Appendix E: Ideal Gas Properties of Air

Ideal gas properties of air are provided in Table E-1. The specific internal energy provided in Table E-1 is computed by integration of the ideal gas specific heat capacity at constant volume:

$$u = \int_{T_{ref}}^{T} c_v(T)\,dT$$

and the specific enthalpy, *h*, provided in Table E-1 is computed by integration of the ideal gas specific heat capacity at constant pressure:

$$h = \int_{T_{ref}}^{T} c_P(T)\,dT$$

The data in Table E-1 have been obtained from EES. For temperatures between 100 K and 2000 K, the property routines use the ideal gas specific heat capacity relations given in:

E.W. Lemmon, R.T. Jacobsen, S.G. Penoncello, and D. Friend, "Thermodynamic Properties of Air and Mixtures of Nitrogen, Argon, and Oxygen from 60 to 2000 K at Pressures to 2000 MPa," *J. Phys. Chem. Ref. Data*, Vol. 29, No. 3, (2000).

For temperatures between 2000 K and 3500 K, the thermodynamic properties are based on data from Keenan, Chao, and Kaye, *Gas Tables*, Wiley, (1983). Note that these tables can be printed from the website associated with this text, www.cambridge.org/kleinandnellis, for use during closed book examinations.

Table E-1: Ideal gas properties of air.

Temp. (K)	c_v (kJ/kg-K)	c_P (kJ/kg-K)	u (kJ/kg)	h (kJ/kg)	$\int_{T_{ref}}^{T} \frac{c_P(T)}{T} dT$ (kJ/kg-K)
200	0.7153	1.002	142.7	200.1	5.299
220	0.7155	1.003	157.0	220.2	5.394
240	0.7158	1.003	171.3	240.2	5.481
260	0.7162	1.003	185.6	260.3	5.562
280	0.7168	1.004	200.0	280.3	5.636
300	0.7177	1.005	214.3	300.4	5.705
320	0.7188	1.006	228.7	320.5	5.770
340	0.7202	1.007	243.1	340.7	5.831
360	0.7219	1.009	257.5	360.8	5.889
380	0.7239	1.011	272.0	381.0	5.944
400	0.7262	1.013	286.5	401.3	5.995
420	0.7289	1.016	301.0	421.6	6.045
440	0.7318	1.019	315.6	441.9	6.092
460	0.7350	1.022	330.3	462.3	6.137
480	0.7385	1.026	345.0	482.8	6.181
500	0.7423	1.029	359.8	503.3	6.223
520	0.7462	1.033	374.7	524.0	6.263
540	0.7504	1.037	389.7	544.7	6.302
560	0.7547	1.042	404.7	565.5	6.340
580	0.7592	1.046	419.9	586.3	6.377
600	0.7638	1.051	435.1	607.3	6.412
620	0.7685	1.055	450.4	628.4	6.447
640	0.7732	1.060	465.8	649.5	6.480
660	0.7780	1.065	481.3	670.8	6.513
680	0.7828	1.070	497.0	692.1	6.545
700	0.7876	1.075	512.7	713.6	6.576
720	0.7925	1.079	528.5	735.1	6.606
740	0.7973	1.084	544.4	756.8	6.636
760	0.8020	1.089	560.3	778.5	6.665
780	0.8068	1.094	576.4	800.3	6.693
800	0.8114	1.098	592.6	822.2	6.721
820	0.8160	1.103	608.9	844.3	6.748
840	0.8206	1.108	625.3	866.4	6.775
860	0.8250	1.112	641.7	888.6	6.801
880	0.8294	1.116	658.3	910.8	6.827
900	0.8337	1.121	674.9	933.2	6.852
920	0.8379	1.125	691.6	955.7	6.876
940	0.8420	1.129	708.4	978.2	6.901
960	0.8460	1.133	725.3	1001	6.924
980	0.8500	1.137	742.2	1024	6.948
1000	0.8538	1.141	759.3	1046	6.971
1020	0.8575	1.145	776.4	1069	6.993
1040	0.8612	1.148	793.6	1092	7.016
1060	0.8648	1.152	810.8	1115	7.038
1080	0.8682	1.155	828.2	1138	7.059
1100	0.8716	1.159	845.6	1161	7.080
1120	0.8749	1.162	863.0	1185	7.101
1140	0.8782	1.165	880.6	1208	7.122

Table E-1 (continued): Ideal gas properties of air.

Temp. (K)	c_v (kJ/kg-K)	c_P (kJ/kg-K)	u (kJ/kg)	h (kJ/kg)	$\int_{T_{ref}}^{T} \frac{c_P(T)}{T} dT$ (kJ/kg-K)
1160	0.8813	1.168	898.2	1231	7.142
1180	0.8843	1.171	915.8	1255	7.162
1200	0.8873	1.174	933.5	1278	7.182
1220	0.8902	1.177	951.3	1301	7.201
1240	0.8930	1.180	969.1	1325	7.220
1260	0.8958	1.183	987.0	1349	7.239
1280	0.8985	1.185	1005	1372	7.258
1300	0.9011	1.188	1023	1396	7.276
1320	0.9036	1.191	1041	1420	7.294
1340	0.9061	1.193	1059	1444	7.312
1360	0.9085	1.196	1077	1468	7.330
1380	0.9109	1.198	1095	1492	7.347
1400	0.9132	1.200	1114	1516	7.365
1420	0.9154	1.202	1132	1540	7.382
1440	0.9176	1.205	1150	1564	7.398
1460	0.9197	1.207	1169	1588	7.415
1480	0.9218	1.209	1187	1612	7.432
1500	0.9239	1.211	1206	1636	7.448
1520	0.9259	1.213	1224	1660	7.464
1540	0.9278	1.215	1243	1685	7.480
1560	0.9297	1.217	1261	1709	7.495
1580	0.9316	1.219	1280	1733	7.511
1600	0.9334	1.220	1298	1758	7.526
1620	0.9352	1.222	1317	1782	7.541
1640	0.9369	1.224	1336	1807	7.556
1660	0.9386	1.226	1355	1831	7.571
1680	0.9403	1.227	1373	1856	7.586
1700	0.9419	1.229	1392	1880	7.600
1720	0.9435	1.231	1411	1905	7.615
1740	0.9451	1.232	1430	1929	7.629
1760	0.9466	1.234	1449	1954	7.643
1780	0.9481	1.235	1468	1979	7.657
1800	0.9496	1.237	1487	2003	7.671
1820	0.9511	1.238	1506	2028	7.684
1840	0.9525	1.240	1525	2053	7.698
1860	0.9539	1.241	1544	2078	7.711
1880	0.9553	1.242	1563	2103	7.725
1900	0.9566	1.244	1582	2127	7.738
1920	0.9579	1.245	1601	2152	7.751
1940	0.9592	1.246	1620	2177	7.764
1960	0.9605	1.248	1640	2202	7.776
1980	0.9618	1.249	1659	2227	7.789
2000	0.9630	1.250	1678	2252	7.802
2020	0.9633	1.250	1698	2277	7.814
2040	0.9645	1.252	1717	2303	7.826
2060	0.9656	1.253	1736	2328	7.839
2080	0.9668	1.254	1756	2353	7.851
2100	0.9679	1.255	1775	2378	7.863

Table E-1 (continued): Ideal gas properties of air.

Temp. (K)	c_V (kJ/kg-K)	c_P (kJ/kg-K)	u (kJ/kg)	h (kJ/kg)	$\int_{T_{ref}}^{T} \frac{c_p(T)}{T} dT$ (kJ/kg-K)
2120	0.9689	1.256	1794	2403	7.875
2140	0.9700	1.257	1814	2428	7.886
2160	0.9711	1.258	1833	2453	7.898
2180	0.9721	1.259	1853	2478	7.910
2200	0.9731	1.260	1872	2503	7.921
2220	0.9741	1.261	1891	2529	7.933
2240	0.9751	1.262	1911	2554	7.944
2260	0.9761	1.263	1930	2579	7.955
2280	0.9770	1.264	1950	2604	7.966
2300	0.9779	1.265	1970	2630	7.977
2320	0.9789	1.266	1989	2655	7.988
2340	0.9798	1.267	2009	2680	7.999
2360	0.9807	1.268	2028	2706	8.010
2380	0.9815	1.269	2048	2731	8.021
2400	0.9824	1.269	2068	2756	8.031
2420	0.9833	1.270	2087	2782	8.042
2440	0.9841	1.271	2107	2807	8.052
2460	0.9850	1.272	2127	2833	8.063
2480	0.9858	1.273	2146	2858	8.073
2500	0.9866	1.274	2166	2884	8.083
2520	0.9874	1.274	2186	2909	8.093
2540	0.9882	1.275	2206	2935	8.103
2560	0.9890	1.276	2225	2960	8.113
2580	0.9897	1.277	2245	2986	8.123
2600	0.9905	1.278	2265	3011	8.133
2650	0.9924	1.279	2314	3075	8.158
2700	0.9942	1.281	2364	3139	8.182
2750	0.9960	1.283	2414	3203	8.205
2800	0.9977	1.285	2464	3267	8.228
2850	0.9994	1.286	2514	3332	8.251
2900	1.001	1.288	2564	3396	8.273
2950	1.003	1.290	2614	3460	8.295
3000	1.004	1.291	2664	3525	8.317
3050	1.006	1.293	2714	3590	8.338
3100	1.007	1.294	2765	3654	8.359
3150	1.009	1.296	2815	3719	8.380
3200	1.010	1.297	2865	3784	8.401
3250	1.012	1.299	2916	3849	8.421
3300	1.013	1.300	2967	3914	8.441
3350	1.015	1.302	3017	3979	8.460
3400	1.016	1.303	3068	4044	8.479
3450	1.017	1.304	3119	4109	8.498
3500	1.019	1.306	3170	4174	8.517