Discussion Examples
Chapter 1: Introduction to Physics

6. Which of the following quantities have the dimensions of a distance? **(a)** vt, **(b)** $\frac{1}{2}at^2$, **(c)** $2at$, **(d)** v^2/a

Picture the Problem: This is a dimensional analysis question.

Strategy: Manipulate the dimensions in the same manner as algebraic expressions.

Solution: 1. (a) Substitute dimensions for the variables:
$$vt = \left(\frac{\text{m}}{\text{s}}\right)(\text{s}) = \text{m} \quad \boxed{\text{Yes}}$$

2. (b) Substitute dimensions for the variables:
$$\tfrac{1}{2}at^2 = \tfrac{1}{2}\left(\frac{\text{m}}{\text{s}^2}\right)(\text{s})^2 = \text{m} \quad \boxed{\text{Yes}}$$

3. (c) Substitute dimensions for the variables:
$$2at = 2\left(\frac{\text{m}}{\text{s}^2}\right)(\text{s}) = \frac{\text{m}}{\text{s}} \quad \boxed{\text{No}}$$

4. (d) Substitute dimensions for the variables:
$$\frac{v^2}{a} = \frac{(\text{m/s})^2}{\text{m/s}^2} = \text{m} \quad \boxed{\text{Yes}}$$

Insight: When squaring the velocity you must remember to square the dimensions of both the numerator (meters) and the denominator (seconds).

28. What is the speed in miles per hour of a beam of light traveling at 3.00×10^8 m/s ?

Picture the Problem: This is a units conversion problem.

Strategy: Multiply the known quantity by appropriate conversion factors to change the units.

Solution: Convert m/s to miles per hour:
$$\left(3.00\times10^8\ \frac{\text{m}}{\text{s}}\right)\left(\frac{1\text{ mi}}{1609\text{ m}}\right)\left(\frac{3600\text{ s}}{1\text{ h}}\right) = \boxed{6.71\times10^8\ \frac{\text{mi}}{\text{h}}}$$

Insight: Conversion factors are conceptually equal to one, even though numerically they often equal something other than one. They are often helpful in displaying a number in a convenient, useful, or easy-to-comprehend fashion.

33. **(a)** A standard sheet of paper measures 8 1/2 by 11 inches. Find the area of one such sheet of paper in m^2.
(b) A second sheet of paper is half as long and half as wide as the one described in part (a). By what factor is its area less than the area found in part (a)?

Picture the Problem: This is a units conversion problem.

Strategy: Multiply the known quantity by appropriate conversion factors to change the units. Then use a ratio to find the factor change in part (b).

Solution: 1. (a) Convert square inches to square meters:
$$A = (8.5\text{ in} \times 11\text{ in})\left(\frac{1\text{ m}^2}{1550\text{ in}^2}\right) = \boxed{0.060\text{ m}^2}$$

2. (b) Calculate a ratio to find the new area:
$$\frac{A_{\text{new}}}{A_{\text{old}}} = \frac{L_{\text{new}}W_{\text{new}}}{L_{\text{old}}W_{\text{old}}} = \frac{\left(\frac{1}{2}L_{\text{old}}\right)\left(\frac{1}{2}W_{\text{old}}\right)}{L_{\text{old}}W_{\text{old}}} = \frac{1}{4}$$
$$A_{\text{new}} = \boxed{\tfrac{1}{4}A_{\text{old}}}$$

Insight: If you learn to use ratios you can often make calculations like these very easily. Always put the new quantity in the numerator and the old quantity in the denominator to make the new quantity easier to calculate at the end.

45. **Ten and Ten** When Coast Guard pararescue jumpers leap from a helicopter to save a person in the water, they like to jump when the helicopter is flying "ten and ten," which means it is 10 feet above the water and moving forward with a speed of 10 knots. What is "ten and ten" in SI units? (A knot is one nautical mile per hour, where a nautical mile is 1.852 km.)

Picture the Problem: This is a units conversion problem.

Strategy: Multiply the known quantity by appropriate conversion factors to change the units.

Solution: 1. Convert ten feet to m: $(10.0\text{ ft})\left(\frac{1\text{ m}}{3.28\text{ ft}}\right) = \boxed{3.05\text{ m}}$ above the water

2. Convert ten knots to m/s: $(10.0\text{ knot})\left(\frac{1.0\text{ n.mi/hr}}{\text{knot}}\right)\left(\frac{1.852\text{ km}}{\text{n.mi}}\right)\left(\frac{1000\text{ m}}{\text{km}}\right)\left(\frac{1\text{ hr}}{3600\text{ s}}\right) = \boxed{5.14\text{ m/s}}$

Insight: If we were to describe the flying parameters of the helicopter in SI units, we would say it is flying "3 and 5"!