Zhasmin Tuiachieva
NYIT ID# 1342449
ETCS 105 Career Discovery
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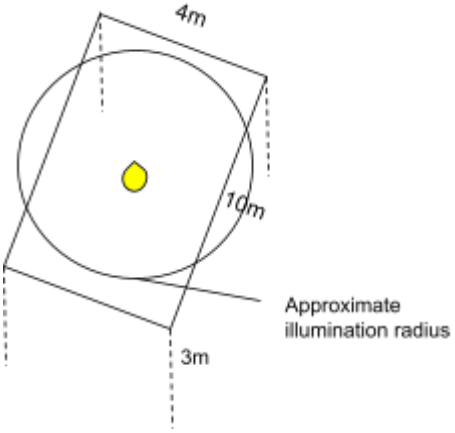
MatLab Project 2

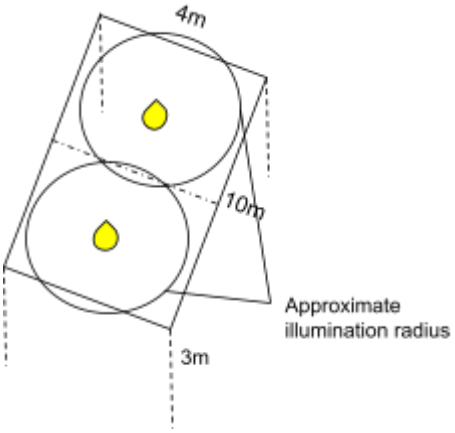
Illuminating a Room

Suppose we need to decide where to put light fixtures on the ceiling of a room measuring 10 meters by 4 meters by 3 meters high in order to illuminate it best. For aesthetic reasons, we are asked to use a small number of incandescent bulbs. We want the bulbs to a total maximum of 300 watts. For a given number of bulbs, how should they be placed to maximize the intensity of the light in the darkest part of the room? We also would like to see how much improvement there is in going from one 300-watt bulb to two 150-watt bulbs to three 100-watt bulbs, and so on. To keep things simple, we assume there is no furniture in the room and that the light reflected from the walls is insignificant compared with the direct light from the bulbs.

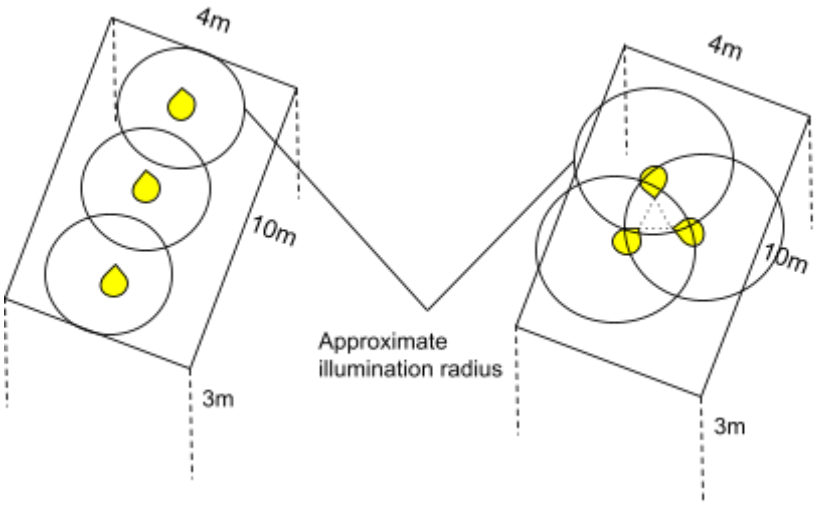
Answer:



Starting with one 300-watt bulb, we should ideally position it at the center of the ceiling to evenly distribute light throughout the room.



Using two 150-watt bulbs. Placing these bulbs equidistant from each other and from the walls could improve the spread of light. By dividing the ceiling into two sections and positioning the bulbs towards the center of each section, we can achieve better coverage, reducing the intensity of shadows in the room's corners and sides.



Moving on to three 100-watt bulbs, we have more flexibility in placement. We can place them in a line equidistant from each other or place them in the corners of an imaginary equilateral triangle at the center of the ceiling Distributing them evenly across the ceiling would maximize light dispersion.

One 300 Watt Light Bulb

If there is only one light bulb, then we want to put the bulb in the center in the center of the ceiling. Let's picture how well the floor is illuminated. We introduce coordinates x running from 0 to 10 in the long direction of the room, and y running from 0 to 4 in the short direction. The intensity at a given point, measured in watts per square meter, is the power of the bulb, 300, divided by 4π times the square of the distance of the bulb. Since the bulb is 3 meters above the point (5, 2) on the floor, at a point (x, y) on the floor, we can express the intensity as follows:

Answer:

Power of the bulb: 300 watts
Distance from the bulb(5, 2, 0) to a point on the floor(x, y, 0):

$D=\sqrt{(x-5)^2+(y-2)^2+(0-3)^2}$

Intenstiy(x, y)= $\frac{300}{4\pi \times D^2}$

We can use ezcontourf to plot this expression over the entire floor. We use the option colormap to arrange for a color gradation that helps us to see the illumination. See the online help for more colormap options.

Answer:

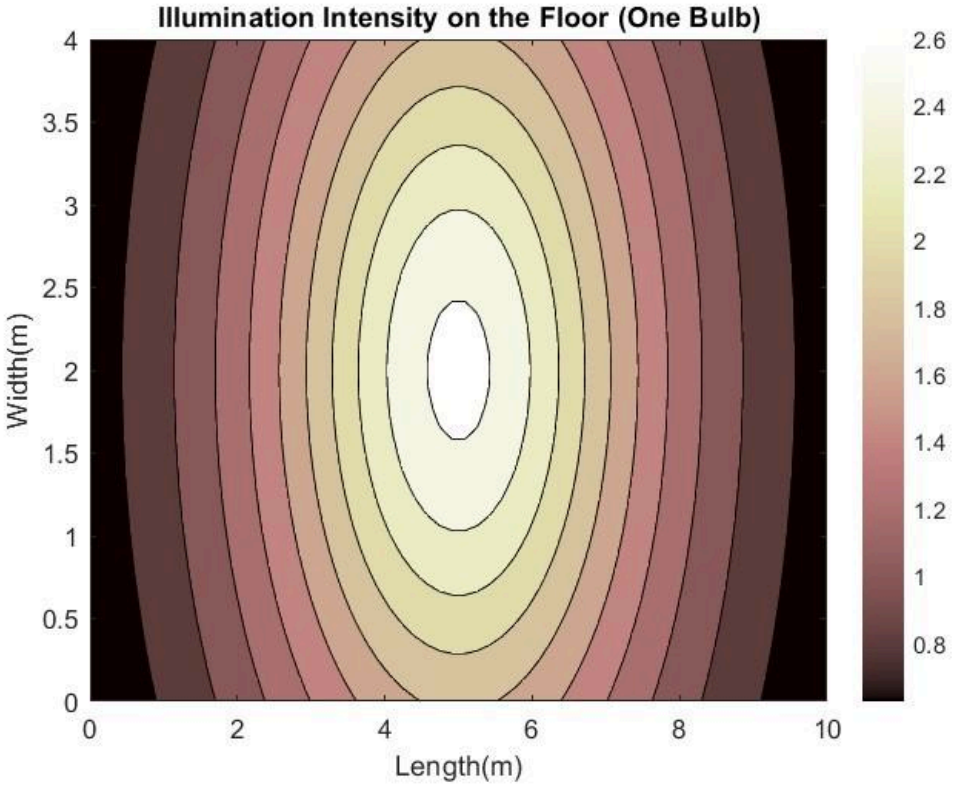
```
% room dimensions
l=10; % length
w=4; % width

% position of the bulb in the center of the ceiling
bulb_x =l/2;
bulb_y =w/2;
bulb_z =3; % height of the room

% power of the bulb
p = 300; % watts

% intensity function
i = @(x, y) p/(4*pi*(sqrt(((x-bulb_x)^2 + (y-bulb_y)^2 + bulb_z^2))^2));

% plot illumination
figure;
ezcontourf(i, [0, l], [0, w]);
colormap('pink');
colorbar;
xlabel('Length(m)');
ylabel('Width(m)');
title('Illumination Intensity on the Floor (One Bulb)');
```



The darkest parts of **the floor are the corners**. Let us find the intensity of the light at the corners and at the center of the room.

Answer:

The upper left corner on the floor is (0,0,0), then

$D=\sqrt{(0-5)^2+(0-2)^2+(0-3)^2}=\sqrt{38}$

Intenstiy(0,0,0)=$\frac{300}{4\pi\sqrt{38}^2}=0.6282.....$

The upper right corner on the floor is (10,0,0), then

$D=\sqrt{(10-5)^2+(0-2)^2+(0-3)^2}=\sqrt{38}$

Intensity(10,0,0)=$\frac{300}{4\pi\sqrt{38}^2}=0.6282.....$

The lower right corner on the floor is (0,4,0), then

$D=\sqrt{(0-5)^2+(4-2)^2+(0-3)^2}=\sqrt{38}$

Intenstiy(0,4,0)=$\frac{300}{4\pi\sqrt{38}^2}=0.6282.....$

The lower left corner on the floor is (10,4,0), then

$D=\sqrt{(10-5)^2+(4-2)^2+(0-3)^2}=\sqrt{38}$

Intenstiy(10,4,0)=$\frac{300}{4\pi\sqrt{38}^2}=0.6282.....$

The center on the floor is (5,2,0), then

$D=\sqrt{(5-5)^2+(2-2)^2+(0-3)^2}=\sqrt{9}=3$

Intenstiy(5,2,0)=$\frac{300}{4\pi\times3^2}=2.65\ W/m^2$