To calculate an answer that will have the dimension of time, you should take the distance and *divide* it by the speed of the car, as follows:

$$\frac{\text{length}}{\text{length/time}} = \frac{\cancel{\text{length}} \times \text{time}}{\cancel{\text{length}}} = \text{time} \qquad \frac{725\ \cancel{\text{km}} \times 1.0\ \text{h}}{88\ \cancel{\text{km}}} = 8.2\ \text{h}$$

In a simple example like this one, you might be able to identify the invalid equation without dimensional analysis. But with more-complicated problems, it is a good idea to check your final equation with dimensional analysis. This step will prevent you from wasting time computing an invalid equation.

Did you know?

The physicist Enrico Fermi made the first nuclear reactor at the University of Chicago in 1942. Fermi was also well known for his ability to make quick order-of-magnitude calculations, such as estimating the number of piano tuners in New York City.

Order-of-magnitude estimations check answers

Because the scope of physics is so wide and the numbers may be astronomically large or subatomically small, it is often useful to estimate an answer to a problem before trying to solve the problem exactly. This kind of estimate is called an *order-of-magnitude* calculation, which means determining the power of 10 that is closest to the actual numerical value of the quantity. Once you have done this, you will be in a position to judge whether the answer you get from a more exacting procedure is correct.

For example, consider the car trip described in the discussion of dimensional analysis. We must divide the distance by the speed to find the time. The distance, 725 km, is closer to 10^3 km (or 1000 km) than to 10^2 km (or 100 km), so we use 10^3 km. The speed, 88 km/h, is about 10^2 km/h (or 100 km/h).

$$\frac{10^3\ \cancel{\text{km}}}{10^2\ \cancel{\text{km}}/\text{h}} = 10\ \text{h}$$

This estimate indicates that the answer should be closer to 10 than to 1 or to 100 (or 10^2). The correct answer (8.2 h) certainly fits this range.

Order-of-magnitude estimates can also be used to estimate numbers in situations in which little information is given. For example, how could you estimate how many gallons of gasoline are used annually by all of the cars in the United States?

First, consider that the United States has almost 300 million people. Assuming that each family of about five people has two cars, an estimate of the number of cars in the country is 120 million.

Next, decide the order of magnitude of the average distance each car travels every year. Some cars travel as few as 1000 mi per year, while others travel more than 100 000 mi per year. The appropriate order of magnitude to include in the estimate is 10 000 mi, or 10^4 mi, per year.

If we assume that cars average 20 mi for every gallon of gas, each car needs about 500 gal per year.

$$\left(\frac{10\ 000\ \cancel{\text{mi}}}{1\ \text{year}}\right)\left(\frac{1\ \text{gal}}{20\ \cancel{\text{mi}}}\right) = 500\ \text{gal/year for each car}$$

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