Appendix I: Conversions

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Appendix I: Unit Conversions and Constants

I.1 Length Conversions

From/To	Millimeter (mm)	Centimeter (cm)	Meter (m)	Inch (in)	Foot (ft)
1 mm	1	0.1	0.001	0.03937	0.003281

From/To	Millimeter (mm)	Centimeter (cm)	Meter (m)	Inch (in)	Foot (ft)
1 cm	10	1	0.01	0.3937	0.03281
1 m	1000	100	1	39.37	3.281
1 in	25.4	2.54	0.0254	1	0.08333
1 ft	304.8	30.48	0.3048	12	1

Common CNC Conversions: - 1 inch = 25.4 mm (exact) - 1 foot = 304.8 mm - 1 mil (0.001") = 0.0254 mm = 25.4 mum - 1 micron (mum) = 0.001 mm = 0.00003937"

I.2 Area and Volume Conversions

I.2.1 Area

From/To	mm^2	cm^2	m^2	in^2	ft^2
1 mm^2	1	0.01	10^{-6}	0.00155	1.076×10^{-5}
1 cm^2	100	1	10^{-4}	0.155	0.001076
1 m^2	10^6	10^4	1	1550	10.76
1 in^2	645.2	6.452	6.452×10^{-4}	1	0.00694
1 ft^2	92,903	929.03	0.0929	144	1

I.2.2 Volume

From/To	cm^3 (cc)	Liter (L)	m^3	in^3	ft^3	US Gallon
1 cm^3	1	0.001	10^{-6}	0.06102	3.531×10^{-5}	0.000264
1 L	1000	1	0.001	61.02	0.03531	0.2642
1 m^3	10^6	1000	1	61,024	35.31	264.2
1 in^3	16.39	0.01639	1.639×10^{-5}		5.787×10^{-4}	0.004329
1 ft^3	28,317	28.32	0.02832	1728	1	7.481
1 US gal	3785	3.785	0.003785	231	0.1337	1

I.3 Force, Pressure, and Torque Conversions

I.3.1 Force

From/To	Newton (N)	Kilonewton (kN)	Kilogram-force (kgf)	Pound-force (lbf)
1 N	1	0.001	0.102	0.2248
1 kN	1000	1	102.0	224.8
1 kgf	9.807	0.009807	1	2.205
1 lbf	4.448	0.004448	0.4536	1

I.3.2 Pressure and Stress

From/To	Pascal (Pa)	kPa	MPa	Bar	PSI	kg/cm^2
1 Pa	1	0.001	10^{-6}	10^{-5}	1.450×10^{-4}	1.020×10^{-5}
1 kPa	1000	1	0.001	0.01	0.1450	0.01020
1 MPa	10^6	1000	1	10	145.0	10.20
1 bar	10^5	100	0.1	1	14.50	1.020
1 PSI	6895	6.895	0.006895	0.06895	1	0.07031
1 kg/cm^2	98,067	98.07	0.09807	0.9807	14.22	1

Common Pneumatic Pressures: - 100 PSI = 6.9 bar = 0.69 MPa - 6 bar (typical CNC) = 87 PSI = 0.6 MPa

I.3.3 Torque

From/To	N·m	kN·m	lb·ft	lb·in	oz·in
1 N·m	1	0.001	0.7376	8.851	141.6
1 kN·m	1000	1	737.6	8851	141,615
1 lb·ft	1.356	0.001356	1	12	192
1 lb·in	0.1130	1.130×10^{-4}	0.08333	1	16
1 oz·in	0.007062	7.062×10^{-6}	0.005208	0.0625	1

I.4 Power and Energy Conversions

I.4.1 Power

From/To	Watt (W)	Kilowatt (kW)	Horsepower (HP)	ft·lb/s
1 W	1	0.001	0.001341	0.7376
1 kW	1000	1	1.341	737.6
1 HP	745.7	0.7457	1	550
1 ft·lb/s	1.356	0.001356	0.001818	1

Spindle Power Example: - 2.2 kW spindle = 2.95 HP - 3 HP spindle = 2.24 kW

I.4.2 Energy and Work

From/To	Joule (J)	Kilojoule (kJ)	Watt-hour (Wh)	Kilowatt-hour (kWh)	BTU
1 J	1	0.001	2.778×10^{-4}	2.778×10^{-7}	9.478×10^{-4}
1 kJ	1000	1	0.2778	2.778×10^{-4}	0.9478
1 Wh	3600	3.6	1	0.001	3.412

From/To	Joule (J)	Kilojoule (kJ)	Watt-hour (Wh)	Kilowatt-hour (kWh)	BTU
1 kWh	3.6×10^6	3600	1000	1	3412
1 BTU	1055	1.055	0.2931	2.931×10⁻4	1

I.5 Velocity and Acceleration Conversions

I.5.1 Linear Velocity

From/To	mm/s	m/s	m/min	in/s	in/min (IPM)	ft/min
1 mm/s	1	0.001	0.06	0.03937	2.362	0.1969
1 m/s	1000	1	60	39.37	2362	196.9
1 m/min	16.67	0.01667	1	0.6562	39.37	3.281
1 in/s	25.4	0.0254	1.524	1	60	5.0
1 IPM	0.4233	4.233×10⁻4	0.0254	0.01667	1	0.08333
1 ft/min	5.08	0.00508	0.3048	0.2	12	1

Common CNC Feeds: - 1000 mm/min = 39.37 IPM - 100 IPM = 2540 mm/min = 42.3 mm/s

I.5.2 Rotational Speed

From/To	RPM	rad/s	deg/s
1 RPM	1	0.1047	6.0
1 rad/s	9.549	1	57.30
1 deg/s	0.1667	0.01745	1

I.5.3 Acceleration

From/To	m/s^2	ft/s^2	g (gravity)
1 m/s^2	1	3.281	0.102
1 ft/s^2	0.3048	1	0.03108
1 g	9.807	32.17	1

CNC Acceleration: 1 m/s^2 = 60,000 mm/min^2 (units commonly seen in controller settings)

I.6 Temperature Conversions

From	To Celsius (°C)	To Fahrenheit (°F)	To Kelvin (K)
Celsius	°C	(°C × 9/5) + 32	°C + 273.15
Fahrenheit	(°F - 32) × 5/9	°F	(°F - 32) × 5/9 + 273.15
Kelvin	K - 273.15	(K - 273.15) × 9/5 + 32	K

Common Temperatures: - Water freezing: 0°C = 32°F = 273.15K - Room temperature: 20°C = 68°F = 293K - Water boiling: 100°C = 212°F = 373K - Grease max temp: 150°C = 302°F

I.7 Material Property Conversions

I.7.1 Density

From/To	kg/m^3	g/cm^3	lb/in^3	lb/ft^3
1 kg/m^3	1	0.001	3.613×10^{-5}	0.06243
1 g/cm^3	1000	1	0.03613	62.43
1 lb/in^3	27,680	27.68	1	1728
1 lb/ft^3	16.02	0.01602	5.787×10^{-4}	1

Common Materials: - Steel: 7.85 g/cm^3 = 7850 kg/m^3 = 0.284 lb/in^3 - Aluminum 6061: 2.70 g/cm^3 = 2700 kg/m^3 = 0.098 lb/in^3

I.7.2 Hardness (Approximate Conversions)

Rockwell C (HRC) to Brinell (HB) to Tensile Strength (MPa):

HRC	HB	Approx. Tensile (MPa)
20	230	800
30	285	1000
40	370	1300
50	480	1700
60	670	2200

Note: Conversions are approximate, vary by material composition.

I.8 Physical Constants

Constant	Symbol	Value	Units
Gravitational acceleration (Earth)	g	9.80665	m/s^2
Speed of light	c	299,792,458	m/s

Constant	Symbol	Value	Units
Pi	π	3.14159265359	-
Euler's number	e	2.71828182846	-
Boltzmann constant	k	$1.380649 \times 10^{-2}{}^3$	J/K
Stefan-Boltzmann constant	σ	5.670374×10^{-8}	$W/(m^{2 \cdot K}4)$

I.9 Quick Reference Formulas

I.9.1 Cutting Speed to Spindle RPM

$$\text{RPM} = \frac{V_c \times 1000}{\pi \times D}$$

where: - V_c = cutting speed (m/min) - D = cutter diameter (mm)

Example: 100 m/min cutting speed, 10mm endmill

$$\text{RPM} = \frac{100 \times 1000}{\pi \times 10} = 3183 \text{ RPM}$$

I.9.2 Feed Rate Calculation

$$F = f_z \times Z \times \text{RPM}$$

where: - F = feed rate (mm/min) - f_z = chip load per tooth (mm) - Z = number of teeth - RPM = spindle speed

Example: 0.1 mm/tooth, 4-flute, 3000 RPM

$$F = 0.1 \times 4 \times 3000 = 1200 \text{ mm/min}$$

I.9.3 Material Removal Rate (MRR)

$$\text{MRR} = W \times D \times F$$

where: - MRR = material removal rate (mm^3/min) - W = width of cut (mm) - D = depth of cut (mm) - F = feed rate (mm/min)

End of Unit Conversions and Constants Appendix