Chapter 1
Quantities and Units

Section 1-2 Scientific Notation

1. (a) $3000 = \mathbf{3 \times 10^3}$ (b) $75{,}000 = \mathbf{7.5 \times 10^4}$ (c) $2{,}000{,}000 = \mathbf{2 \times 10^6}$

2. (a) $\dfrac{1}{500} = 0.002 = \mathbf{2 \times 10^{-3}}$

(b) $\dfrac{1}{2000} = 0.0005 = \mathbf{5 \times 10^{-4}}$

(c) $\dfrac{1}{5{,}000{,}000} = 0.0000002 = \mathbf{2 \times 10^{-7}}$

3. (a) $8400 = \mathbf{8.4 \times 10^3}$ (b) $99{,}000 = \mathbf{9.9 \times 10^4}$ (c) $0.2 \times 10^6 = \mathbf{2 \times 10^5}$

4. (a) $0.0002 = \mathbf{2 \times 10^{-4}}$ (b) $0.6 = \mathbf{6 \times 10^{-1}}$

(c) $\mathbf{7.8 \times 10^{-2}}$ (already in scientific notation)

5. (a) $32 \times 10^3 = \mathbf{3.2 \times 10^4}$

(b) $6800 \times 10^{-6} = \mathbf{6.8 \times 10^{-3}}$

(c) $870 \times 10^8 = \mathbf{8.7 \times 10^{10}}$

6. (a) $2 \times 10^5 = \mathbf{200{,}000}$

(b) $5.4 \times 10^{-9} = \mathbf{0.0000000054}$

(c) $1.0 \times 10^1 = \mathbf{10}$

7. (a) $2.5 \times 10^{-6} = \mathbf{0.0000025}$ (b) $5.0 \times 10^2 = \mathbf{500}$ (c) $3.9 \times 10^{-1} = \mathbf{0.39}$

8. (a) $4.5 \times 10^{-6} = \mathbf{0.0000045}$

(b) $8 \times 10^{-9} = \mathbf{0.000000008}$

(c) $4.0 \times 10^{-12} = \mathbf{0.0000000000040}$

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) $\dfrac{1.0 \times 10^3}{2.5 \times 10^2} = 0.4 \times 10^{3-2} = 0.4 \times 10^1 = \mathbf{4}$

(b) $\dfrac{2.5 \times 10^{-6}}{50 \times 10^{-8}} = 0.05 \times 10^{-6-(-8)} = 0.05 \times 10^2 = \mathbf{5}$

(c) $\dfrac{4.2 \times 10^8}{2 \times 10^{-5}} = 2.1 \times 10^{8-(-5)} = \mathbf{2.1 \times 10^{13}}$

13.

(a) $\left(8 \times 10^4 + 4 \times 10^3\right) \div 2 \times 10^2 = \left(80 \times 10^3 + 4 \times 10^3\right) \div 2 \times 10^2 = 84 \times 10^3 \div 2 \times 10^2 = 4.20 \times 10^2$

(b) $\left(3 \times 10^7\right)\left(5 \times 10^5\right) - 9 \times 10^{12} = \left(15 \times 10^{12}\right) - 9 \times 10^{12} = 6 \times 10^{12}$

(c) $\left(2.2 \times 10^2 \div 1.1 \times 10^2\right)\left(5.5 \times 10^4\right) = 11 \times 10^4$

Section 1-3 Engineering Notation and Metric Prefixes

14. The powers of ten used in engineering notation are multiples of 3:
$\mathbf{10^{-12}, 10^{-9}, 10^{-6}, 10^{-3}, 10^3, 10^6, 10^9, 10^{12}}$

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) $2.35 \times 10^5 = \mathbf{235 \times 10^3}$

(b) $7.32 \times 10^7 = \mathbf{73.2 \times 10^6}$

(c) $\mathbf{1.333 \times 10^9}$ (already in engineering notation)

17. (a) $0.000345 = \mathbf{345 \times 10^{-6}}$

(b) $0.025 = \mathbf{25 \times 10^{-3}}$

(c) $0.00000000129 = \mathbf{1.29 \times 10^{-9}}$

18. (a) $9.81 \times 10^{-3} = \mathbf{9.81 \times 10^{-3}}$

(b) $4.82 \times 10^{-4} = \mathbf{482 \times 10^{-6}}$

(c) $4.38 \times 10^{-7} = \mathbf{438 \times 10^{-9}}$

19. (a) $2.5 \times 10^{-3} + 4.6 \times 10^{-3} = (2.5 + 4.6) \times 10^{-3} = \mathbf{7.1 \times 10^{-3}}$

(b) $68 \times 10^6 + 33 \times 10^6 = (68 + 33) \times 10^6 = \mathbf{101 \times 10^6}$

(c) $1.25 \times 10^6 + 250 \times 10^3 = 1.25 \times 10^6 + 0.25 \times 10^6 = (1.25 + 0.25) \times 10^6 = \mathbf{1.50 \times 10^6}$

20. (a) $(32 \times 10^{-3})(56 \times 10^3) = 1792 \times 10^{(-3+3)} = 1792 \times 10^0 = \mathbf{1.792 \times 10^3}$

(b) $(1.2 \times 10^{-6})(1.2 \times 10^{-6}) = 1.44 \times 10^{(-6-6)} = \mathbf{1.44 \times 10^{-12}}$

(c) $(100)(55 \times 10^{-3}) = 5500 \times 10^{-3} = \mathbf{5.5}$

21. (a) $\dfrac{50}{2.2 \times 10^3} = \mathbf{22.7 \times 10^{-3}}$

(b) $\dfrac{5 \times 10^3}{25 \times 10^{-6}} = 0.2 \times 10^{(3-(-6))} = 0.2 \times 10^9 = \mathbf{200 \times 10^6}$

(c) $\dfrac{560 \times 10^3}{660 \times 10^3} = 0.848 \times 10^{(3-3)} = 0.848 \times 10^0 = \mathbf{848 \times 10^{-3}}$

22. (a) $89{,}000 = 89 \times 10^3 = \mathbf{89\ k}$

(b) $450{,}000 = 450 \times 10^3 = \mathbf{450\ k}$

(c) $12{,}040{,}000{,}000{,}000 = 12.04 \times 10^{12} = \mathbf{12.04\ T}$

23. (a) $0.000345\text{ A} = 345 \times 10^{-6}\text{ A} = \mathbf{345\ \mu A}$

(b) $0.025\text{ A} = 25 \times 10^{-3}\text{ A} = \mathbf{25\ mA}$

(c) $0.00000000129\text{ A} = 1.29 \times 10^{-9}\text{ A} = \mathbf{1.29\ nA}$

24. (a) $31 \times 10^{-3}\text{ A} = \mathbf{31\ mA}$ (b) $5.5 \times 10^{3}\text{ V} = \mathbf{5.5\ kV}$ (c) $20 \times 10^{-12}\text{ F} = \mathbf{20\ pF}$

25. (a) $3 \times 10^{-6}\text{ F} = \mathbf{3\ \mu F}$ (b) $3.3 \times 10^{6}\ \Omega = \mathbf{3.3\ M\Omega}$ (c) $350 \times 10^{-9}\text{ A} = \mathbf{350\ nA}$

26. (a) $2.5 \times 10^{-12}\text{ A} = \mathbf{2.5\ pA}$

(b) $8 \times 10^{9}\text{ Hz} = \mathbf{8\ GHz}$

(c) $4.7 \times 10^{3}\ \Omega = \mathbf{4.7\ k\Omega}$

27. (a) $7.5\text{ pA} = \mathbf{7.5 \times 10^{-12}\ A}$

(b) $3.3\text{ GHz} = \mathbf{3.3 \times 10^{9}\ Hz}$

(c) $280\text{ nW} = \mathbf{2.8 \times 10^{-7}\ W}$

28. (a) $5\ \mu\text{A} = \mathbf{5 \times 10^{-6}\ A}$ (b) $43\text{ mV} = \mathbf{43 \times 10^{-3}\ V}$

(c) $275\ \text{k}\Omega = \mathbf{275 \times 10^{3}\ \Omega}$ (d) $10\text{ MW} = \mathbf{10 \times 10^{6}\ W}$

Section 1-4 Metric Unit Conversions

29. (a) $(5\text{ mA})\,(1 \times 10^{3}\ \mu\text{A/mA}) = 5 \times 10^{3}\ \mu\text{A} = \mathbf{5000\ \mu A}$

(b) $(3200\ \mu\text{W})(1 \times 10^{-3}\text{ W}/\mu\text{W}) = \mathbf{3.2\ mW}$

(c) $(5000\text{ kV})(1 \times 10^{-3})\text{ MV/kV} = \mathbf{5\ MV}$

(d) $(10\text{ MW})(1 \times 10^{3}\text{ kW/MW}) = 10 \times 10^{3}\text{ kW} = \mathbf{10{,}000\ kW}$

30. (a) $\dfrac{1\text{ mA}}{1\ \mu\text{A}} = \dfrac{1\times10^{-3}\text{A}}{1\times10^{-6}\text{A}} = 1 \times 10^{3} = \mathbf{1000}$

(b) $\dfrac{0.05\text{ kV}}{1\text{ mV}} = \dfrac{0.05\times10^{3}\text{ V}}{1\times10^{-3}\text{ V}} = 0.05 \times 10^{6} = \mathbf{50{,}000}$

(c) $\dfrac{0.02\ \text{k}\Omega}{1\ \text{M}\Omega} = \dfrac{0.02\times10^{3}\ \Omega}{1\times10^{6}\ \Omega} = 0.02 \times 10^{-3} = \mathbf{2 \times 10^{-5}}$

(d) $\dfrac{155\text{ mW}}{1\text{ kW}} = \dfrac{155\times10^{-3}\text{ W}}{1\times10^{3}\text{ W}} = 155 \times 10^{-6} = \mathbf{1.55 \times 10^{-4}}$

31. (a) 50 mA + 680 μA = 50 mA + 0.68 mA = **50.68 mA**

(b) 120 kΩ + 2.2 MΩ = 0.12 MΩ + 2.2 MΩ = **2.32 MΩ**

(c) 0.02 μF + 3300 pF = 0.02 μF + 0.0033 μF = **0.0233 μF**

32. (a) $\dfrac{10\,\text{k}\Omega}{2.2\,\text{k}\Omega + 10\,\text{k}\Omega} = \dfrac{10\,\text{k}\Omega}{12.2\,\text{k}\Omega} = \mathbf{0.8197}$

(b) $\dfrac{250\,\text{mV}}{50\,\mu\text{V}} = \dfrac{250\times10^{-3}}{50\times10^{-6}} = \mathbf{5000}$

(c) $\dfrac{1\,\text{MW}}{2\,\text{kW}} = \dfrac{1\times10^{6}}{2\times10^{3}} = \mathbf{500}$

Section 1-5 Measured Numbers

33. The significant digits are shown in bold face.

(a) Three: **1.00** x 10^3 (b) Two: 0.00**57** (c) Five: **1502.0**

(d) Two: 0.000**036** (e) Three: 0.**105** (f) Two: **2.6** x 10^2

34. (a) 50,505 rounds to **5.05** x 10^4 (b) 220.45 rounds to **220**

(c) 4646 rounds to **4.65** x 10^3 (d) 10.99 rounds to **11.0**

(e) 1.005 rounds to **1.00**

Chapter 2
Voltage, Current, and Resistance

Note: Solutions show conventional current direction.

Section 2-2 Electrical Charge

1. $29\text{ e} \times 1.6 \times 10^{-19}\text{ C/e} = \mathbf{4.64 \times 10^{-18}\ C}$

2. $17\text{ e} \times 1.6 \times 10^{-19}\text{ C/e} = \mathbf{2.72 \times 10^{-18}\ C}$

3. Q = (charge per electron)(number of electrons) = $(1.6 \times 10^{-19}\text{ C/e})(50 \times 10^{31}\text{e}) = \mathbf{80 \times 10^{12}\ C}$

4. $(6.25 \times 10^{18}\text{ e/C})(80 \times 10^{-6}\text{ C}) = \mathbf{5 \times 10^{14}\ electrons}$

Section 2-3 Voltage

5. (a) $V = \dfrac{W}{Q} = \dfrac{10\text{ J}}{1\text{ C}} = \mathbf{10\ V}$ (b) $V = \dfrac{W}{Q} = \dfrac{5\text{ J}}{2\text{ C}} = \mathbf{2.5\ V}$

(c) $V = \dfrac{W}{Q} = \dfrac{100\text{ J}}{25\text{ C}} = \mathbf{4\ V}$

6. $V = \dfrac{W}{Q} = \dfrac{500\text{ J}}{100\text{ C}} = \mathbf{5\ V}$

7. $V = \dfrac{W}{Q} = \dfrac{24\text{ J}}{2.0\text{ C}} = \mathbf{12\ V}$

8. $W = VQ = (12\text{ V})(2.5\text{ C}) = \mathbf{30\ J}$

9. $I = \dfrac{Q}{t}$

$Q = It = (20\text{ mA})(60\text{ s}) = 1.2\text{ C}$

$V = \dfrac{W}{Q} = \dfrac{12\text{ J}}{1.2\text{ C}} = \mathbf{10\ V}$

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.