ASIA PACIFIC UNIVERSITY TECHNOLOGY & INNOVATION

EE037-3-2 ELECTRICAL POWER UTILIZATION
INDIVIDUAL ASSIGNMENT

TITLE	DESIGN OF LIGHTING SCHEME
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DATE	06-01-2024

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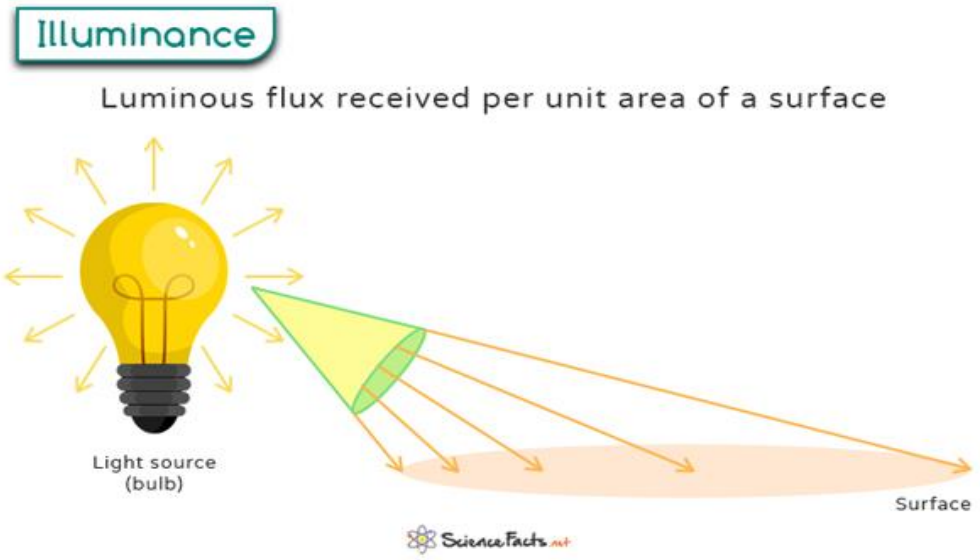
Theoretical Concepts Using Research Techniques

The lighting schemes that were the subject of this project considered the luminaire specs, luminance flux, colour temperature, illuminance, and number of lights.

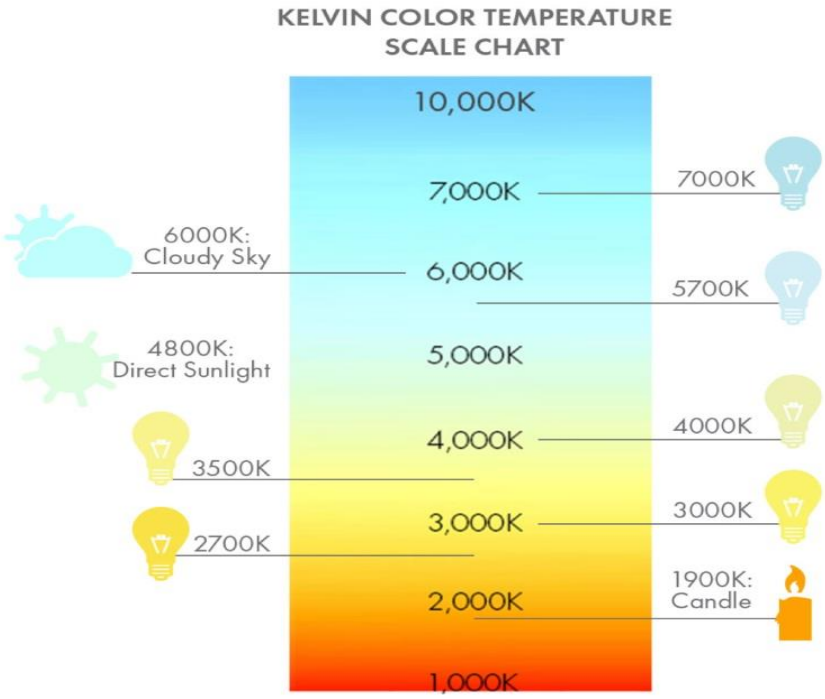
The definitions of the lighting schemes discussed above, together with an explanation of reliable sources, are provided in the sections below:

1) **Luminance flux:** The total amount of light energy emitted in all directions in a second. A lumen (lm) is the unit of light flux. [guideline], Assists in achieving the right illumination levels in a variety of commercial, industrial, and residential settings, guaranteeing both functionality and aesthetic appeal. [Luminous Flux: Sciencefacts.net - Definition, Unit, and Applications], application]
2) **Luminaire specification:** A data sheet comprising the following information: colour temperature, polar intensity diagram, luminous efficacy, input power/wattage, lumen output/luminous flux, and Colour Rendering Index (CRI). [page 4, 2.1]
3) **Illuminance:** The amount of light that reaches a specific surface area; the lux unit aids in dispersing light evenly, reduces glare, and guarantees constant lighting quality.



4) **Number of lamps:** First, ascertain the level of illumination needed for a given application. Next, compute the gross lumen needed based on the area of the room and divide the result by the maintenance factor and the utilisation coefficient. Determine the number of fittings and choose bulbs with the desired models and efficacy.

5) **Colour Temperature:** Denotes the colour of light emitted by a light source when heated to a particular temperature and is measured in Kelvin (K). Improves the room's colour appearance and atmosphere, leading to better interior design. [Identical] Affect one's capacity for efficient job completion; colder lights (5000k and above) are frequently chosen for activities requiring attention and concentration, while warmer lighting (around or below 4000k) can foster a cosier and more relaxed environment.



Design Implementation

The design of lighting scheme before the simulation shown in Figure 1.

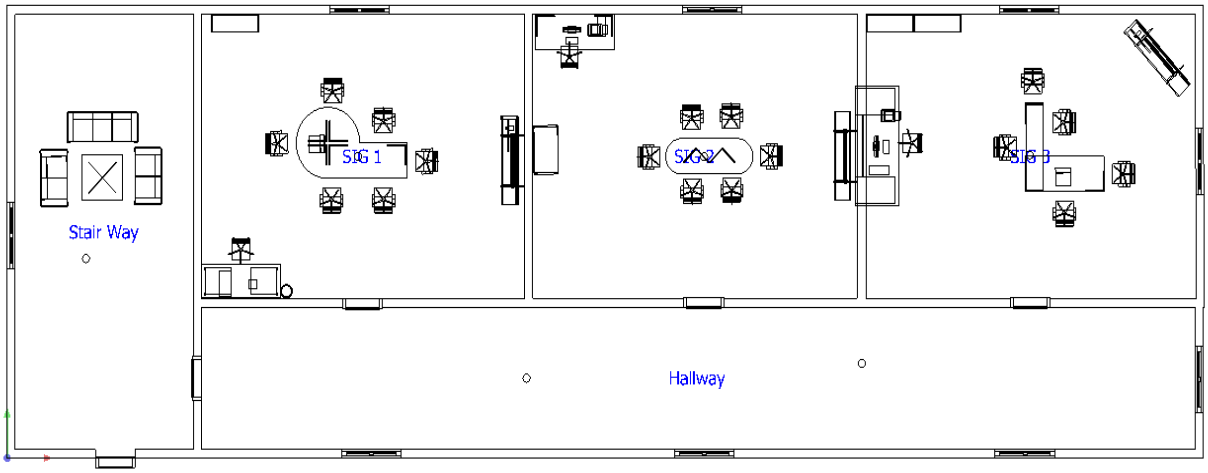


Figure 1: Lighting scheme before simulation.

There are three room in this space named SIG-1 (Art room), SIG-2 (Academic room) and SIG-3 (Cultural room), one hallway and one stairway. Guidelines on Occupational Safety and Health for Lighting at Workplace are cited in most Lux recommendations for three themed rooms, one hallway and one stairway.

Standard maintained illuminance (lux)	Space type
300	Classrooms
500	Library
500	Lecture hall
500	Black board
500	Art room
750	Technical drawing room
200	Entrance hall
100	Circulation area, corridor
150	Stairs
200	Student common room, assembly hall

		Standard Maintained Illuminance lux	Uniformity Ratio	Limiting Glare Index
1.	General Teaching Spaces	300 *	0.8	19
2.	Teaching Spaces with close and detailed work (eg, art and craft rooms)	500 *	0.8	19
3.	Circulation Spaces: corridors, stairs	80 - 120	-	19
	entrance halls, lobbies & waiting areas	175 - 250	-	19
	reception areas	250 - 350	-	19
4.	Atria	400 *	-	19

1) **Art Room (SIG-1):** Creating an art room is an exciting project that combines creativity and usefulness. It's a place where creative expression has no boundaries, where colours dance, and where imagination runs wild.

   a) The measurements of the room have been thoroughly examined.

   b) Recommended Lux: 566 lux

   c) Lamp Selection: Industrial Area master LED High Bay 400W IAMLED77YBU1

   d) Design of lighting scheme:

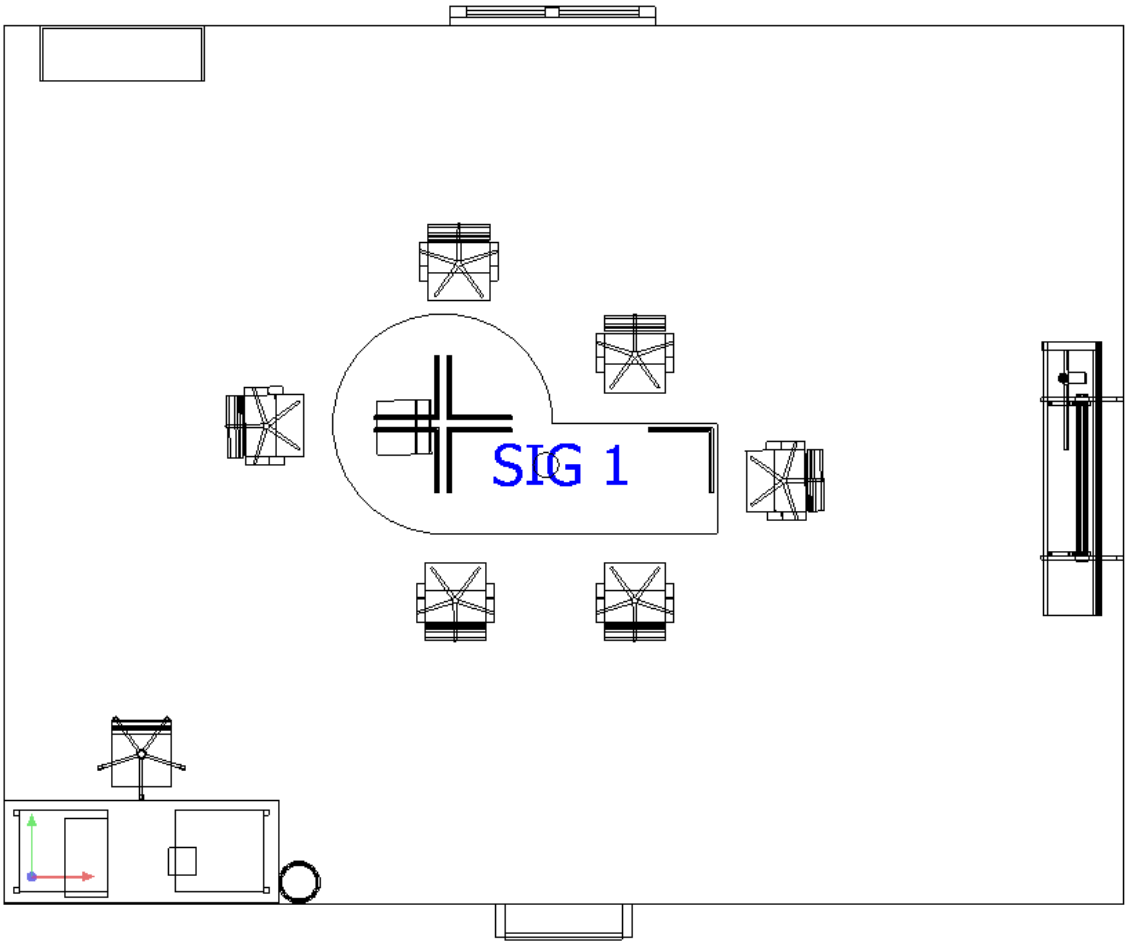


Figure 2:Lighting scheme of SIG-1(a) before simulation.

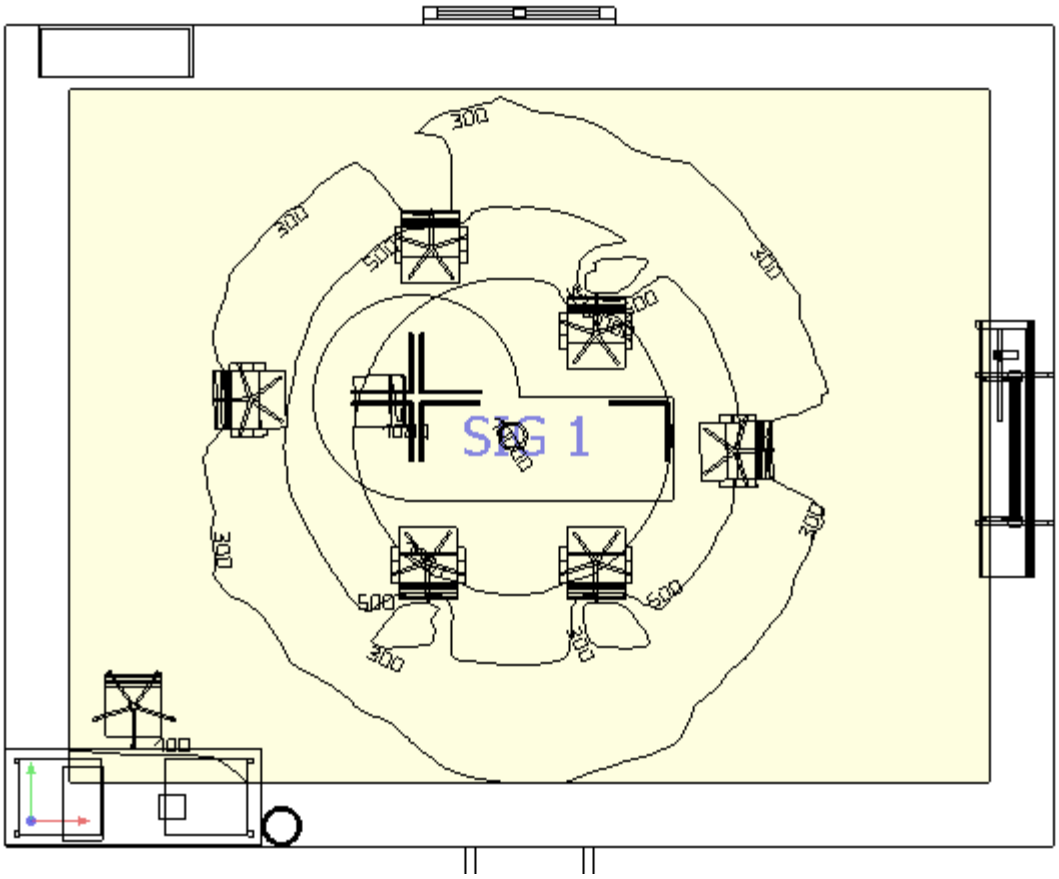
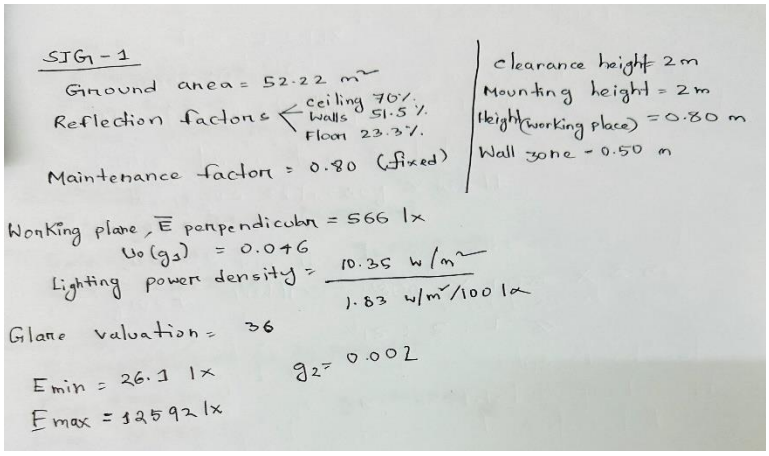


Figure 3:Lighting scheme of SIG-1(b) before simulation.

e) Calculation:



2) **Academic Room (SIG-2):** A judicious balance between functionality and a favourable learning atmosphere is necessary when designing an academic space. It's a place where ideas are developed, curiosity is encouraged, and knowledge is exchanged.
   a) The room's design tone reflects a minimalist aesthetic.
   b) Recommended Lux: 565 lux
   c) Lamp Selection: Industrial Area master LED High Bay 400W IAMLED77YBU1
   d) Design of Lighting scheme:

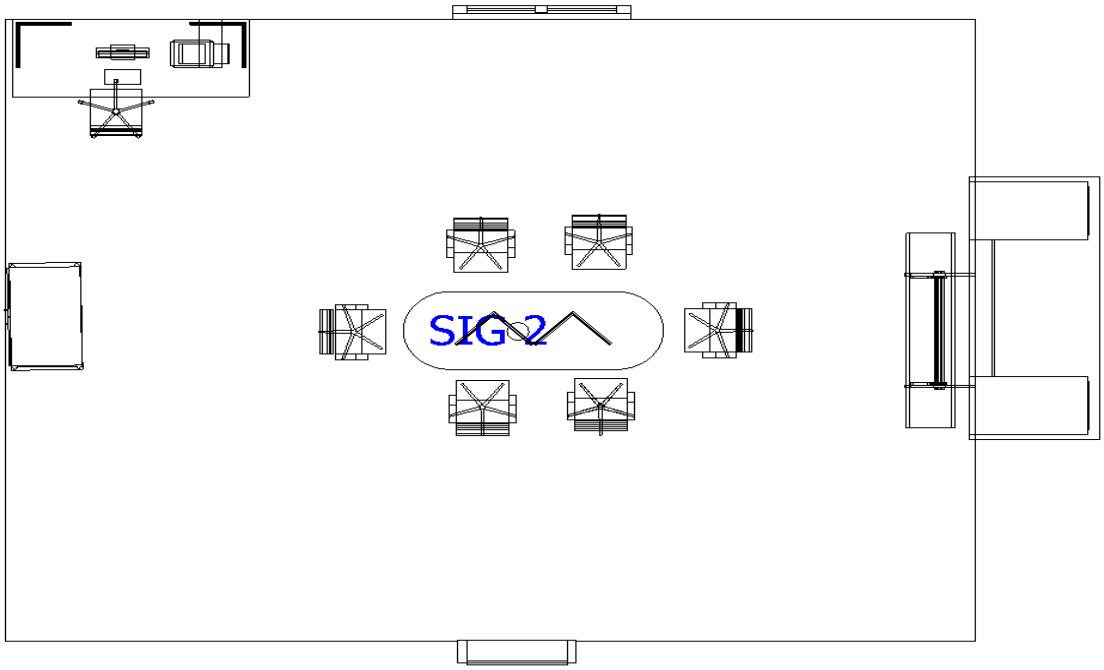


Figure 4:Lighting scheme of SIG-2(a) before simulation.

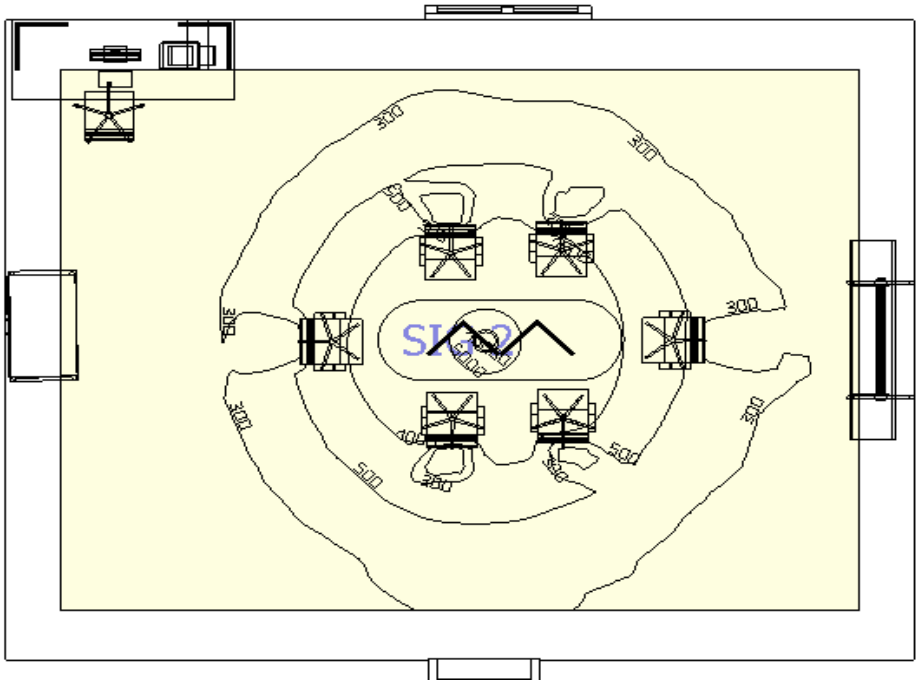
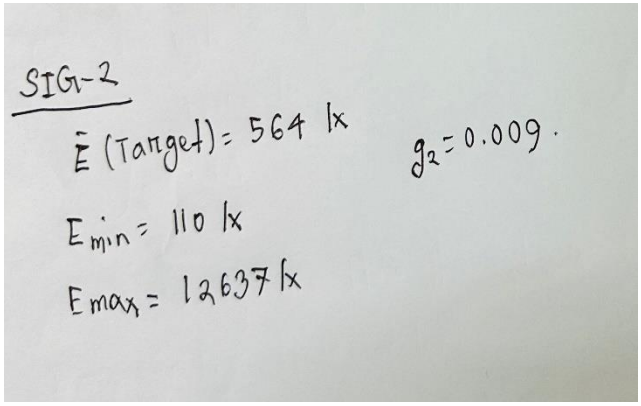


Figure 5:Lighting scheme of SIG-2(b) before simulation.

e) Calculation:



3) **Cultural Room (SIG-3):** Creating a cultural space offers a special chance to honour history, diversity, and the arts. It's a place where ties between generations and cultures are made, customs are respected, and stories are exchanged.

a) Recommended Lux:537 lux

b) Lamp Selection: Industrial Area master LED High Bay 400W IAMLED77YBU1

c) Design of Lighting Scheme:

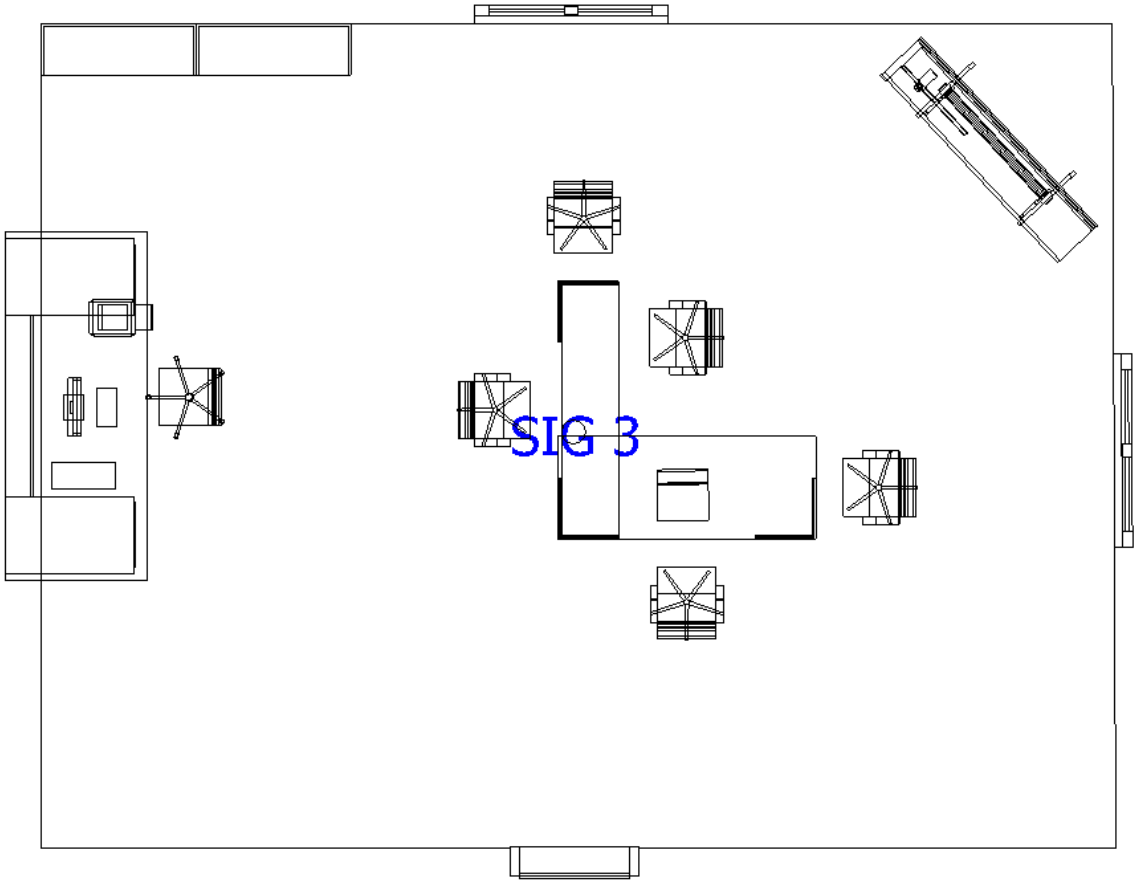


Figure 6:Lighting scheme of SIG-3(a) before simulation.

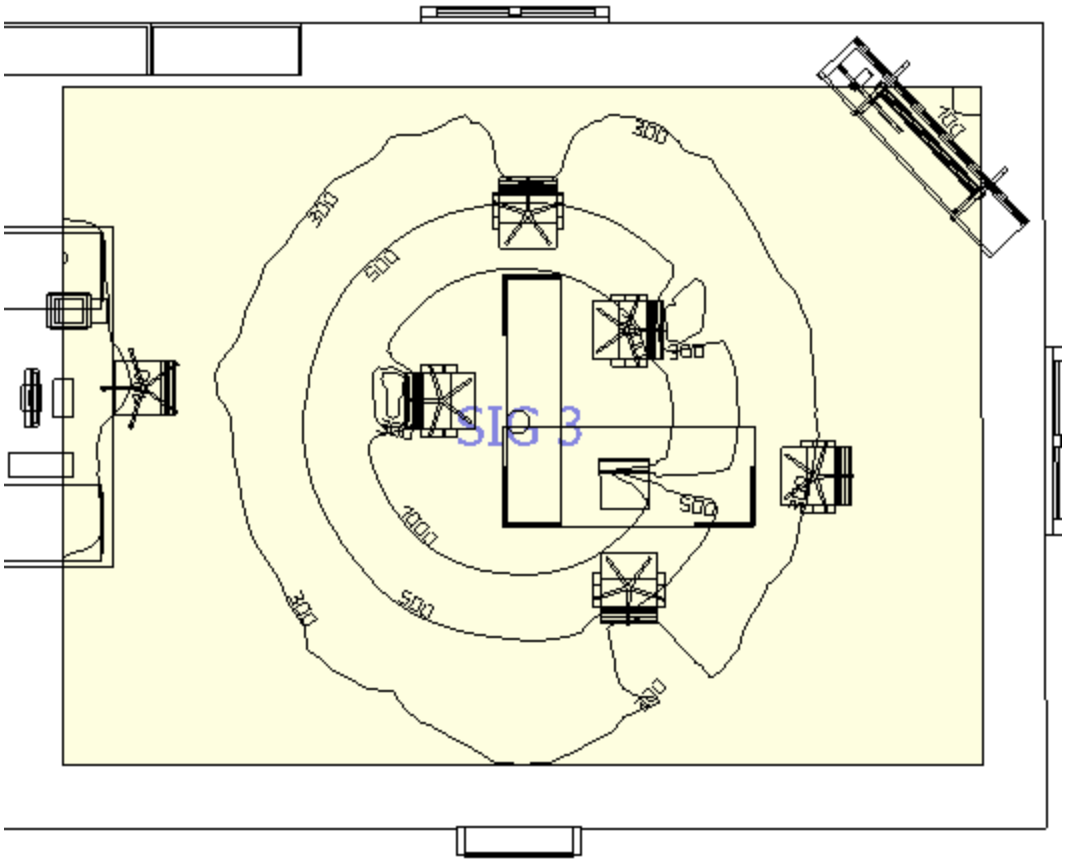
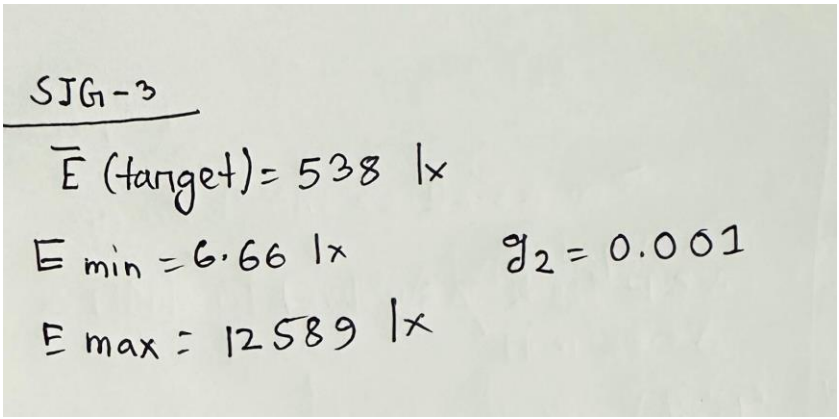


Figure 7:Lighting scheme of SIG-3(b) before simulation.

d) Calculation:



4) Hallway: Like a building's arteries, hallways connect its various sections and make travel easier. They could be beautiful architectural details or just plain transitional areas.
   a) Recommended Lux: 646 lux.
   b) Lamp Selection: Industrial Area master LED High Bay 400W IAMLED77YBU1
   c) Design of Lighting Scheme:

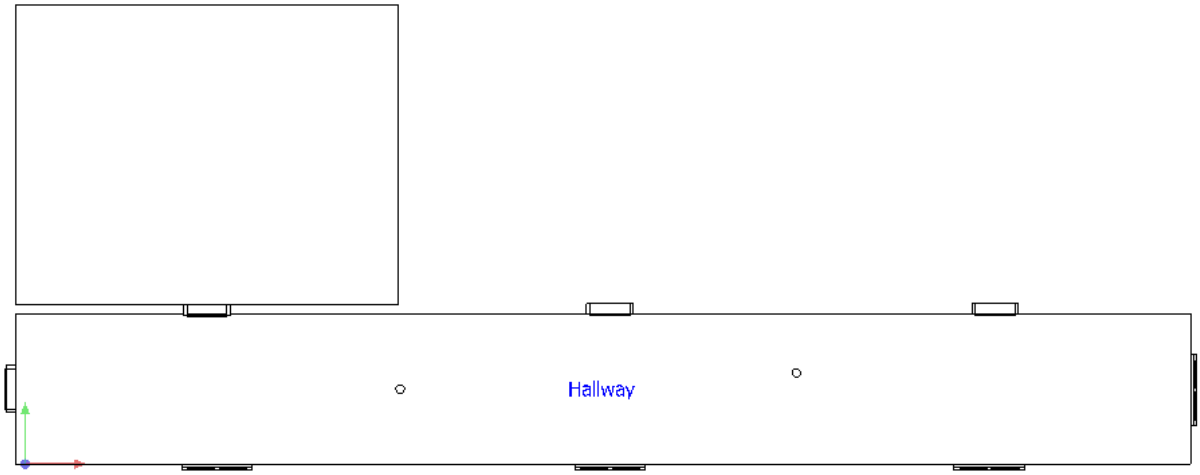
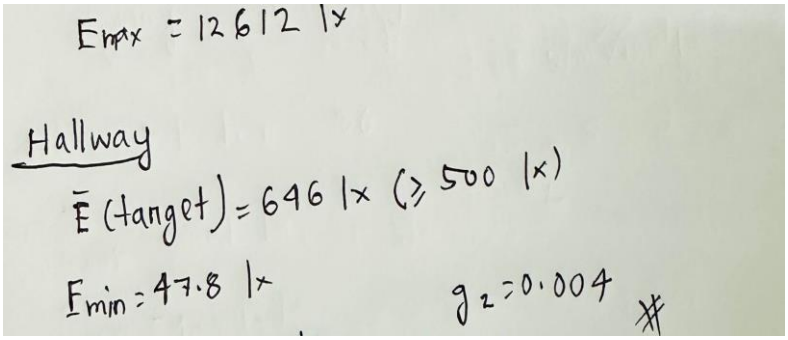


Figure 8:Lighting scheme of Hallway.

   d) Calculation:



5) **Stairway:** The staircase is an intriguing example of architecture that skilfully blends form and function. In addition to vertical circulation, they offer a stage for artistic expression. There are many different shapes, sizes, and styles of stairs; from grand, sweeping staircases seen in palaces to simple, useful ones found in homes, there is no shortage of staircase variation.
   a) Recommended lux: 619 lux
   b) Lamp Selection: Industrial Area master LED High Bay 400W IAMLED77YBU1
   c) Design of Lighting scheme:

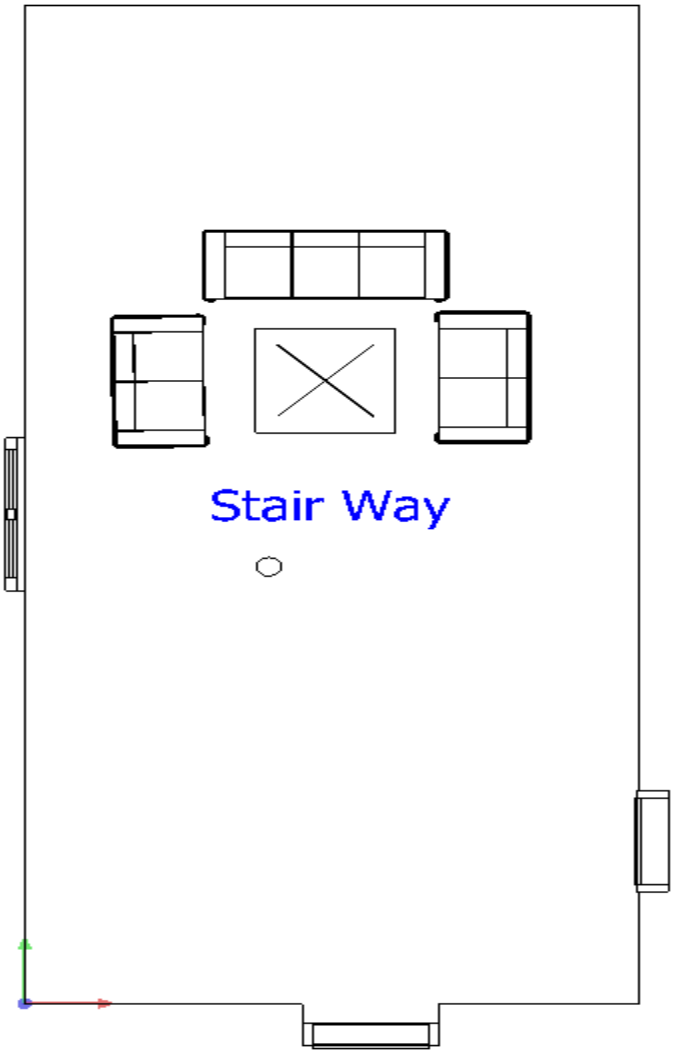
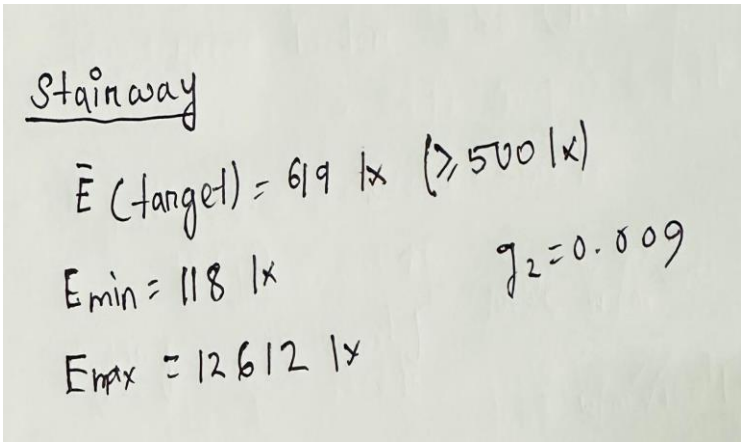
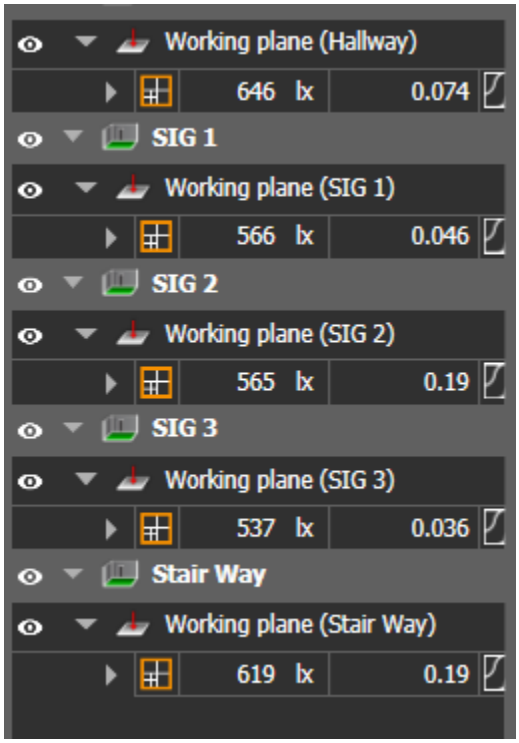


Figure 9:Lighting scheme of Stairway.

d) Calculation:





The Lux of the whole simulation.

Simulation Results

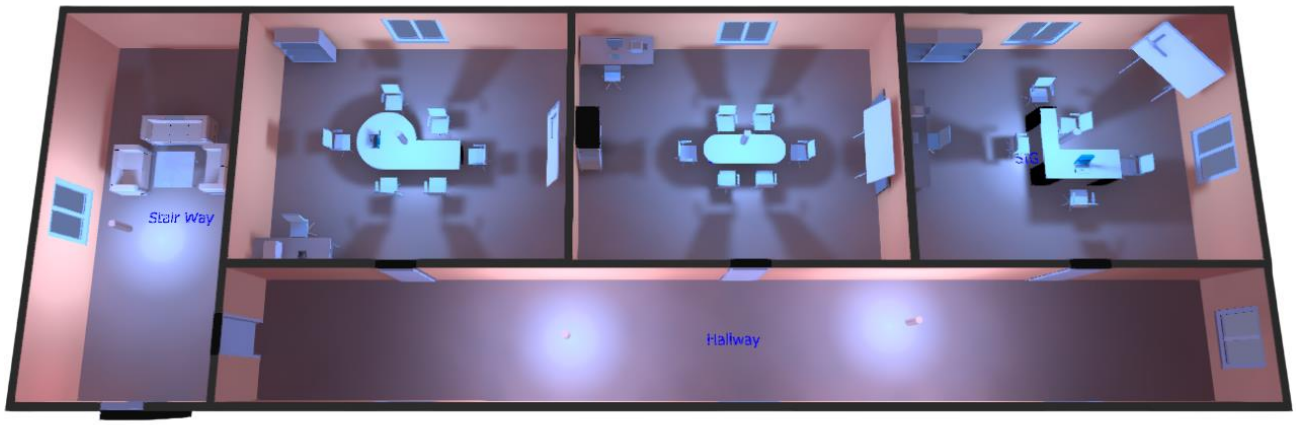


Figure 10:Top view of Lighting scheme design after simulation.

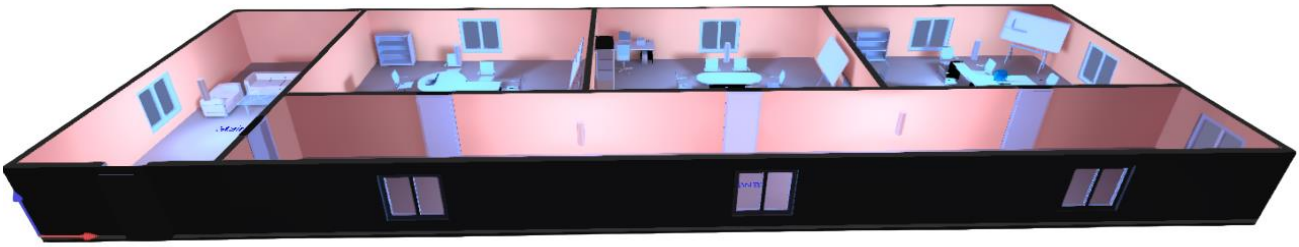


Figure 11:Side view of Lighting scheme design after simulation.

Figure 12:Lighting scheme of SIG-1(a) after simulation.

Figure 13:Lighting scheme of SIG-1(b) after simulation.

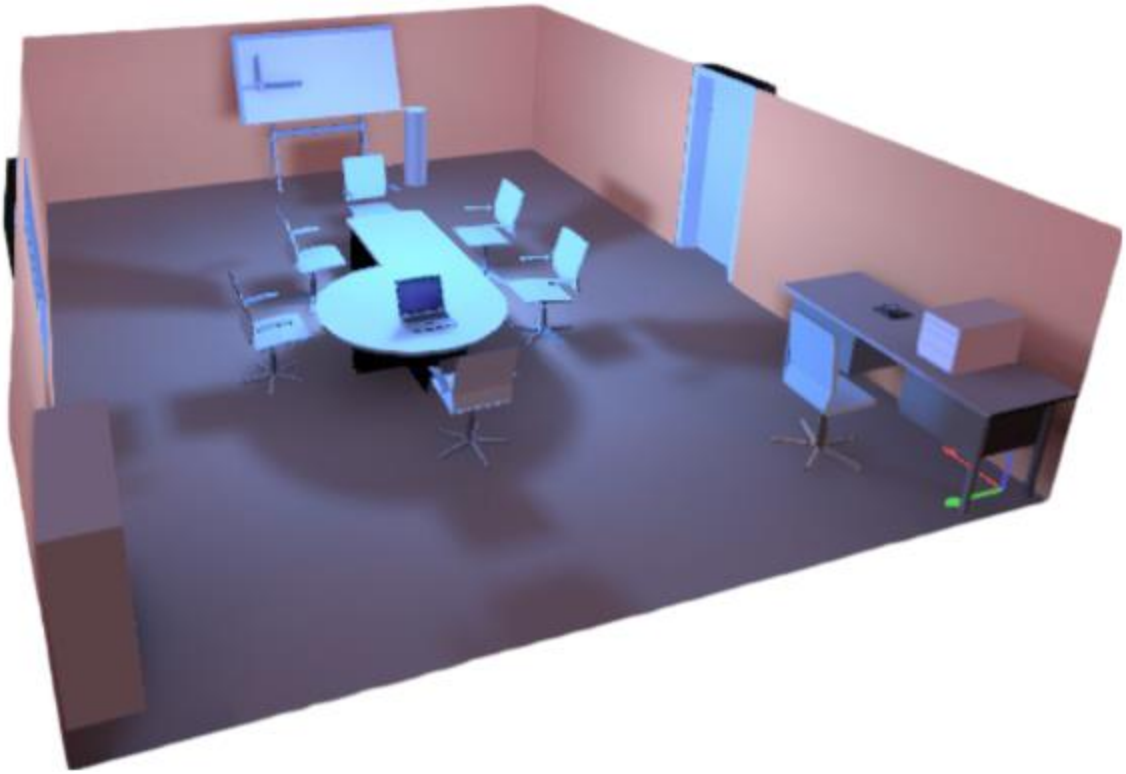


Figure 14:Lighting scheme of SIG-1(c) after simulation.

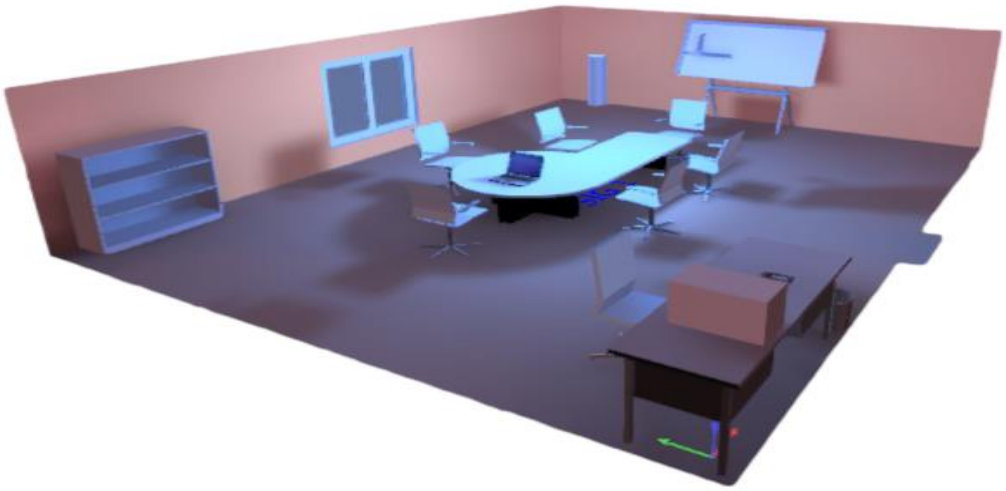


Figure 15:Lighting scheme of SIG-1(d) after simulation.

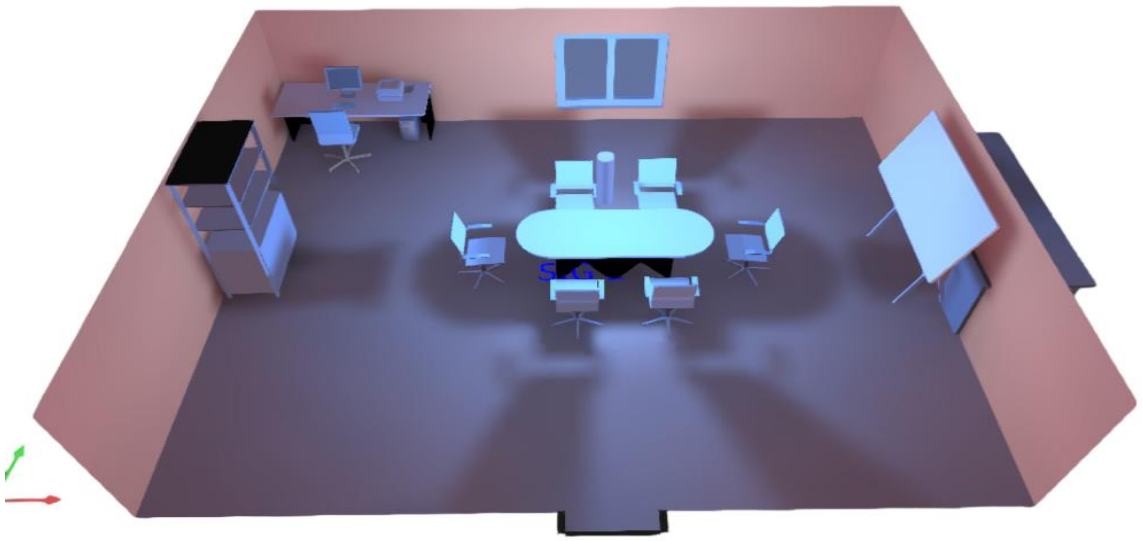


Figure 16:Lighting scheme of SIG-2(a) after simulation.

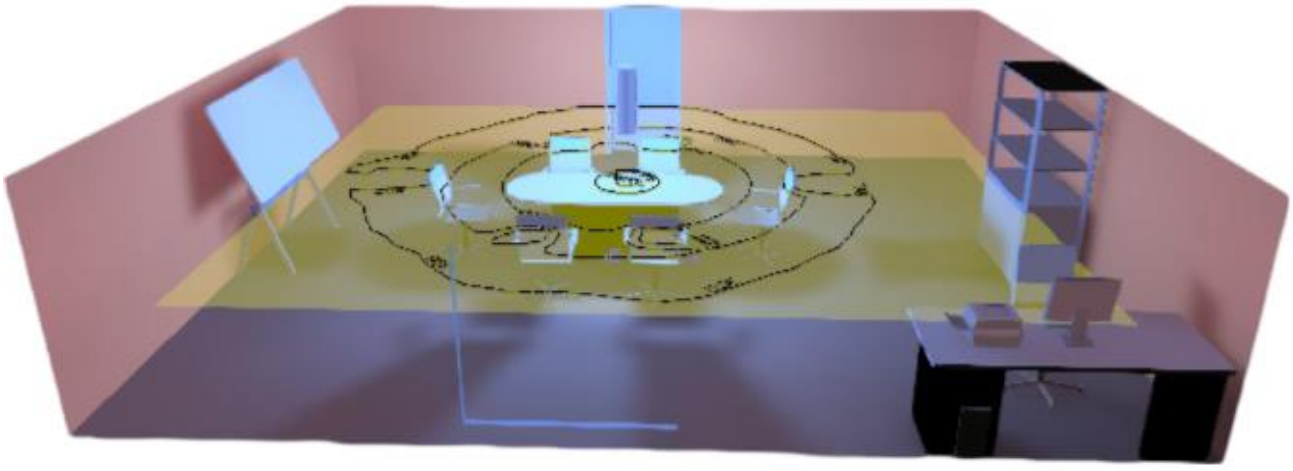


Figure 17:Lighting scheme of SIG-2(b) after simulation.

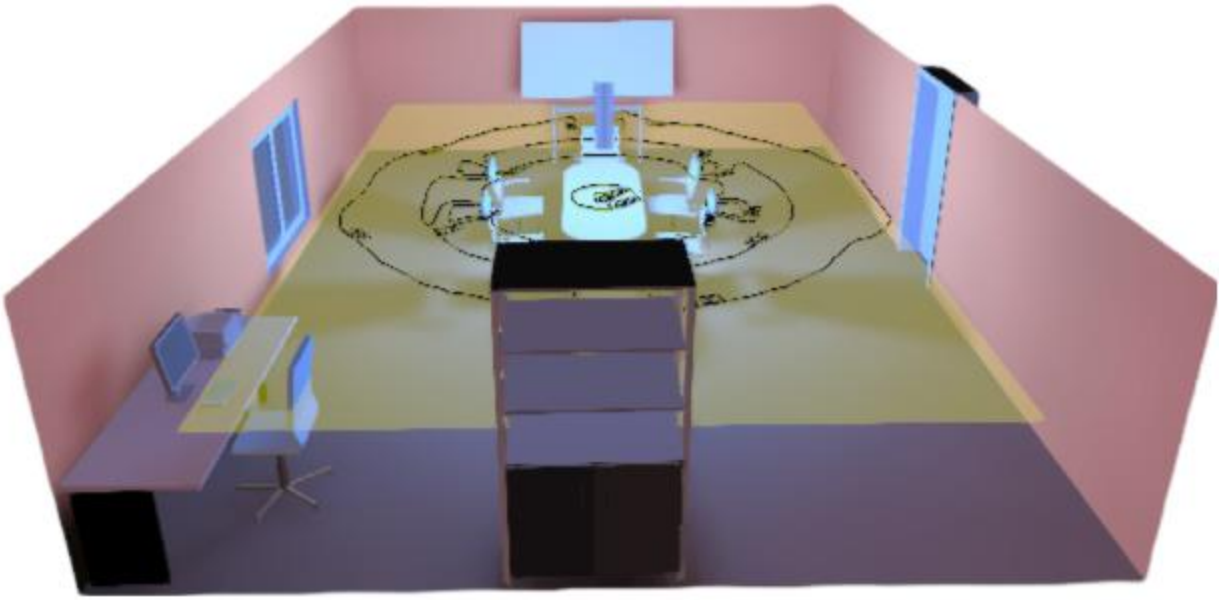


Figure 18:Lighting scheme of SIG-2(c) after simulation.

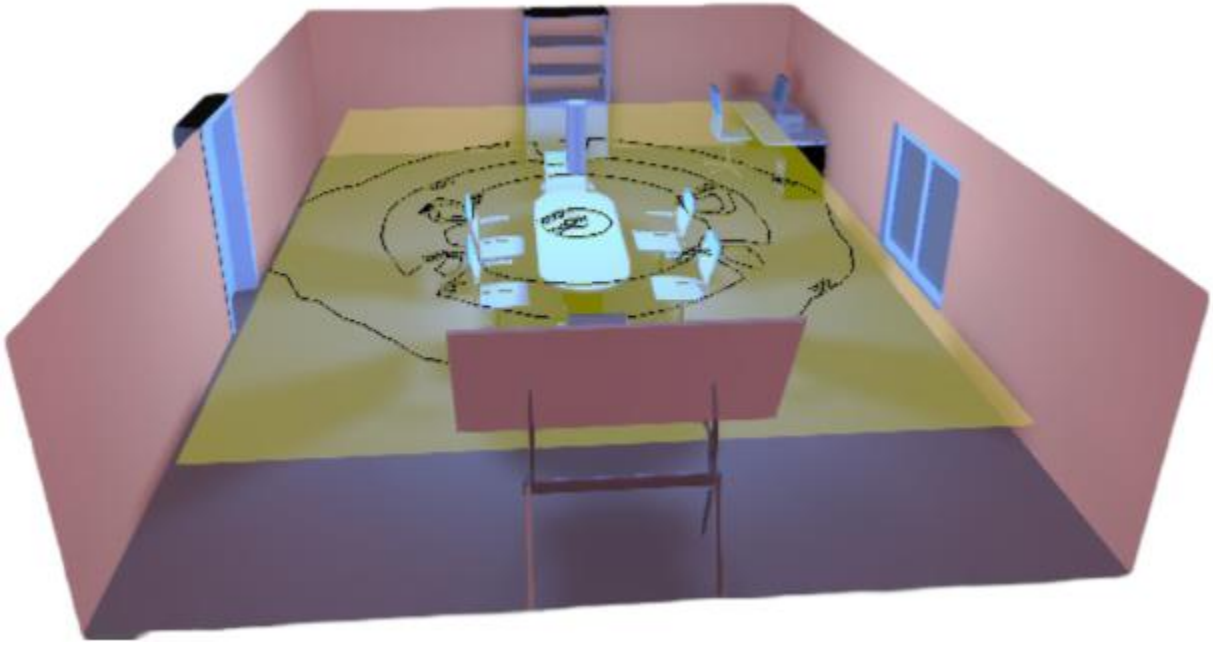


Figure 19:Lighting scheme of SIG-2(d) after simulation.

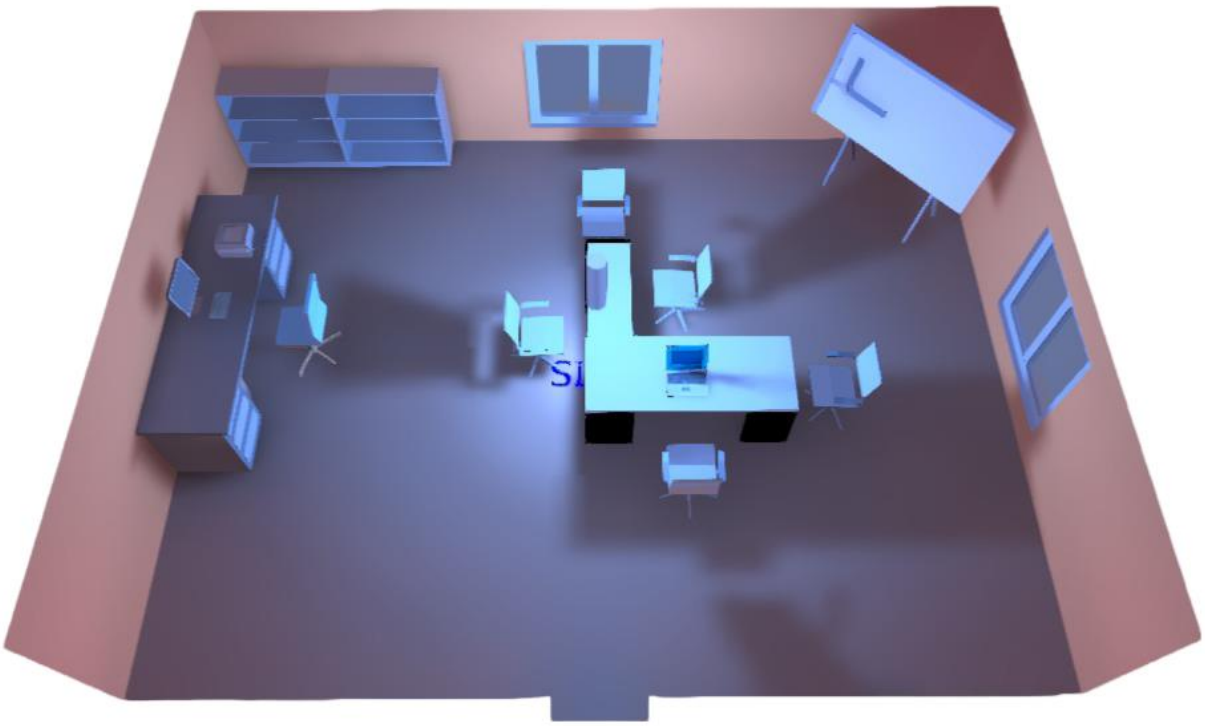


Figure 20:Lighting scheme of SIG-3(a) after simulation.

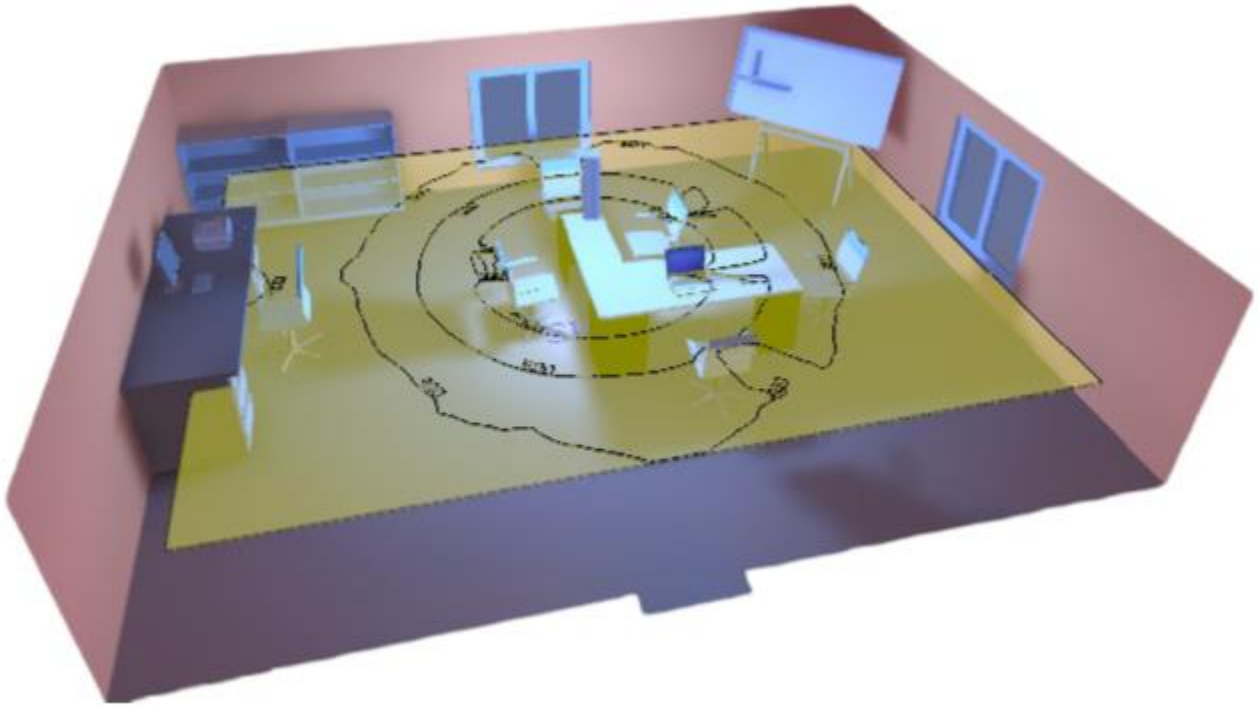


Figure 21:Lighting scheme of SIG-3(b) after simulation.

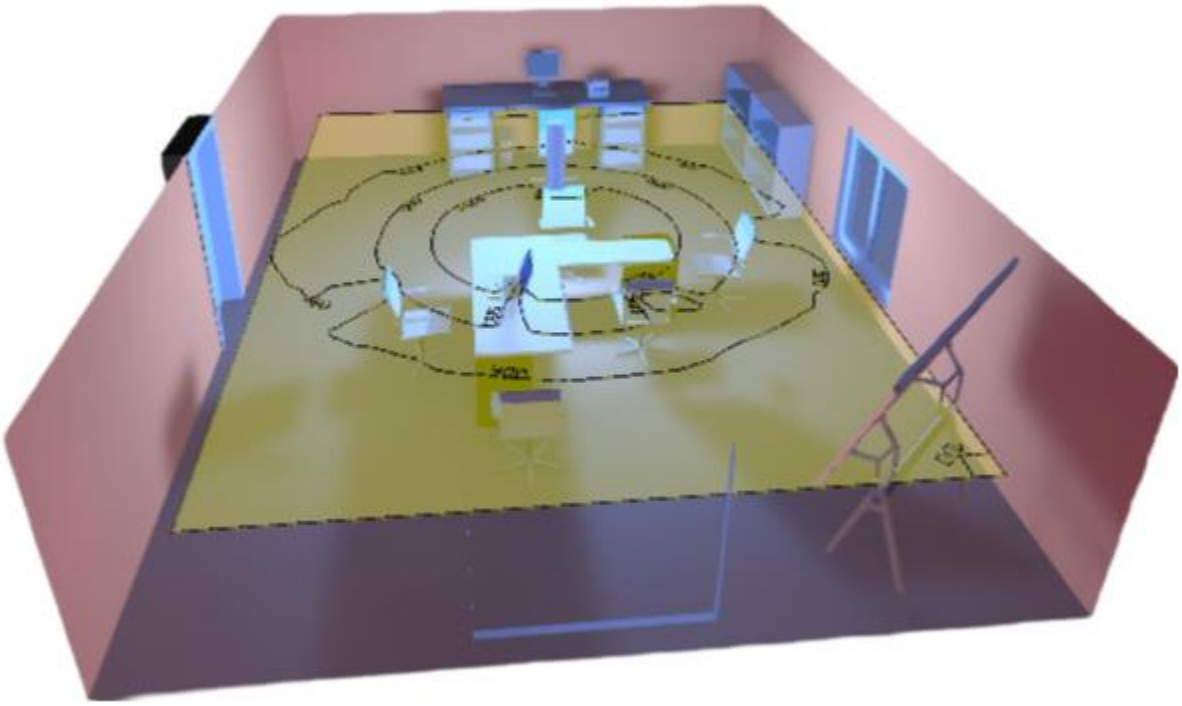


Figure 22:Lighting scheme of SIG-3(c) after simulation.

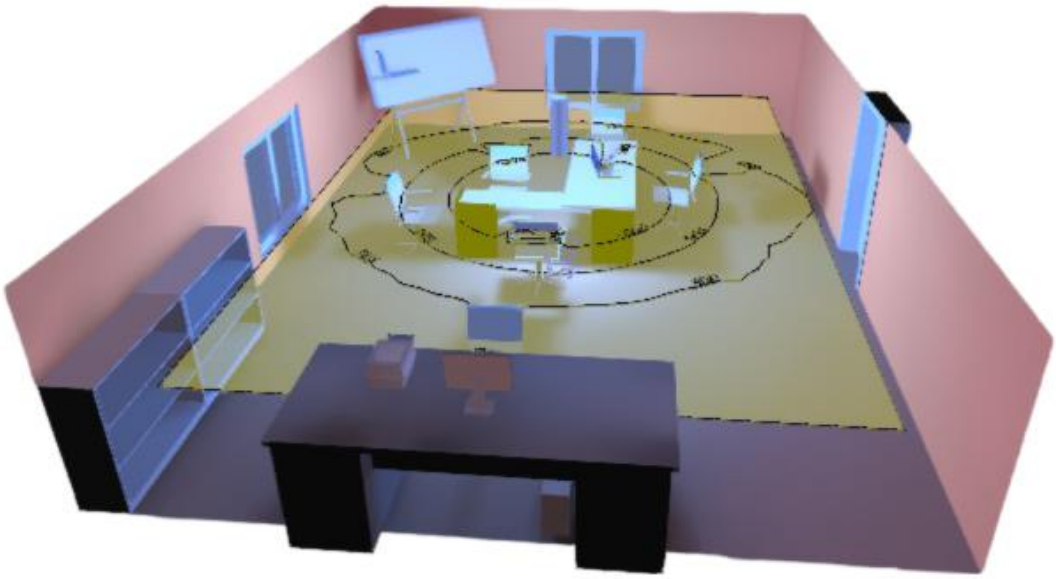


Figure 23:Lighting scheme of SIG-3(d) after simulation.

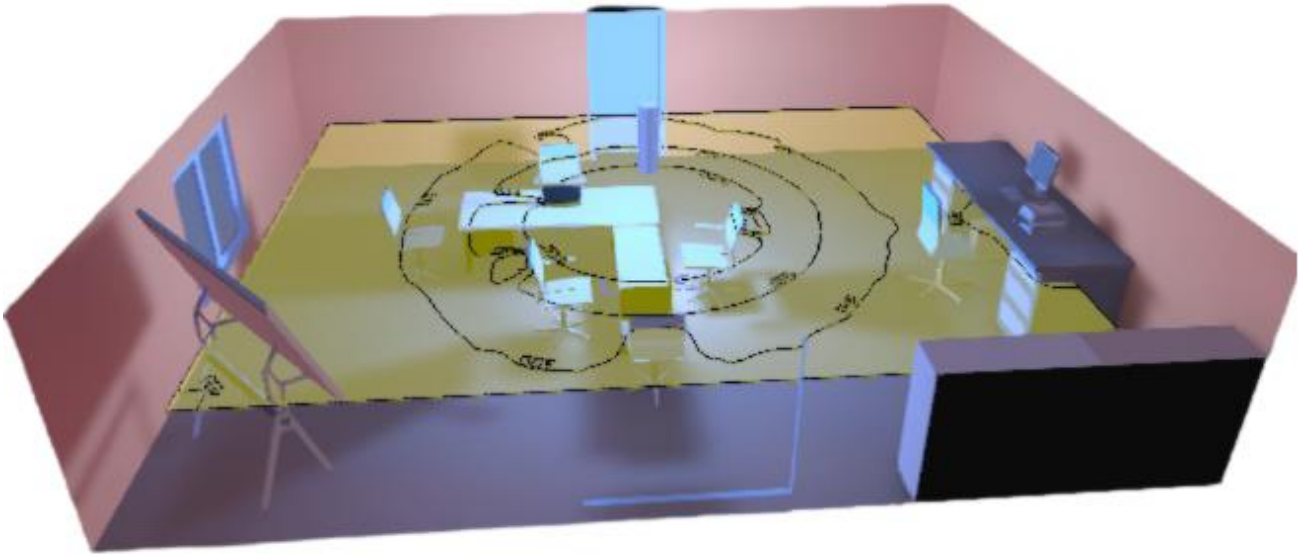


Figure 24:Lighting scheme of SIG-3(e) after simulation.

Figure 25:Lighting scheme of Hallway after simulation.

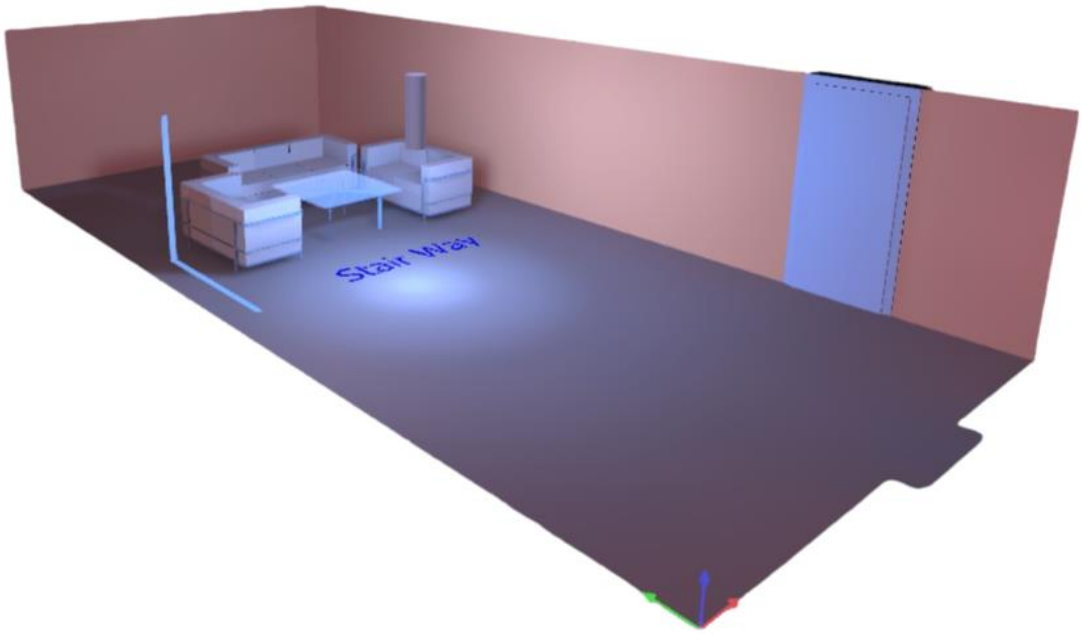
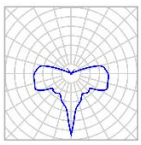


Figure 26: Lighting scheme of Stairway after simulation.

Building 1 · Storey 1 · SIG 1

Luminaire layout plan



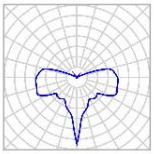
Manufacturer	Eaton´s Crouse-Hinds Business	P	400.0 W
Article No.	EVM	$\Phi_{Luminaire}$	30903 lm
Article name	EVMA92400-S828		
Fitting	1x MS400/BU/PS		

Individual luminaires

X	Y	Mounting height	Luminaire
3.753 m	2.999 m	2.000 m	1

Building 1 · Storey 1 · SIG 2

Luminaire layout plan



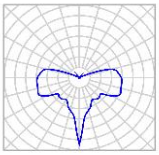
Manufacturer	Eaton´s Crouse-Hinds Business	P	400.0 W
Article No.	EVM	$\Phi_{Luminaire}$	30903 lm
Article name	EVMA92400-S828		
Fitting	1x MS400/BU/PS		

Individual luminaires

X	Y	Mounting height	Luminaire
5.700 m	2.990 m	2.000 m	1

Building 1 · Storey 1 · SIG 3

Luminaire layout plan



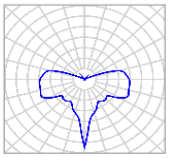
Manufacturer	Eaton´s Crouse-Hinds Business	P	400.0 W
Article No.	EVM	$\Phi_{Luminaire}$	30903 lm
Article name	EVMA92400-S828		
Fitting	1x MS400/BU/PS		

Individual luminaires

X	Y	Mounting height	Luminaire
25.822 m	6.831 m	2.000 m	1

Building 1 · Storey 1 · Hallway

Luminaire layout plan



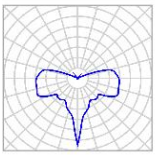
Manufacturer	Eaton´s Crouse-Hinds Business	P	400.0 W
Article No.	EVM	$\Phi_{Luminaire}$	30903 lm
Article name	EVMA92400-S828		
Fitting	1x MS400/BU/PS		

Individual luminaires

X	Y	Mounting height	Luminaire
16.482 m	1.939 m	2.000 m	1
8.013 m	1.600 m	2.000 m	2

Building 1 · Storey 1 · Stair Way

Luminaire layout plan

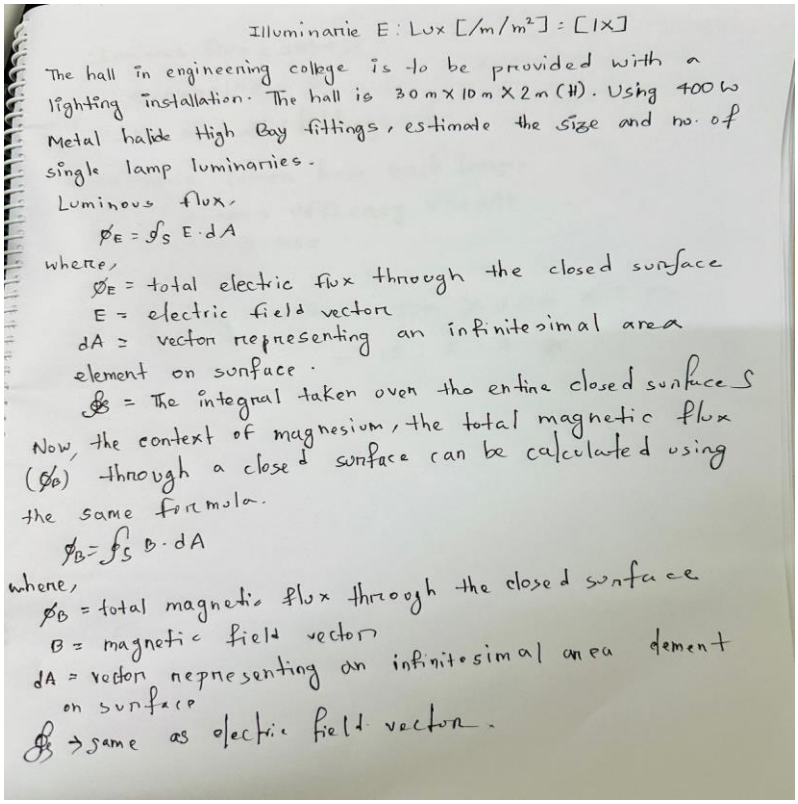


Manufacturer	Eaton´s Crouse-Hinds Business	P	400.0 W
Article No.	EVM	$\Phi_{Luminaire}$	30903 lm
Article name	EVMA92400-S828		
Fitting	1x MS400/BU/PS		

Individual luminaires

X	Y	Mounting height	Luminaire
1.787 m	4.292 m	2.000 m	1

Analysis and Discussion



Illuminarie E: Lux [/m/m²] = [lx]

The hall in engineering college is to be provided with a lighting installation. The hall is 30 m × 10 m × 2 m (H). Using 400 W Metal halide High Bay fittings, estimate the size and no. of single lamp luminaries.

Luminous flux.

$\Phi_E = \oint_S E \cdot dA$

where,

Φ_E = total electric flux through the closed surface

E = electric field vector

dA = vector representing an infinitesimal area element on surface.

$\oint_S$ = The integral taken over the entire closed surface S

Now, the context of magnesium, the total magnetic flux (Φ_B) through a closed surface can be calculated using the same formula.

$\Phi_B = \oint_S B \cdot dA$

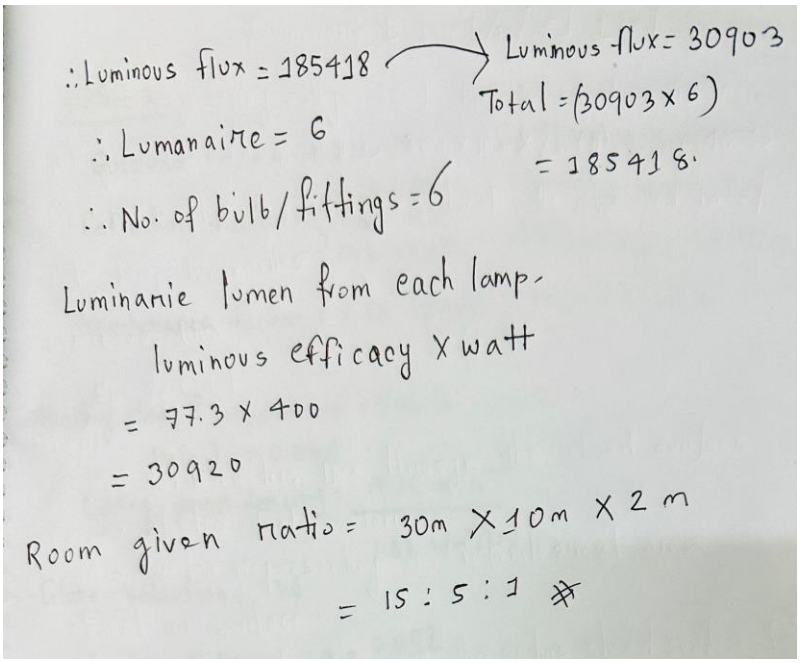
where,

Φ_B = total magnetic flux through the closed surface

B = magnetic field vector

dA = vector representing an infinitesimal area element on surface

$\oint_S$ → same as electric field vector.



∴ Luminous flux = 185418 → Luminous flux = 30903

Total = (30903 × 6)

= 185418.

∴ Lumanaire = 6

∴ No. of bulb/fittings = 6

Luminarie lumen from each lamp.

luminous efficacy × watt

= 77.3 × 400

= 30920

Room given ratio = 30m × 10m × 2m

= 15 : 5 : 1

Flux, typically denoted as Φ (phi), refers to the total amount of light energy emitted or transferred through a given surface area. It is measured in lumens (lm). Flux doesn't consider the area over which the light is spread, focusing solely on the total amount of light emitted.

Lux: Lux (lx), on the other hand, measures the illuminance or the amount of light that falls on a surface per unit area. It is expressed in lumens per square meter (lm/m^2). Lux accounts for the intensity of light reaching a specific surface area, indicating how bright the light appears from the perspective of an observer at that point.

Now, why is the total flux less than the total lux? Consider this analogy: imagine you have a light bulb emitting a certain number of lumens (flux). If you move closer to the light bulb, the area over which the light is spread decreases, thus increasing the lux because the same amount of light energy is now concentrated over a smaller area. Conversely, if you move farther away from the light source, the area over which the light spreads increases, resulting in a lower lux value because the same amount of light energy is now distributed over a larger area.

In summary, while total flux represents the overall amount of light emitted, total lux considers both the intensity of light and the area over which it is distributed. Lux provides a more meaningful measure of how brightly a surface is illuminated from the perspective of an observer.

Evaluation of Proposed Design: The proposed lighting design was evaluated based on its ability to meet the diverse needs of SIGs, considering factors such as comfort, functionality, and energy efficiency.

Comparison with Existing Setup: A comparative analysis between the existing lighting setup and the proposed design revealed significant enhancements in terms of flexibility, aesthetics, and user experience.

Addressing Movement and Functionality Requirements: The design ensures seamless movement between rooms while maintaining adequate illumination levels and visual comfort throughout the space.

Visual, Psychological, and Physiological Impacts: The proposed lighting scheme considers the visual, psychological, and physiological impacts on occupants, promoting a conducive environment for learning, collaboration, and relaxation.

Conclusion

Finally, the suggested lighting design is shown to be a complete solution after giving great thought to the lighting requirements within the university space devoted to Special Interest Groups (SIGs). It addresses the practical issues of lighting while also prioritising the involvement and well-being of students through the seamless integration of human-centric design principles with functional requirements.

Some components of the suggested lighting scheme are specifically crafted to improve the surroundings for the SIGs. It promotes a dynamic and flexible environment by including movable colour temperatures and illumination settings that accommodate a range of activities and moods. Natural light sources and biophilic design features also help to establish a link between the interior and outside environments, fostering a sense of life and calm.

The administration of the institution must acknowledge the numerous advantages linked to the installation of this lighting design. Its adoption can have a substantial impact on student engagement, productivity, and general well-being in addition to merely providing illumination. In addition, the

focus on energy efficiency supports sustainability objectives by providing long-term financial and environmental advantages.

The university administration is very encouraged to proceed with the execution of the suggested lighting scheme considering these factors. Through a focus on comprehensive student needs and an embrace of new lighting strategies, the institution may create an environment that supports learning, creativity, and student achievement.

References

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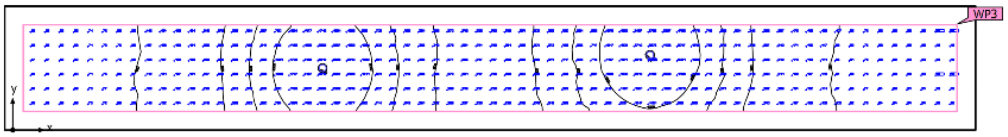
Appendix

Project

DIALux

Building 1 · Storey 1 · Hallway (Light scene 2)

Summary



Ground area	80.34 m²	Clearance height	2.000 m
Reflection factors	Ceiling: 70.0 %, Walls: 51.5 %, Floor: 23.3 %	Mounting height	2.000 m
		Height Working plane	0.800 m
Maintenance factor	0.80 (fixed)	Wall zone Working plane	0.480 m

Building 1 · Storey 1 · Hallway (Light scene 2)

Summary

Results

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	646 lx	≥ 500 lx	✓	WP3
	U_o (g_1)	0.074	≥ 0.60	✗	WP3
	Lighting power density	14.79 W/m²	–		
		2.29 W/m²/100 lx	–		
Glare valuation(1)	$R_{UG,max}$	36	≤ 19	✗	
Energy estimation(2)	Consumption	[1247.62 - 1980.00] kWh/a	max. 2850 kWh/a	✓	
Room	Lighting power density	9.96 W/m²	–		
		1.54 W/m²/100 lx	–		

(1) Based on a rectangular space of 3.200 m x 25.106 m and SHR of 0.25.
(2) Calculated using DIN:18599-4.

Utilisation profile: DIALux presetting (34.2 Standard (office))

Luminaire list

pcs.	Manufacturer	Article No.	Article name	R_{UG}	P	Φ	Luminous efficacy
2	Eaton´s Crouse-Hinds Business	EVM	EVMA92400-S828	36	400.0 W	30903 lm	77.3 lm/W