

Chapter 1

Quantities and Units

Section 1-2 Scientific Notation

1. (a) $3000 = 3 \times 10^3$ (b) $75,000 = 7.5 \times 10^4$ (c) $2,000,000 = 2 \times 10^6$
2. (a) $\frac{1}{500} = 0.002 = 2 \times 10^{-3}$
- (b) $\frac{1}{2000} = 0.0005 = 5 \times 10^{-4}$
- (c) $\frac{1}{5,000,000} = 0.0000002 = 2 \times 10^{-7}$
3. (a) $8400 = 8.4 \times 10^3$ (b) $99,000 = 9.9 \times 10^4$ (c) $0.2 \times 10^6 = 2 \times 10^5$
4. (a) $0.0002 = 2 \times 10^{-4}$ (b) $0.6 = 6 \times 10^{-1}$
- (c) 7.8×10^{-2} (already in scientific notation)
5. (a) $32 \times 10^3 = 3.2 \times 10^4$
- (b) $6800 \times 10^{-6} = 6.8 \times 10^{-3}$
- (c) $870 \times 10^8 = 8.7 \times 10^{10}$
6. (a) $2 \times 10^5 = 200,000$
- (b) $5.4 \times 10^{-9} = 0.0000000054$
- (c) $1.0 \times 10^1 = 10$
7. (a) $2.5 \times 10^{-6} = 0.0000025$ (b) $5.0 \times 10^2 = 500$ (c) $3.9 \times 10^{-1} = 0.39$
8. (a) $4.5 \times 10^{-6} = 0.0000045$
- (b) $8 \times 10^{-9} = 0.000000008$
- (c) $4.0 \times 10^{-12} = 0.0000000000040$

9. (a) $9.2 \times 10^6 + 3.4 \times 10^7 = 9.2 \times 10^6 + 34 \times 10^6 = \mathbf{4.32 \times 10^7}$
 (b) $5 \times 10^3 + 8.5 \times 10^{-1} = 5 \times 10^3 + 0.00085 \times 10^3 = \mathbf{5.00085 \times 10^3}$
 (c) $5.6 \times 10^{-8} + 4.6 \times 10^{-9} = 56 \times 10^{-9} + 4.6 \times 10^{-9} = \mathbf{6.06 \times 10^{-8}}$
10. (a) $3.2 \times 10^{12} - 1.1 \times 10^{12} = \mathbf{2.1 \times 10^{12}}$
 (b) $2.6 \times 10^8 - 1.3 \times 10^7 = 26 \times 10^7 - 1.3 \times 10^7 = \mathbf{24.7 \times 10^7}$
 (c) $1.5 \times 10^{-12} - 8 \times 10^{-13} = 15 \times 10^{-13} - 8 \times 10^{-13} = \mathbf{7 \times 10^{-13}}$
11. (a) $(5 \times 10^3)(4 \times 10^5) = 5 \times 4 \times 10^{3+5} = 20 \times 10^8 = \mathbf{2.0 \times 10^9}$
 (b) $(1.2 \times 10^{12})(3 \times 10^2) = 1.2 \times 3 \times 10^{12+2} = \mathbf{3.6 \times 10^{14}}$
 (c) $(2.2 \times 10^{-9})(7 \times 10^{-6}) = 2.2 \times 7 \times 10^{-9-6} = 15.4 \times 10^{-15} = \mathbf{1.54 \times 10^{-14}}$
12. (a) $\frac{1.0 \times 10^3}{2.5 \times 10^2} = 0.4 \times 10^{3-2} = 0.4 \times 10^1 = \mathbf{4}$
 (b) $\frac{2.5 \times 10^{-6}}{50 \times 10^{-8}} = 0.05 \times 10^{-6-(-8)} = 0.05 \times 10^2 = \mathbf{5}$
 (c) $\frac{4.2 \times 10^8}{2 \times 10^{-5}} = 2.1 \times 10^{8-(-5)} = \mathbf{2.1 \times 10^{13}}$
13. (a) $(8 \times 10^4 + 4 \times 10^3) \div 2 \times 10^2 = (80 \times 10^3 + 4 \times 10^3) \div 2 \times 10^2 = 84 \times 10^3 \div 2 \times 10^2 = 4.20 \times 10^2$
 (b) $(3 \times 10^7)(5 \times 10^5) - 9 \times 10^{12} = (15 \times 10^{12}) - 9 \times 10^{12} = 6 \times 10^{12}$
 (c) $(2.2 \times 10^2 \div 1.1 \times 10^2)(5.5 \times 10^4) = 11 \times 10^4$

Section 1-3 Engineering Notation and Metric Prefixes

14. The powers of ten used in engineering notation are multiples of 3:
 $10^{-12}, 10^{-9}, 10^{-6}, 10^{-3}, 10^3, 10^6, 10^9, 10^{12}$
15. (a) $89000 = \mathbf{89 \times 10^3}$
 (b) $450,000 = \mathbf{450 \times 10^3}$
 (c) $12,040,000,000,000 = \mathbf{12.04 \times 10^{12}}$

16. (a) $2.35 \times 10^5 = 235 \times 10^3$
 (b) $7.32 \times 10^7 = 73.2 \times 10^6$
 (c) 1.333×10^9 (already in engineering notation)
17. (a) $0.000345 = 345 \times 10^{-6}$
 (b) $0.025 = 25 \times 10^{-3}$
 (c) $0.00000000129 = 1.29 \times 10^{-9}$
18. (a) $9.81 \times 10^{-3} = 9.81 \times 10^{-3}$
 (b) $4.82 \times 10^{-4} = 482 \times 10^{-6}$
 (c) $4.38 \times 10^{-7} = 438 \times 10^{-9}$
19. (a) $2.5 \times 10^{-3} + 4.6 \times 10^{-3} = (2.5 + 4.6) \times 10^{-3} = 7.1 \times 10^{-3}$
 (b) $68 \times 10^6 + 33 \times 10^6 = (68 + 33) \times 10^6 = 101 \times 10^6$
 (c) $1.25 \times 10^6 + 250 \times 10^3 = 1.25 \times 10^6 + 0.25 \times 10^6 = (1.25 + 0.25) \times 10^6 = 1.50 \times 10^6$
20. (a) $(32 \times 10^{-3})(56 \times 10^3) = 1792 \times 10^{(-3+3)} = 1792 \times 10^0 = 1.792 \times 10^3$
 (b) $(1.2 \times 10^{-6})(1.2 \times 10^{-6}) = 1.44 \times 10^{(-6-6)} = 1.44 \times 10^{-12}$
 (c) $(100)(55 \times 10^{-3}) = 5500 \times 10^{-3} = 5.5$
21. (a) $\frac{50}{2.2 \times 10^3} = 22.7 \times 10^{-3}$
 (b) $\frac{5 \times 10^3}{25 \times 10^{-6}} = 0.2 \times 10^{(3-(-6))} = 0.2 \times 10^9 = 200 \times 10^6$
 (c) $\frac{560 \times 10^3}{660 \times 10^3} = 0.848 \times 10^{(3-3)} = 0.848 \times 10^0 = 848 \times 10^{-3}$
22. (a) $89,000 = 89 \times 10^3 = 89 \text{ k}$
 (b) $450,000 = 450 \times 10^3 = 450 \text{ k}$
 (c) $12,040,000,000,000 = 12.04 \times 10^{12} = 12.04 \text{ T}$

23. (a) $0.000345 \text{ A} = 345 \times 10^{-6} \text{ A} = \mathbf{345 \mu A}$
 (b) $0.025 \text{ A} = 25 \times 10^{-3} \text{ A} = \mathbf{25 \text{ mA}}$
 (c) $0.00000000129 \text{ A} = 1.29 \times 10^{-9} \text{ A} = \mathbf{1.29 \text{ nA}}$
24. (a) $31 \times 10^{-3} \text{ A} = \mathbf{31 \text{ mA}}$ (b) $5.5 \times 10^3 \text{ V} = \mathbf{5.5 \text{ kV}}$ (c) $20 \times 10^{-12} \text{ F} = \mathbf{20 \text{ pF}}$
25. (a) $3 \times 10^{-6} \text{ F} = \mathbf{3 \mu F}$ (b) $3.3 \times 10^6 \Omega = \mathbf{3.3 \text{ M}\Omega}$ (c) $350 \times 10^{-9} \text{ A} = \mathbf{350 \text{ nA}}$
26. (a) $2.5 \times 10^{-12} \text{ A} = \mathbf{2.5 \text{ pA}}$
 (b) $8 \times 10^9 \text{ Hz} = \mathbf{8 \text{ GHz}}$
 (c) $4.7 \times 10^3 \Omega = \mathbf{4.7 \text{ k}\Omega}$
27. (a) $7.5 \text{ pA} = \mathbf{7.5 \times 10^{-12} \text{ A}}$
 (b) $3.3 \text{ GHz} = \mathbf{3.3 \times 10^9 \text{ Hz}}$
 (c) $280 \text{ nW} = \mathbf{2.8 \times 10^{-7} \text{ W}}$
28. (a) $5 \mu\text{A} = \mathbf{5 \times 10^{-6} \text{ A}}$ (b) $43 \text{ mV} = \mathbf{43 \times 10^{-3} \text{ V}}$
 (c) $275 \text{ k}\Omega = \mathbf{275 \times 10^3 \Omega}$ (d) $10 \text{ MW} = \mathbf{10 \times 10^6 \text{ W}}$

Section 1-4 Metric Unit Conversions

29. (a) $(5 \text{ mA})(1 \times 10^3 \mu\text{A}/\text{mA}) = 5 \times 10^3 \mu\text{A} = \mathbf{5000 \mu A}$
 (b) $(3200 \mu\text{W})(1 \times 10^{-3} \text{ W}/\mu\text{W}) = \mathbf{3.2 \text{ mW}}$
 (c) $(5000 \text{ kV})(1 \times 10^{-3} \text{ MV}/\text{kV}) = \mathbf{5 \text{ MV}}$
 (d) $(10 \text{ MW})(1 \times 10^3 \text{ kW}/\text{MW}) = 10 \times 10^3 \text{ kW} = \mathbf{10,000 \text{ kW}}$
30. (a) $\frac{1 \text{ mA}}{1 \mu\text{A}} = \frac{1 \times 10^{-3} \text{ A}}{1 \times 10^{-6} \text{ A}} = 1 \times 10^3 = \mathbf{1000}$
 (b) $\frac{0.05 \text{ kV}}{1 \text{ mV}} = \frac{0.05 \times 10^3 \text{ V}}{1 \times 10^{-3} \text{ V}} = 0.05 \times 10^6 = \mathbf{50,000}$
 (c) $\frac{0.02 \text{ k}\Omega}{1 \text{ M}\Omega} = \frac{0.02 \times 10^3 \Omega}{1 \times 10^6 \Omega} = 0.02 \times 10^{-3} = \mathbf{2 \times 10^{-5}}$
 (d) $\frac{155 \text{ mW}}{1 \text{ kW}} = \frac{155 \times 10^{-3} \text{ W}}{1 \times 10^3 \text{ W}} = 155 \times 10^{-6} = \mathbf{1.55 \times 10^{-4}}$

31. (a) $50 \text{ mA} + 680 \text{ } \mu\text{A} = 50 \text{ mA} + 0.68 \text{ mA} = \mathbf{50.68 \text{ mA}}$
 (b) $120 \text{ k}\Omega + 2.2 \text{ M}\Omega = 0.12 \text{ M}\Omega + 2.2 \text{ M}\Omega = \mathbf{2.32 \text{ M}\Omega}$
 (c) $0.02 \text{ } \mu\text{F} + 3300 \text{ pF} = 0.02 \text{ } \mu\text{F} + 0.0033 \text{ } \mu\text{F} = \mathbf{0.0233 \text{ } \mu\text{F}}$
32. (a) $\frac{10 \text{ k}\Omega}{2.2 \text{ k}\Omega + 10 \text{ k}\Omega} = \frac{10 \text{ k}\Omega}{12.2 \text{ k}\Omega} = \mathbf{0.8197}$
 (b) $\frac{250 \text{ mV}}{50 \text{ } \mu\text{V}} = \frac{250 \times 10^{-3}}{50 \times 10^{-6}} = \mathbf{5000}$
 (c) $\frac{1 \text{ MW}}{2 \text{ kW}} = \frac{1 \times 10^6}{2 \times 10^3} = \mathbf{500}$

Section 1-5 Measured Numbers

33. The significant digits are shown in bold face.
- (a) Three: $\mathbf{1.00} \times 10^3$ (b) Two: $0.00\mathbf{57}$ (c) Five: $\mathbf{1502.0}$
 (d) Two: $0.0000\mathbf{36}$ (e) Three: $0.\mathbf{105}$ (f) Two: $\mathbf{2.6} \times 10^2$
34. (a) 50,505 rounds to $\mathbf{5.05} \times 10^4$ (b) 220.45 rounds to $\mathbf{220}$
 (c) 4646 rounds to $\mathbf{4.65} \times 10^3$ (d) 10.99 rounds to $\mathbf{11.0}$
 (e) 1.005 rounds to $\mathbf{1.00}$

Chapter 2

Voltage, Current, and Resistance

Note: Solutions show conventional current direction.

Section 2-2 Electrical Charge

1. $29 e \times 1.6 \times 10^{-19} \text{ C/e} = 4.64 \times 10^{-18} \text{ C}$
2. $17 e \times 1.6 \times 10^{-19} \text{ C/e} = 2.72 \times 10^{-18} \text{ C}$
3. $Q = (\text{charge per electron})(\text{number of electrons}) = (1.6 \times 10^{-19} \text{ C/e})(50 \times 10^{31} e) = 80 \times 10^{12} \text{ C}$
4. $(6.25 \times 10^{18} \text{ e/C})(80 \times 10^{-6} \text{ C}) = 5 \times 10^{14} \text{ electrons}$

Section 2-3 Voltage

5. (a) $V = \frac{W}{Q} = \frac{10 \text{ J}}{1 \text{ C}} = 10 \text{ V}$ (b) $V = \frac{W}{Q} = \frac{5 \text{ J}}{2 \text{ C}} = 2.5 \text{ V}$
(c) $V = \frac{W}{Q} = \frac{100 \text{ J}}{25 \text{ C}} = 4 \text{ V}$
6. $V = \frac{W}{Q} = \frac{500 \text{ J}}{100 \text{ C}} = 5 \text{ V}$
7. $V = \frac{W}{Q} = \frac{24 \text{ J}}{2.0 \text{ C}} = 12 \text{ V}$
8. $W = VQ = (12 \text{ V})(2.5 \text{ C}) = 30 \text{ J}$
9. $I = \frac{Q}{t}$
 $Q = It = (20 \text{ mA})(60 \text{ s}) = 1.2 \text{ C}$
 $V = \frac{W}{Q} = \frac{12 \text{ J}}{1.2 \text{ C}} = 10 \text{ V}$
10. Four common sources of voltage are **dc power supply, solar cell, generator, and battery.**
11. The operation of electrical generators is based on the principle of **electromagnetic induction.**
12. A power supply converts electricity in one form (ac) to another form (dc). The other sources convert other forms of energy into electrical energy.