Tutorial Exercise 01 – Lighting Calculations (Solutions)

1. A general area requires a lighting level of 500 lux from a regular array of louvred luminaries. Given the following data calculate the number of luminaries required and arrange a suitable layout.

   Room dimensions are: length 8 m, width 8 m, height 2.8 m
   Room reflectances: ceiling 0.7, walls 0.5, working plane cavity 0.2
   Working plane height = 0.8 m

Utilisation Factor (*UF*) table for 0.7, 0.5, 0.2 reflectances (*RI* = room index)								
RI =	1.00	1.25	1.50	2.00	2.50	3.00	4.00	5.00
UF =	0.45	0.50	0.53	0.58	0.61	0.63	0.66	0.67

   Maintenance factor = 0.75
   Maximum space to height ratio = 1.75
   Luminaire versions available:
   2 x 1800 mm 70W (each lamp gives) 6550 lumens
   2 x 1500 mm 58W (each lamp gives) 5400 lumens
   2 x 1200 mm 36W (each lamp gives) 3450 lumens
   [Ans.: *RI* = 2.0, *UF* = 0.58, 9 luminaries, layout 3 by 3]

Answer:

(i) Calculate room index and obtain UF value: with a working plane height of 0.8 m, h_m = 2.8 – 0.8 = 2 m; so RI = L x W / h_m (L + W) = 8 x 8 / 2 (8+8) = **2**. From table, **UF = 0.58**; MF = 0.75 (given).

(ii) Calculate the total lumens required: Using the lumen method formula:
E = F x n x UF x MF / A
F x n = E x A / (UF x MF) = 500 x 8 x 8 / (0.58 x 0.75) = 73,563 lumens

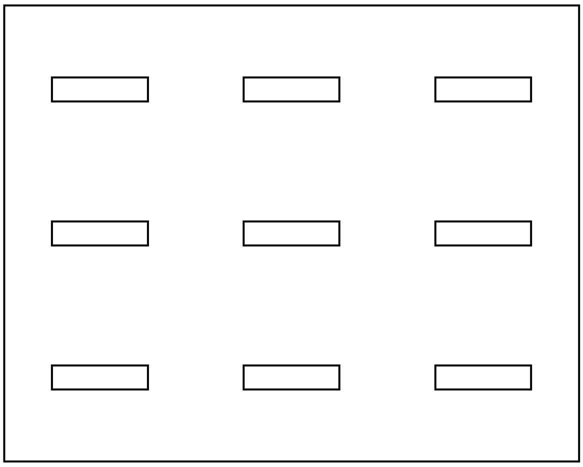
(iii) Calculate the number of luminaires:
The minimum number of luminaires will give the minimum number of electrical points and so the largest lamp size should be tried first. There are 2 lamps per luminaire: two 70W lamps give 2 x 6550 lumens = 13,100 lumens. Therefore, n = 73,563/13,100 = 5.6 luminaires. This would be rounded up to 6 luminaires arranged in two rows of three. Will the spacing for two rows exceed the maximum specified by the manufacturer?

Width of office = 8 m, spacing between rows 4 m with 2 m to the wall at each side. The maximum spacing/mounting height ratio from the manufacturer is S/h_m = 1.75. If h_m = 2 m, so allowable spacing is S = 1.75 x 2 = 3.5 m. It is necessary to have 9 luminaires in 3 rows to provide acceptable uniformity.

Recalculate lamp output = 73,563/(9 x 2) = 4,087 lumens

The only available lamp size that will provide 500 lux or more is the 58 W lamp giving 5,400 lumens. This solution will give a higher illuminance than that specified, but this is a common outcome and has to be accepted. The new illuminance value is = 5,400 x 18 x 0.58 x 0.75 / 64 = 660 lux.

The spacing for 9 luminaires would be 8/3 = 2.7 m with 1.3 m at the walls. S/h_m = 2.7/2 = 1.35, which is well within the 1.75 limit. The luminiare layout is shown below. Please note that the room shape, uniformity requirements and the available luminaire/lamp combinations may dictate solutions that give a higher performance than the minimum recommendations.



2. A laboratory has dimensions 9 m (depth) x 9 m (width) x 3.4 m (height) and one single-glazed window of 4 m (width) x 2.5 m (height) on the exterior wall. The angle of sky component is 60 degrees, the maintenance factor is 0.75 and the reflection factor is 0.7. Determine the average daylight factor of this room.

Given: $DF = \dfrac{T \times G \times \theta \times MF}{A \times (1 - R^2)}$

where DF = average daylight factor (%)

T = light transmittance (assume 0.85 for clear single glazing)

G = glazed window area (m^2)

θ = angle of sky component (degree)

MF = maintenance factor

A = total area of interior surfaces including windows (m^2)

R = reflection factor

If the window is changed to one double-glazed window (light transmittance is 0.5) of 5 m (width) x 2.4 m (height), what would the average daylight factor be?

[Ans.: DF = 2.64%, when the window is changed to double-glazed DF = 1.86%]

Answer:

(i) Total area of interior surfaces = [(9x9) + (9x3.4) + (9x3.4)] x 2 = 284.4 m^2

Average daylight factor of this room:

DF = [0.85 x (4x2.5) x 60 x 0.75] / [284.4 x (1 – 0.7^2)] = **2.64%**

(ii) If the window is changed to one double-glazed window (light transmittance is 0.5) of 5 m (width) x 2.4 m (height), the average daylight factor is:

DF = [0.5 x (5x2.4) x 60 x 0.75] / [284.4 x (1 – 0.7^2)] = **1.86%**