Chapter 2

Table 2.1 Atmospheric properties in ISA

Altit-ude (m)	Tempe-rature (K)	Pressure (N/m^2)	δ (p/p_o)	Density (kg/m^3)	σ (ρ/ρ_o)	speed of sound (m/s)	Kinematic viscosity (m^2/s)
0	288.15	101325.0	1.00000	1.22500	1.00000	340.29	1.4607E-005
200	286.85	98945.3	0.97651	1.20165	0.98094	339.53	1.4839E-005
400	285.55	96611.0	0.95348	1.17864	0.96216	338.76	1.5075E-005
600	284.25	94321.6	0.93088	1.15598	0.94365	337.98	1.5316E-005
800	282.95	92076.3	0.90872	1.13364	0.92542	337.21	1.5562E-005
1000	281.65	89874.4	0.88699	1.11164	0.90746	336.43	1.5813E-005
1200	280.35	87715.4	0.86568	1.08997	0.88977	335.66	1.6069E-005
1400	279.05	85598.6	0.84479	1.06862	0.87234	334.88	1.6331E-005
1600	277.75	83523.3	0.82431	1.04759	0.85518	334.10	1.6598E-005
1800	276.45	81489.0	0.80423	1.02688	0.83827	333.31	1.6870E-005
2000	275.15	79494.9	0.78455	1.00649	0.82162	332.53	1.7148E-005
2200	273.85	77540.6	0.76527	0.98640	0.80523	331.74	1.7432E-005
2400	272.55	75625.4	0.74636	0.96663	0.78908	330.95	1.7723E-005
2600	271.25	73748.6	0.72784	0.94716	0.77319	330.16	1.8019E-005
2800	269.95	71909.7	0.70969	0.92799	0.75754	329.37	1.8321E-005
3000	268.65	70108.2	0.69191	0.90912	0.74214	328.58	1.8630E-005
3200	267.35	68343.3	0.67450	0.89054	0.72697	327.78	1.8946E-005
3400	266.05	66614.6	0.65744	0.87226	0.71205	326.98	1.9269E-005
3600	264.75	64921.5	0.64073	0.85426	0.69736	326.18	1.9598E-005
3800	263.45	63263.4	0.62436	0.83655	0.68290	325.38	1.9935E-005
4000	262.15	61639.8	0.60834	0.81912	0.66867	324.58	2.0279E-005
4200	260.85	60050.0	0.59265	0.80197	0.65467	323.77	2.0631E-005
4400	259.55	58493.7	0.57729	0.78510	0.64090	322.97	2.0990E-005
4600	258.25	56970.1	0.56225	0.76850	0.62735	322.16	2.1358E-005

Table 2.1 Atmospheric properties in ISA (Cont..)

4800	256.95	55478.9	0.54753	0.75217	0.61402	321.34	2.1734E-005
5000	255.65	54019.4	0.53313	0.73611	0.60091	320.53	2.2118E-005
5200	254.35	52591.2	0.51903	0.72031	0.58801	319.71	2.2511E-005
5400	253.05	51193.7	0.50524	0.70477	0.57532	318.90	2.2913E-005
5600	251.75	49826.4	0.49175	0.68949	0.56285	318.08	2.3324E-005
5800	250.45	48488.8	0.47855	0.67446	0.55058	317.25	2.3744E-005
6000	249.15	47180.5	0.46564	0.65969	0.53852	316.43	2.4174E-005
6200	247.85	45900.9	0.45301	0.64516	0.52666	315.60	2.4614E-005
6400	246.55	44649.5	0.44066	0.63088	0.51501	314.77	2.5064E-005
6600	245.25	43425.9	0.42858	0.61685	0.50355	313.94	2.5525E-005
6800	243.95	42229.6	0.41677	0.60305	0.49229	313.11	2.5997E-005
7000	242.65	41060.2	0.40523	0.58949	0.48122	312.27	2.6480E-005
7200	241.35	39917.1	0.39395	0.57617	0.47034	311.44	2.6974E-005
7400	240.05	38799.9	0.38292	0.56308	0.45965	310.60	2.7480E-005
7600	238.75	37708.1	0.37215	0.55021	0.44915	309.75	2.7998E-005
7800	237.45	36641.4	0.36162	0.53757	0.43884	308.91	2.8529E-005
8000	236.15	35599.2	0.35134	0.52516	0.42870	308.06	2.9073E-005
8200	234.85	34581.2	0.34129	0.51296	0.41875	307.21	2.9629E-005
8400	233.55	33586.9	0.33148	0.50099	0.40897	306.36	3.0200E-005
8600	232.25	32615.8	0.32189	0.48923	0.39937	305.51	3.0784E-005
8800	230.95	31667.6	0.31254	0.47768	0.38994	304.65	3.1383E-005
9000	229.65	30741.9	0.30340	0.46634	0.38069	303.79	3.1997E-005
9200	228.35	29838.2	0.29448	0.45521	0.37160	302.93	3.2627E-005
9400	227.05	28956.1	0.28577	0.44428	0.36268	302.07	3.3272E-005
9600	225.75	28095.2	0.27728	0.43355	0.35392	301.20	3.3933E-005
9800	224.45	27255.2	0.26899	0.42303	0.34533	300.33	3.4611E-005
10000	223.15	26435.7	0.26090	0.41270	0.33690	299.46	3.5307E-005
10200	221.85	25636.2	0.25301	0.40256	0.32862	298.59	3.6020E-005
10400	220.55	24856.4	0.24531	0.39262	0.32050	297.71	3.6752E-005

Table 2.1 Atmospheric properties in ISA (Cont..)

10600	219.25	24096.0	0.23781	0.38286	0.31254	296.83	3.7503E-005
10800	217.95	23354.4	0.23049	0.37329	0.30473	295.95	3.8274E-005
11000	216.65	22631.5	0.22336	0.36391	0.29707	295.07	3.9065E-005
11200	216.65	21929.4	0.21643	0.35262	0.28785	295.07	4.0316E-005
11400	216.65	21248.6	0.20971	0.34167	0.27892	295.07	4.1608E-005
11600	216.65	20588.9	0.20320	0.33106	0.27026	295.07	4.2941E-005
11800	216.65	19949.7	0.19689	0.32079	0.26187	295.07	4.4317E-005
12000	216.65	19330.4	0.19078	0.31083	0.25374	295.07	4.5736E-005
12200	216.65	18730.2	0.18485	0.30118	0.24586	295.07	4.7202E-005
12400	216.65	18148.7	0.17911	0.29183	0.23823	295.07	4.8714E-005
12600	216.65	17585.3	0.17355	0.28277	0.23083	295.07	5.0275E-005
12800	216.65	17039.4	0.16817	0.27399	0.22366	295.07	5.1886E-005
13000	216.65	16510.4	0.16294	0.26548	0.21672	295.07	5.3548E-005
13200	216.65	15997.8	0.15789	0.25724	0.20999	295.07	5.5264E-005
13400	216.65	15501.1	0.15298	0.24925	0.20347	295.07	5.7035E-005
13600	216.65	15019.9	0.14823	0.24152	0.19716	295.07	5.8862E-005
13800	216.65	14553.6	0.14363	0.23402	0.19104	295.07	6.0748E-005
14000	216.65	14101.8	0.13917	0.22675	0.18510	295.07	6.2694E-005
14200	216.65	13664.0	0.13485	0.21971	0.17936	295.07	6.4703E-005
14400	216.65	13239.8	0.13067	0.21289	0.17379	295.07	6.6776E-005
14600	216.65	12828.7	0.12661	0.20628	0.16839	295.07	6.8916E-005
14800	216.65	12430.5	0.12268	0.19988	0.16317	295.07	7.1124E-005
15000	216.65	12044.6	0.11887	0.19367	0.15810	295.07	7.3403E-005
15200	216.65	11670.6	0.11518	0.18766	0.15319	295.07	7.5754E-005
15400	216.65	11308.3	0.11160	0.18183	0.14844	295.07	7.8182E-005
15600	216.65	10957.2	0.10814	0.17619	0.14383	295.07	8.0687E-005
15800	216.65	10617.1	0.10478	0.17072	0.13936	295.07	8.3272E-005
16000	216.65	10287.5	0.10153	0.16542	0.13504	295.07	8.5940E-005
16200	216.65	9968.1	0.09838	0.16028	0.13084	295.07	8.8693E-005

Table 2.1 Atmospheric properties in ISA (Cont..)

16400	216.65	9658.6	0.09532	0.15531	0.12678	295.07	9.1535E-005
16600	216.65	9358.8	0.09236	0.15049	0.12285	295.07	9.4468E-005
16800	216.65	9068.2	0.08950	0.14581	0.11903	295.07	9.7495E-005
17000	216.65	8786.7	0.08672	0.14129	0.11534	295.07	1.0062E-004
17200	216.65	8513.9	0.08403	0.13690	0.11176	295.07	1.0384E-004
17400	216.65	8249.6	0.08142	0.13265	0.10829	295.07	1.0717E-004
17600	216.65	7993.5	0.07889	0.12853	0.10492	295.07	1.1060E-004
17800	216.65	7745.3	0.07644	0.12454	0.10167	295.07	1.1415E-004
18000	216.65	7504.8	0.07407	0.12068	0.09851	295.07	1.1780E-004
18200	216.65	7271.9	0.07177	0.11693	0.09545	295.07	1.2158E-004
18400	216.65	7046.1	0.06954	0.11330	0.09249	295.07	1.2547E-004
18600	216.65	6827.3	0.06738	0.10978	0.08962	295.07	1.2949E-004
18800	216.65	6615.4	0.06529	0.10637	0.08684	295.07	1.3364E-004
19000	216.65	6410.0	0.06326	0.10307	0.08414	295.07	1.3793E-004
19200	216.65	6211.0	0.06130	0.09987	0.08153	295.07	1.4234E-004
19400	216.65	6018.2	0.05939	0.09677	0.07900	295.07	1.4690E-004
19600	216.65	5831.3	0.05755	0.09377	0.07654	295.07	1.5161E-004
19800	216.65	5650.3	0.05576	0.09086	0.07417	295.07	1.5647E-004
20000	216.65	5474.9	0.05403	0.08803	0.07187	295.07	1.6148E-004
20200	216.85	5305.0	0.05236	0.08522	0.06957	295.21	1.6694E-004
20400	217.05	5140.5	0.05073	0.08251	0.06735	295.34	1.7257E-004
20600	217.25	4981.3	0.04916	0.07988	0.06521	295.48	1.7839E-004
20800	217.45	4827.1	0.04764	0.07733	0.06313	295.61	1.8440E-004
21000	217.65	4677.9	0.04617	0.07487	0.06112	295.75	1.9060E-004
21200	217.85	4533.3	0.04474	0.07249	0.05918	295.89	1.9701E-004
21400	218.05	4393.4	0.04336	0.07019	0.05730	296.02	2.0363E-004
21600	218.25	4257.9	0.04202	0.06796	0.05548	296.16	2.1046E-004
21800	218.45	4126.8	0.04073	0.06581	0.05372	296.29	2.1752E-004
22000	218.65	3999.7	0.03947	0.06373	0.05202	296.43	2.2480E-004

Table 2.1 Atmospheric properties in ISA (Cont..)

22200	218.85	3876.7	0.03826	0.06171	0.05038	296.56	2.3232E-004
22400	219.05	3757.6	0.03708	0.05976	0.04878	296.70	2.4009E-004
22600	219.25	3642.3	0.03595	0.05787	0.04724	296.83	2.4811E-004
22800	219.45	3530.5	0.03484	0.05605	0.04575	296.97	2.5639E-004
23000	219.65	3422.4	0.03378	0.05428	0.04431	297.11	2.6494E-004
23200	219.85	3317.6	0.03274	0.05257	0.04291	297.24	2.7376E-004
23400	220.05	3216.1	0.03174	0.05091	0.04156	297.38	2.8287E-004
23600	220.25	3117.8	0.03077	0.04931	0.04026	297.51	2.9228E-004
23800	220.45	3022.6	0.02983	0.04776	0.03899	297.65	3.0198E-004
24000	220.65	2930.4	0.02892	0.04627	0.03777	297.78	3.1200E-004
24200	220.85	2841.1	0.02804	0.04482	0.03658	297.92	3.2235E-004
24400	221.05	2754.6	0.02719	0.04341	0.03544	298.05	3.3302E-004
24600	221.25	2670.8	0.02636	0.04205	0.03433	298.19	3.4404E-004
24800	221.45	2589.6	0.02556	0.04074	0.03325	298.32	3.5542E-004
25000	221.65	2510.9	0.02478	0.03946	0.03222	298.45	3.6716E-004
25200	221.85	2434.7	0.02403	0.03823	0.03121	298.59	3.7927E-004
25400	222.05	2360.9	0.02330	0.03704	0.03024	298.72	3.9178E-004
25600	222.25	2289.4	0.02259	0.03589	0.02929	298.86	4.0468E-004
25800	222.45	2220.1	0.02191	0.03477	0.02838	298.99	4.1800E-004
26000	222.65	2153.0	0.02125	0.03369	0.02750	299.13	4.3174E-004
26200	222.85	2087.9	0.02061	0.03264	0.02664	299.26	4.4593E-004
26400	223.05	2024.9	0.01998	0.03163	0.02582	299.40	4.6056E-004
26600	223.25	1963.9	0.01938	0.03064	0.02502	299.53	4.7566E-004
26800	223.45	1904.7	0.01880	0.02969	0.02424	299.66	4.9124E-004
27000	223.65	1847.3	0.01823	0.02878	0.02349	299.80	5.0732E-004
27200	223.85	1791.8	0.01768	0.02788	0.02276	299.93	5.2391E-004
27400	224.05	1737.9	0.01715	0.02702	0.02206	300.07	5.4102E-004
27600	224.25	1685.8	0.01664	0.02619	0.02138	300.20	5.5868E-004
27800	224.45	1635.2	0.01614	0.02538	0.02072	300.33	5.7690E-004

Table 2.1 Atmospheric properties in ISA (Cont..)

28000	224.65	1586.2	0.01565	0.02460	0.02008	300.47	5.9569E-004
28200	224.85	1538.7	0.01519	0.02384	0.01946	300.60	6.1508E-004
28400	225.05	1492.6	0.01473	0.02311	0.01886	300.74	6.3508E-004
28600	225.25	1448.0	0.01429	0.02239	0.01828	300.87	6.5572E-004
28800	225.45	1404.8	0.01386	0.02171	0.01772	301.00	6.7700E-004
29000	225.65	1362.9	0.01345	0.02104	0.01718	301.14	6.9896E-004
29200	225.85	1322.2	0.01305	0.02040	0.01665	301.27	7.2161E-004
29400	226.05	1282.8	0.01266	0.01977	0.01614	301.40	7.4497E-004
29600	226.25	1244.7	0.01228	0.01916	0.01564	301.54	7.6906E-004
29800	226.45	1207.6	0.01192	0.01858	0.01517	301.67	7.9391E-004
30000	226.65	1171.8	0.01156	0.01801	0.01470	301.80	8.1954E-004
30200	226.85	1137.0	0.01122	0.01746	0.01425	301.94	8.4598E-004
30400	227.05	1103.3	0.01089	0.01693	0.01382	302.07	8.7324E-004
30600	227.25	1070.6	0.01057	0.01641	0.01340	302.20	9.0136E-004
30800	227.45	1038.9	0.01025	0.01591	0.01299	302.33	9.3035E-004
31000	227.65	1008.1	0.00995	0.01543	0.01259	302.47	9.6026E-004
31200	227.85	978.3	0.00966	0.01496	0.01221	302.60	9.9109E-004
31400	228.05	949.5	0.00937	0.01450	0.01184	302.73	1.0229E-003
31600	228.25	921.4	0.00909	0.01406	0.01148	302.87	1.0557E-003
31800	228.45	894.3	0.00883	0.01364	0.01113	303.00	1.0895E-003
32000	228.65	867.9	0.00857	0.01322	0.01079	303.13	1.1243E-003

Table 2.1 Atmospheric properties in ISA

Note: Following values / expressions have been used while preparing ISA table.

$R=287.05287\,m^2sec^{-2}\,K$

$g= 9.80665\,m/s^2$

Sutherland formula for viscosity:

$$\mu = 1.458X10^{-6}\,[\frac{T^{3/2}}{T+110.4}]$$

In troposphere (h = 0 to 11000 m): T= 288.15 - 0.0065 h.

$$p = 101325 [1-0.000022588h]^{5.25588}$$

$$\rho = 1.225 [1-0.000022588h]^{4.25588} .$$

In lower stratosphere (h = 11000 to 20000 km): T=216.65 K.

$$p = 22632 \exp \{-0.000157688 (h-11000)\}$$

$$\rho = 0.36391 \exp \{-0.000157688 (h-11000)\}$$

In middle stratosphere (h = 20000 to 32000 km):

$$T = 216.65 + 0.001h$$

$$p = 5474.9 [1+0.000004616(h-20000)]^{-34.1632}$$

$$\rho = 0.08803 [1+0.000004616(h-20000)]^{-35.1632}$$