Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, JAN. 2021

SUBJECT: GAS DYNAMICS [AAE 3158]

REVISED CREDIT SYSTEM
(30/01/2021)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Stepwise answer carries marks.
- Draw a neat sketch wherever necessary.

Q1. Define the terms (i) calorically perfect gas and (ii) thermally perfect gas. **(02)**

Q2. Isentropic flow of air takes place through a nozzle with an exit flow velocity of 270 m/s and temperature of 35^{o}C. Determine the Mach number and stagnation temperature at the nozzle exit. Also, determine the Mach number at a location where the temperature is 70 ^{o}C. **(04)**

Q3. Prove that for a stationary normal shock wave, the total pressure across the normal shock wave must decrease. **(03)**

Q4. Air at stagnation pressure and stagnation temperature of 100 kPa and 330 K, respectively, enters a tube with a mass flow rate of 0.06 kg/s. The static pressure of the air is 90 kPa. Determine the tube diameter for the above mass flow rate. Also, determine what should be the tube diameter to maintain the same mass flow rate through the tube of length 10 m. Consider, f=0.004 in 4f*L/D. **(05)**

Q5. Describe whether isentropic compression should be preferred or the shock wave compression and why? **(02)**

Q6. For a given Prandtl-Meyer expansion the upstream Mach number is 2 and the pressure ratio across the shock wave is 0.6. Determine the angles of forward and rearward Mach lines of the expansion fan relative to the free-stream direction. **(04)**

Q7. Prove that the supersonic flow decelerates in a converging nozzle. **(03)**

Q8. Air from a reservoir at 8.5 atm and 60^{o}C is discharged through a convergent-divergent nozzle. The jet issuing from the nozzle exerts a thrust of 9 kN. Considering the back pressure of 1 atm, determine the nozzle throat and exit areas and Mach number of the jet issuing from the nozzle. Assume the flow through the nozzle to be isentropic and correctly expanded. **(04)**

Q9. Describe the significance of substantial derivative and write the expression for the substantial derivative of velocity. **(02)**

Q10. Describe the significance of improved compressibility correction. **(03)**

Q11. With a neat sketch describe the region of influence and domain of dependence for supersonic flows. Does domain of dependence depend upon region of influence? **(03)**

Q12. What do you mean by characteristic line in case of supersonic flows? Explain the importance of initial data line and describe the unit process to obtain the flow condition at the wall point. **(04)**

Q13. For hypersonic flows, show that the shock wave angle is 20% higher than the wedge angle for a specific heat ratio of 1.4. **(03)**

Q14. Explain the significance of Newtonian theory for hypersonic flows. Consider a flat plate kept at an angle of θ in hypersonic flow. Show the variation in lift coefficient, drag coefficient and lift-to-drag ratio at various angles of attack. **(04)**

Q15. With a neat sketch describe the working principle of Laser Doppler Anemometer (LDA). Also, explain how the turbulence intensity is computed from the velocity data of LDA. **(04)**

Formula Book - Gas Dynamics AAE 3158 (Vth Aero)

1. Compressible Flow	
1.1 Compressibility of the fluid $$\tau = -\frac{1}{v}\frac{dv}{d\rho}$$	ρ - density of fluid ν – volume of the fluid
1.2 Basic thermodynamic equation $$\frac{P_2}{P_1} = \left(\frac{\rho_2}{\rho_1}\right)^{\gamma} = \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{(\gamma-1)}}$$	P- Pressure ρ - density of fluid T-temperature γ- gas constant
2. One Dimensional Flow	
2.1 1D Continuity equation $$\rho_1 u_1 = \rho_2 u_2$$ 2.2 1D Momentum equation $$P_1 + \rho_1 u_1^2 = P_2 + \rho_2 u_2^2$$ 2.3 1D Energy equation $$h_1 + \frac{u_1^2}{2} + q = h_2 + \frac{u_2^2}{2}$$	ρ - density of fluid u-velocity of the fluid P-pressure of the fluid h-enthalpy q – heat added
2.4 Speed of sound $$a = \sqrt{\left(\frac{\partial p}{\partial \rho}\right)_s} = \sqrt{\frac{\nu}{\tau_s}}$$	ρ - density of fluid P-pressure of the fluid ν – volume of the fluid τ - compressibility of the fluid
2.5 Isentropic relations $$\frac{T_0}{T} = 1 + \frac{\gamma-1}{2}M^2$$ $$\frac{P_0}{P} = \left(1 + \frac{\gamma-1}{2}M^2\right)^{\frac{\gamma}{\gamma-1}}$$ $$\frac{\rho_0}{\rho} = \left(1 + \frac{\gamma-1}{2}M^2\right)^{\frac{1}{\gamma-1}}$$	ρ - density of fluid T_0-total temperature T – temperature P_0 – total pressure P – pressure ρ_0 – total density of fluid γ- gas constant
2.6 Relation between characteristic and total parameters $$\left(\frac{a^*}{a_0}\right)^2 = \frac{T^*}{T_0} = \frac{2}{\gamma+1}$$ $$M^2 = \frac{2}{\left[\frac{(\gamma+1)}{M^{*2}}\right] - (\gamma-1)}$$	a^* - characteristic speed of sound a_0 – total speed of sound M^* - characteristic mach number M – local Mach number
2.7 Normal shock relation $$M_2^2 = \frac{1 + [(\gamma-1)/2]M_1^2}{\gamma M_1^2 - (\gamma-1)/2}$$	M_2 – downstream Mach number M_1 – upstream Mach number γ- gas constant
2.8 Hugoniot equation $$e_2 - e_1 = \frac{P_1 + P_2}{2}(v_1 - v_2)$$	e – internal energy P – pressure ν – volume of the fluid
2.9 Rayleigh equations $$\frac{P_2}{P_1} = \frac{1+\gamma M_1^2}{1+\gamma M_2^2}$$ $$\frac{T_2}{T_1} = \left(\frac{1+\gamma M_1^2}{1+\gamma M_2^2}\right)^2 \left(\frac{M_2}{M_1}\right)^2$$ $$\frac{\rho_2}{\rho_1} = \left(\frac{1+\gamma M_2^2}{1+\gamma M_1^2}\right)\left(\frac{M_1}{M_2}\right)^2$$	M_2 – downstream Mach number M_1 – upstream Mach number γ- gas constant P – pressure T – temperature ρ - density of fluid $\bar{f}$ – friction coefficient L^* - reference length

2.10 Fanno equations $$\frac{P_2}{P_1} = \frac{M_1}{M_2}\left[\frac{2+(\gamma-1)M_1^2}{2+(\gamma-1)M_2^2}\right]^{1/2}$$ $$\frac{T_2}{T_1} = \frac{2+(\gamma-1)M_1^2}{2+(\gamma-1)M_2^2}$$ $$\frac{\rho_2}{\rho_1} = \frac{M_1}{M_2}\left[\frac{2+(\gamma-1)M_1^2}{2+(\gamma-1)M_2^2}\right]^{1/2}$$ $$\frac{4\bar{f}L^*}{D} = \frac{1-M^2}{\gamma M^2} + \frac{\gamma+1}{2\gamma} ln\left[\frac{(\gamma+1)M^2}{2+(\gamma-1)M^2}\right]$$	
3. **Oblique Shock waves**	
3.1 Mach angle $$\mu = sin^{-1}\frac{1}{M}$$	μ - Mach angle M – local Mach number
3.2 Theta-beta-M- relation $$tan\theta = 2\cot\beta\left[\frac{M_1^2 sin^2\beta - 1}{M_1^2(\gamma + cos2\beta) + 2}\right]$$	θ - deflection angle β - wave angle M_1 – inflow Mach number
3.3 Prandtl-Meyer Expansion wave equation $$d\theta = \sqrt{M^2-1}\frac{dV}{V}$$ $$\upsilon(M) = \sqrt{\frac{\gamma+1}{\gamma-1}}tan^{-1}\sqrt{\frac{\gamma-1}{\gamma+1}(M^2-1)} - tan^{-1}\sqrt{M^2-1}$$ $$\theta_2 = \upsilon(M_2) - \upsilon(M_1)$$	θ - deflection angle M – local Mach number γ- gas constant $\upsilon(M)$ – Prandtl-Meyer function
4. **Quasi one dimensional flow**	
4.1 Area Velocity relation $$\frac{dA}{A} = (M^2-1)\frac{du}{u}$$	A – Area M – Mach number u - velocity
4.2 Area Mach number relation $$\left(\frac{A}{A^*}\right)^2 = \frac{1}{M^2}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}M^2\right)\right]^{\frac{(\gamma+1)}{(\gamma-1)}}$$	A – Area A^* - Characteristic area M – Mach number γ- gas constant
5. **Differential conservation equations for inviscid flow**	
5.1 Substantial derivative $$\frac{D}{Dt} \equiv \frac{\partial}{\partial t} + u\frac{\partial}{\partial x} + \upsilon\frac{\partial}{\partial y} + w\frac{\partial}{\partial z} = \frac{\partial}{\partial t} + (\nabla\cdot V)$$	V - velocity
5.2 Continuity equation $$\frac{D\rho}{Dt} + \rho\nabla\cdot V = 0$$ 5.3 Momentum equation $$\rho\frac{DV}{Dt} = -\nabla p + \rho f$$ 5.4 Energy equation $$\rho\frac{De}{Dt} = -p\nabla\cdot V + \rho\dot{q}$$	V – velocity ρ - density of fluid f – body force per unit mass e – internal energy q – heat added p - pressure

5.5 Crocco's theorem $$T\nabla s = \nabla h_0 - V \times (\nabla \times V)$$	s – entropy T – temperature h_o – total enthalpy V - velocity
6. **General conservation equations**	
6.1 Euler equation $$dp = -\rho V dV$$	V – velocity ρ - density of fluid
6.2 Velocity potential equation $$\left(1-\frac{\Phi_x^2}{a^2}\right)\Phi_{xx} + \left(1-\frac{\Phi_y^2}{a^2}\right)\Phi_{yy} + \left(1-\frac{\Phi_z^2}{a^2}\right)\Phi_{zz} - \frac{2\Phi_x\Phi_y}{a^2}\Phi_{xy} - \frac{2\Phi_x\Phi_z}{a^2}\Phi_{xz} - \frac{2\Phi_y\Phi_z}{a^2}\Phi_{yz} = 0$$	Φ_x, Φ_y, Φ_z – velocity potential along x, y and z direction Φ_{xx}, Φ_{yy}, Φ_{zz} – 2nd derivative of velocity potential along x, y and z direction a – speed of sound
6.3 Speed of sound $$a^2 = a_0^2 - \frac{\gamma-1}{2}\left(\Phi_x^2 + \Phi_y^2 + \Phi_z^2\right)$$	Φ_x, Φ_y, Φ_z – velocity potential along x, y and z direction a – speed of sound a_0 – total speed of sound γ- gas constant
7. **Linearized Flow**	
7.1 Linearized perturbation velocity potential equation $$(1-M_\infty^2)\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2} = 0$$	ϕ - velocity potential M_∞ - free stream Mach number
7.2 Pressure coefficient $$C_p = \frac{2}{\gamma M_\infty^2}\left(\frac{P}{P_\infty} - 1\right)$$	C_p – coefficient of pressure M_∞ - free stream Mach number P – local pressure P_∞ - free stream pressure
7.3 Linearized Pressure coefficient $$C_p = -\frac{2u'}{V_\infty}$$	u' – perturbed velocity along x-axis V_∞ - free stream velocity
7.4 Prandtl – Glauert relation $$C_p = \frac{C_{p0}}{\sqrt{1-M_\infty^2}}$$	M_∞ - free stream Mach number C_{p0} – incompressible pressure coefficient
7.5 Laitone relation $$C_p = -\frac{C_{p0}}{\sqrt{1-M_\infty^2} + \left[\frac{M_\infty^2\left(1+\frac{\gamma-1}{2}M_\infty^2\right)}{2\sqrt{1-M_\infty^2}}\right]C_{p0}}$$ 7.6 Karman Tsien relation $$C_p = -\frac{C_{p0}}{\sqrt{1-M_\infty^2} + \left[\frac{M_\infty^2}{1+\sqrt{1-M_\infty^2}}\right]C_{p0}/2}$$	C_{p0} – incompressible pressure coefficient M_∞ - free stream Mach number γ- gas constant
7.7 Linearized supersonic flow $$C_p = \frac{2\theta}{\sqrt{M_\infty^2 - 1}}$$	M_∞ - free stream Mach number θ - deflection angle
7.8 Critical coefficient of Pressure	M_{ccr} – critical Mach number

$C_{p.cr} = \frac{2}{\gamma M_{cr}^2}\left[\left(\frac{1+\frac{\gamma-1}{2}M_{cr}^2}{1+\frac{\gamma-1}{2}}\right)^{\frac{\gamma}{\gamma-1}} - 1\right]$	γ- gas constant
8. **Numerical techniques**	
8.1 Characteristic line $\left(\frac{dy}{dx}\right)_{char} = \tan(\theta \pm \mu)$	θ - deflection angle μ - Mach angle
8.2 Compatibility equation $d\theta = \pm\sqrt{M^2 - 1}\frac{dV}{V}$	V – velocity M – Mach number
8.3 Compatibility equations along streamlines $\frac{dp}{\rho V^2 tan\mu} \pm d\theta + \frac{j\, sin\theta\, sin\mu\, dy}{\sin(\theta \pm \mu)\, y} = 0$	dp – pressure variation ρ - density of fluid θ - deflection angle μ - Mach angle y - distance

APPENDIX

TABLE A.1
Isentropic flow properties

M	$\frac{p_o}{p}$	$\frac{\rho_o}{\rho}$	$\frac{T_o}{T}$	$\frac{A}{A^*}$
0 2000 − 01	0 1000 + 01	0 1000 + 01	0 1000 + 01	0 2894 + 02
0 4000 − 01	0 1001 + 01	0 1001 + 01	0 1000 + 01	0 1448 + 02
0 6000 − 01	0 1003 + 01	0 1002 + 01	0 1001 + 01	0 9666 + 01
0 8000 − 01	0 1004 + 01	0 1003 + 01	0 1001 + 01	0 7262 + 01
0 1000 + 00	0 1007 + 01	0 1005 + 01	0 1002 + 01	0 5822 + 01
0 1200 + 00	0 1010 + 01	0 1007 + 01	0 1003 + 01	0 4864 + 01
0 1400 + 00	0 1014 + 01	0 1010 + 01	0 1004 + 01	0 4182 + 01
0 1600 + 00	0 1018 + 01	0 1013 + 01	0 1005 + 01	0 3673 + 01
0 1800 + 00	0 1023 + 01	0 1016 + 01	0 1006 + 01	0 3278 + 01
0 2000 + 00	0 1028 + 01	0 1020 + 01	0 1008 + 01	0 2964 + 01
0 2200 + 00	0 1034 + 01	0 1024 + 01	0 1010 + 01	0 2708 + 01
0 2400 + 00	0 1041 + 01	0 1029 + 01	0 1012 + 01	0 2496 + 01
0 2600 + 00	0 1048 + 01	0 1034 + 01	0 1014 + 01	0 2317 + 01
0 2800 + 00	0 1056 + 01	0 1040 + 01	0 1016 + 01	0 2166 + 01
0 3000 + 00	0 1064 + 01	0 1046 + 01	0 1018 + 01	0 2035 + 01
0 3200 + 00	0 1074 + 01	0 1052 + 01	0 1020 + 01	0 1922 + 01
0 3400 + 00	0 1083 + 01	0 1059 + 01	0 1023 + 01	0 1823 + 01
0 3600 + 00	0 1094 + 01	0 1066 + 01	0 1026 + 01	0 1736 + 01
0 3800 + 00	0 1105 + 01	0 1074 + 01	0 1029 + 01	0 1659 + 01
0 4000 + 00	0 1117 + 01	0 1082 + 01	0 1032 + 01	0 1590 + 01
0 4200 + 00	0 1129 + 01	0 1091 + 01	0 1035 + 01	0 1529 + 01
0 4400 + 00	0 1142 + 01	0 1100 + 01	0 1039 + 01	0 1474 + 01
0 4600 + 00	0 1156 + 01	0 1109 + 01	0 1042 + 01	0 1425 + 01
0 4800 + 00	0 1171 + 01	0 1119 + 01	0 1046 + 01	0 1380 + 01
0 5000 + 00	0 1186 + 01	0 1130 + 01	0 1050 + 01	0 1340 + 01
0 5200 + 00	0 1202 + 01	0 1141 + 01	0 1054 + 01	0 1303 + 01
0 5400 + 00	0 1219 + 01	0 1152 + 01	0 1058 + 01	0 1270 + 01
0 5600 + 00	0 1237 + 01	0 1164 + 01	0 1063 + 01	0 1240 + 01
0 5800 + 00	0 1256 + 01	0 1177 + 01	0 1067 + 01	0 1213 + 01
0 6000 + 00	0 1276 + 01	0 1190 + 01	0 1072 + 01	0 1188 + 01

M	$\frac{p_o}{p}$	$\frac{\rho_o}{\rho}$	$\frac{T_o}{T}$	$\frac{A}{A^*}$
0 6200 + 00	0 1296 + 01	0 1203 + 01	0 1077 + 01	0 1166 + 01
0 6400 + 00	0 1317 + 01	0 1218 + 01	0 1082 + 01	0 1145 + 01
0 6600 + 00	0 1340 + 01	0 1232 + 01	0 1087 + 01	0 1127 + 01
0 6800 + 00	0 1363 + 01	0 1247 + 01	0 1092 + 01	0 1110 + 01
0 7000 + 00	0 1387 + 01	0 1263 + 01	0 1098 + 01	0 1094 + 01
0 7200 + 00	0 1412 + 01	0 1280 + 01	0 1104 + 01	0 1081 + 01
0 7400 + 00	0 1439 + 01	0 1297 + 01	0 1110 + 01	0 1068 + 01
0 7600 + 00	0 1466 + 01	0 1314 + 01	0 1116 + 01	0 1057 + 01
0 7800 + 00	0 1495 + 01	0 1333 + 01	0 1122 + 01	0 1047 + 01
0 8000 + 00	0 1524 + 01	0 1351 + 01	0 1128 + 01	0 1038 + 01
0 8200 + 00	0 1555 + 01	0 1371 + 01	0 1134 + 01	0 1030 + 01
0 8400 + 00	0 1587 + 01	0 1391 + 01	0 1141 + 01	0 1024 + 01
0 8600 + 00	0 1621 + 01	0 1412 + 01	0 1148 + 01	0 1018 + 01
0 8800 + 00	0 1655 + 01	0 1433 + 01	0 1155 + 01	0 1013 + 01
0 9000 + 00	0 1691 + 01	0 1456 + 01	0 1162 + 01	0 1009 + 01
0 9200 + 00	0 1729 + 01	0 1478 + 01	0 1169 + 01	0 1006 + 01
0 9400 + 00	0 1767 + 01	0 1502 + 01	0 1177 + 01	0 1003 + 01
0 9600 + 00	0 1808 + 01	0 1526 + 01	0 1184 + 01	0 1001 + 01
0 9800 + 00	0 1850 + 01	0 1552 + 01	0 1192 + 01	0 1000 + 01
0 1000 + 01	0 1893 + 01	0 1577 + 01	0 1200 + 01	0 1000 + 01
0 1020 + 01	0 1938 + 01	0 1604 + 01	0 1208 + 01	0 1000 + 01
0 1040 + 01	0 1985 + 01	0 1632 + 01	0 1216 + 01	0 1001 + 01
0 1060 + 01	0 2033 + 01	0 1660 + 01	0 1225 + 01	0 1003 + 01
0 1080 + 01	0 2083 + 01	0 1689 + 01	0 1233 + 01	0 1005 + 01
0 1100 + 01	0 2135 + 01	0 1719 + 01	0 1242 + 01	0 1008 + 01
0 1120 + 01	0 2189 + 01	0 1750 + 01	0 1251 + 01	0 1011 + 01
0 1140 + 01	0 2245 + 01	0 1782 + 01	0 1260 + 01	0 1015 + 01
0 1160 + 01	0 2303 + 01	0 1814 + 01	0 1269 + 01	0 1020 + 01
0 1180 + 01	0 2363 + 01	0 1848 + 01	0 1278 + 01	0 1025 + 01
0 1200 + 01	0 2425 + 01	0 1883 + 01	0 1288 + 01	0 1030 + 01
0 1220 + 01	0 2489 + 01	0 1918 + 01	0 1298 + 01	0 1037 + 01
0 1240 + 01	0 2556 + 01	0 1955 + 01	0 1308 + 01	0 1043 + 01
0 1260 + 01	0 2625 + 01	0 1992 + 01	0 1318 + 01	0 1050 + 01
0 1280 + 01	0 2697 + 01	0 2031 + 01	0 1328 + 01	0 1058 + 01
0 1300 + 01	0 2771 + 01	0 2071 + 01	0 1338 + 01	0 1066 + 01
0 1320 + 01	0 2847 + 01	0 2112 + 01	0 1348 + 01	0 1075 + 01
0 1340 + 01	0 2927 + 01	0 2153 + 01	0 1359 + 01	0 1084 + 01
0 1360 + 01	0 3009 + 01	0 2197 + 01	0 1370 + 01	0 1094 + 01
0 1380 + 01	0 3094 + 01	0 2241 + 01	0 1381 + 01	0 1104 + 01
0 1400 + 01	0 3182 + 01	0 2286 + 01	0 1392 + 01	0 1115 + 01
0 1420 + 01	0 3273 + 01	0 2333 + 01	0 1403 + 01	0 1126 + 01
0 1440 + 01	0 3368 + 01	0 2381 + 01	0 1415 + 01	0 1138 + 01
0 1460 + 01	0 3465 + 01	0 2430 + 01	0 1426 + 01	0 1150 + 01
0 1480 + 01	0 3566 + 01	0 2480 + 01	0 1438 + 01	0 1163 + 01
0 1500 + 01	0 3671 + 01	0 2532 + 01	0 1450 + 01	0 1176 + 01
0 1520 + 01	0 3779 + 01	0 2585 + 01	0 1462 + 01	0 1190 + 01
0 1540 + 01	0 3891 + 01	0 2639 + 01	0 1474 + 01	0 1204 + 01
0 1560 + 01	0 4007 + 01	0 2695 + 01	0 1487 + 01	0 1219 + 01
0 1580 + 01	0 4127 + 01	0 2752 + 01	0 1499 + 01	0 1234 + 01
0 1600 + 01	0 4250 + 01	0 2811 + 01	0 1512 + 01	0 1250 + 01

Continued

TABLE A.1—*Continued*

M	$\frac{p_o}{p}$	$\frac{\rho_o}{\rho}$	$\frac{T_o}{T}$	$\frac{A}{A^*}$
0 1620+01	0 4378+01	0 2871+01	0 1525+01	0 1267+01
0 1640+01	0 4511+01	0 2933+01	0 1538+01	0 1284+01
0 1660+01	0 4648+01	0 2996+01	0 1551+01	0 1301+01
0 1680+01	0 4790+01	0 3061+01	0 1564+01	0 1319+01
0 1700+01	0 4936+01	0 3128+01	0 1578+01	0 1338+01
0 1720+01	0 5087+01	0 3196+01	0 1592+01	0 1357+01
0 1740+01	0 5244+01	0 3266+01	0 1606+01	0 1376+01
0 1760+01	0 5406+01	0 3338+01	0 1620+01	0 1397+01
0 1780+01	0 5573+01	0 3411+01	0 1634+01	0 1418+01
0 1800+01	0 5746+01	0 3487+01	0 1648+01	0 1439+01
0 1820+01	0 5924+01	0 3564+01	0 1662+01	0 1461+01
0 1840+01	0 6109+01	0 3643+01	0 1677+01	0 1484+01
0 1860+01	0 6300+01	0 3723+01	0 1692+01	0 1507+01
0 1880+01	0 6497+01	0 3806+01	0 1707+01	0 1531+01
0 1900+01	0 6701+01	0 3891+01	0 1722+01	0 1555+01
0 1920+01	0 6911+01	0 3978+01	0 1737+01	0 1580+01
0 1940+01	0 7128+01	0 4067+01	0 1753+01	0 1606+01
0 1960+01	0 7353+01	0 4158+01	0 1768+01	0 1633+01
0 1980+01	0 7585+01	0 4251+01	0 1784+01	0 1660+01
0 2000+01	0 7824+01	0 4347+01	0 1800+01	0 1687+01
0 2050+01	0 8458+01	0 4596+01	0 1840+01	0 1760+01
0 2100+01	0 9145+01	0 4859+01	0 1882+01	0 1837+01
0 2150+01	0 9888+01	0 5138+01	0 1924+01	0 1919+01
0 2200+01	0 1069+02	0 5433+01	0 1968+01	0 2005+01
0 2250+01	0 1156+02	0 5746+01	0 2012+01	0 2096+01
0 2300+01	0 1250+02	0 6076+01	0 2058+01	0.2193+01
0 2350+01	0 1352+02	0 6425+01	0 2104+01	0 2295+01
0 2400+01	0 1462+02	0 6794+01	0 2152+01	0 2403+01
0 2450+01	0 1581+02	0 7183+01	0 2200+01	0 2517+01
0 2500+01	0 1709+02	0 7594+01	0 2250+01	0 2637+01
0 2550+01	0 1847+02	0 8027+01	0 2300+01	0 2763+01
0 2600+01	0 1995+02	0 8484+01	0 2352+01	0 2896+01
0 2650+01	0 2156+02	0 8965+01	0 2404+01	0 3036+01
0 2700+01	0 2328+02	0 9472+01	0 2458+01	0 3183+01
0 2750+01	0 2514+02	0 1001+02	0 2512+01	0 3338+01
0 2800+01	0 2714+02	0 1057+02	0 2568+01	0 3500+01
0 2850+01	0 2929+02	0 1116+02	0 2624+01	0 3671+01
0 2900+01	0 3159+02	0 1178+02	0 2682+01	0 3850+01
0 2950+01	0 3407+02	0 1243+02	0 2740+01	0 4038+01
0 3000+01	0 3673+02	0 1312+02	0 2800+01	0 4235+01
0 3050+01	0 3959+02	0 1384+02	0 2860+01	0 4441+01
0 3100+01	0 4265+02	0 1459+02	0 2922+01	0 4657+01
0 3150+01	0 4593+02	0 1539+02	0 2984+01	0 4884+01
0 3200+01	0 4944+02	0 1622+02	0 3048+01	0 5121+01
0 3250+01	0 5320+02	0 1709+02	0 3112+01	0 5369+01
0 3300+01	0 5722+02	0 1800+02	0 3178+01	0 5629+01
0 3350+01	0 6152+02	0 1896+02	0 3244+01	0 5900+01
0 3400+01	0 6612+02	0 1996+02	0 3312+01	0 6184+01
0 3450+01	0 7103+02	0 2101+02	0 3380+01	0 6480+01
0 3500+01	0 7627+02	0 2211+02	0 3450+01	0 6790+01

M	$\frac{p_o}{p}$	$\frac{\rho_o}{\rho}$	$\frac{T_o}{T}$	$\frac{A}{A^*}$
0 3550+01	0 8187+02	0 2325+02	0 3520+01	0 7113+01
0 3600+01	0 8784+02	0 2445+02	0 3592+01	0 7450+01
0 3650+01	0 9420+02	0 2571+02	0 3664+01	0 7802+01
0 3700+01	0 1010+03	0 2701+02	0 3738+01	0 8169+01
0 3750+01	0 1082+03	0 2838+02	0 3812+01	0 8552+01
0 3800+01	0 1159+03	0 2981+02	0 3888+01	0 8951+01
0 3850+01	0 1241+03	0 3129+02	0 3964+01	0 9366+01
0 3900+01	0 1328+03	0 3285+02	0 4042+01	0 9799+01
0 3950+01	0 1420+03	0 3446+02	0 4120+01	0 1025+02
0 4000+01	0 1518+03	0 3615+02	0 4200+01	0 1072+02
0 4050+01	0 1623+03	0 3791+02	0 4280+01	0 1121+02
0 4100+01	0 1733+03	0 3974+02	0 4362+01	0 1171+02
0 4150+01	0 1851+03	0 4164+02	0 4444+01	0 1224+02
0 4200+01	0 1975+03	0 4363+02	0 4528+01	0 1279+02
0 4250+01	0 2108+03	0 4569+02	0 4612+01	0 1336+02
0 4300+01	0 2247+03	0 4784+02	0 4698+01	0 1395+02
0 4350+01	0 2396+03	0 5007+02	0 4784+01	0 1457+02
0 4400+01	0 2553+03	0 5239+02	0 4872+01	0 1521+02
0 4450+01	0 2719+03	0 5480+02	0 4960+01	0 1587+02
0 4500+01	0 2894+03	0 5731+02	0 5050+01	0 1656+02
0 4550+01	0 3080+03	0 5991+02	0 5140+01	0 1728+02
0 4600+01	0 3276+03	0 6261+02	0 5232+01	0 1802+02
0 4650+01	0 3483+03	0 6542+02	0 5324+01	0 1879+02
0 4700+01	0 3702+03	0 6833+02	0 5418+01	0 1958+02
0 4750+01	0 3933+03	0 7135+02	0 5512+01	0 2041+02
0 4800+01	0 4177+03	0 7448+02	0 5608+01	0 2126+02
0 4850+01	0 4434+03	0 7772+02	0 5704+01	0 2215+02
0 4900+01	0 4705+03	0 8109+02	0 5802+01	0 2307+02
0 4950+01	0 4990+03	0 8457+02	0 5900+01	0 2402+02
0 5000+01	0 5291+03	0 8818+02	0 6000+01	0 2500+02
0 5100+01	0 5941+03	0 9579+02	0 6202+01	0 2707+02
0 5200+01	0 6661+03	0 1039+03	0 6408+01	0 2928+02
0 5300+01	0 7457+03	0 1127+03	0 6618+01	0 3165+02
0 5400+01	0 8335+03	0 1220+03	0 6832+01	0 3417+02
0 5500+01	0 9304+03	0 1320+03	0 7050+01	0 3687+02
0 5600+01	0 1037+04	0 1426+03	0 7272+01	0 3974+02
0 5700+01	0 1154+04	0 1539+03	0 7498+01	0 4280+02
0 5800+01	0 1283+04	0 1660+03	0 7728+01	0 4605+02
0 5900+01	0 1424+04	0 1789+03	0 7962+01	0 4951+02
0 6000+01	0 1579+04	0 1925+03	0 8200+01	0 5318+02
0 6100+01	0 1748+04	0 2071+03	0 8442+01	0 5708+02
0 6200+01	0 1933+04	0 2225+03	0 8688+01	0 6121+02
0 6300+01	0 2135+04	0 2388+03	0 8938+01	0 6559+02
0 6400+01	0 2355+04	0 2562+03	0 9192+01	0 7023+02
0 6500+01	0 2594+04	0 2745+03	0 9450+01	0 7513+02
0 6600+01	0 2855+04	0 2939+03	0 9712+01	0 8032+02
0 6700+01	0 3138+04	0 3145+03	0 9978+01	0 8580+02
0 6800+01	0 3445+04	0 3362+03	0 1025+02	0 9159+02
0 6900+01	0 3779+04	0 3591+03	0 1052+02	0 9770+02
0 7000+01	0 4140+04	0 3833+03	0 1080+02	0 1041+03

Continued

TABLE A.1—*Continued*

M	$\frac{p_o}{p}$	$\frac{\rho_o}{\rho}$	$\frac{T_o}{T}$	$\frac{A}{A^*}$
0 7100 + 01	0 4531 + 04	0 4088 + 03	0 1108 + 02	0 1109 + 03
0 7200 + 01	0 4953 + 04	0 4357 + 03	0 1137 + 02	0 1181 + 03
0 7300 + 01	0 5410 + 04	0 4640 + 03	0 1166 + 02	0 1256 + 03
0 7400 + 01	0 5903 + 04	0 4939 + 03	0 1195 + 02	0 1335 + 03
0 7500 + 01	0 6434 + 04	0 5252 + 03	0 1225 + 02	0 1418 + 03
0 7600 + 01	0 7006 + 04	0 5582 + 03	0 1255 + 02	0 1506 + 03
0 7700 + 01	0 7623 + 04	0 5928 + 03	0 1286 + 02	0 1598 + 03
0 7800 + 01	0 8285 + 04	0 6292 + 03	0 1317 + 02	0 1694 + 03
0 7900 + 01	0 8998 + 04	0 6674 + 03	0 1348 + 02	0,1795 + 03
0 8000 + 01	0 9763 + 04	0 7075 + 03	0 1380 + 02	0 1901 + 03
0 9000 + 01	0 2110 + 05	0 1227 + 04	0 1720 + 02	0 3272 + 03
0 1000 + 02	0 4244 + 05	0 2021 + 04	0 2100 + 02	0 5359 + 03
0 1100 + 02	0 8033 + 05	0 3188 + 04	0 2520 + 02	0 8419 + 03
0 1200 + 02	0 1445 + 06	0 4848 + 04	0 2980 + 02	0 1276 + 04
0 1300 + 02	0 2486 + 06	0 7144 + 04	0 3480 + 02	0 1876 + 04
0 1400 + 02	0 4119 + 06	0 1025 + 05	0 4020 + 02	0 2685 + 04
0 1500 + 02	0 6602 + 06	0 1435 + 05	0 4600 + 02	0 3755 + 04
0 1600 + 02	0 1028 + 07	0 1969 + 05	0 5220 + 02	0 5145 + 04
0 1700 + 02	0 1559 + 07	0 2651 + 05	0 5880 + 02	0 6921 + 04
0 1800 + 02	0 2311 + 07	0 3512 + 05	0 6580 + 02	0 9159 + 04
0 1900 + 02	0 3356 + 07	0 4584 + 05	0 7320 + 02	0 1195 + 05
0 2000 + 02	0 4783 + 07	0 5905 + 05	0 8100 + 02	0 1538 + 05
0 2200 + 02	0 9251 + 07	0 9459 + 05	0 9780 + 02	0 2461 + 05
0 2400 + 02	0 1691 + 08	0 1456 + 06	0 1162 + 03	0 3783 + 05
0 2600 + 02	0 2949 + 08	0 2165 + 06	0 1362 + 03	0 5624 + 05
0 2800 + 02	0 4936 + 08	0 3128 + 06	0 1578 + 03	0 8121 + 05
0 3000 + 02	0 7978 + 08	0 4408 + 06	0 1810 + 03	0 1144 + 06
0 3200 + 02	0 1250 + 09	0 6076 + 06	0 2058 + 03	0 1576 + 06
0 3400 + 02	0 1908 + 09	0 8216 + 06	0 2322 + 03	0 2131 + 06
0 3600 + 02	0 2842 + 09	0 1092 + 07	0 2602 + 03	0 2832 + 06
0 3800 + 02	0 4143 + 09	0 1430 + 07	0 2898 + 03	0 3707 + 06
0 4000 + 02	0 5926 + 09	0 1846 + 07	0 3210 + 03	0 4785 + 06
0 4200 + 02	0 8330 + 09	0 2354 + 07	0 3538 + 03	0 6102 + 06
0 4400 + 02	0 1153 + 10	0 2969 + 07	0 3882 + 03	0 7694 + 06
0 4600 + 02	0 1572 + 10	0 3706 + 07	0 4242 + 03	0 9603 + 06
0 4800 + 02	0 2116 + 10	0 4583 + 07	0 4618 + 03	0 1187 + 07
0 5000 + 02	0 2815 + 10	0 5618 + 07	0 5010 + 03	0 1455 + 07

Normal shock properties

M	$\frac{p_2}{p_1}$	$\frac{\rho_2}{\rho_1}$	$\frac{T_2}{T_1}$	$\frac{p_{o_2}}{p_{o_1}}$	$\frac{p_{o_2}}{p_1}$	M_2
0 1000+01	0 1000+01	0 1000+01	0 1000+01	0 1000+01	0 1893+01	0 1000+01
0 1020+01	0 1047+01	0 1033+01	0 1013+01	0 1000+01	0 1938+01	0 9805+00
0 1040+01	0 1095+01	0 1067+01	0 1026+01	0 9999+00	0 1984+01	0 9620+00
0 1060+01	0 1144+01	0 1101+01	0 1039+01	0 9998+00	0 2032+01	0 9444+00
0 1080+01	0 1194+01	0 1135+01	0 1052+01	0 9994+00	0 2082+01	0 9277+00
0 1100+01	0 1245+01	0 1169+01	0 1065+01	0 9989+00	0 2133+01	0 9118+00
0 1120+01	0 1297+01	0 1203+01	0 1078+01	0 9982+00	0 2185+01	0 8966+00
0 1140+01	0 1350+01	0 1238+01	0 1090+01	0 9973+00	0 2239+01	0 8820+00
0 1160+01	0 1403+01	0 1272+01	0 1103+01	0 9961+00	0 2294+01	0 8682+00
0 1180+01	0 1458+01	0 1307+01	0 1115+01	0 9946+00	0 2350+01	0 8549+00
0 1200+01	0 1513+01	0 1342+01	0 1128+01	0 9928+00	0 2408+01	0 8422+00
0 1220+01	0 1570+01	0 1376+01	0 1141+01	0 9907+00	0 2466+01	0 8300+00
0 1240+01	0 1627+01	0 1411+01	0 1153+01	0 9884+00	0 2526+01	0 8183+00
0 1260+01	0 1686+01	0 1446+01	0 1166+01	0 9857+00	0 2588+01	0 8071+00
0 1280+01	0 1745+01	0 1481+01	0 1178+01	0 9827+00	0 2650+01	0 7963+00
0 1300+01	0 1805+01	0 1516+01	0 1191+01	0 9794+00	0 2714+01	0 7860+00
0 1320+01	0 1866+01	0 1551+01	0 1204+01	0 9758+00	0 2778+01	0 7760+00
0 1340+01	0 1928+01	0 1585+01	0 1216+01	0 9718+00	0 2844+01	0 7664+00
0 1360+01	0 1991+01	0 1620+01	0 1229+01	0 9676+00	0 2912+01	0 7572+00
0 1380+01	0 2055+01	0 1655+01	0 1242+01	0 9630+00	0 2980+01	0 7483+00
0 1400+01	0 2120+01	0 1690+01	0 1255+01	0 9582+00	0 3049+01	0 7397+00
0 1420+01	0 2186+01	0 1724+01	0 1268+01	0 9531+00	0 3120+01	0 7314+00
0 1440+01	0 2253+01	0 1759+01	0 1281+01	0 9476+00	0 3191+01	0 7235+00
0 1460+01	0 2320+01	0 1793+01	0 1294+01	0 9420+00	0 3264+01	0 7157+00
0 1480+01	0 2389+01	0 1828+01	0 1307+01	0 9360+00	0 3338+01	0 7083+00
0 1500+01	0 2458+01	0 1862+01	0 1320+01	0 9298+00	0 3413+01	0 7011+00
0 1520+01	0 2529+01	0 1896+01	0 1334+01	0 9233+00	0 3489+01	0 6941+00
0 1540+01	0 2600+01	0 1930+01	0 1347+01	0 9166+00	0 3567+01	0 6874+00
0 1560+01	0 2673+01	0 1964+01	0 1361+01	0 9097+00	0 3645+01	0 6809+00
0 1580+01	0 2746+01	0 1998+01	0 1374+01	0 9026+00	0 3724+01	0 6746+00
0 1600+01	0 2820+01	0 2032+01	0 1388+01	0 8952+00	0 3805+01	0 6684+00
0 1620+01	0 2895+01	0 2065+01	0 1402+01	0 8877+00	0 3887+01	0 6625+00
0 1640+01	0 2971+01	0 2099+01	0 1416+01	0 8799+00	0 3969+01	0 6568+00
0 1660+01	0 3048+01	0 2132+01	0 1430+01	0 8720+00	0 4053+01	0 6512+00
0 1680+01	0 3126+01	0 2165+01	0 1444+01	0 8639+00	0 4138+01	0 6458+00
0 1700+01	0 3205+01	0 2198+01	0 1458+01	0 8557+00	0 4224+01	0 6405+00
0 1720+01	0 3285+01	0 2230+01	0 1473+01	0 8474+00	0 4311+01	0 6355+00
0 1740+01	0 3366+01	0 2263+01	0 1487+01	0 8389+00	0 4399+01	0 6305+00
0 1760+01	0 3447+01	0 2295+01	0 1502+01	0 8302+00	0 4488+01	0 6257+00
0 1780+01	0 3530+01	0 2327+01	0 1517+01	0 8215+00	0 4578+01	0 6210+00
0 1800+01	0 3613+01	0 2359+01	0 1532+01	0 8127+00	0 4670+01	0 6165+00
0 1820+01	0 3698+01	0 2391+01	0 1547+01	0 8038+00	0 4762+01	0 6121+00
0 1840+01	0 3783+01	0 2422+01	0 1562+01	0 7948+00	0 4855+01	0 6078+00
0 1860+01	0 3870+01	0 2454+01	0 1577+01	0 7857+00	0 4950+01	0 6036+00
0 1880+01	0 3957+01	0 2485+01	0 1592+01	0 7765+00	0 5045+01	0 5996+00
0 1900+01	0 4045+01	0 2516+01	0 1608+01	0 7674+00	0 5142+01	0 5956+00
0 1920+01	0 4134+01	0 2546+01	0 1624+01	0 7581+00	0 5239+01	0 5918+00
0 1940+01	0 4224+01	0 2577+01	0 1639+01	0 7488+00	0 5338+01	0 5880+00
0 1960+01	0 4315+01	0 2607+01	0 1655+01	0 7395+00	0 5438+01	0 5844+00
0 1980+01	0 4407+01	0 2637+01	0 1671+01	0 7302+00	0 5539+01	0 5808+00

Continued

TABLE A.2—*Continued*

M	$\frac{p_2}{p_1}$	$\frac{\rho_2}{\rho_1}$	$\frac{T_2}{T_1}$	$\frac{p_{o_2}}{p_{o_1}}$	$\frac{p_{o_2}}{p_1}$	M_2
0 2000+01	0 4500+01	0 2667+01	0 1687+01	0 7209+00	0 5640+01	0 5774+00
0 2050+01	0 4736+01	0 2740+01	0 1729+01	0 6975+00	0 5900+01	0 5691+00
0 2100+01	0 4978+01	0 2812+01	0 1770+01	0 6742+00	0 6165+01	0 5613+00
0 2150+01	0 5226+01	0 2882+01	0 1813+01	0 6511+00	0 6438+01	0 5540+00
0 2200+01	0 5480+01	0 2951+01	0 1857+01	0 6281+00	0 6716+01	0 5471+00
0 2250+01	0 5740+01	0 3019+01	0 1901+01	0 6055+00	0 7002+01	0 5406+00
0 2300+01	0 6005+01	0 3085+01	0 1947+01	0 5833+00	0 7294+01	0 5344+00
0 2350+01	0 6276+01	0 3149+01	0 1993+01	0 5615+00	0 7592+01	0 5286+00
0 2400+01	0 6553+01	0 3212+01	0 2040+01	0 5401+00	0 7897+01	0 5231+00
0 2450+01	0 6836+01	0 3273+01	0 2088+01	0 5193+00	0 8208+01	0 5179+00
0 2500+01	0 7125+01	0 3333+01	0 2137+01	0 4990+00	0 8526+01	0 5130+00
0 2550+01	0 7420+01	0 3392+01	0 2187+01	0 4793+00	0 8850+01	0 5083+00
0 2600+01	0 7720+01	0 3449+01	0 2238+01	0 4601+00	0 9181+01	0 5039+00
0 2650+01	0 8026+01	0 3505+01	0 2290+01	0 4416+00	0 9519+01	0 4996+00
0 2700+01	0 8338+01	0 3559+01	0 2343+01	0 4236+00	0 9862+01	0 4956+00
0 2750+01	0 8656+01	0 3612+01	0 2397+01	0 4062+00	0 1021+02	0 4918+00
0 2800+01	0 8980+01	0 3664+01	0 2451+01	0 3895+00	0 1057+02	0 4882+00
0 2850+01	0 9310+01	0 3714+01	0 2507+01	0 3733+00	0 1093+02	0 4847+00
0 2900+01	0 9645+01	0 3763+01	0 2563+01	0 3577+00	0 1130+02	0 4814+00
0 2950+01	0 9986+01	0 3811+01	0 2621+01	0 3428+00	0 1168+02	0 4782+00
0 3000+01	0 1033+02	0 3857+01	0 2679+01	0 3283+00	0 1206+02	0 4752+00
0 3050+01	0 1069+02	0 3902+01	0 2738+01	0 3145+00	0 1245+02	0 4723+00
0 3100+01	0 1104+02	0 3947+01	0 2799+01	0 3012+00	0 1285+02	0 4695+00
0 3150+01	0 1141+02	0 3990+01	0 2860+01	0 2885+00	0 1325+02	0 4669+00
0 3200+01	0 1178+02	0 4031+01	0 2922+01	0 2762+00	0 1366+02	0 4643+00
0 3250+01	0 1216+02	0 4072+01	0 2985+01	0 2645+00	0 1407+02	0 4619+00
0 3300+01	0 1254+02	0 4112+01	0 3049+01	0 2533+00	0 1449+02	0 4596+00
0 3350+01	0 1293+02	0 4151+01	0 3114+01	0 2425+00	0 1492+02	0 4573+00
0 3400+01	0 1332+02	0 4188+01	0 3180+01	0 2322+00	0 1535+02	0 4552+00
0 3450+01	0 1372+02	0 4225+01	0 3247+01	0 2224+00	0 1579+02	0 4531+00
0 3500+01	0 1412+02	0 4261+01	0 3315+01	0 2129+00	0 1624+02	0 4512+00
0 3550+01	0 1454+02	0 4296+01	0 3384+01	0 2039+00	0 1670+02	0 4492+00
0 3600+01	0 1495+02	0 4330+01	0 3454+01	0 1953+00	0 1716+02	0 4474+00
0 3650+01	0 1538+02	0 4363+01	0 3525+01	0 1871+00	0 1762+02	0 4456+00
0 3700+01	0 1580+02	0 4395+01	0 3596+01	0 1792+00	0 1810+02	0 4439+00
0 3750+01	0 1624+02	0 4426+01	0 3669+01	0 1717+00	0 1857+02	0 4423+00
0 3800+01	0 1668+02	0 4457+01	0 3743+01	0 1645+00	0 1906+02	0 4407+00
0 3850+01	0 1713+02	0 4487+01	0 3817+01	0 1576+00	0 1955+02	0 4392+00
0 3900+01	0 1758+02	0 4516+01	0 3893+01	0 1510+00	0 2005+02	0 4377+00
0 3950+01	0 1804+02	0 4544+01	0 3969+01	0 1448+00	0 2056+02	0 4363+00
0 4000+01	0 1850+02	0 4571+01	0 4047+01	0 1388+00	0 2107+02	0 4350+00
0 4050+01	0 1897+02	0 4598+01	0 4125+01	0 1330+00	0 2159+02	0 4336+00
0 4100+01	0 1944+02	0 4624+01	0 4205+01	0 1276+00	0 2211+02	0 4324+00
0 4150+01	0 1993+02	0 4650+01	0 4285+01	0 1223+00	0 2264+02	0 4311+00
0 4200+01	0 2041+02	0 4675+01	0 4367+01	0 1173+00	0 2318+02	0 4299+00
0 4250+01	0 2091+02	0 4699+01	0 4449+01	0 1126+00	0 2372+02	0 4288+00
0 4300+01	0 2140+02	0 4723+01	0 4532+01	0 1080+00	0 2427+02	0 4277+00
0 4350+01	0 2191+02	0 4746+01	0 4616+01	0 1036+00	0 2483+02	0 4266+00
0 4400+01	0 2242+02	0 4768+01	0 4702+01	0 9948−01	0 2539+02	0 4255+00
0 4450+01	0 2294+02	0 4790+01	0 4788+01	0 9550−01	0 2596+02	0 4245+00

M	$\frac{p_2}{p_1}$	$\frac{\rho_2}{\rho_1}$	$\frac{T_2}{T_1}$	$\frac{p_{o_2}}{p_{o_1}}$	$\frac{p_{o_2}}{p_1}$	M_2
0 4500 +01	0 2346 +02	0 4812 +01	0 4875 +01	0 9170 −01	0 2654 +02	0 4236 +00
0.4550 +01	0 2399 + 02	0 4833 +01	0 4963 +01	0 8806 −01	0 2712 +02	0 4226 +00
0 4600 +01	0 2452 +02	0 4853 +01	0 5052 +01	0 8459 −01	0 2771 +02	0 4217 +00
0 4650 +01	0 2506 +02	0 4873 +01	0 5142 +01	0 8126 −01	0 2831 +02	0 4208 +00
0 4700 +01	0 2560 +02	0 4893 +01	0 5233 +01	0 7809 −01	0 2891 +02	0 4199 +00
0 4750 +01	0 2616 +02	0 4912 +01	0 5325 +01	0 7505 −01	0 2952 +02	0 4191 +00
0 4800 +01	0 2671 +02	0 4930 +01	0 5418 +01	0 7214 −01	0 3013 +02	0 4183 +00
0 4850 +01	0 2728 +02	0 4948 +01	0 5512 +01	0 6936 −01	0 3075 +02	0 4175 +00
0 4900 +01	0 2784 +02	0 4966 +01	0 5607 +01	0 6670 −01	0 3138 +02	0 4167 +00
0 4950 +01	0 2842 +02	0 4983 +01	0 5703 +01	0 6415 −01	0 3201 +02	0 4160 +00
0 5000 +01	0 2900 +02	0 5000 +01	0 5800 +01	0 6172 −01	0 3265 +02	0 4152 +00
0 5100 +01	0 3018 +02	0 5033 +01	0 5997 +01	0 5715 −01	0 3395 +02	0 4138 +00
0 5200 +01	0 3138 +02	0 5064 +01	0 6197 +01	0 5297 −01	0 3528 +02	0 4125 +00
0 5300 +01	0 3260 +02	0 5093 +01	0 6401 +01	0 4913 −01	0 3663 +02	0 4113 + 00
0 5400 +01	0 3385 +02	0 5122 +01	0 6610 +01	0 4560 −01	0 3801 +02	0 4101 +00
0 5500 +01	0 3512 +02	0 5149 +01	0 6822 +01	0 4236 −01	0 3941 +02	0 4090 +00
0 5600 +01	0 3642 +02	0 5175 +01	0 7038 +01	0 3938 −01	0 4084 +02	0 4079 +00
0 5700 +01	0 3774 +02	0 5200 +01	0 7258 +01	0 3664 −01	0 4230 +02	0 4069 +00
0 5800 +01	0 3908 + 02	0 5224 +01	0 7481 +01	0 3412 −01	0 4378 +02	0 4059 +00
0 5900 +01	0 4044 +02	0 5246 +01	0 7709 +01	0 3180 −01	0 4528 +02	0 4050 +00
0 6000 +01	0 4183 +02	0 5268 +01	0 7941 +01	0 2965 −01	0 4682 +02	0 4042 +00
0 6100 +01	0 4324 +02	0 5289 +01	0 8176 +01	0 2767 −01	0 4837 +02	0 4033 +00
0 6200 +01	0 4468 +02	0 5309 +01	0 8415 +01	0 2584 −01	0 4996 +02	0 4025 +00
0 6300 +01	0 4614 +02	0 5329 +01	0 8658 +01	0 2416 −01	0 5157 +02	0 4018 +00
0 6400 +01	0 4762 +02	0 5347 +01	0 8905 +01	0 2259 −01	0 5320 +02	0 4011 +00
0 6500 +01	0 4912 +02	0 5365 +01	0 9156 +01	0 2115 −01	0 5486 +02	0 4004 +00
0 6600 +01	0 5065 +02	0 5382 +01	0 9411 +01	0 1981 −01	0 5655 +02	0 3997 +00
0 6700 +01	0 5220 +02	0 5399 +01	0 9670 +01	0 1857 −01	0 5826 +02	0 3991 +00
0 6800 +01	0 5378 +02	0 5415 +01	0 9933 +01	0 1741 −01	0 6000 + 02	0 3985 +00
0 6900 +01	0 5538 +02	0 5430 +01	0 1020 +02	0 1635 −01	0 6176 + 02	0 3979 +00
0 7000 +01	0 5700 +02	0 5444 +01	0 1047 +02	0 1535 −01	0 6355 +02	0 3974 +00
0 7100 +01	0 5864 +02	0 5459 +01	0 1074 +02	0 1443 −01	0 6537 +02	0 3968 +00
0 7200 +01	0 6031 +02	0 5472 +01	0 1102 + 02	0 1357 −01	0 6721 +02	0 3963 +00
0 7300 +01	0 6200 +02	0 5485 +01	0 1130 +02	0 1277 −01	0 6908 +02	0 3958 +00
0 7400 +01	0 6372 +02	0 5498 +01	0 1159 +02	0 1202 −01	0 7097 +02	0 3954 +00
0 7500 +01	0 6546 +02	0 5510 +01	0 1188 +02	0 1133 −01	0 7289 +02	0 3949 +00
0 7600 +01	0 6722 +02	0 5522 +01	0 1217 +02	0 1068 −01	0 7483 +02	0 3945 +00
0 7700 +01	0 6900 +02	0 5533 +01	0 1247 +02	0 1008 −01	0 7680 +02	0 3941 +00
0 7800 +01	0 7081 +02	0 5544 +01	0 1277 +02	0 9510 −02	0 7880 + 02	0 3937 +00
0 7900 +01	0 7264 +02	0 5555 +01	0 1308 +02	0 8982 −02	0 8082 +02	0 3933 +00
0 8000 +01	0 7450 +02	0 5565 +01	0 1339 +02	0 8488 −02	0 8287 +02	0 3929 +00
0 9000 +01	0 9433 +02	0 5651 +01	0 1669 +02	0 4964 −02	0 1048 +03	0 3898 +00
0 1000 +02	0 1165 +03	0 5714 +01	0 2039 +02	0 3045 −02	0 1292 +03	0 3876 +00
0 1100 +02	0 1410 +03	0 5762 +01	0 2447 +02	0 1945 −02	0 1563 +03	0 3859 +00
0 1200 +02	0 1678 +03	0 5799 +01	0 2894 +02	0 1287 −02	0 1859 +03	0 3847 +00
0 1300 +02	0 1970 +03	0 5828 +01	0 3380 +02	0 8771 −03	0 2181 +03	0 3837 +00
0 1400 +02	0 2285 +03	0 5851 +01	0 3905 + 02	0 6138 −03	0 2528 +03	0 3829 +00
0 1500 +02	0 2623 +03	0 5870 +01	0 4469 +02	0 4395 −03	0 2902 +03	0 3823 +00
0 1600 +02	0 2985 +03	0 5885 +01	0 5072 +02	0 3212 −03	0 3301 +03	0 3817 +00
0 1700 +02	0 3370 +03	0 5898 +01	0 5714 +02	0 2390 −03	0 3726 +03	0 3813 +00

Continued

TABLE A.2— *Continued*

M	$\frac{p_2}{p_1}$	$\frac{\rho_2}{\rho_1}$	$\frac{T_2}{T_1}$	$\frac{p_{o_2}}{p_{o_1}}$	$\frac{p_{o_2}}{p_1}$	M_2
0 1800+02	0 3778+03	0 5909+01	0 6394+02	0 1807−03	0 4176+03	0 3810+00
0 1900+02	0 4210+03	0 5918+01	0 7114+02	0 1386−03	0 4653+03	0 3806+00
0 2000+02	0 4665+03	0 5926+01	0 7872+02	0 1078−03	0 5155+03	0 3804+00
0 2200+02	0 5645+03	0 5939+01	0 9506+02	0 6741−04	0 6236+03	0 3800+00
0 2400+02	0 6718+03	0 5948+01	0 1129+03	0 4388−04	0 7421+03	0 3796+00
0 2600+02	0 7885+03	0 5956+01	0 1324+03	0 2953−04	0 8709+03	0 3794+00
0 2800+02	0 9145+03	0 5962+01	0 1534+03	0 2046−04	0 1010+04	0 3792+00
0 3000+02	0 1050+04	0 5967+01	0 1759+03	0 1453−04	0 1159+04	0 3790+00
0 3200+02	0 1194+04	0 5971+01	0 2001+03	0 1055−04	0 1319+04	0 3789+00
0 3400+02	0 1348+04	0 5974+01	0 2257+03	0 7804−05	0 1489+04	0 3788+00
0 3600+02	0 1512+04	0 5977+01	0 2529+03	0 5874−05	0 1669+04	0 3787+00
0 3800+02	0 1684+04	0 5979+01	0 2817+03	0 4488−05	0 1860+04	0 3786+00
0 4000+02	0 1866+04	0 5981+01	0 3121+03	0 3477−05	0 2061+04	0 3786+00
0.4200+02	0 2058+04	0 5983+01	0 3439+03	0 2727−05	0 2272+04	0 3785+00
0 4400+02	0 2258+04	0 5985+01	0 3774+03	0 2163−05	0 2493+04	0 3785+00
0 4600+02	0 2468+04	0 5986+01	0 4124+03	0 1733−05	0 2725+04	0 3784+00
0 4800+02	0 2688+04	0 5987+01	0 4489+03	0 1402−05	0 2967+04	0 3784+00
0 5000+02	0 2916+04	0 5988+01	0 4871+03	0 1144−05	0 3219+04	0 3784+00

TABLE A.3
One-dimensional flow with heat addition

M	$\frac{p}{p^*}$	$\frac{T}{T^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{T_o}{T_o^*}$
0 2000 − 01	0 2399 + 01	0 2301 − 02	0 1042 + 04	0 1268 + 01	0 1918 − 02
0 4000 − 01	0 2395 + 01	0 9175 − 02	0 2610 + 03	0 1266 + 01	0 7648 − 02
0 6000 − 01	0 2388 + 01	0 2053 − 01	0 1163 + 03	0 1265 + 01	0 1712 − 01
0 8000 − 01	0 2379 + 01	0 3621 − 01	0 6569 + 02	0 1262 + 01	0 3022 − 01
0 1000 + 00	0 2367 + 01	0 5602 − 01	0 4225 + 02	0 1259 + 01	0 4678 − 01
0 1200 + 00	0 2353 + 01	0 7970 − 01	0 2952 + 02	0 1255 + 01	0 6661 − 01
0 1400 + 00	0 2336 + 01	0 1069 + 00	0 2184 + 02	0 1251 + 01	0 8947 − 01
0 1600 + 00	0 2317 + 01	0 1374 + 00	0 1686 + 02	0 1246 + 01	0 1151 + 00
0 1800 + 00	0 2296 + 01	0 1708 + 00	0 1344 + 02	0 1241 + 01	0 1432 + 00
0 2000 + 00	0 2273 + 01	0 2066 + 00	0 1100 + 02	0 1235 + 01	0 1736 + 00
0 2200 + 00	0 2248 + 01	0 2445 + 00	0 9192 + 01	0 1228 + 01	0 2057 + 00
0 2400 + 00	0 2221 + 01	0 2841 + 00	0 7817 + 01	0 1221 + 01	0 2395 + 00
0 2600 + 00	0 2193 + 01	0 3250 + 00	0 6747 + 01	0 1214 + 01	0 2745 + 00
0 2800 + 00	0 2163 + 01	0 3667 + 00	0 5898 + 01	0 1206 + 01	0 3104 + 00
0 3000 + 00	0 2131 + 01	0 4089 + 00	0 5213 + 01	0 1199 + 01	0 3469 + 00
0 3200 + 00	0 2099 + 01	0 4512 + 00	0 4652 + 01	0 1190 + 01	0 3837 + 00
0 3400 + 00	0 2066 + 01	0 4933 + 00	0 4188 + 01	0 1182 + 01	0 4206 + 00
0 3600 + 00	0 2031 + 01	0 5348 + 00	0 3798 + 01	0 1174 + 01	0 4572 + 00
0 3800 + 00	0 1996 + 01	0 5755 + 00	0 3469 + 01	0 1165 + 01	0 4935 + 00
0 4000 + 00	0 1961 + 01	0 6151 + 00	0 3188 + 01	0 1157 + 01	0 5290 + 00
0 4200 + 00	0 1925 + 01	0 6535 + 00	0 2945 + 01	0 1148 + 01	0 5638 + 00
0 4400 + 00	0 1888 + 01	0 6903 + 00	0 2736 + 01	0 1139 + 01	0 5975 + 00
0 4600 + 00	0 1852 + 01	0 7254 + 00	0 2552 + 01	0 1131 + 01	0 6301 + 00
0 4800 + 00	0 1815 + 01	0 7587 + 00	0 2392 + 01	0 1122 + 01	0 6614 + 00
0 5000 + 00	0 1778 + 01	0 7901 + 00	0 2250 + 01	0 1114 + 01	0 6914 + 00
0 5200 + 00	0 1741 + 01	0 8196 + 00	0 2124 + 01	0 1106 + 01	0 7199 + 00
0 5400 + 00	0 1704 + 01	0 8469 + 00	0 2012 + 01	0 1098 + 01	0 7470 + 00
0 5600 + 00	0 1668 + 01	0 8723 + 00	0 1912 + 01	0 1090 + 01	0 7725 + 00
0 5800 + 00	0 1632 + 01	0 8955 + 00	0 1822 + 01	0 1083 + 01	0 7965 + 00
0 6000 + 00	0 1596 + 01	0 9167 + 00	0 1741 + 01	0 1075 + 01	0 8189 + 00
0 6200 + 00	0 1560 + 01	0 9358 + 00	0 1667 + 01	0 1068 + 01	0 8398 + 00
0 6400 + 00	0 1525 + 01	0 9530 + 00	0 1601 + 01	0 1061 + 01	0 8592 + 00
0 6600 + 00	0 1491 + 01	0 9682 + 00	0 1540 + 01	0 1055 + 01	0 8771 + 00
0 6800 + 00	0 1457 + 01	0 9814 + 00	0 1484 + 01	0 1049 + 01	0 8935 + 00
0 7000 + 00	0 1423 + 01	0 9929 + 00	0 1434 + 01	0 1043 + 01	0 9085 + 00
0 7200 + 00	0 1391 + 01	0 1003 + 01	0 1387 + 01	0 1038 + 01	0 9221 + 00
0 7400 + 00	0 1359 + 01	0 1011 + 01	0 1344 + 01	0 1033 + 01	0 9344 + 00
0 7600 + 00	0 1327 + 01	0 1017 + 01	0 1305 + 01	0 1028 + 01	0 9455 + 00
0 7800 + 00	0 1296 + 01	0 1022 + 01	0 1268 + 01	0 1023 + 01	0 9553 + 00
0 8000 + 00	0 1266 + 01	0 1025 + 01	0 1234 + 01	0 1019 + 01	0 9639 + 00
0 8200 + 00	0 1236 + 01	0 1028 + 01	0 1203 + 01	0 1016 + 01	0 9715 + 00
0 8400 + 00	0 1207 + 01	0 1029 + 01	0 1174 + 01	0 1012 + 01	0 9781 + 00
0 8600 + 00	0 1179 + 01	0 1028 + 01	0 1147 + 01	0 1010 + 01	0 9836 + 00
0 8800 + 00	0 1152 + 01	0 1027 + 01	0 1121 + 01	0 1007 + 01	0 9883 + 00
0 9000 + 00	0 1125 + 01	0 1025 + 01	0 1098 + 01	0 1005 + 01	0 9921 + 00
0 9200 + 00	0 1098 + 01	0 1021 + 01	0 1076 + 01	0 1003 + 01	0 9951 + 00
0 9400 + 00	0 1073 + 01	0 1017 + 01	0 1055 + 01	0 1002 + 01	0 9973 + 00
0 9600 + 00	0 1048 + 01	0 1012 + 01	0 1035 + 01	0 1001 + 01	0 9988 + 00
0 9800 + 00	0 1024 + 01	0 1006 + 01	0 1017 + 01	0 1000 + 01	0 9997 + 00
0 1000 + 01	0 1000 + 01	0 1000 + 01	0 1000 + 01	0 1000 + 01	0 1000 + 01

Continued

TABLE A.3—*Continued*

M	$\frac{p}{p^*}$	$\frac{T}{T^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{T_o}{T_o^*}$
0 1020+01	0 9770+00	0 9930+00	0 9838+00	0 1000+01	0 9997+00
0 1040+01	0 9546+00	0 9855+00	0 9686+00	0 1001+01	0 9989+00
0 1060+01	0 9327+00	0 9776+00	0 9542+00	0 1002+01	0 9977+00
0 1080+01	0 9115+00	0 9691+00	0 9406+00	0 1003+01	0 9960+00
0 1100+01	0 8909+00	0 9603+00	0 9277+00	0 1005+01	0 9939+00
0 1120+01	0 8708+00	0 9512+00	0 9155+00	0 1007+01	0 9915+00
0 1140+01	0 8512+00	0 9417+00	0 9039+00	0 1010+01	0 9887+00
0 1160+01	0 8322+00	0 9320+00	0 8930+00	0 1012+01	0 9856+00
0 1180+01	0 8137+00	0 9220+00	0 8826+00	0 1016+01	0 9823+00
0 1200+01	0 7958+00	0 9118+00	0 8727+00	0 1019+01	0 9787+00
0 1220+01	0 7783+00	0 9015+00	0 8633+00	0 1023+01	0 9749+00
0 1240+01	0 7613+00	0 8911+00	0 8543+00	0 1028+01	0 9709+00
0 1260+01	0 7447+00	0 8805+00	0 8458+00	0 1033+01	0 9668+00
0 1280+01	0 7287+00	0 8699+00	0 8376+00	0 1038+01	0 9624+00
0 1300+01	0 7130+00	0 8592+00	0 8299+00	0 1044+01	0 9580+00
0 1320+01	0 6978+00	0 8484+00	0 8225+00	0 1050+01	0 9534+00
0 1340+01	0 6830+00	0 8377+00	0 8154+00	0 1056+01	0 9487+00
0 1360+01	0 6686+00	0 8269+00	0 8086+00	0 1063+01	0 9440+00
0 1380+01	0 6546+00	0 8161+00	0 8021+00	0 1070+01	0 9391+00
0 1400+01	0 6410+00	0 8054+00	0 7959+00	0 1078+01	0 9343+00
0 1420+01	0 6278+00	0 7947+00	0 7900+00	0 1086+01	0 9293+00
0 1440+01	0 6149+00	0 7840+00	0 7843+00	0 1094+01	0 9243+00
0 1460+01	0 6024+00	0 7735+00	0 7788+00	0 1103+01	0 9193+00
0 1480+01	0 5902+00	0 7629+00	0 7736+00	0 1112+01	0 9143+00
0 1500+01	0 5783+00	0 7525+00	0 7685+00	0 1122+01	0 9093+00
0 1520+01	0 5668+00	0 7422+00	0 7637+00	0 1132+01	0 9042+00
0 1540+01	0 5555+00	0 7319+00	0 7590+00	0 1142+01	0 8992+00
0 1560+01	0 5446+00	0 7217+00	0 7545+00	0 1153+01	0 8942+00
0 1580+01	0 5339+00	0 7117+00	0 7502+00	0 1164+01	0 8892+00
0 1600+01	0 5236+00	0 7017+00	0 7461+00	0 1176+01	0 8842+00
0 1620+01	0 5135+00	0 6919+00	0 7421+00	0 1188+01	0 8792+00
0 1640+01	0 5036+00	0 6822+00	0 7383+00	0 1200+01	0 8743+00
0 1660+01	0 4940+00	0 6726+00	0 7345+00	0 1213+01	0 8694+00
0 1680+01	0 4847+00	0 6631+00	0 7310+00	0 1226+01	0 8645+00
0 1700+01	0 4756+00	0 6538+00	0 7275+00	0 1240+01	0 8597+00
0 1720+01	0 4668+00	0 6445+00	0 7242+00	0 1254+01	0 8549+00
0 1740+01	0 4581+00	0 6355+00	0 7210+00	0 1269+01	0 8502+00
0 1760+01	0 4497+00	0 6265+00	0 7178+00	0 1284+01	0 8455+00
0 1780+01	0 4415+00	0 6176+00	0 7148+00	0 1300+01	0 8409+00
0 1800+01	0 4335+00	0 6089+00	0 7119+00	0 1316+01	0 8363+00
0 1820+01	0 4257+00	0 6004+00	0 7091+00	0 1332+01	0 8317+00
0 1840+01	0 4181+00	0 5919+00	0 7064+00	0 1349+01	0 8273+00
0 1860+01	0 4107+00	0 5836+00	0 7038+00	0 1367+01	0 8228+00
0 1880+01	0 4035+00	0 5754+00	0 7012+00	0 1385+01	0 8185+00
0 1900+01	0 3964+00	0 5673+00	0 6988+00	0 1403+01	0 8141+00
0 1920+01	0 3895+00	0 5594+00	0 6964+00	0 1422+01	0 8099+00
0 1940+01	0 3828+00	0 5516+00	0 6940+00	0 1442+01	0 8057+00
0 1960+01	0 3763+00	0 5439+00	0 6918+00	0 1462+01	0 8015+00
0 1980+01	0 3699+00	0 5364+00	0 6896+00	0 1482+01	0 7974+00
0 2000+01	0 3636+00	0 5289+00	0 6875+00	0 1503+01	0 7934+00

M	$\frac{p}{p^*}$	$\frac{T}{T^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{T_o}{T_o^*}$
0 2050+01	0 3487+00	0 5109+00	0 6825+00	0 1558+01	0 7835+00
0 2100+01	0 3345+00	0 4936+00	0 6778+00	0 1616+01	0 7741+00
0 2150+01	0 3212+00	0 4770+00	0 6735+00	0 1678+01	0 7649+00
0 2200+01	0 3086+00	0 4611+00	0 6694+00	0 1743+01	0 7561+00
0 2250+01	0 2968+00	0 4458+00	0 6656+00	0 1813+01	0 7477+00
0 2300+01	0 2855+00	0 4312+00	0 6621+00	0 1886+01	0 7395+00
0 2350+01	0 2749+00	0 4172+00	0 6588+00	0 1963+01	0 7317+00
0 2400+01	0 2648+00	0 4038+00	0 6557+00	0 2045+01	0 7242+00
0 2450+01	0 2552+00	0 3910+00	0 6527+00	0 2131+01	0 7170+00
0 2500+01	0 2462+00	0 3787+00	0 6500+00	0 2222+01	0 7101+00
0 2550+01	0 2375+00	0 3669+00	0 6474+00	0 2317+01	0 7034+00
0 2600+01	0 2294+00	0 3556+00	0 6450+00	0 2418+01	0 6970+00
0 2650+01	0 2216+00	0 3448+00	0 6427+00	0 2523+01	0 6908+00
0 2700+01	0 2142+00	0 3344+00	0 6405+00	0 2634+01	0 6849+00
0 2750+01	0 2071+00	0 3244+00	0 6384+00	0 2751+01	0 6793+00
0 2800+01	0 2004+00	0 3149+00	0 6365+00	0 2873+01	0 6738+00
0 2850+01	0 1940+00	0 3057+00	0 6346+00	0 3001+01	0 6685+00
0 2900+01	0 1879+00	0 2969+00	0 6329+00	0 3136+01	0 6635+00
0 2950+01	0 1820+00	0 2884+00	0 6312+00	0 3277+01	0 6586+00
0 3000+01	0 1765+00	0 2803+00	0 6296+00	0 3424+01	0 6540+00
0 3050+01	0 1711+00	0 2725+00	0 6281+00	0 3579+01	0 6495+00
0 3100+01	0 1660+00	0 2650+00	0 6267+00	0 3741+01	0 6452+00
0 3150+01	0 1612+00	0 2577+00	0 6253+00	0 3910+01	0 6410+00
0 3200+01	0 1565+00	0 2508+00	0 6240+00	0 4087+01	0 6370+00
0 3250+01	0 1520+00	0 2441+00	0 6228+00	0 4272+01	0 6331+00
0 3300+01	0.1477+00	0 2377+00	0 6216+00	0 4465+01	0.6294+00
0 3350+01	0 1436+00	0 2315+00	0 6205+00	0 4667+01	0 6258+00
0 3400+01	0.1397+00	0 2255+00	0 6194+00	0 4878+01	0 6224+00
0 3450+01	0 1359+00	0 2197+00	0 6183+00	0 5098+01	0 6190+00
0 3500+01	0 1322+00	0 2142+00	0 6173+00	0 5328+01	0 6158+00
0 3550+01	0 1287+00	0 2088+00	0 6164+00	0 5568+01	0 6127+00
0 3600+01	0 1254+00	0 2037+00	0 6155+00	0 5817+01	0 6097+00
0 3650+01	0 1221+00	0 1987+00	0 6146+00	0 6078+01	0 6068+00
0 3700+01	0 1190+00	0 1939+00	0 6138+00	0 6349+01	0 6040+00
0 3750+01	0 1160+00	0 1893+00	0 6130+00	0 6631+01	0 6013+00
0 3800+01	0 1131+00	0 1848+00	0 6122+00	0 6926+01	0 5987+00
0 3850+01	0 1103+00	0 1805+00	0 6114+00	0 7232+01	0 5962+00
0 3900+01	0 1077+00	0 1763+00	0 6107+00	0 7550+01	0 5937+00
0 3950+01	0 1051+00	0 1722+00	0 6100+00	0 7882+01	0 5914+00
0 4000+01	0 1026+00	0 1683+00	0 6094+00	0 8227+01	0 5891+00
0 4050+01	0 1002+00	0 1645+00	0 6087+00	0 8585+01	0 5869+00
0 4100+01	0 9782−01	0 1609+00	0 6081+00	0 8958+01	0 5847+00
0 4150+01	0 9557−01	0 1573+00	0 6075+00	0 9345+01	0 5827+00
0 4200+01	0 9340−01	0 1539+00	0 6070+00	0 9747+01	0 5807+00
0 4250+01	0 9130−01	0 1506+00	0 6064+00	0 1016+02	0 5787+00
0 4300+01	0 8927−01	0 1473+00	0 6059+00	0 1060+02	0 5768+00
0 4350+01	0 8730−01	0 1442+00	0 6054+00	0 1105+02	0 5750+00
0 4400+01	0 8540−01	0 1412+00	0 6049+00	0 1152+02	0 5732+00
0 4450+01	0 8356−01	0 1383+00	0 6044+00	0 1200+02	0 5715+00
0 4500+01	0 8177−01	0 1354+00	0 6039+00	0 1250+02	0 5698+00

Continued

TABLE A 3—*Continued*

M	$\frac{p}{p^*}$	$\frac{T}{T^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{T_o}{T_o^*}$
0 4550 + 01	0 8004 − 01	0 1326 + 00	0 6035 + 00	0 1302 + 02	0 5682 + 00
0 4600 + 01	0 7837 − 01	0 1300 + 00	0 6030 + 00	0 1356 + 02	0 5666 + 00
0 4650 + 01	0 7675 − 01	0 1274 + 00	0 6026 + 00	0 1412 + 02	0 5651 + 00
0 4700 + 01	0 7517 − 01	0 1248 + 00	0 6022 + 00	0 1470 + 02	0 5636 + 00
0 4750 + 01	0 7365 − 01	0 1224 + 00	0 6018 + 00	0 1530 + 02	0 5622 + 00
0 4800 + 01	0 7217 − 01	0 1200 + 00	0 6014 + 00	0 1592 + 02	0 5608 + 00
0 4850 + 01	0 7073 − 01	0 1177 + 00	0 6010 + 00	0 1657 + 02	0 5594 + 00
0 4900 + 01	0 6934 − 01	0 1154 + 00	0 6007 + 00	0 1723 + 02	0 5581 + 00
0 4950 + 01	0 6798 − 01	0 1132 + 00	0 6003 + 00	0 1792 + 02	0 5568 + 00
0 5000 + 01	0 6667 − 01	0 1111 + 00	0 6000 + 00	0 1863 + 02	0 5556 + 00
0 5100 + 01	0 6415 − 01	0 1070 + 00	0 5994 + 00	0 2013 + 02	0 5532 + 00
0 5200 + 01	0 6177 − 01	0 1032 + 00	0 5987 + 00	0 2173 + 02	0 5509 + 00
0 5300 + 01	0 5951 − 01	0 9950 − 01	0 5982 + 00	0 2344 + 02	0 5487 + 00
0 5400 + 01	0 5738 − 01	0 9602 − 01	0 5976 + 00	0 2527 + 02	0 5467 + 00
0 5500 + 01	0 5536 − 01	0 9272 − 01	0 5971 + 00	0 2721 + 02	0 5447 + 00
0 5600 + 01	0 5345 − 01	0 8958 − 01	0 5966 + 00	0 2928 + 02	0 5429 + 00
0 5700 + 01	0 5163 − 01	0 8660 − 01	0 5962 + 00	0 3148 + 02	0 5411 + 00
0 5800 + 01	0 4990 − 01	0 8376 − 01	0 5957 + 00	0 3382 + 02	0 5394 + 00
0 5900 + 01	0 4826 − 01	0 8106 − 01	0 5953 + 00	0 3631 + 02	0 5378 + 00
0 6000 + 01	0 4669 − 01	0 7849 − 01	0 5949 + 00	0 3895 + 02	0 5363 + 00
0 6100 + 01	0 4520 − 01	0 7603 − 01	0 5945 + 00	0 4174 + 02	0 5349 + 00
0 6200 + 01	0 4378 − 01	0 7369 − 01	0 5942 + 00	0 4471 + 02	0 5335 + 00
0 6300 + 01	0 4243 − 01	0 7145 − 01	0 5938 + 00	0 4785 + 02	0 5322 + 00
0 6400 + 01	0 4114 − 01	0 6931 − 01	0 5935 + 00	0 5117 + 02	0 5309 + 00
0 6500 + 01	0 3990 − 01	0 6726 − 01	0 5932 + 00	0 5468 + 02	0 5297 + 00
0 6600 + 01	0 3872 − 01	0 6531 − 01	0 5929 + 00	0 5840 + 02	0 5285 + 00
0 6700 + 01	0 3759 − 01	0 6343 − 01	0 5926 + 00	0 6232 + 02	0 5274 + 00
0 6800 + 01	0 3651 − 01	0 6164 − 01	0 5923 + 00	0 6645 + 02	0 5264 + 00
0 6900 + 01	0 3547 − 01	0 5991 − 01	0 5921 + 00	0 7082 + 02	0 5254 + 00
0 7000 + 01	0 3448 − 01	0 5826 − 01	0 5918 + 00	0 7541 + 02	0 5244 + 00
0 7100 + 01	0 3353 − 01	0 5668 − 01	0 5916 + 00	0 8026 + 02	0 5234 + 00
0 7200 + 01	0 3262 − 01	0 5516 − 01	0 5914 + 00	0 8536 + 02	0 5225 + 00
0 7300 + 01	0 3174 − 01	0 5370 − 01	0 5912 + 00	0 9072 + 02	0 5217 + 00
0 7400 + 01	0 3090 − 01	0 5229 − 01	0 5909 + 00	0 9636 + 02	0 5208 + 00
0 7500 + 01	0 3009 − 01	0 5094 − 01	0 5907 + 00	0 1023 + 03	0 5200 + 00
0 7600 + 01	0 2932 − 01	0 4964 − 01	0 5905 + 00	0 1085 + 03	0 5193 + 00
0 7700 + 01	0 2857 − 01	0 4839 − 01	0 5904 + 00	0 1150 + 03	0 5185 + 00
0 7800 + 01	0 2785 − 01	0 4719 − 01	0 5902 + 00	0 1219 + 03	0 5178 + 00
0 7900 + 01	0 2716 − 01	0 4603 − 01	0 5900 + 00	0 1291 + 03	0 5171 + 00
0 8000 + 01	0 2649 − 01	0 4491 − 01	0 5898 + 00	0 1366 + 03	0 5165 + 00
0 9000 + 01	0 2098 − 01	0 3565 − 01	0 5885 + 00	0 2339 + 03	0 5110 + 00
0 1000 + 02	0 1702 − 01	0 2897 − 01	0 5875 + 00	0 3816 + 03	0 5070 + 00
0 1100 + 02	0 1408 − 01	0 2400 − 01	0 5868 + 00	0 5977 + 03	0 5041 + 00
0 1200 + 02	0 1185 − 01	0 2021 − 01	0 5862 + 00	0 9041 + 03	0 5018 + 00
0 1300 + 02	0 1010 − 01	0 1724 − 01	0 5858 + 00	0 1327 + 04	0 5001 + 00
0 1400 + 02	0 8715 − 02	0 1489 − 01	0 5855 + 00	0 1896 + 04	0 4986 + 00
0 1500 + 02	0 7595 − 02	0 1298 − 01	0 5852 + 00	0 2649 + 04	0 4975 + 00
0 1600 + 02	0 6678 − 02	0 1142 − 01	0 5850 + 00	0 3625 + 04	0 4966 + 00
0 1700 + 02	0 5917 − 02	0 1012 − 01	0 5848 + 00	0 4873 + 04	0 4958 + 00
0 1800 + 02	0 5279 − 02	0 9030 − 02	0 5846 + 00	0 6445 + 04	0 4952 + 00

M	$\frac{p}{p^*}$	$\frac{T}{T^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{T_o}{T_o^*}$
0 1900 + 02	0 4739 − 02	0 8109 − 02	0 5845 + 00	0 8402 + 04	0 4946 + 00
0 2000 + 02	0 4278 − 02	0 7321 − 02	0 5844 + 00	0 1081 + 05	0 4942 + 00
0 2200 + 02	0 3537 − 02	0 6054 − 02	0 5842 + 00	0 1728 + 05	0 4934 + 00
0 2400 + 02	0 2973 − 02	0 5089 − 02	0 5841 + 00	0 2656 + 05	0 4928 + 00
0 2600 + 02	0 2533 − 02	0 4338 − 02	0 5839 + 00	0 3946 + 05	0 4924 + 00
0 2800 + 02	0 2185 − 02	0 3742 − 02	0 5839 + 00	0 5697 + 05	0 4920 + 00
0 3000 + 02	0 1903 − 02	0 3260 − 02	0 5838 + 00	0 8021 + 05	0 4917 + 00
0 3200 + 02	0 1673 − 02	0 2866 − 02	0 5837 + 00	0 1105 + 06	0 4915 + 00
0 3400 + 02	0 1482 − 02	0 2539 − 02	0 5837 + 00	0 1494 + 06	0 4913 + 00
0 3600 + 02	0 1322 − 02	0 2265 − 02	0 5837 + 00	0 1985 + 06	0 4911 + 00
0 3800 + 02	0 1187 − 02	0 2033 − 02	0 5836 + 00	0 2597 + 06	0 4910 + 00
0 4000 + 02	0 1071 − 02	0 1835 − 02	0 5836 + 00	0 3353 + 06	0 4909 + 00
0 4200 + 02	0 9714 − 03	0 1665 − 02	0 5836 + 00	0 4275 + 06	0 4908 + 00
0 4400 + 02	0 8852 − 03	0 1517 − 02	0 5835 + 00	0 5390 + 06	0 4907 + 00
0 4600 + 02	0 8099 − 03	0 1388 − 02	0 5835 + 00	0 6726 + 06	0 4906 + 00
0 4800 + 02	0 7438 − 03	0 1275 − 02	0 5835 + 00	0 8316 + 06	0 4906 + 00
0 5000 + 02	0 6855 − 03	0 1175 − 02	0 5835 + 00	0 1019 + 07	0 4905 + 00

TABLE A.4
One-dimensional flow with friction

M	$\frac{T}{T^*}$	$\frac{p}{p^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{4fL^*}{D}$
0 2000 − 01	0 1200 + 01	0 5477 + 02	0 4565 + 02	0 2894 + 02	0 1778 + 04
0 4000 − 01	0 1200 + 01	0 2738 + 02	0 2283 + 02	0 1448 + 02	0 4404 + 03
0 6000 − 01	0 1199 + 01	0 1825 + 02	0 1522 + 02	0 9666 + 01	0 1930 + 03
0 8000 − 01	0 1198 + 01	0 1368 + 02	0 1142 + 02	0 7262 + 01	0 1067 + 03
0 1000 + 00	0 1198 + 01	0 1094 + 02	0 9138 + 01	0 5822 + 01	0 6692 + 02
0 1200 + 00	0 1197 + 01	0 9116 + 01	0 7618 + 01	0 4864 + 01	0 4541 + 02
0 1400 + 00	0 1195 + 01	0 7809 + 01	0 6533 + 01	0 4182 + 01	0 3251 + 02
0 1600 + 00	0 1194 + 01	0 6829 + 01	0 5720 + 01	0 3673 + 01	0 2420 + 02
0 1800 + 00	0 1192 + 01	0 6066 + 01	0 5088 + 01	0 3278 + 01	0 1854 + 02
0 2000 + 00	0 1190 + 01	0 5455 + 01	0 4583 + 01	0 2964 + 01	0 1453 + 02
0 2200 + 00	0 1188 + 01	0 4955 + 01	0 4169 + 01	0 2708 + 01	0 1160 + 02
0 2400 + 00	0 1186 + 01	0 4538 + 01	0 3825 + 01	0 2496 + 01	0 9386 + 01
0 2600 + 00	0 1184 + 01	0 4185 + 01	0 3535 + 01	0 2317 + 01	0 7688 + 01
0 2800 + 00	0 1181 + 01	0 3882 + 01	0 3286 + 01	0 2166 + 01	0 6357 + 01
0 3000 + 00	0 1179 + 01	0 3619 + 01	0 3070 + 01	0 2035 + 01	0 5299 + 01
0 3200 + 00	0 1176 + 01	0 3389 + 01	0 2882 + 01	0 1922 + 01	0 4447 + 01
0 3400 + 00	0 1173 + 01	0 3185 + 01	0 2716 + 01	0 1823 + 01	0 3752 + 01
0 3600 + 00	0 1170 + 01	0 3004 + 01	0 2568 + 01	0 1736 + 01	0 3180 + 01
0 3800 + 00	0 1166 + 01	0 2842 + 01	0 2437 + 01	0 1659 + 01	0 2705 + 01
0 4000 + 00	0 1163 + 01	0 2696 + 01	0 2318 + 01	0 1590 + 01	0 2308 + 01
0 4200 + 00	0 1159 + 01	0 2563 + 01	0 2212 + 01	0 1529 + 01	0 1974 + 01
0 4400 + 00	0 1155 + 01	0 2443 + 01	0 2114 + 01	0 1474 + 01	0 1692 + 01
0 4600 + 00	0 1151 + 01	0 2333 + 01	0 2026 + 01	0 1425 + 01	0 1451 + 01
0 4800 + 00	0 1147 + 01	0 2231 + 01	0 1945 + 01	0 1380 + 01	0 1245 + 01
0 5000 + 00	0 1143 + 01	0 2138 + 01	0 1871 + 01	0 1340 + 01	0 1069 + 01
0 5200 + 00	0 1138 + 01	0 2052 + 01	0 1802 + 01	0 1303 + 01	0 9174 + 00
0 5400 + 00	0 1134 + 01	0 1972 + 01	0 1739 + 01	0 1270 + 01	0 7866 + 00
0 5600 + 00	0 1129 + 01	0 1898 + 01	0 1680 + 01	0 1240 + 01	0 6736 + 00
0 5800 + 00	0 1124 + 01	0 1828 + 01	0 1626 + 01	0 1213 + 01	0 5757 + 00
0 6000 + 00	0 1119 + 01	0 1763 + 01	0 1575 + 01	0 1188 + 01	0 4908 + 00
0 6200 + 00	0 1114 + 01	0 1703 + 01	0 1528 + 01	0 1166 + 01	0 4172 + 00
0 6400 + 00	0 1109 + 01	0 1646 + 01	0 1484 + 01	0 1145 + 01	0 3533 + 00
0 6600 + 00	0 1104 + 01	0 1592 + 01	0 1442 + 01	0 1127 + 01	0 2979 + 00
0 6800 + 00	0 1098 + 01	0 1541 + 01	0 1403 + 01	0 1110 + 01	0 2498 + 00
0 7000 + 00	0 1093 + 01	0 1493 + 01	0 1367 + 01	0 1094 + 01	0 2081 + 00
0 7200 + 00	0 1087 + 01	0 1448 + 01	0 1332 + 01	0 1081 + 01	0 1721 + 00
0 7400 + 00	0 1082 + 01	0 1405 + 01	0 1299 + 01	0 1068 + 01	0 1411 + 00
0 7600 + 00	0 1076 + 01	0 1365 + 01	0 1269 + 01	0 1057 + 01	0 1145 + 00
0 7800 + 00	0 1070 + 01	0 1326 + 01	0 1240 + 01	0 1047 + 01	0 9167 − 01
0 8000 + 00	0 1064 + 01	0 1289 + 01	0 1212 + 01	0 1038 + 01	0 7229 − 01
0 8200 + 00	0 1058 + 01	0 1254 + 01	0 1186 + 01	0 1030 + 01	0 5593 − 01
0 8400 + 00	0 1052 + 01	0 1221 + 01	0 1161 + 01	0 1024 + 01	0 4226 − 01
0 8600 + 00	0 1045 + 01	0 1189 + 01	0 1137 + 01	0 1018 + 01	0 3097 − 01
0 8800 + 00	0 1039 + 01	0 1158 + 01	0 1115 + 01	0 1013 + 01	0 2179 − 01
0 9000 + 00	0 1033 + 01	0 1129 + 01	0 1093 + 01	0 1009 + 01	0 1451 − 01
0 9200 + 00	0 1026 + 01	0 1101 + 01	0 1073 + 01	0 1006 + 01	0 8913 − 02
0 9400 + 00	0 1020 + 01	0 1074 + 01	0 1053 + 01	0 1003 + 01	0 4815 − 02
0 9600 + 00	0 1013 + 01	0 1049 + 01	0 1035 + 01	0 1001 + 01	0 2057 − 02
0 9800 + 00	0 1007 + 01	0 1024 + 01	0 1017 + 01	0 1000 + 01	0 4947 − 03
0 1000 + 01	0 1000 + 01	0 1000 + 01	0 1000 + 01	0 1000 + 01	0 0000 + 00

M	$\frac{T}{T^*}$	$\frac{p}{p^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{4fL^*}{D}$
0 1020+01	0 9933+00	0 9771+00	0 9837+00	0 1000+01	0 4587−03
0 1040+01	0 9866+00	0 9551+00	0 9681+00	0 1001+01	0 1768−02
0 1060+01	0 9798+00	0 9338+00	0 9531+00	0 1003+01	0 3838−02
0 1080+01	0 9730+00	0 9133+00	0 9387+00	0 1005+01	0 6585−02
0 1100+01	0 9662+00	0 8936+00	0 9249+00	0 1008+01	0 9935−02
0 1120+01	0 9593+00	0 8745+00	0 9116+00	0 1011+01	0 1382−01
0 1140+01	0 9524+00	0 8561+00	0 8988+00	0 1015+01	0 1819−01
0 1160+01	0 9455+00	0 8383+00	0 8865+00	0 1020+01	0 2298−01
0 1180+01	0 9386+00	0 8210+00	0 8747+00	0 1025+01	0 2814−01
0 1200+01	0 9317+00	0 8044+00	0 8633+00	0 1030+01	0 3364−01
0 1220+01	0 9247+00	0 7882+00	0 8524+00	0 1037+01	0 3943−01
0 1240+01	0 9178+00	0 7726+00	0 8418+00	0 1043+01	0 4547−01
0 1260+01	0 9108+00	0 7574+00	0 8316+00	0 1050+01	0 5174−01
0 1280+01	0 9038+00	0 7427+00	0 8218+00	0 1058+01	0 5820−01
0 1300+01	0 8969+00	0 7285+00	0 8123+00	0 1066+01	0 6483−01
0 1320+01	0 8899+00	0 7147+00	0 8031+00	0 1075+01	0 7161−01
0 1340+01	0 8829+00	0 7012+00	0 7942+00	0 1084+01	0 7850−01
0 1360+01	0 8760+00	0 6882+00	0 7856+00	0 1094+01	0 8550−01
0 1380+01	0 8690+00	0 6755+00	0 7773+00	0 1104+01	0 9259−01
0 1400+01	0 8621+00	0 6632+00	0 7693+00	0 1115+01	0 9974−01
0 1420+01	0 8551+00	0 6512+00	0 7615+00	0 1126+01	0 1069+00
0 1440+01	0 8482+00	0 6396+00	0 7540+00	0 1138+01	0 1142+00
0 1460+01	0 8413+00	0 6282+00	0 7467+00	0 1150+01	0 1215+00
0 1480+01	0 8344+00	0 6172+00	0 7397+00	0 1163+01	0 1288+00
0 1500+01	0 8276+00	0 6065+00	0 7328+00	0 1176+01	0 1361+00
0 1520+01	0 8207+00	0 5960+00	0 7262+00	0 1190+01	0 1433+00
0 1540+01	0 8139+00	0 5858+00	0 7198+00	0 1204+01	0 1506+00
0 1560+01	0 8071+00	0 5759+00	0 7135+00	0 1219+01	0 1579+00
0 1580+01	0 8004+00	0 5662+00	0 7074+00	0 1234+01	0 1651+00
0 1600+01	0 7937+00	0 5568+00	0 7016+00	0 1250+01	0 1724+00
0 1620+01	0 7869+00	0 5476+00	0 6958+00	0 1267+01	0 1795+00
0 1640+01	0 7803+00	0 5386+00	0 6903+00	0 1284+01	0.1867+00
0 1660+01	0 7736+00	0 5299+00	0 6849+00	0 1301+01	0 1938+00
0 1680+01	0 7670+00	0 5213+00	0 6796+00	0 1319+01	0 2008+00
0 1700+01	0 7605+00	0 5130+00	0 6745+00	0 1338+01	0 2078+00
0 1720+01	0 7539+00	0 5048+00	0.6696+00	0 1357+01	0 2147+00
0 1740+01	0 7474+00	0 4969+00	0 6648+00	0 1376+01	0 2216+00
0 1760+01	0 7410+00	0 4891+00	0 6601+00	0 1397+01	0 2284+00
0 1780+01	0 7345+00	0 4815+00	0 6555+00	0 1418+01	0 2352+00
0 1800+01	0 7282+00	0 4741+00	0 6511+00	0 1439+01	0 2419+00
0 1820+01	0 7218+00	0 4668+00	0 6467+00	0 1461+01	0 2485+00
0 1840+01	0 7155+00	0 4597+00	0 6425+00	0 1484+01	0 2551+00
0 1860+01	0 7093+00	0 4528+00	0 6384+00	0 1507+01	0 2616+00
0 1880+01	0 7030+00	0 4460+00	0 6344+00	0 1531+01	0 2680+00
0 1900+01	0 6969+00	0 4394+00	0 6305+00	0 1555+01	0 2743+00
0 1920+01	0 6907+00	0 4329+00	0 6267+00	0 1580+01	0 2806+00
0 1940+01	0 6847+00	0 4265+00	0 6230+00	0 1606+01	0 2868+00
0 1960+01	0 6786+00	0 4203+00	0 6193+00	0 1633+01	0 2929+00
0 1980+01	0 6726+00	0 4142+00	0 6158+00	0 1660+01	0 2990+00
0 2000+01	0 6667+00	0 4082+00	0 6124+00	0 1687+01	0 3050+00

Continued

TABLE A.4—*Continued*

M	$\frac{T}{T^*}$	$\frac{p}{p^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{4fL^*}{D}$
0 2050+01	0 6520+00	0 3939+00	0 6041+00	0 1760+01	0 3197+00
0 2100+01	0 6376+00	0 3802+00	0 5963+00	0 1837+01	0 3339+00
0 2150+01	0 6235+00	0 3673+00	0 5890+00	0 1919+01	0 3476+00
0 2200+01	0 6098+00	0 3549+00	0 5821+00	0 2005+01	0 3609+00
0 2250+01	0 5963+00	0 3432+00	0 5756+00	0 2096+01	0 3738+00
0 2300+01	0 5831+00	0 3320+00	0 5694+00	0 2193+01	0 3862+00
0 2350+01	0 5702+00	0 3213+00	0 5635+00	0 2295+01	0 3983+00
0 2400+01	0 5576+00	0 3111+00	0 5580+00	0 2403+01	0 4099+00
0 2450+01	0 5453+00	0 3014+00	0 5527+00	0 2517+01	0 4211+00
0 2500+01	0 5333+00	0 2921+00	0 5477+00	0 2637+01	0 4320+00
0 2550+01	0 5216+00	0 2832+00	0 5430+00	0 2763+01	0 4425+00
0 2600+01	0 5102+00	0 2747+00	0 5385+00	0 2896+01	0 4526+00
0 2650+01	0 4991+00	0 2666+00	0 5342+00	0 3036+01	0 4624+00
0 2700+01	0 4882+00	0 2588+00	0 5301+00	0 3183+01	0 4718+00
0 2750+01	0 4776+00	0 2513+00	0 5262+00	0 3338+01	0 4809+00
0 2800+01	0 4673+00	0 2441+00	0 5225+00	0 3500+01	0 4898+00
0 2850+01	0 4572+00	0 2373+00	0 5189+00	0 3671+01	0 4983+00
0 2900+01	0 4474+00	0 2307+00	0 5155+00	0 3850+01	0 5065+00
0 2950+01	0 4379+00	0 2243+00	0 5123+00	0 4038+01	0 5145+00
0 3000+01	0 4286+00	0 2182+00	0 5092+00	0 4235+01	0 5222+00
0 3050+01	0 4195+00	0 2124+00	0 5062+00	0 4441+01	0 5296+00
0 3100+01	0 4107+00	0 2067+00	0 5034+00	0 4657+01	0 5368+00
0 3150+01	0 4021+00	0 2013+00	0 5007+00	0 4884+01	0 5437+00
0 3200+01	0 3937+00	0 1961+00	0 4980+00	0 5121+01	0 5504+00
0 3250+01	0 3855+00	0 1911+00	0 4955+00	0 5369+01	0 5569+00
0 3300+01	0 3776+00	0 1862+00	0 4931+00	0 5629+01	0 5632+00
0 3350+01	0 3699+00	0 1815+00	0 4908+00	0 5900+01	0 5693+00
0 3400+01	0 3623+00	0 1770+00	0 4886+00	0 6184+01	0 5752+00
0 3450+01	0 3550+00	0 1727+00	0 4865+00	0 6480+01	0 5809+00
0 3500+01	0 3478+00	0 1685+00	0 4845+00	0 6790+01	0 5864+00
0 3550+01	0 3409+00	0 1645+00	0 4825+00	0 7113+01	0 5918+00
0 3600+01	0 3341+00	0 1606+00	0 4806+00	0 7450+01	0 5970+00
0 3650+01	0 3275+00	0 1568+00	0 4788+00	0 7802+01	0 6020+00
0 3700+01	0 3210+00	0 1531+00	0 4770+00	0 8169+01	0 6068+00
0 3750+01	0 3148+00	0 1496+00	0 4753+00	0 8552+01	0 6115+00
0 3800+01	0 3086+00	0 1462+00	0 4737+00	0 8951+01	0 6161+00
0 3850+01	0 3027+00	0 1429+00	0 4721+00	0 9366+01	0 6206+00
0 3900+01	0 2969+00	0 1397+00	0 4706+00	0 9799+01	0 6248+00
0 3950+01	0 2912+00	0 1366+00	0 4691+00	0 1025+02	0 6290+00
0 4000+01	0 2857+00	0 1336+00	0 4677+00	0 1072+02	0 6331+00
0 4050+01	0 2803+00	0 1307+00	0 4663+00	0 1121+02	0 6370+00
0 4100+01	0 2751+00	0 1279+00	0 4650+00	0 1171+02	0 6408+00
0 4150+01	0 2700+00	0 1252+00	0 4637+00	0 1224+02	0 6445+00
0 4200+01	0 2650+00	0 1226+00	0 4625+00	0 1279+02	0 6481+00
0 4250+01	0 2602+00	0 1200+00	0 4613+00	0 1336+02	0 6516+00
0 4300+01	0 2554+00	0 1175+00	0 4601+00	0 1395+02	0 6550+00
0 4350+01	0 2508+00	0 1151+00	0 4590+00	0 1457+02	0 6583+00
0 4400+01	0 2463+00	0 1128+00	0 4579+00	0 1521+02	0 6615+00
0 4450+01	0 2419+00	0 1105+00	0 4569+00	0 1587+02	0 6646+00
0 4500+01	0 2376+00	0 1083+00	0 4559+00	0 1656+02	0 6676+00

M	$\frac{T}{T^*}$	$\frac{p}{p^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{4fL^*}{D}$
0 4550+01	0 2334+00	0 1062+00	0 4549+00	0 1728+02	0 6706+00
0 4600+01	0 2294+00	0 1041+00	0 4539+00	0 1802+02	0 6734+00
0 4650+01	0 2254+00	0 1021+00	0 4530+00	0 1879+02	0 6762+00
0 4700+01	0 2215+00	0 1001+00	0 4521+00	0 1958+02	0 6790+00
0 4750+01	0 2177+00	0 9823−01	0 4512+00	0 2041+02	0 6816+00
0 4800+01	0 2140+00	0 9637−01	0 4504+00	0 2126+02	0 6842+00
0 4850+01	0 2104+00	0 9457−01	0 4495+00	0 2215+02	0 6867+00
0 4900+01	0 2068+00	0 9281−01	0 4487+00	0 2307+02	0 6891+00
0 4950+01	0 2034+00	0 9110−01	0 4480+00	0 2402+02	0 6915+00
0 5000+01	0 2000+00	0 8944−01	0 4472+00	0 2500+02	0 6938+00
0 5100+01	0 1935+00	0 8625−01	0 4458+00	0 2707+02	0 6983+00
0 5200+01	0 1873+00	0 8322−01	0 4444+00	0 2928+02	0 7025+00
0 5300+01	0 1813+00	0 8034−01	0 4431+00	0 3165+02	0 7065+00
0 5400+01	0 1756+00	0 7761−01	0 4419+00	0 3417+02	0 7104+00
0 5500+01	0 1702+00	0 7501−01	0 4407+00	0 3687+02	0 7140+00
0 5600+01	0 1650+00	0 7254−01	0 4396+00	0 3974+02	0 7175+00
0 5700+01	0 1600+00	0 7018−01	0 4385+00	0 4280+02	0.7208+00
0 5800+01	0 1553+00	0 6794−01	0 4375+00	0 4605+02	0 7240+00
0 5900+01	0 1507+00	0 6580−01	0 4366+00	0 4951+02	0 7270+00
0 6000+01	0 1463+00	0 6376−01	0 4357+00	0 5318+02	0 7299+00
0 6100+01	0 1421+00	0 6181−01	0 4348+00	0 5708+02	0 7326+00
0 6200+01	0 1381+00	0 5994−01	0 4340+00	0 6121+02	0 7353+00
0 6300+01	0 1343+00	0 5816−01	0 4332+00	0 6559+02	0 7378+00
0 6400+01	0 1305+00	0 5646−01	0 4324+00	0 7023+02	0 7402+00
0 6500+01	0 1270+00	0 5482−01	0 4317+00	0 7513+02	0 7425+00
0 6600+01	0 1236+00	0 5326−01	0 4310+00	0 8032+02	0 7448+00
0 6700+01	0 1203+00	0 5176−01	0 4304+00	0 8580+02	0 7469+00
0 6800+01	0 1171+00	0 5032−01	0 4298+00	0 9159+02	0 7489+00
0 6900+01	0 1140+00	0 4894−01	0 4292+00	0 9770+02	0 7509+00
0 7000+01	0 1111+00	0 4762−01	0 4286+00	0 1041+03	0 7528+00
0 7100+01	0 1083+00	0 4635−01	0 4280+00	0 1109+03	0 7546+00
0 7200+01	0 1056+00	0 4512−01	0 4275+00	0 1181+03	0 7564+00
0 7300+01	0 1029+00	0 4395−01	0 4270+00	0 1256+03	0 7580+00
0 7400+01	0 1004+00	0 4282−01	0 4265+00	0 1335+03	0 7597+00
0 7500+01	0 9796−01	0 4173−01	0 4260+00	0 1418+03	0 7612+00
0 7600+01	0 9560−01	0 4068−01	0 4256+00	0 1506+03	0 7627+00
0 7700+01	0 9333−01	0 3967−01	0 4251+00	0 1598+03	0 7642+00
0 7800+01	0 9113−01	0 3870−01	0 4247+00	0 1694+03	0 7656+00
0 7900+01	0 8901−01	0 3776−01	0 4243+00	0 1795+03	0 7669+00
0 8000+01	0 8696−01	0 3686−01	0 4239+00	0 1901+03	0 7682+00
0 9000+01	0 6977−01	0 2935−01	0 4207+00	0 3272+03	0 7790+00
0 1000+02	0 5714−01	0 2390−01	0 4183+00	0 5359+03	0 7868+00
0 1100+02	0 4762−01	0 1984−01	0 4166+00	0 8419+03	0 7927+00
0 1200+02	0 4027−01	0 1672−01	0 4153+00	0 1276+04	0 7972+00
0 1300+02	0 3448−01	0 1428−01	0 4142+00	0 1876+04	0 8007+00
0 1400+02	0 2985−01	0 1234−01	0 4134+00	0 2685+04	0 8036+00
0 1500+02	0 2609−01	0 1077−01	0 4128+00	0 3755+04	0 8058+00
0 1600+02	0 2299−01	0 9476−02	0 4122+00	0 5145+04	0 8077+00
0 1700+02	0 2041−01	0 8403−02	0 4118+00	0 6921+04	0 8093+00
0 1800+02	0 1824−01	0 7502−02	0 4114+00	0 9159+04	0 8106+00

Continued

TABLE A 4—*Continued*

M	$\frac{T}{T^*}$	$\frac{p}{p^*}$	$\frac{\rho}{\rho^*}$	$\frac{p_o}{p_o^*}$	$\frac{4fL^*}{D}$
0 1900+02	0 1639−01	0 6739−02	0 4111+00	0 1195+05	0 8117+00
0 2000+02	0 1481−01	0 6086−02	0 4108+00	0 1538+05	0 8126+00
0 2200+02	0 1227−01	0 5035−02	0 4104+00	0 2461+05	0 8142+00
0 2400+02	0 1033−01	0 4234−02	0 4100+00	0 3783+05	0 8153+00
0 2600+02	0 8811−02	0 3610−02	0 4098+00	0 5624+05	0 8162+00
0 2800+02	0 7605−02	0 3114−02	0 4095+00	0 8121+05	0 8170+00
0 3000+02	0 6630−02	0 2714−02	0 4094+00	0 1144+06	0 8176+00
0 3200+02	0 5831−02	0 2386−02	0 4092+00	0 1576+06	0 8180+00
0 3400+02	0 5168−02	0 2114−02	0 4091+00	0 2131+06	0 8184+00
0 3600+02	0 4612−02	0 1886−02	0 4090+00	0 2832+06	0 8188+00
0 3800+02	0 4141−02	0 1693−02	0 4090+00	0 3707+06	0 8190+00
0 4000+02	0 3738−02	0 1529−02	0 4089+00	0 4785+06	0 8193+00
0 4200+02	0 3392−02	0 1387−02	0 4088+00	0 6102+06	0 8195+00
0 4400+02	0 3091−02	0 1264−02	0 4088+00	0 7694+06	0 8197+00
0 4600+02	0 2829−02	0 1156−02	0 4087+00	0 9603+06	0 8198+00
0 4800+02	0 2599−02	0 1062−02	0 4087+00	0 1187+07	0 8200+00
0 5000+02	0 2395−02	0 9788−03	0 4087+00	0 1455+07	0 8201+00

TABLE A.5
Prandtl-Meyer function a. Mach angle

M	ν	μ	M	ν	μ
0 1000+01	0 0000	0 9000+02	0 2000+01	0 2638+02	0 3000+02
0 1020+01	0 1257+00	0 7864+02	0 2050+01	0 2775+02	0 2920+02
0 1040+01	0 3510+00	0 7406+02	0 2100+01	0 2910+02	0 2844+02
0 1060+01	0 6367+00	0 7063+02	0 2150+01	0 3043+02	0 2772+02
0 1080+01	0 9680+00	0 6781+02	0 2200+01	0 3173+02	0 2704+02
0 1100+01	0 1336+01	0 6538+02	0 2250+01	0 3302+02	0 2639+02
0 1120+01	0 1735+01	0 6323+02	0 2300+01	0 3428+02	0 2577+02
0 1140+01	0 2160+01	0 6131+02	0 2350+01	0 3553+02	0 2518+02
0 1160+01	0 2607+01	0 5955+02	0 2400+01	0 3675+02	0 2462+02
0 1180+01	0 3074+01	0 5794+02	0 2450+01	0 3795+02	0 2409+02
0 1200+01	0 3558+01	0 5644+02	0 2500+01	0 3912+02	0 2358+02
0 1220+01	0 4057+01	0 5505+02	0 2550+01	0 4028+02	0 2309+02
0 1240+01	0 4569+01	0 5375+02	0 2600+01	0 4141+02	0 2262+02
0 1260+01	0 5093+01	0 5253+02	0 2650+01	0 4253+02	0 2217+02
0 1280+01	0 5627+01	0 5138+02	0 2700+01	0 4362+02	0 2174+02
0 1300+01	0 6170+01	0 5028+02	0 2750+01	0 4469+02	0 2132+02
0 1320+01	0 6721+01	0 4925+02	0 2800+01	0 4575+02	0 2092+02
0 1340+01	0 7279+01	0 4827+02	0 2850+01	0 4678+02	0 2054+02
0 1360+01	0 7844+01	0 4733+02	0 2900+01	0 4779+02	0 2017+02
0 1380+01	0 8413+01	0 4644+02	0 2950+01	0 4878+02	0 1981+02
0 1400+01	0 8987+01	0 4558+02	0 3000+01	0 4976+02	0 1947+02
0 1420+01	0 9565+01	0 4477+02	0 3050+01	0 5071+02	0 1914+02
0 1440+01	0 1015+02	0 4398+02	0 3100+01	0 5165+02	0 1882+02
0 1460+01	0 1073+02	0 4323+02	0 3150+01	0 5257+02	0 1851+02
0 1480+01	0 1132+02	0 4251+02	0 3200+01	0 5347+02	0 1821+02
0 1500+01	0 1191+02	0 4181+02	0 3250+01	0 5435+02	0 1792+02
0 1520+01	0 1249+02	0 4114+02	0 3300+01	0 5522+02	0 1764+02
0 1540+01	0 1309+02	0 4049+02	0 3350+01	0 5607+02	0 1737+02
0 1560+01	0 1368+02	0 3987+02	0 3400+01	0 5691+02	0 1710+02
0 1580+01	0 1427+02	0 3927+02	0 3450+01	0 5773+02	0 1685+02
0 1600+01	0 1486+02	0 3868+02	0 3500+01	0 5853+02	0 1660+02
0 1620+01	0 1545+02	0 3812+02	0 3550+01	0 5932+02	0 1636+02
0 1640+01	0 1604+02	0 3757+02	0 3600+01	0 6009+02	0 1613+02
0 1660+01	0 1663+02	0 3704+02	0 3650+01	0 6085+02	0 1590+02
0 1680+01	0 1722+02	0 3653+02	0 3700+01	0 6160+02	0 1568+02
0 1700+01	0 1781+02	0 3603+02	0 3750+01	0 6233+02	0 1547+02
0 1720+01	0 1840+02	0 3555+02	0 3800+01	0 6304+02	0 1526+02
0 1740+01	0 1898+02	0 3508+02	0 3850+01	0 6375+02	0 1505+02
0 1760+01	0 1956+02	0 3462+02	0 3900+01	0 6444+02	0 1486+02
0 1780+01	0 2015+02	0 3418+02	0 3950+01	0 6512+02	0 1466+02
0 1800+01	0 2073+02	0 3375+02	0 4000+01	0 6578+02	0 1448+02
0 1820+01	0 2130+02	0 3333+02	0 4050+01	0 6644+02	0 1429+02
0 1840+01	0 2188+02	0 3292+02	0 4100+01	0 6708+02	0 1412+02
0 1860+01	0 2245+02	0 3252+02	0 4150+01	0 6771+02	0 1394+02
0 1880+01	0 2302+02	0 3213+02	0 4200+01	0 6833+02	0 1377+02
0 1900+01	0 2359+02	0 3176+02	0 4250+01	0 6894+02	0 1361+02
0 1920+01	0 2415+02	0 3139+02	0 4300+01	0 6954+02	0 1345+02
0 1940+01	0 2471+02	0 3103+02	0 4350+01	0 7013+02	0 1329+02
0 1960+01	0 2527+02	0 3068+02	0 4400+01	0 7071+02	0 1314+02
0 1980+01	0 2583+02	0 3033+02	0 4450+01	0 7127+02	0 1299+02

Continued

TABLE A.5—*Continued*

M	ν	μ	M	ν	μ
0 4500+01	0 7183+02	0 1284+02	0 7400+01	0 9297+02	0 7766+01
0 4550+01	0 7238+02	0 1270+02	0 7500+01	0 9344+02	0 7662+01
0 4600+01	0 7292+02	0 1256+02	0 7600+01	0 9390+02	0 7561+01
0 4650+01	0 7345+02	0 1242+02	0 7700+01	0 9434+02	0 7462+01
0 4700+01	0 7397+02	0 1228+02	0 7800+01	0 9478+02	0 7366+01
0 4750+01	0 7448+02	0 1215+02	0 7900+01	0 9521+02	0 7272+01
0 4800+01	0 7499+02	0 1202+02	0 8000+01	0 9562+02	0 7181+01
0 4850+01	0 7548+02	0 1190+02	0 9000+01	0 9932+02	0 6379+01
0 4900+01	0 7597+02	0 1178+02	0 1000+02	0 1023+03	0 5739+01
0 4950+01	0 7645+02	0 1166+02	0 1100+02	0 1048+03	0 5216+01
0 5000+01	0 7692+02	0 1154+02	0 1200+02	0 1069+03	0 4780+01
0 5100+01	0 7784+02	0 1131+02	0 1300+02	0 1087+03	0 4412+01
0 5200+01	0 7873+02	0 1109+02	0 1400+02	0 1102+03	0 4096+01
0 5300+01	0 7960+02	0 1088+02	0 1500+02	0 1115+03	0 3823+01
0 5400+01	0 8043+02	0 1067+02	0 1600+02	0 1127+03	0 3583+01
0 5500+01	0 8124+02	0 1048+02	0 1700+02	0 1137+03	0 3372+01
0 5600+01	0 8203+02	0 1029+02	0 1800+02	0 1146+03	0 3185+01
0 5700+01	0 8280+02	0 1010+02	0 1900+02	0 1155+03	0 3017+01
0 5800+01	0 8354+02	0 9928+01	0 2000+02	0 1162+03	0 2866+01
0 5900+01	0 8426+02	0 9758+01	0 2200+02	0 1175+03	0 2605+01
0 6000+01	0 8496+02	0 9594+01	0 2400+02	0 1186+03	0 2388+01
0 6100+01	0 8563+02	0 9435+01	0 2600+02	0 1195+03	0 2204+01
0 6200+01	0 8629+02	0 9282+01	0 2800+02	0 1202+03	0 2047+01
0 6300+01	0 8694+02	0 9133+01	0 3000+02	0 1209+03	0 1910+01
0 6400+01	0 8756+02	0 8989+01	0 3200+02	0 1215+03	0 1791+01
0 6500+01	0 8817+02	0 8850+01	0 3400+02	0 1220+03	0 1685+01
0 6600+01	0 8876+02	0 8715+01	0 3600+02	0 1225+03	0 1592+01
0 6700+01	0 8933+02	0 8584+01	0 3800+02	0 1229+03	0 1508+01
0 6800+01	0 8989+02	0 8457+01	0 4000+02	0 1233+03	0 1433+01
0 6900+01	0 9044+02	0 8333+01	0 4200+02	0 1236+03	0 1364+01
0 7000+01	0 9097+02	0 8213+01	0 4400+02	0 1239+03	0 1302+01
0 7100+01	0 9149+02	0 8097+01	0 4600+02	0 1242+03	0 1246+01
0 7200+01	0 9200+02	0 7984+01	0 4800+02	0 1245+03	0 1194+01
0 7300+01	0 9249+02	0 7873+01	0 5000+02	0 1247+03	0 1146+01