CONVERSION TABLES

PRESSURE	1 atm	101325 Pa
	1 bar	100000 Pa
Pa = N/m^2 = J/m^3	1 dyn/cm^2	0.1 Pa
	1 in Hg (0°C)	3386.389 Pa
	1 inH_2O (4°C)	249.082 Pa
	1 inH_2O (20°C)	248.642 Pa
	1 kg f/m^2	9.80665 Pa
	1 kg f/cm^2	98066.5 Pa
	1 kg f/mm^2	9806650 Pa
	1 lb f/in^2	6894.757 Pa
	1 mbar	100 Pa
	1 mm Hg (0°C)	133.3224 Pa
	1 N/m^2	1 Pa
	1 kg/mm^2	10000000 Pa
	1 psi	7030.7 Pa
	1 kg/ms^2	1 Pa
POWER	1 ft lbf/s	1.355818 W
	1 hp	745.6999 W
W = J/s		550 ft lbf/s
	1 metric hp	735.4987 W
		75 m kgf/s
LENGTH	1 Angstrom	1E-10 m
	1 ft	0.3048 m
	1 in	0.0254 m
	1 mile	1609.344 m
	1 nautical mile (UK)	1853.184 m
	1 nautical mile (Int)	1852 m
	1 yd	0.9144 m

Formulas

$Q = VA$

$H_f = f\,l\,u^2/\,(D \times 2g)$

$f = 16/Re$

$f = 64/Re$

$f = 0.316/Re^{1/4}$

$f = [1.14 + 2\log_{10}(D/\varepsilon)]^{-2}$

$f = \{-2\log_{10}[(\varepsilon/D)/3.7 + 2.51/(Re(f^{1/2})]\}^{-2}$

$P = \rho g H Q$

$$N_s = \frac{NQ^{0.5}}{H^{0.75}}$$

inch x 1.133/ sg = ft of liquid

Pounds/square inch x 2.31/sg = ft of liquid

mm / (22.4 x sg) = ft of liquid

$NPSHA = P_a - (V_p + H_l + H_f)$ or $P_a + H_s - (V_p + H_f)$ or $P_t - (V_p + H_l + H_f)$ or $P_t + H_s - (V_p + H_f)$

$H_{vapor} = 0.0623 \exp[(17.27 \times T)/(T + 237.3)]$

$H_{atm} = 10.3 - (0.00105 \times Z)$

$Re = DV/v$

$Re = \rho VD/\mu$

$$\tau = \mu \frac{du}{dy}$$

$$\nu = \frac{\mu}{\rho}$$

$$p = \rho g h$$

$$R = \rho g \bar{z} A$$

R = pressure at centroid × area

$$S_c = \frac{I_{GG}}{A\bar{x}}$$

$$I_{oo} = I_{GG} + A\bar{x}^2$$

$$Q = Au = A_1 u_1 = A_2 u_2$$

$$\frac{p_1}{\rho g} + \frac{u_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{u_2^2}{2g} + z_2 + h_f$$

$$u = \sqrt{2g(h_2 - h_1)}$$

$$u_1 = \sqrt{\frac{2gh(\rho_m - \rho)}{\rho}}$$

$$h_f = \frac{32 \mu L u}{\rho g d^2}$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^2}}$$

$$Q = C_d A_o \sqrt{2gh}$$

$$Q_{theoretical} = \sqrt{2g} \int_0^H b h^{1/2} \, dh$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{A_1^2 - A_2^2}}$$

$$Q = C_d \frac{2}{3} B \sqrt{2g} H^{3/2}$$

$$Q = C_d \frac{8}{15} \sqrt{2g} \tan\left(\frac{\theta}{2}\right) H^{5/2}$$

$$F_T = F_R + F_B + F_P$$

$$\mathrm{Re} = \frac{\rho u d}{\mu}$$

$$Q = \frac{\Delta p}{L} \frac{\pi d^4}{128 \mu}$$

$$F = Q\rho(u_2 - u_1)$$

Fluid Mechanics: Formula sheet

This sheet should be used as an aid to memory. You should know how to use all these formulae

$$\tau = \mu \frac{du}{dy} \qquad \nu = \frac{\mu}{\rho} \qquad \gamma = \rho g \qquad p_{gauge} = \rho g h$$

$$p_{absolute} = p_{atmospheric} + \rho g h$$

$$Q = Au = A_1 u_1 = A_2 u_2 \qquad \frac{p_1}{\rho g} + \frac{u_1^2}{2g} + z_1 - h_f + h_a - h_s = \frac{p_2}{\rho g} + \frac{u_2^2}{2g} + z_2$$

$$u_1 = \sqrt{2g(h_2 - h_1)} \qquad u_1 = \sqrt{\frac{2gh(\rho_{man} - \rho_{fluid})}{\rho_{fluid}}}$$

$$u_1 = \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{\left(\frac{A_1}{A_2}\right)^2 - 1}} = \sqrt{\frac{2gh\left(\frac{\rho_{man} - \rho_{fluid}}{\rho_{fluid}}\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$\mathrm{Re} = \frac{\rho u d}{\mu} = \frac{u d}{\nu} \qquad Q = \frac{\Delta p}{L} \times \frac{\pi d^4}{128 \mu} \qquad h_f = 4 \times \frac{16}{\mathrm{Re}} \times \frac{L}{d} \times \frac{u^2}{2g}$$

$$h_f = 4f \times \frac{L}{d} \times \frac{u^2}{2g} = \frac{f L Q^2}{3 d^5}$$

$$N_s = \frac{N\sqrt{Q}}{H^{\frac{3}{4}}} \qquad P_{delivered} = \rho g Q h_a \qquad P_{supplied} = \frac{\rho g Q h_a}{\eta}$$

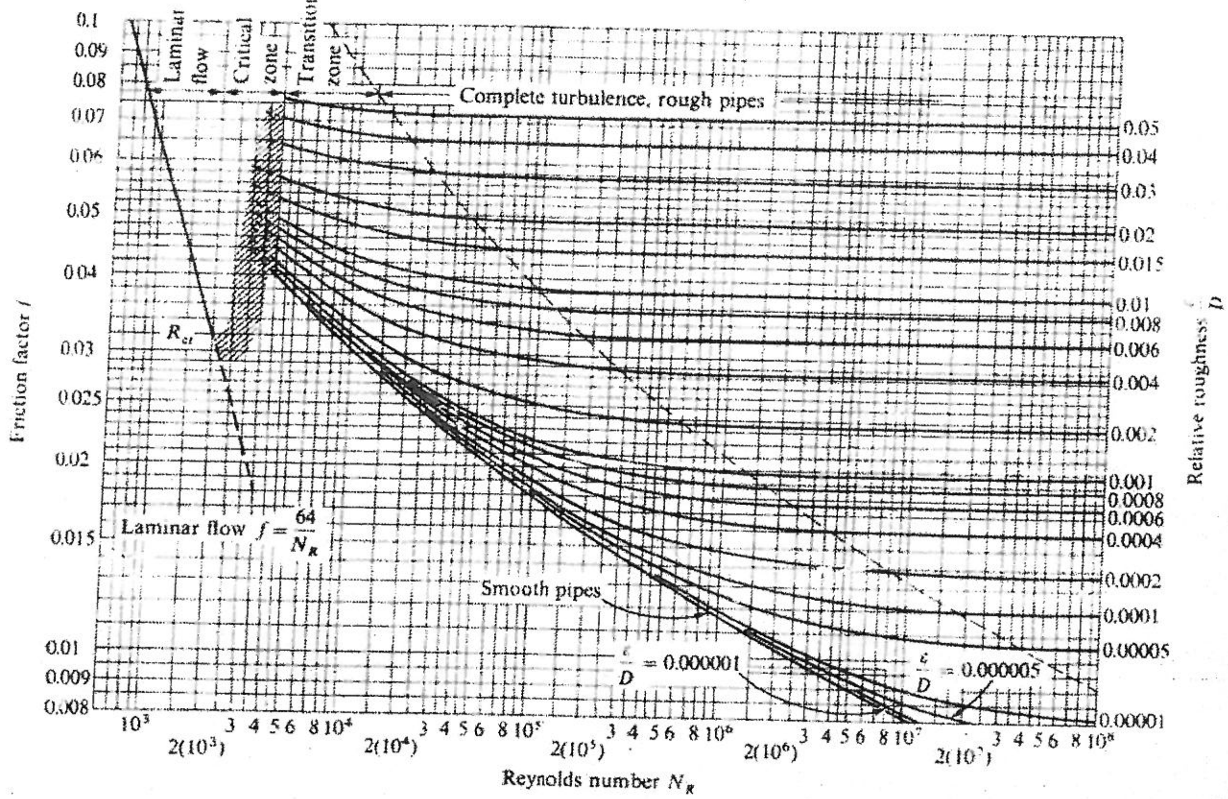


Fig. A-5

Moody diagram.

From Lewis F. Moody, "Friction Factors for Pipe Flows," *ASME Trans.*, vol. 66, pp. 671–684, 1944.

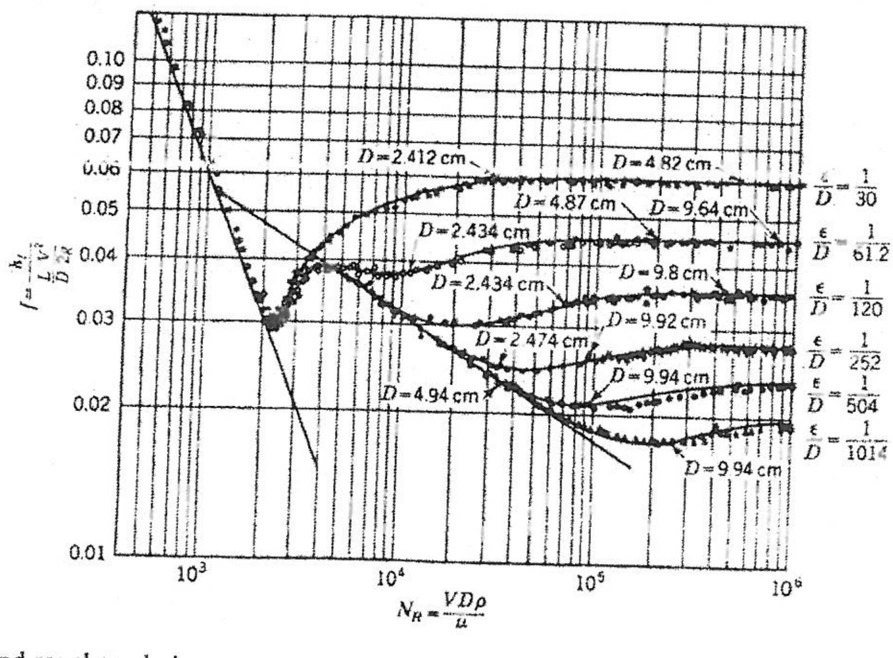


Fig. A-6

Nikuradse's sand-roughened-pipe tests.

Moody Diagram

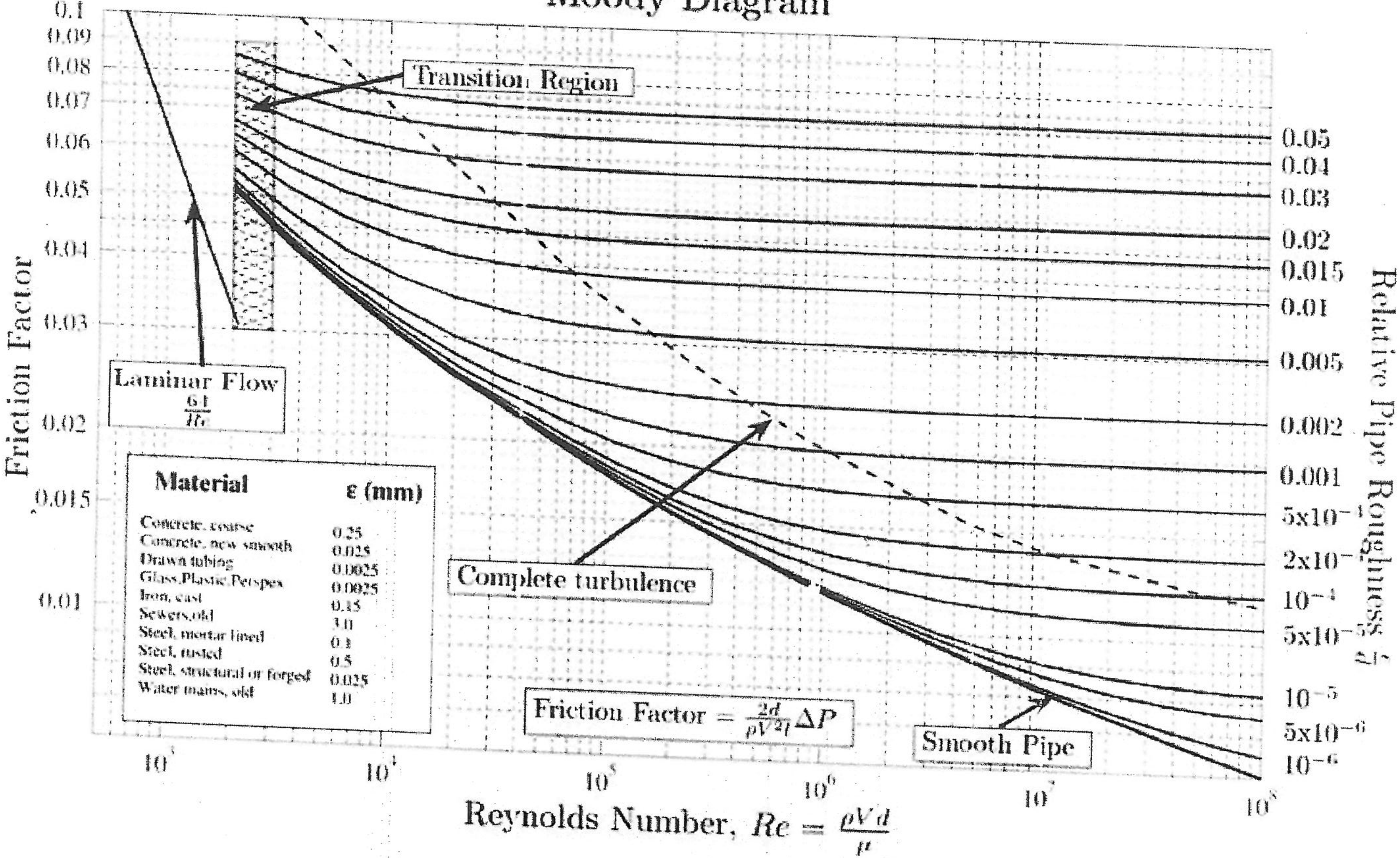


TABLE A-1 Approximate physical properties of water (English Gravitational Unit System)

Temperature (°F)	Specific (or unit) weight, γ (lb/ft^3)	Mass density, ρ (slugs/ft^3)	Dynamic viscosity, μ (lb-s/ft^2)	Kinematic viscosity, ν (ft^2/s)	Vapor pressure, p_v (lb/ft^2)	Surface tension,† σ (lb/ft)	Bulk modulus of elasticity, K (lb/in^2)
32	62.4	1.94	3.66×10^{-5}	1.89×10^{-5}	12.8	0.00518	293,000
40	62.4	1.94	3.23×10^{-5}	1.67×10^{-5}	18.5	0.00514	294,000
50	62.4	1.94	2.72×10^{-5}	1.40×10^{-5}	25.7	0.00509	305,000
60	62.4	1.94	2.35×10^{-5}	1.21×10^{-5}	36.5	0.00504	311,000
70	62.3	1.93	2.04×10^{-5}	1.05×10^{-5}	52.2	0.00500	320,000
80	62.2	1.93	1.77×10^{-5}	9.15×10^{-6}	73.5	0.00492	322,000
90	62.1	1.93	1.50×10^{-5}	8.29×10^{-6}	101	0.00486	323,000
100	62.0	1.93	1.42×10^{-5}	7.37×10^{-6}	135	0.00480	327,000
110	61.9	1.92	1.26×10^{-5}	6.55×10^{-6}	189	0.00473	331,000
120	61.7	1.92	1.14×10^{-5}	5.94×10^{-6}	251	0.00465	333,000
130	61.5	1.91	1.05×10^{-5}	5.49×10^{-6}	322	0.00460	334,000
140	61.4	1.91	9.60×10^{-6}	5.03×10^{-6}	416	0.00454	330,000
150	61.2	1.90	8.90×10^{-6}	4.68×10^{-6}	545	0.00447	328,000
160	61.0	1.90	8.30×10^{-6}	4.38×10^{-6}	693	0.00441	326,000
170	60.8	1.89	7.70×10^{-6}	4.07×10^{-6}	875	0.00433	322,000
180	60.6	1.88	7.23×10^{-6}	3.84×10^{-6}	1086	0.00426	318,000
190	60.4	1.88	6.80×10^{-6}	3.62×10^{-6}	1358	0.00419	313,000
200	60.1	1.87	6.25×10^{-6}	3.35×10^{-6}	1671	0.00412	308,000
210	59.9	1.86	5.95×10^{-6}	3.20×10^{-6}	2042	0.00405	301,000
212	59.8	1.86	5.89×10^{-6}	3.17×10^{-6}	2116	0.00404	300,000

† In contact with air.

TABLE A-2 Approximate physical properties of water (International System of Units)

Temperature (°C)	Specific (or unit) weight, γ (kN/m^3)	Mass density, ρ (kg/m^3)	Dynamic Viscosity, μ (Pa · s)	Kinematic Viscosity, ν (m^2/s)	Vapor Pressure (kPa)	Surface Tension,† σ (N/m)	Bulk modulus of elasticity, K (GPa)
0	9.81	1000	1.75×10^{-3}	1.75×10^{-6}	0.611	0.0756	2.02
10	9.81	1000	1.30×10^{-3}	1.30×10^{-6}	1.23	0.0742	2.10
20	9.79	998	1.02×10^{-3}	1.02×10^{-6}	2.34	0.0728	2.18
30	9.77	996	8.00×10^{-4}	8.03×10^{-7}	4.24	0.0712	2.25
40	9.73	992	6.51×10^{-4}	6.56×10^{-7}	7.38	0.0696	2.28
50	9.69	988	5.41×10^{-4}	5.48×10^{-7}	12.3	0.0679	2.29
60	9.65	984	4.60×10^{-4}	4.67×10^{-7}	19.9	0.0662	2.28
70	9.59	978	4.02×10^{-4}	4.11×10^{-7}	31.2	0.0644	2.25
80	9.53	971	3.50×10^{-4}	3.60×10^{-7}	47.4	0.0626	2.20
90	9.47	965	3.11×10^{-4}	3.22×10^{-7}	70.1	0.0608	2.14
100	9.40	958	2.82×10^{-4}	2.94×10^{-7}	101.3	0.0589	2.07

† In contact with air.

TABLE A-3 Approximate physical properties of some common liquids at 1 atmosphere pressure and 20 °C (68 °F)

Liquid	Specific (or unit) weight, γ		Mass density, ρ		Specific gravity	Dynamic viscosity, μ		Vapor pressure		Surface tension,† σ	
	(lb/ft^3)	(kN/m^3)	($slugs/ft^3$)	(kg/m^3)		($lb\text{-}s/ft^2$)	($Pa \cdot s$)	(lb/ft^2)	(kPa)	(lb/ft)	(N/m)
Ammonia	51.7	8.13	1.61	829	0.83	4.60×10^{-6}	2.20×10^{-4}	19,000	910	0.00146	0.0213
Benzene	54.8	8.62	1.70	879	0.88	1.36×10^{-5}	6.51×10^{-4}	210	10.1	0.00198	0.0289
Carbon tetrachloride	99.1	15.57	3.08	1,588	1.59	2.02×10^{-5}	9.67×10^{-4}	250	12.0	0.00185	0.0270
Ethanol	49.2	7.73	1.53	788	0.79	2.51×10^{-5}	1.20×10^{-3}	120	5.75	0.00156	0.0228
Gasoline	44.9	7.05	1.40	719	0.72	6.10×10^{-6}	2.92×10^{-4}	1,150	[illegible]		
Glycerin	78.5	12.34	2.44	1,258	1.26	3.11×10^{-2}	1.49	0.0003	0.000014	0.00434	0.0633
Kerosine	51.1	8.03	1.59	819	0.82	4.00×10^{-5}	1.92×10^{-3}	65	3.11	0.00190	0.0277
Mercury	847.3	133.1	26.34	13,570	13.6	3.25×10^{-5}	1.56×10^{-3}	0.000023	0.0000011	0.0352	0.514
Methanol	49.2	7.73	1.53	788	0.79	1.25×10^{-5}	5.98×10^{-4}	280	13.4	0.00155	0.0226
SAE 10 Oil	54.2	8.52	1.68	869	0.87	1.70×10^{-3}	8.14×10^{-2}	....	....	0.00250	0.0365
SAE 30 Oil	55.4	8.71	1.72	888	0.89	9.20×10^{-3}	4.40×10^{-1}	....	....	0.00240	0.0350
Water	62.3	9.79	1.94	998	1.00	2.09×10^{-5}	1.02×10^{-3}	48	2.34	0.00500	0.0728
Seawater	64.2	10.08	2.00	1,028	1.03	2.23×10^{-5}	1.07×10^{-3}	48	2.34	0.00500	0.0728

† In contact with air.

TABLE A-4 Approximate physical properties of air at standard atmospheric pressure (English Gravitational Unit System)

Temperature (°F)	Specific (or unit) weight, γ (lb/ft^3)	Mass density, ρ (slugs/ft^3)	Dynamic viscosity, μ (lb-s/ft^2)	Kinematic viscosity, ν (ft^2/s)
32	0.0808	0.00251	3.59×10^{-7}	1.43×10^{-4}
40	0.0794	0.00247	3.62×10^{-7}	1.46×10^{-4}
50	0.0779	0.00242	3.68×10^{-7}	1.52×10^{-4}
60	0.0763	0.00237	3.74×10^{-7}	1.58×10^{-4}
70	0.0750	0.00233	3.82×10^{-7}	1.64×10^{-4}
80	0.0735	0.00228	3.85×10^{-7}	1.69×10^{-4}
90	0.0723	0.00224	3.90×10^{-7}	1.74×10^{-4}
100	0.0709	0.00220	3.96×10^{-7}	1.80×10^{-4}
110	0.0696	0.00218	4.02×10^{-7}	1.84×10^{-4}
120	0.0684	0.00215	4.07×10^{-7}	1.89×10^{-4}
130	0.0674	0.00210	4.10×10^{-7}	1.95×10^{-4}
140	0.0663	0.00206	4.14×10^{-7}	2.01×10^{-4}
150	0.0652	0.00202	4.18×10^{-7}	2.06×10^{-4}
160	0.0641	0.00199	4.22×10^{-7}	2.12×10^{-4}
170	0.0631	0.00196	4.28×10^{-7}	2.18×10^{-4}
180	0.0621	0.00193	4.34×10^{-7}	2.25×10^{-4}
190	0.0612	0.00190	4.42×10^{-7}	2.32×10^{-4}
200	0.0602	0.00187	4.49×10^{-7}	2.40×10^{-4}
210	0.0594	0.00184	4.57×10^{-7}	2.48×10^{-4}
212	0.0592	0.00184	4.58×10^{-7}	2.50×10^{-4}

TABLE A-5 Approximate physical properties of air at standard atmospheric pressure (International System of Units)

Temperature (°C)	Specific (or unit) weight, γ (N/m^3)	Mass density, ρ (kg/m^3)	Dynamic viscosity, μ (Pa · s)	Kinematic viscosity, ν (m^2/s)
0	12.7	1.29	1.72×10^{-5}	1.33×10^{-5}
10	12.2	1.25	1.77×10^{-5}	1.42×10^{-5}
20	11.8	1.20	1.81×10^{-5}	1.51×10^{-5}
30	11.4	1.16	1.86×10^{-5}	1.60×10^{-5}
40	11.0	1.13	1.91×10^{-5}	1.69×10^{-5}
50	10.7	1.09	1.95×10^{-5}	1.79×10^{-5}
60	10.4	1.06	1.99×10^{-5}	1.89×10^{-5}
70	10.1	1.03	2.04×10^{-5}	1.99×10^{-5}
80	9.80	1.00	2.09×10^{-5}	2.09×10^{-5}
90	9.53	0.972	2.13×10^{-5}	2.19×10^{-5}
100	9.28	0.946	2.17×10^{-5}	2.30×10^{-5}

TABLE A-6 Approximate physical properties of some common gases at 1 atmosphere pressure and 30 °C (68 °F)

Gas	Specific (or unit) weight, γ (lb/ft³)	Specific (or unit) weight, γ (N/m³)	Mass density, ρ (slugs/ft³)	Mass density, ρ (kg/m³)	Dynamic viscosity (μ) (lb-s/ft²)	Dynamic viscosity (μ) (kPa · s)	Gas constant (R) (ft/°R)	Gas constant (R) (m/k)	Gas constant (R) (lb-ft/slug-°R)	Gas constant (R) (J/kg · K)
Air	0.0752	11.8	0.00234	1.20	3.78×10^{-7}	1.81×10^{-8}	53.3	29.3	1 716	287
Carbon dioxide	0.115	18.1	0.00357	1.84	3.10×10^{-7}	1.48×10^{-8}	35.1	19.3	1 130	189
Helium	0.0104	1.63	0.000323	0.166	4.11×10^{-7}	1.97×10^{-8}	385.7	212.0	12 420	2079
Hydrogen	0.00522	0.823	0.000162	0.0839	1.89×10^{-7}	9.05×10^{-9}	765.5	420.8	24 649	4127
Methane	0.0416	6.53	0.00129	0.666	2.80×10^{-7}	1.34×10^{-8}	96.2	52.9	3 098	519
Nitrogen	0.0726	11.4	0.00225	1.16	3.68×10^{-7}	1.76×10^{-8}	55.1	30.3	1 774	297
Oxygen	0.0830	13.0	0.00258	1.33	4.18×10^{-7}	2.00×10^{-8}	48.2	26.5	1 552	260

Gas	Specific heat ratio (k) Dimensionless ratio c_p/c_v	Specific heat (c_p) lb-ft/slug-°R	Specific heat (c_p) J/kg · K	Specific heat (c_v) lb-ft/slug-°R	Specific heat (c_v) J/kg · K	Molecular weight (M)
Air	1.40	6 000	1 003	4 285	716	29.00
Carbon dioxide	1.30	5 132	858	4 009	670	44.00
Helium	1.66	31 230	5 220	18 810	3 143	4.00
Hydrogen	1.41	86 390	14 450	61 710	10 330	2.02
Methane	1.32	13 400	2 250	10 300	1 730	16.00
Nitrogen	1.40	6 210	1 040	4 437	743	28.00
Oxygen	1.40	5 437	909	3 883	649	32.00

TABLE A-11 Resistance coefficients $K = \dfrac{h_m}{v^2/2g}$ for open valves, elbows, and tees

Nominal diameter, in	Screwed				Flanged				
	$\frac{1}{2}$	1	2	4	1	2	4	8	20
Valves (fully open):									
Globe	14	8.2	6.9	5.7	13	8.5	6.0	5.8	5.5
Gate	0.30	0.24	0.16	0.11	0.80	0.35	0.16	0.07	0.03
Swing check	5.1	2.9	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Angle	9.0	4.7	2.0	1.0	4.5	2.4	2.0	2.0	2.0
Elbows:									
45° regular	0.39	0.32	0.30	0.29					
45° long radius					0.21	0.20	0.19	0.16	0.14
90° regular	2.0	1.5	0.95	0.64	0.50	0.39	0.30	0.26	0.21
90° long radius	1.0	0.72	0.41	0.23	0.40	0.30	0.19	0.15	0.10
180° regular	2.0	1.5	0.95	0.64	0.41	0.35	0.30	0.25	0.20
180° long radius					0.40	0.30	0.21	0.15	0.10
Tees:									
Line flow	0.90	0.90	0.90	0.90	0.24	0.19	0.14	0.10	0.07
Branch flow	2.4	1.8	1.4	1.1	1.0	0.80	0.64	0.58	0.41

TABLE A-8 The ICAO standard atmosphere in SI units

Elevation above sea level, km	Temp. °C	Absolute pressure, kPa, abs	Specific weight γ, N/m^3	Density ρ, kg/m^3	Viscosity $\mu \times 10^5$, Pa · s
0	15.0	101.33	12.01	1.225	1.79
2	2.0	79.50	9.86	1.007	1.73
4	−4.5	60.12	8.02	0.909	1.66
6	−24.0	47.22	6.46	0.660	1.60
8	−36.9	35.65	5.14	0.526	1.53
10	−49.9	26.50	4.04	0.414	1.46
12	−56.5	19.40	3.05	0.312	1.42
14	−56.5	14.20	2.22	0.228	1.42
16	−56.5	10.35	1.62	0.166	1.42
18	−56.5	7.57	1.19	0.122	1.42
20	−56.5	5.53	0.87	0.089	1.42
25	−51.6	2.64	0.41	0.042	1.45
30	−40.2	1.20	0.18	0.018	1.51

TABLE A-9 Typical wall roughness values for commercial conduits

	Roughness (ϵ)	
Material (new)	ft	m
Riveted steel	0.003–0.03	0.0009–0.009
Concrete	0.001–0.01	0.0003–0.003
Wood stave	0.0006–0.003	0.0002–0.0009
Cast iron	0.00085	0.00026
Galvanized iron	0.0005	0.00015
Asphalted cast iron	0.0004	0.0001
Commercial steel or wrought iron	0.00015	0.000046
Drawn brass or copper tubing	0.000005	0.0000015
Glass and plastic	"smooth"	"smooth"

From: Lewis F. Moody, "Friction Factors for Pipe Flow," *ASME Trans.*, vol. 66, pp. 671–684, 1944.

TABLE A-12 Increased losses of partially open valves

	Ratio K/K(open condition)	
Condition	Gate value	Globe value
Open	1.0	1.0
Closed, 25%	3.0–5.0	1.5–2.0
50%	12–22	2.0–3.0
75%	70–120	6.0–8.0

TABLE A-13 Values of n in Manning's formula
Prepared by R. E. Horton and others

	n	
Nature of surface	Min	Max
Neat cement surface	0.010	0.013
Wood-stave pipe	0.010	0.013
Plank flumes, planed	0.010	0.014
Vitrified sewer pipe	0.010	0.017
Metal flumes, smooth	0.011	0.015
Concrete, precast	0.011	0.013
Cement mortar surfaces	0.011	0.015
Plank flumes, unplaned	0.011	0.015
Common-clay drainage tile	0.011	0.017
Concrete, monolithic	0.012	0.016
Brick with cement mortar	0.012	0.017
Cast iron—new	0.013	0.017
Cement rubble surfaces	0.017	0.030
Riveted steel	0.017	0.020
Corrugated metal pipe	0.021	0.025
Canals and ditches, smooth earth	0.017	0.025
Metal flumes, corrugated	0.022	0.030
Canals:		
Dredged in earth, smooth	0.025	0.033
In rock cuts smooth	0.025	0.035
Rough beds and weeds on sides	0.025	0.040
Rock cuts, jagged and irregular	0.035	0.045
Natural streams:		
Smoothest	0.025	0.033
Roughest	0.045	0.060
Very weedy	0.075	0.150

TABLE A-14 Typical values of the Hazen-Williams Coefficient, C

Extremely smooth and straight pipes	140
New steel or cast iron	130
Wood; concrete	120
New riveted steel; vitrified	110
Old cast iron	100
Very old and corroded cast iron	80

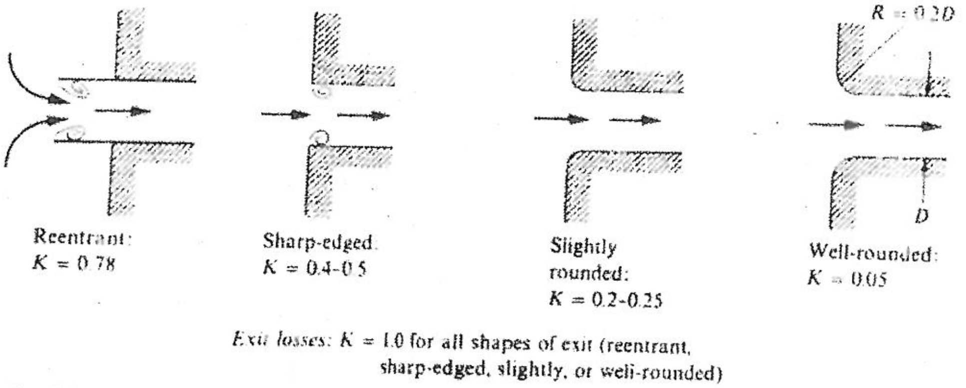


Fig. A-7

Entrance and exit loss coefficients.

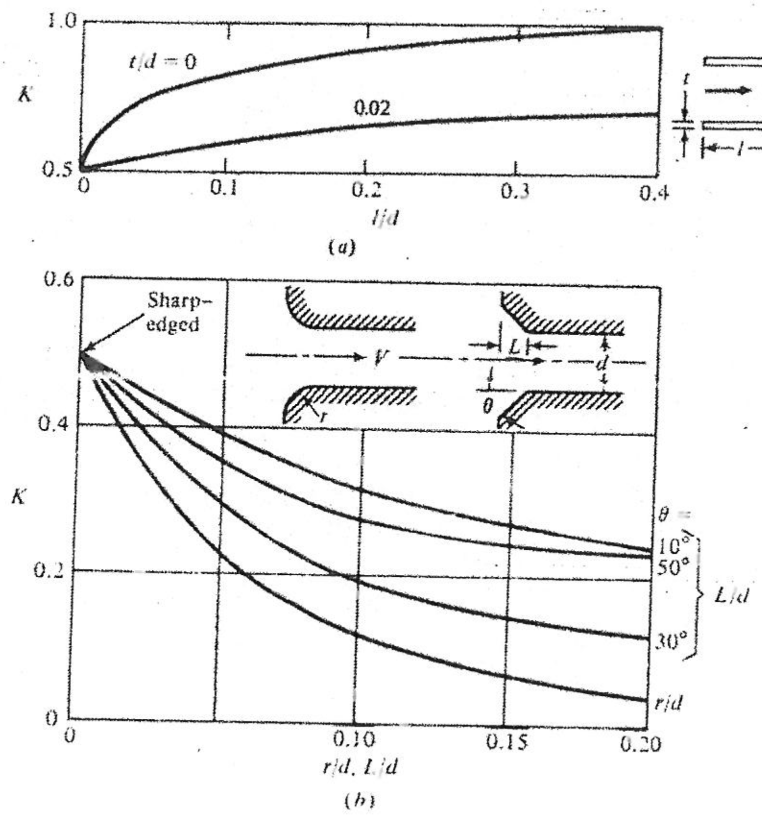
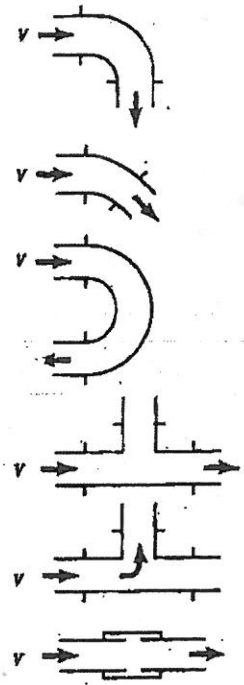


Fig. A-8

Entrance and exit loss coefficients: (*a*) reentrant inlets; (*b*) rounded and beveled inlets. Exit losses are $K = 1.0$ for all shapes of exit (reentrant, sharp, beveled, or rounded). (Adapted by permission from *ASHRAE Handbook of Fundamentals*, Atlanta, 1985.)

Component	K_L
a. Elbows	
Regular 90°, flanged	0.3
Regular 90°, threaded	1.5
Long radius 90°, flanged	0.2
Long radius 90°, threaded	0.7
Long radius 45°, flanged	0.2
Regular 45°, threaded	0.4
b. 180° return bends	
180° return bend, flanged	0.2
180° return bend, threaded	1.5
c. Tees	
Line flow, flanged	0.2
Line flow, threaded	0.9
Branch flow, flanged	1.0
Branch flow, threaded	2.0
d. Union, threaded	0.08
e. Valves	
Globe, fully open	10
Angle, fully open	2
Gate, fully open	0.15
Gate, $\frac{1}{4}$ closed	0.26
Gate, $\frac{1}{2}$ closed	2.1
Gate, $\frac{3}{4}$ closed	17
Swing check, forward flow	2
Swing check, backward flow	∞
Ball valve, fully open	0.05
Ball valve, $\frac{1}{3}$ closed	5.5
Ball valve, $\frac{2}{3}$ closed	210



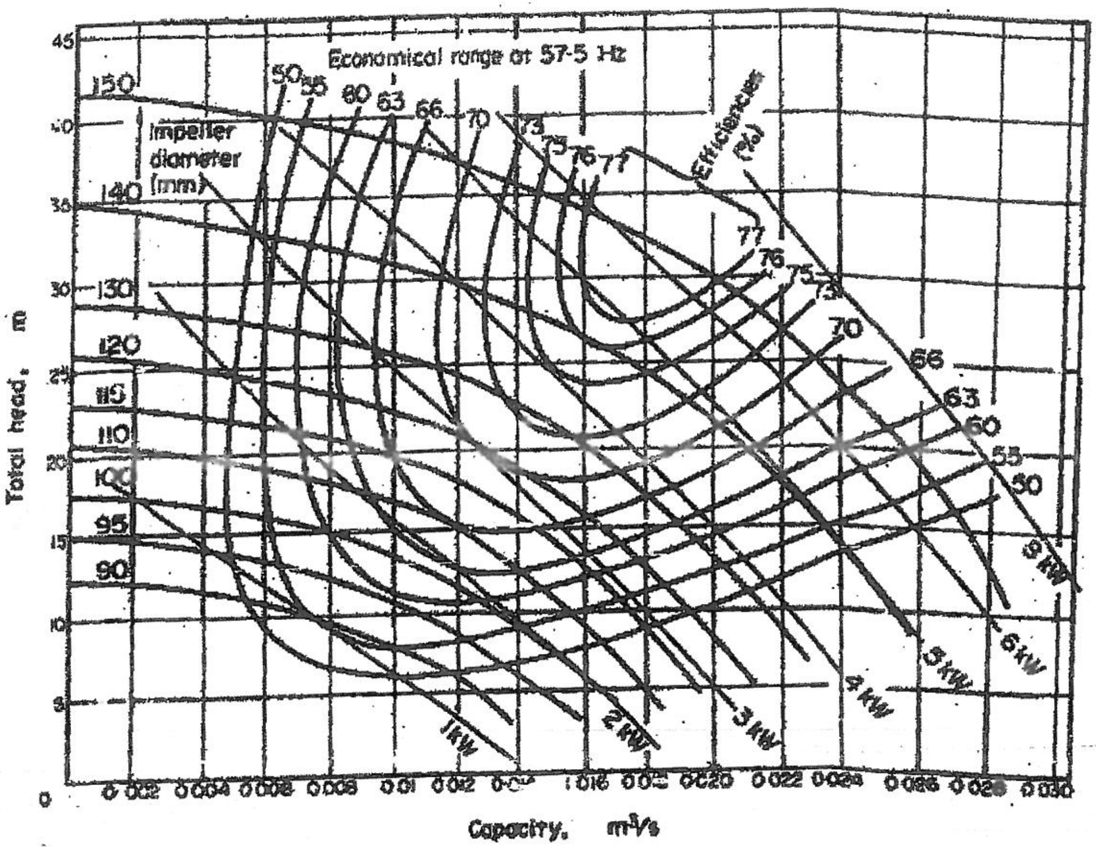
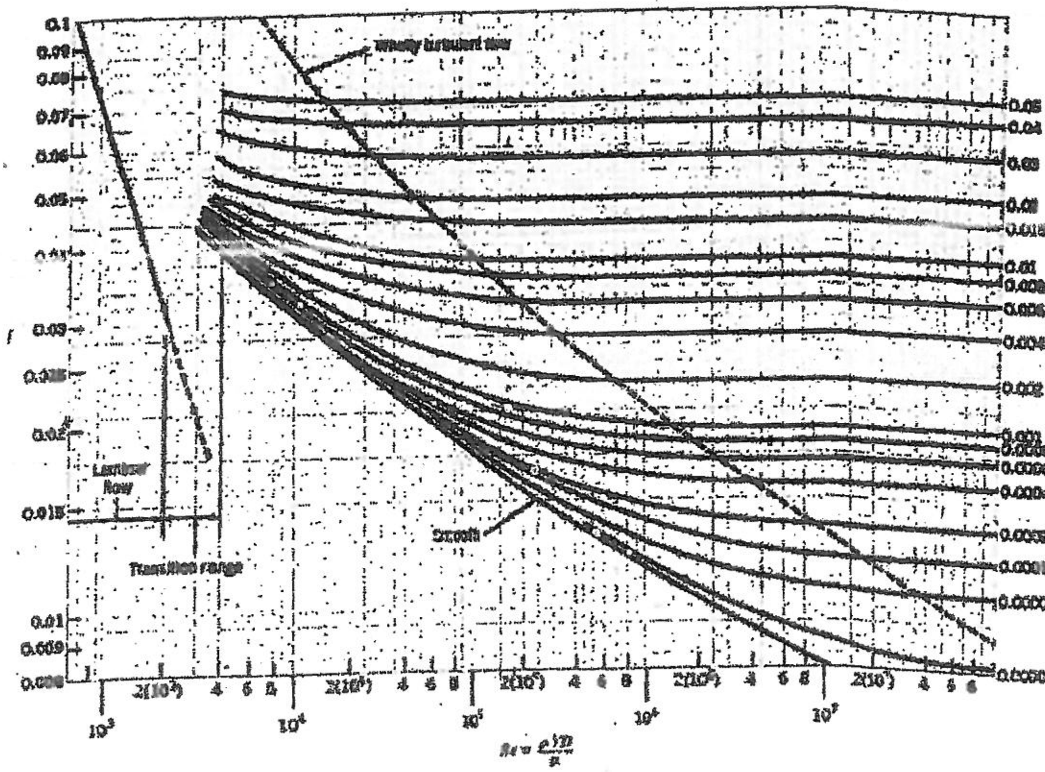


Figure 2: Characteristic curves for centrifugal pumps



Moody Diagram

Figure 3: Moody Diagram