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The inverse square law is sometimes, for some people, a difficult equation to master. Simply put, the inverse square law states that as you move away from a source of energy the intensity is reduced. The law specifies that if the distance from the source of energy is doubled, the intensity is reduced by a factor of four.

This law is amazing and wonderful in that it works for many types of energy, light, sound, radiation, and even gravity. The problem is that we don't always double our distance from the source and therefore can't always take the intensity at a distance to be 1/4th of the intensity at a closer point.

Historically, the inverse square law in radiation safety has been fraught with long sighs and gnashing of teeth because of the math involved. The formula is straightforward and easy to conceptualize as an equality; one side (the intensity) is equal to the other side (distance). I don't think it's the *math* so much as the *method* used in teaching the inverse square law. In this article, we'll explore what we consider to be a much easier method of solving the inverse square law.

We'll begin by looking at the inverse square law formula:

$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$

Picking apart the formula shows that there are two Intensities, denoted by I_1 and I_2, and two distances, D_1 and D_2. This is easy enough to understand on its' face; you need three of the four to work out the problem. Substitute the numbers into their respective places and work out the math. However, *where* to put the numbers is the difficult part because, depending upon where the variable lies, the formula can be simplified four ways:

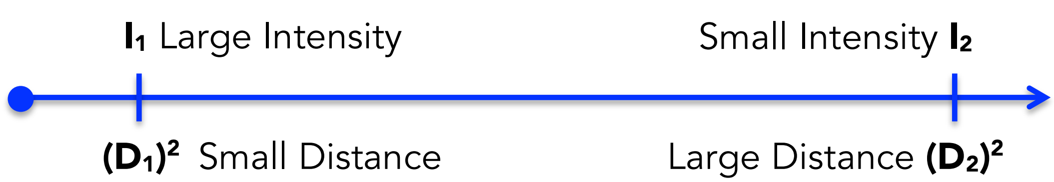
$$I_1 = \frac{I_2 \times (D_2)^2}{(D_1)^2} \qquad\qquad I_2 = \frac{I_1 \times (D_1)^2}{(D_2)^2}$$

$$D_1 = \sqrt{\frac{I_2 \times (D_2)^2}{I_1}} \qquad D_2 = \sqrt{\frac{I_1 \times (D_1)^2}{I_2}}$$

This method has proven intimidating to people who are learning radiation safety partly because they are inundated by so much new information and partly because it may be difficult to internalize the formula as derivatives of the same.

So, making the inverse square law easier to learn, and therefore more usable, pays dividends by decreasing stress over math in general, and simplifying four formulas (5 if you count the original) into something as simple to understand as a drawing.

A drawing using distance is intuitive and easily understood by nearly everyone. After all, saying that 4 feet is closer than 50 feet is no guesswork at all. Therefore, we start with a small dot (the source), and an arrow signifying a distance. If we place two tic marks on the arrow, we now have the basis for an intuitive drawing of the inverse square law and for what is being asked.



Let's say that we have a typical inverse square law problem such as:

The radiation intensity at 10 feet from the source is 200 mR/hr. What is the distance to the restricted area boundary?

If we isolate the numerical values and units (including the inferred values) from the problem, we are left with:

10 feet

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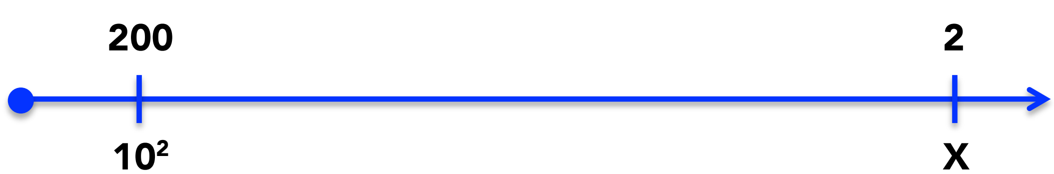
200 mR/hr
2 mR/hr (restricted area boundary

We choose the units that we have 2 values for, in this case mR/hr, intensity. Intuitively, we can understand that "200" is more than "2" therefore 200 will be closest to the source in our drawing. But where to put it?

In our drawing, there are a few simple rules that always apply:

- Intensities are always placed on the top of the drawing above the arrow
- Distances are always placed on the bottom of the drawing, below the arrow
- Distances are always supplied with an exponent (^{2})
- Small distances are placed near the dot (source) and large distances away from the dot.
- Large intensities are placed near the dot (source) and small intensities away from the dot.
- The question will always give three of the four values so put the two of the same units on the drawing first.
- Match the remaining value to the corresponding opposite on the drawing.

So, to answer the question that we posed above, the "200" is placed above the arrow near the source dot and the "2" is placed above the arrow away from the source dot. The remaining "10" is placed under the arrow at the position corresponding to its' opposite, the "200", and since the "10" represents a distance, the number has an exponent added; 10^2. Our drawing now looks like this:



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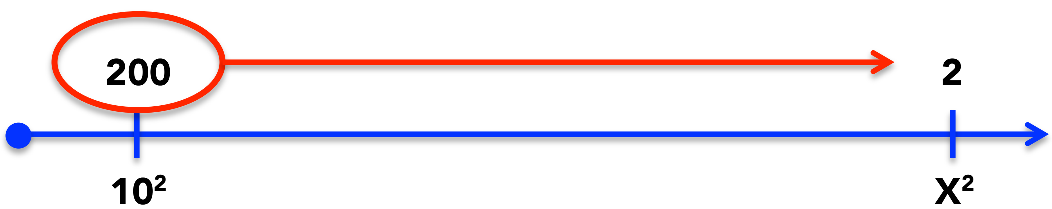
Beginning with I_1 or the "200", we write it down. Since we read left to right, continue from left to right. We come to I_2, the "2" and write it down under the "200" so our formula looks like this:

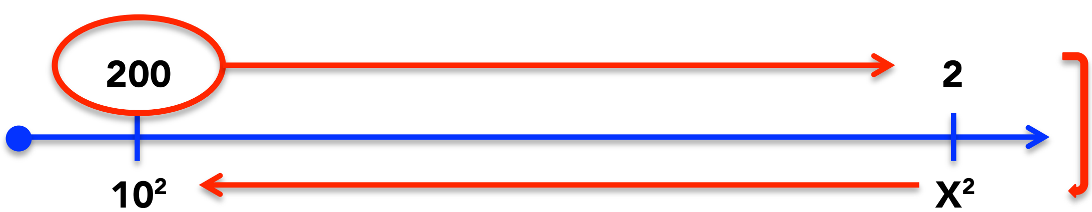
$$\frac{200}{2} =$$

and our drawing looks like this:



Since we cannot go any further, we turn the corner; this is the equal sign. The next thing that we come to is the "X^2", which we write down on the right of the equal sign and continue towards the "10^2", which we write down under the "X^2". Our formula and drawing looks like the following:

$$\frac{200}{2} = \frac{X^2}{10^2}$$



At this point, our inverse square law formula is set up and we can solve for "X" by the following method:

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$\frac{200}{2} = \frac{X^2}{100}$ Square the distances that can be squared, leaving the "X^2" alone

$\frac{200}{2} = \frac{X^2}{100}$ Cross-multiply away from the "X^2". Where the number (circled) was, put a "1", and put the product opposite of the "X^2".

$\frac{20000}{2} = \frac{X^2}{1}$ If the "1" is under the "X^2", get rid of it because it doesn't count. Divide the other side.

$\sqrt{10000} = X^2$ Since the number is on one side and the letter on the other the problem is solved except there is an exponent on the "X". To get rid of the exponent, take the square root of the numeric side.

$100 = X$ The answer is 100 in this case. Meaning the 2 mR/hr boundary must be set at 100 feet.

Using the above method, the inverse square law is straightforward and easy to calculate. There is no complicated formula to remember or the various permutations of the formula. This allows the radiographer to use the equation every day and make his or her radiation areas more accurate thus assuring a higher level of compliance and safety.

Next we'll expand on the basic inverse square law formula by adding activity and shielding. Later we'll calculate the Dose Rate formula and show how both can be used together daily by the radiographic team.