APPENDIX A

Important Constants, Units, Conversion Factors, and Equations

Table A.1 Metric unit prefixes and their meanings

Prefix	Symbol	Multiple
peta-	P	10^{15} (quadrillion)
tera-	T	10^{12} (trillion)
giga-	G	10^{9} (billion)
mega-	M	10^{6} (million)
kilo-	k	10^{3} (thousand)
hecto-	h	10^{2} (hundred)
deca-	da	10^{1} (ten)
deci-	d	10^{-1} (tenth)
centi-	c	10^{-2} (hundredth)
milli-	m	10^{-3} (thousandth)
micro-	μ	10^{-6} (millionth)
nano-	n	10^{-9} (billionth)
pico-	p	10^{-12} (trillionth)
femto-	f	10^{-15} (quadrillionth)
atto-	a	10^{-18} (quintillionth)

Table A.2 Standard symbols in optics and physics

Quantity	Symbol
Angle	θ (Greek theta) or φ (Greek phi)
Boltzmann constant	k
Change	Δ (Greek delta)
Decibels	dB
Decibels relative to 1 mW	dBm
Decibels relative to 1 μW	dBμ
Energy	E (sometimes Q)
Frequency	ν (Greek nu)
Intensity	I
Planck's constant	h
Power	P
Pulse spreading	Δt
Refractive index	n
Speed of light	c
Time	t
Wavelength	λ (Greek lambda)

Table A.3 Important physical constants

Boltzmann constant *(k)*	2.380658×10^{-23} J/K
Charge of electron *(e)*	1.602177×10^{-19} coulomb
Planck's constant *(h)*	4.14×10^{-15} eV/sec
Planck's constant *(h)*	$6.6260755 \times 10^{-34}$ J/sec
Speed of light *(c)*	299,792.458 km/sec

Table A.4 Important conversion factors

From	To	Multiply by
Ångstroms (Å)	nm	0.1
electron volts (eV)	joules (J)	1.602177×10^{-19}
ergs	joules (J)	10^{-7}
inch	mm	25.4

continues

Table A.4 (continued)

joules (J)	ergs	10^7
km	miles (statute)	0.6214
lb	kg	0.453592
miles (statute)	km	1.6093
mils (0.001 inch)	μm	25.4
mm	inch	0.03937

Table A.5 Other useful data and formulas

Attenuation in decibels: $\text{dB} = -10 \log_{10} \frac{P_{\text{out}}}{P_{\text{in}}}$

Bandwidth (MHz) $= \frac{350}{\Delta t\,(\text{ns})}$

Critical angle: $\theta_c = \arcsin\left(\frac{n_{\text{clad}}}{n_{\text{core}}}\right)$

Cutoff wavelength (single-mode): $\lambda_c = \frac{\pi D \sqrt{n_{\text{core}}^2 - n_{\text{clad}}^2}}{2.4}$

Data rate: Maximum NRZ in bits per second $= \frac{0.7}{\Delta t\,(\text{total})}$

Data rate: Maximum RZ in bits per second $= \frac{0.35}{\Delta t\,(\text{total})}$

Dispersion: $\Delta t_{\text{total}} = \sqrt{(\Delta t_{\text{modal}})^2 + (\Delta t_{\text{chromatic}})^2 + (\Delta t_{\text{PMD}})^2}$

Frequency in terms of wavelength and speed of light: $v = c/\lambda$

Numerical aperture: NA $= \sqrt{n_{\text{core}}^2 - n_{\text{clad}}^2}$ (sine of half-acceptance angle)

Photon energy in terms of frequency: $E = hv$

Photon energy in terms of electron volts: $E = v \times (4.14 \times 10^{-15}\ \text{eV/sec})$

Photon energy in terms of joules: $E = v \times 6.6260755 \times 10^{-34}\ \text{J/sec}$

Photon energy in terms of wavelength: $E = hc/\lambda$

Power output when input and loss are known: $P_{\text{out}} = P_{\text{in}} \times 10^{(-\text{dB}/10)}$

Refractive index of material: $n = \frac{c_{\text{vacuum}}}{c_{\text{material}}}$

Resonances of laser cavity (length L): $N\lambda = 2nL$

Snell's law of refraction: $n_i \sin I = n_r \sin R$

continues

Table A.5 Other useful data and formulas (continued)

Speed of light in terms of frequency and wavelength: $c = \lambda v$
Wavelength in terms of frequency and speed of light: $\lambda = c/v$
Wavelength of 1 eV photon = 1.2399 μm
Wavelength of photon with energy E: $\lambda = hc/E$

Table A.6 ITU wavelength bands

Name	Meaning	Wavelengths (nm)
O-band	Original	1260–1360
E-band	Extended	1360–1460
S-band	Short	1460–1530
C-band	Conventional	1530–1565
L-band	Long	1565–1625
U-band	Ultra-long	1625–1675

Table A.7 CWDM channels (ITU G.964.2)

O-band	1270 nm
	1290 nm
	1310 nm
	1330 nm
	1350 nm
E-band	1370 nm
	1390 nm
	1410 nm
	1430 nm
	1450 nm
S-band	1470 nm
	1490 nm
	1510 nm
C-band	1530 nm
	1550 nm
L-band	1570 nm
	1590 nm
	1610 nm