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Lumens, Illuminance, Foot-candles and bright shiny beads....

In defining how bright something is, we have two things to consider.

1. How bright it is at the source- How Bright is that light?
2. How much light is falling on something a certain distance away from the light.

Lets' do some definitions now.....

We're in America, so we are going to talk about units of measurement that concern distance in feet and inches. So, we will use some terms that folks in Europe don't use. We're going to talk about "foot-candles".

This one's simple. Get a birthday cake candle. Get a ruler. Stick the candle on one end of the ruler. Light the candle. Turn out the lights. Sing Happy Birthday to Doc. It was his 47th on the 23rd. OK, quiet down. Enough of that nonsense. One foot-candle of light is the amount of light that birthday cake candle generates one foot away.

That's a neat unit of measurement. Why? Say you have a lamp. You are told it produces 100 foot candles of light. That means at one foot from the lamp, you will receive 100 foot candles of light.

But here's where it gets tricky. The further away you move the light from what you want to illuminate, the less bright the light seems! If you measure it at the light, it's just as bright. But when you measure at the object you want illuminated, there is less light! A Physics teacher is going to tell you that light measured on an object is INVERSELY PROPORTIONAL to the distance the object is from the light source. That's a very scientific and math rich way of saying, the closer you are to the light bulb, the brighter that bulb is. Or, think of it this way. You can't change how much light comes out of your light bulb. So, to make more light on an object, you have to either move the light closer, or add more lights.

Now, lets get to LUMENS.

A LUMEN is a unit of measurement of light. It measures light much the same way. Remember, a foot-candle is how bright the light is one foot away from the source. A lumen is a way of measuring how much light gets to what you want to light! A LUMEN is equal to one foot-candle falling on one square foot of area.



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So, if we take your candle and ruler, let's place a book at the opposite end from the candle. We'd have a bit of a light up if we put the book right next to the candle, you know. If that book happens to be one foot by one foot, it's one square foot. Ok, got the math done there. Now, all the light falling on that book, one foot away from your candle equals both.....1 foot candle AND one LUMEN!

Ahh, we've confused you. Let's split off from this and talk about the difference between RADIANCE and ILLUMINANCE.

RADIANCE is another way of saying how much energy is released from that light source. Again, you measure it at the source. Unless you're talking about measuring the radiance of something intensely hot, like the Sun. Then you might want to measure it at night, when it's off.

ILLUMINANCE is what results from the use of light. You turn your flashlight on in a dark room, and you light something up. That's ILLUMINANCE. Turning on a light in a dark room to make the burglar visible gives you ILLUMINANCE. It also gives you another problem when you note the burglar is pointing your duck gun at your bellybutton.

Illuminance is the intensity or degree to which something is illuminated and is therefore not the amount of light produced by the light source. This is measured in foot-candles again! And when people talk about LUX, it's illuminance measured in metric units rather than English units of measure. To reinforce that, LUX is the measurement of actual light available at a given distance. A lux equals one lumen incident per square meter of illuminated surface area. They're measuring the same thing, just using different measurement units.

Pretend you're an old photographer, like O. Winston Link, or Ansel Adams. These two gods of black and white photography (and a print made by either can fetch quite a hefty sum of money these days) used a device called a light meter to help them judge their exposure. (There is another way of judging exposure-that's when someone whispers in our ear at a cocktail party, "You silly twit, your fly's come undone!").

These light meters were nifty devices. You could use it to show how much light was falling on an object, light from the sun, and reflected light energy from every thing else. Or you could use it to show how much light energy was reflected off the object itself.

All this brings back two points. Well, three.

The first point is if we measure the output of a light at the source that gives us one thing.

The second point is that we use an entirely different unit of measure if we are measuring the results of that light's output.

The third point is the instructor is right off his trolley, isn't he?

Now back to the book at the end of the ruler.

We've measured two different things. We have a unit of measure for how much light is produced. We Yankees express that as a foot-candle. Being lazy, we use it all over the



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place.

More Confusion! Candlepower!

Candlepower is a way of measuring how much light is produced by a light bulb, LED or by striking an arc in a Carbon-Arc spotlight. Is it a measure of how much light falls upon an object some distance away? No. That's illuminance. Is it a measure of how well we see an object that is illuminated by that light source? No. That's something all together different, and we are not going there!

Nowadays we use the term CANDELA instead of candlepower. Candlepower, or CANDELA is a measure of how much light the bulb produces, measured at the bulb, rather than how much falls upon the thing you want to light up. Further confusing the matter is beam focus. That's how much candlepower can be focused using a reflector/lens assembly. Obviously, if you project all your light bulbs intensity at a given spot, or towards something, it will be more intense, and the illuminance will be higher.

And here comes the confuser! A candlepower as a unit of measure is not the same as a foot-candle. A candlepower is a measurement of the light at the source, not at the object you light up.

And a candela is the metric equivalent of the light output of that one candle, based on metric calculations. And since using a candle is rather imprecise, the definition was amended to replace a light source using carbon filaments with a very specific light source, see the following:

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $1/683$ watt per steradian.

The above from the National Institute of Standards Reference on Constants, Units, and Uncertainty.

Candlepower is a measure of light taken at the source-not at the target. Foot-candles tell us how much of that light is directed at an object we want to illuminate.

Now, lets convert the lumens, a metric unit of light measurement, to candlepower.

We understand a candle radiates light equally in all directions, its output, in this consideration is not focused by any mechanical means (lenses or reflectors). Pretend for a moment that a transparent sphere one meter in radius surrounds your candle. We know that there are 12.57 square meters of surface area in such a sphere. Remember your Solid Geometry classes?

That one candle (1 Candlepower/Candela) is illuminating equally the entire surface of that sphere. The amount of light energy then reflected from that surface is defined thusly:

The amount of energy emanating from one square meter of surface is one lumen. And if we decrease the size of the sphere to one foot radius, we increase the reflected energy 12.57 times of that which fell on the square meter area.



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LUX is an abbreviation for Lumens per square meter.
Foot-candles equal the amount of Lumens per square feet of area.

So, that one candlepower equivalent equals 12.57 lumens.

And for you figuring out LED equivalents, first you must know how many lumens your LED's each produce. Then divide that value by 12.57 and you have candlepower of the LED. You don't have foot-candles, remember foot-candles are illuminance. And we are measuring radiance.

Summing it all up:

Candlepower is a rating of light output at the source, using English measurements.

Foot-candles are a measurement of light at an illuminated object.

Lumens are a metric equivalent to foot-candles in that they are measured at an object you want to illuminate.

Divide the number of lumens you have produced, or are capable of producing, by 12.57 and you get the candlepower equivalent of that light source.