Inverse Square Law

Worked Example
An ambulance started its siren 200 metres after it left the scene of an accident. The sound intensity heard at this distance was 8.0 x 10^{-6} Wm^{-2}. After a short time the intensity of the siren's sound had fallen top 2.0 x 10^{-6} Wm^{-2}. Assuming the volume does not change, how far was the ambulance from the accident scene at the time?

Solution
d_1 = 200 m
I_1 = 8.0 x 10^{-6} Wm^{-2}
d_2 = ?
I_2 = 2.0 x 10^{-6} Wm^{-2}

Inverse square law gives us $I\alpha\frac{1}{d^2}$ or $I=\frac{m}{d^2}$ or $Id^2=m$
If the source does not change, then m = constant $\therefore I_1d_1^2=I_2d_2^2$
Substituting in values gives us: (8.0 x 10^{-6})(200^2) = (2.0 x 10^{-6})(d_2^2)

$\therefore\ d_2=\sqrt{\frac{(8.0x10^{-6})(200^2)}{2.0x10^{-6}}}$ = 400 m

Questions

1. The intensity of light 5.0 m away from a lamp is 128 lux. Calculate the intensity 20.0 m away from the same lamp.
   $I_1d_1^2=I_2d_2^2$
   128 x 5^2 = I_2 x 20^2
   I_2 = 8.9 lux

2. At a distance of 2.0 m away from a point source of infra red waves, the intensity is 4.0 Wm^{-2}. Calculate the intensity at a distance of:
   (A) 1.0 m from the source
   $I_1d_1^2=I_2d_2^2$
   4x 2^2 = I_2 x 1^2
   I_2 = 16 Wm^{-2}
   (B) 4.0 m from the source
   $I_1d_1^2=I_2d_2^2$
   4x 2^2 = I_2 x 4^2
   I_2 = 1.0 Wm^{-2}

3. The intensity of light detected from a light source is I units when the detector is placed 1.0 m from the source. If the detector is moved to 50 cm from the source, what is the new intensity reading?
   $I_1d_1^2=I_2d_2^2$
   I x 1^2 = I_2 x 0.5^2
   I_2 = 4I

4. The intensity of light from a point source at a distance of 0.5 m is 2.4 x 10^{-2} Wm^{-2}. The point source is now moved so that the intensity is now 0.6 Wm^{-2}. Calculate the new distance of the detector from the point source.

$$I_1 d_1^2 = I_2 d_2^2$$

$(2.4 \times 10^{-2})(0.5^2) = 0.6 \times d_2^2$

$d_2 = 0.1$ m

5. Calculate the intensity of light from a source if the distance from the source is:
Give your answers in terms of the original intensity I_o.

(A) doubled

$$I_1 d_1^2 = I_2 d_2^2$$

$I_o d^2 = I_2 \times (2d)^2$

$I_o d^2 = 4 I_o d^2$

$I_2 = I_o/4$

(B) quadrupled

$$I_1 d_1^2 = I_2 d_2^2$$

$I_o d^2 = I_2 \times (4d)^2$

$I_2 = I_o/16$

(C) increased by 8 times

$$I_1 d_1^2 = I_2 d_2^2$$

$I_o d^2 = I_2 \times (8d)^2$

$I_2 = I_o/64$

(D) reduced to one third

$$I_1 d_1^2 = I_2 d_2^2$$

$I_o d^2 = I_2 \times (d/3)^2$

$I_2 = 9 I_o$

(E) reduced by one third

$$I_1 d_1^2 = I_2 d_2^2$$

$I_o d^2 = I_2 \times (2/3d)^2$

$I_2 = 9 I_o/4$