Light Intensity

The term **intensity** is used to describe the rate at which light spreads over a surface of a given area some distance from a source. The intensity varies with the distance from the source and the power of the source. **Power** is a property of the light source that describes the rate at which light energy is emitted by the source. Power is often expressed in units of watts. **Table 1** shows the dependence of intensity (**I**) upon the distance (**r**) from a 60-watt light bulb. Numbers are rounded to the second decimal place.

Table 1

r (m)	I (W/m^2)
0.10	477.46
0.20	119.37
0.50	19.10
1.00	4.77
2.00	1.19
5.00	0.19
10.00	0.05

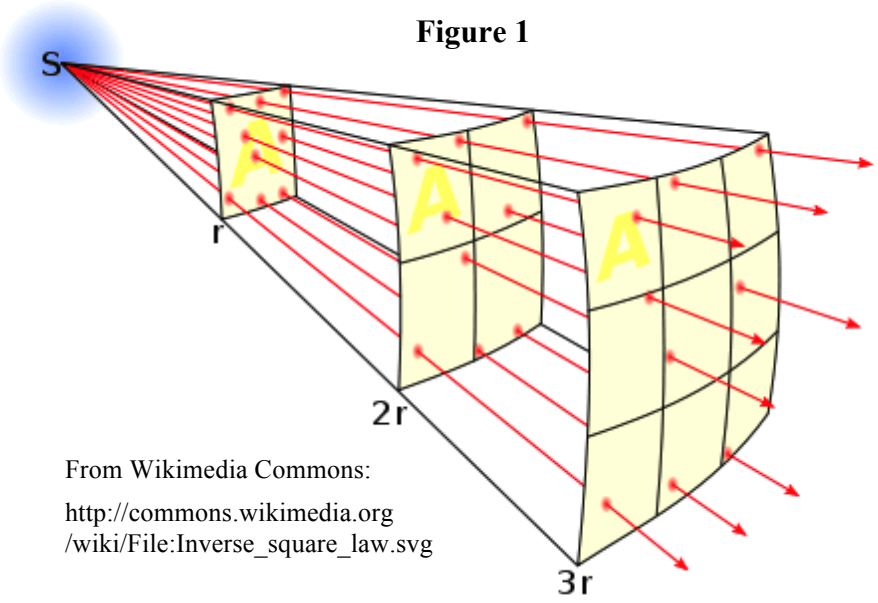
Different light bulbs are rated to have different power values. Typically, the purpose of a light determines what power bulb will be used in the light. Obviously, a night light bulb will have a lower power rating than the light bulb used in a floor lamp. **Table 2** shows the dependence of intensity (I) at a distance of 1.0 meter from various types of light bulbs.

Table 2: Intensities at 1-m Distances

	Power (W)	I (W/m^2)
Night Light Bulb	7.5	0.60
Vanity Bulb	30	2.39
Appliance Bulb	40	3.18
Desk Lamp	60	4.77
Floor Lamp	100	7.96
3-Way Bulb (Max.)	150	11.94
Work light	1000	79.58

In Physics, the model for explaining how light travels from a source through space is represented in **Figure 1**. Light energy emitted by the source (S) travels outward in all directions. The *rays* indicate the straight-line paths of a photon through space. Of course, the greater the distance (r) from the source, the further apart that the *rays* become. At a distance **r** from the source, there are nine *rays* passing through the square area. These *rays* carry energy through the surroundings. At distances further from the source, the same energy spreads over a wider area. For example, at a distance of **2r**, these same nine *rays* pass through an area that is four times larger than the original square. Thus, the intensity (rate at which light lands upon a surface) decreases with increasing distance from the source.

Figure 1



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Questions:

1. Which one of these statements describes the dependence of intensity upon distance from the source as represented in **Table 1**?
   a. The intensity increases as the distance from the source increases.
   b. The intensity decreases as the distance from the source increases.
   c. The intensity is unaffected by changes in the distance from the source.
   d. As distance from the source increases, the intensity first decreases and then gradually increases.

2. According to **Table 1**, at what rate will light from a 60-Watt bulb land on a given area a distance of 5.0 meters from a source?
   a. 0.0076 W/m^2 b. 0.038 W/m^2
   c. 0.19 W/m^2 d. 0.95 W/m^2

3. According to **Table 1**, at what rate will light from a 60-Watt bulb land on a given area a distance of 0.05 meters from a source?
   a. Approximately 19 W/m^2 b. Approximately 190 W/m^2
   c. Approximately 955 W/m^2 d. Approximately 1910 W/m^2

4. Based on the data in **Table 1**, what effect does increasing the distance from the source by a factor of 10 have upon the intensity of light?
   a. Light is 10 times more intense at locations 10 times further from the source.
   b. A 10-fold increase in distance causes the intensity of light to decrease by a factor of 100.
   c. Light intensity decreases by a factor of 10 as distance from the source increases by a factor of 10.
   d. Increasing distance by a factor of 10 will decrease intensity, but there is no predictable pattern in exactly how much it decreases.

5. How does the light intensity at a distance of 0.20 meters from a 60-Watt light bulb compare to the light intensity at a distance of 0.10 meters from the same light bulb?
   a. Light intensity is twice as intense at the 0.20-meter location.
   b. Light intensity is four times as intense at the 0.20-meter location.
   c. Light intensity is one-half as intense at the 0.20-meter location.
   d. Light intensity is one-fourth as intense at the 0.20-meter location.

6. Which two bulbs in **Table 2** illustrate the effect of a doubling of the power upon the intensity of light measured on a surface 1-meter away?
   a. Night light bulb and vanity bulb. b. Vanity bulb and desk lamp bulb.
   c. Desk lamp bulb and floor lamp bulb. d. Floor lamp bulb and work light bulb.

7. Use **Table 2** to predict the intensity of light landing on a surface 1 meter away from a 500-Watt light source.
   a. 19.90 W/m^2 b. 39.79 W/m^2
   c. 43.77 W/m^2 d. 500 W/m^2

8. Use **Table 1** and **Table 2** to predict the intensity of light on a surface that is 2 meters from a 100-watt appliance bulb.
   a. Approximately 1.99 W/m^2
   b. Approximately 3.98 W/m^2
   c. Approximately 15.92 W/m^2
   d. Approximately 31.84 W/m^2

9. Use **Table 1** and **Table 2** to identify which one of the following sets of conditions would result in the greatest intensity light on the given surface.
   a. A distance of 0.50 meters from a 40-Watt light source.
   b. A distance of 0.50 meters from a 120-Watt light source.
   c. A distance of 2.00 meters from a 40-Watt light source.
   d. A distance of 4.00 meters from a 120-Watt light source.

10. The planet Neptune is approximately 30 times further from the Sun as the Earth is from the Sun. Which statement accurately compares the intensity of light from the sun on the surfaces of these two planets?
   a. The intensity is approximately 5-6 times more intense on the Earth.
   b. The intensity is approximately 30 times more intense on the Earth.
   c. The intensity is approximately 900 times more intense on the Earth.
   d. The intensity is approximately 30 times more intense on Neptune.

11. Two students were conducting an experiment to determine the effect of the distance from the source upon the intensity of light. Consider their data table shown at the right. Based on the information presented in this lab, what intensity values would be expected for row 2 (20 cm) and row 3(30 cm)?

Distance (cm)	Intensity (W/m^2)
10	180
20	???
30	???

   a. 45 W/m^2, 20 W/m^2
   b. 90 W/m^2, 60 W/m^2
   c. 170 W/m^2, 160 W/m^2
   d. 360 W/m^2, 540 W/m^2

12. Consider **Figure 1**. How does the amount of energy landing on the 3x3 square area a distance **3r** from the source compare to the amount of energy landing on the 1x1 square area a distance of **r** from the source?
   a. The same amount of energy lands on each of these surfaces.
   b. Three as much energy lands on the 3x3 square area.
   c. Nine times as much energy lands on the 3x3 square area.
   d. One-ninth as much energy lands on the 3x3 square area.

13. Which one of the following statements explaining why intensity decreases with distance is consistent with the model of light propagation as presented in **Figure 1**?
   a. Light rays become less energized at further distances from the source.
   b. The weaker light rays are unable to reach to the further distances, thus lowering intensity.
   c. As light travels further from the source, the same amount of energy spreads over a larger surface area.
   d. Relativity effects bend the light rays towards one another, causing interference of light and a weaker intensity.