 12.82 MW, $8.69 \text{ m}^3/\text{s}$; (2) 1.0 m; (3) 37.6 m/s; (4) 0.226 m
6. (1) 663.2 rev/min; (2) 69.55 deg., 59.2 deg; (3) 0.152 m and 0.169 m.
7. (b) (1) 1.459 rad; (2) $107.6 \text{ m}^3/\text{s}$; (3) 3.153 m, 15.52 m/s; (c) (1) 398.7 rev/min, $0.456 \text{ m}^3/\text{s}$; (2) 20.6 kW (uncorrected), 19.55 kW (corrected); (3) 4.06 (rad); (d) $z = 1.748 \text{ m}$
8. (a) (1) 0.94; (2) 115.2 rev/min, 5.068 m; (3) $197.2 \text{ m}^3/\text{s}$; (4) 0.924 m.
9. (1) $11.4 \text{ m}^3/\text{s}$, 19.47 MW; (2) At hub, mean and tip radii the flow angles (deg) are as follows: Inlet 25.81, 62.99, 72.59; Outlet 59.55, 69.83, 75.04.