

## Lecture Hall Lighting Redesign



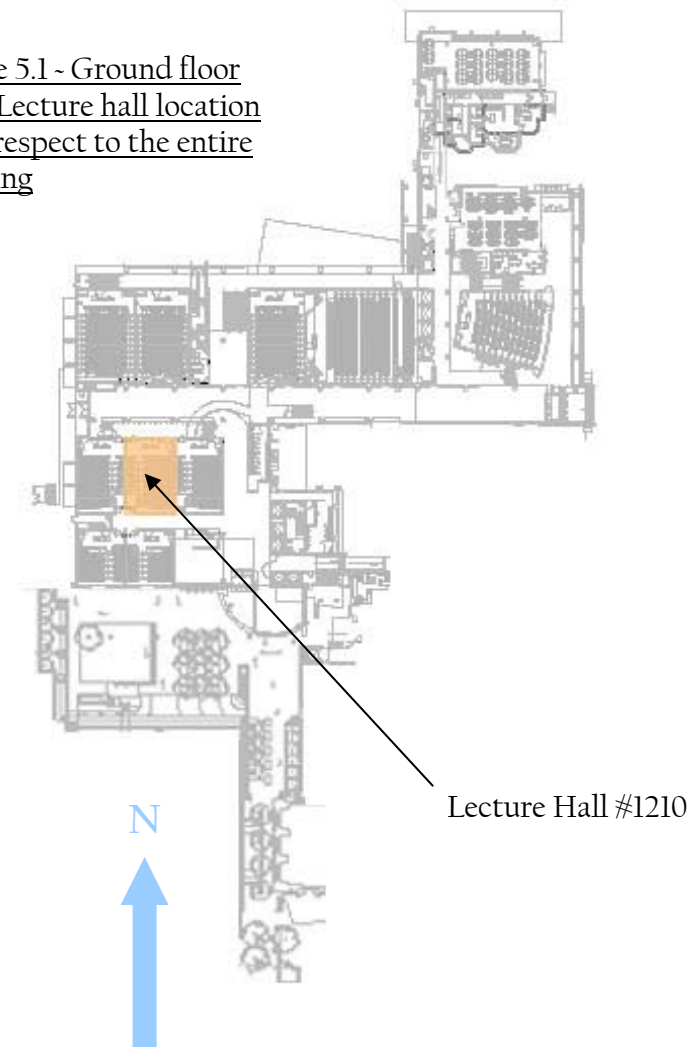
### Introduction

The Lecture Hall (room #1210) is located on the ground floor of the Bahen Centre. The room features 85 seats arranged in 9 rows on a sloped floor. At the front of the room there is a desk for the lecturer and alternating blackboards and screen for projection displays. The room is equipped with an overhead video projector and a screen for audio/visual presentations. There are no windows in the room. The lecture hall overall dimensions are 9m (29.53ft) in width and 14.89m (48.85ft) in length, resulting in an area of 134m<sup>2</sup> (1442.5 ft<sup>2</sup>).

This space will be used in the in-depth comparison of two lighting systems. One of those systems will be a direct

downlight system, and the other will be an indirect pendant mounted lighting system.

Figure 5.1 - Ground floor plan; Lecture hall location with respect to the entire building



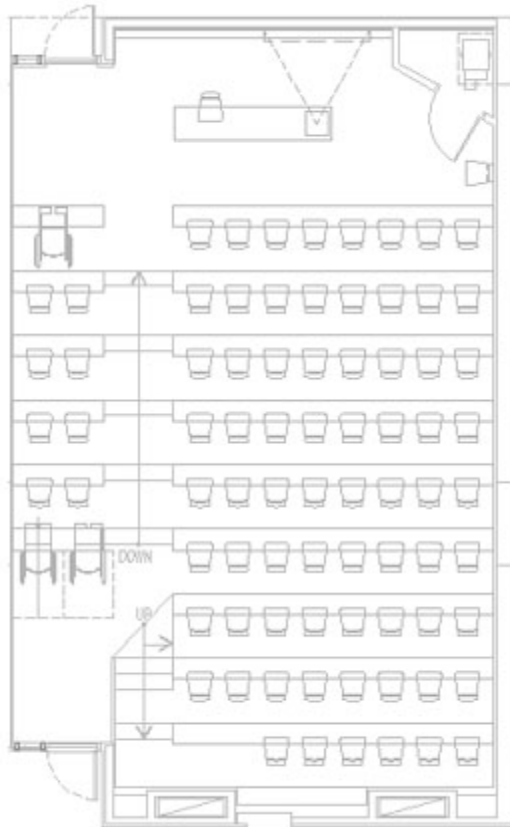


Figure 5.2 - Lecture Hall #1210 room layout

## Design Goal

- To provide an even ambient lighting scheme that causes minimal shadow and glare
- To highlight architectural detail (cove) in the space
- To provide adequate illuminances on the vertical surfaces at the front of the room

## Design Criteria

- Consider veiling reflections on tables, blackboard, glare, and reflected glare issues.
- Vertical surface illuminances must be adequate
- Visual appearance of lecturer at the front of the room
- Provide different illuminance schemes of lighting (i.e. lectures, note-taking, audio/visual presentations)
- Target Illuminance
  - Horizontal: 30 fc
  - Vertical (blackboard): 30 fc
- Power Allowance: 1.6 W/ft<sup>2</sup>

## Design Concept

Since this space is to be used for the detailed comparison of two lighting systems, two lighting designs will be applied to the Lecture Hall separately and will be compared throughout the analysis.

### System #1: Direct System

The direct system will involve the use of:

- compact fluorescent downlights which is laid out in a rectangular array configuration.
- a row of downlights is arranged above the main floor for the major traffic flow of the room.
- Concealed linear fluorescent cove fixtures are used on the two openings of the drop-down ceiling to accentuate the drop ceiling in the room.

(Table 5.1 lists the luminaires used in the direct lighting system)

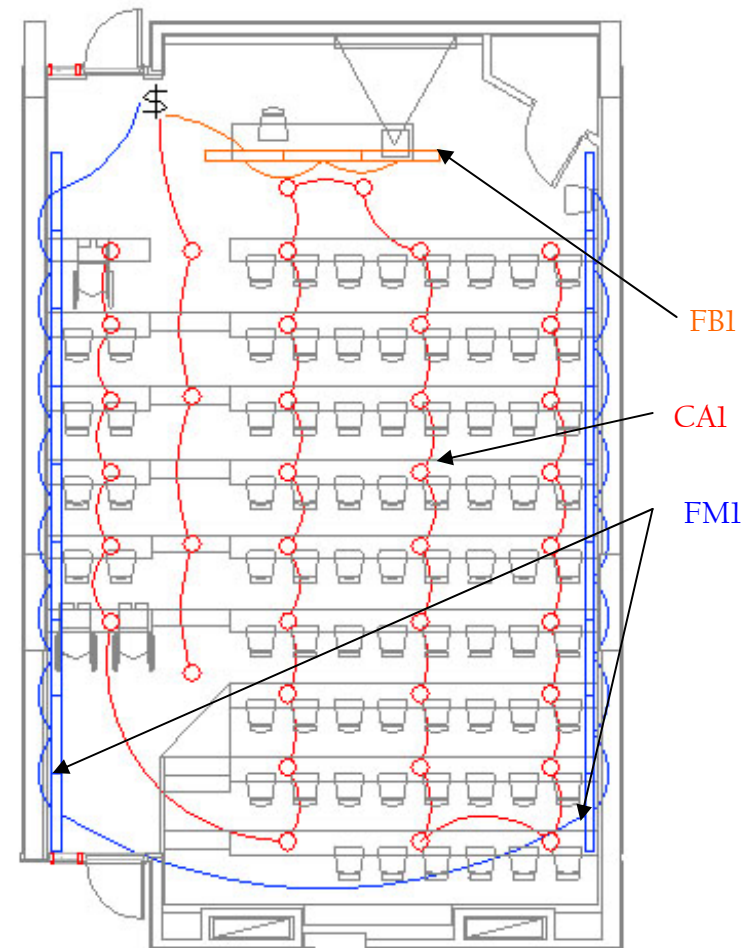

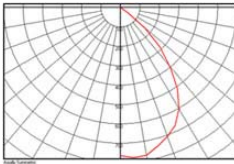

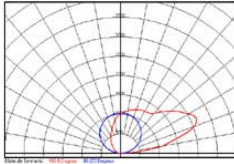

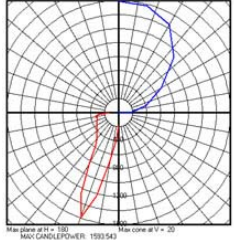


Figure 5.3 - Luminaire layout for the direct system of Lecture Hall #1210

Table 5.1 - Lighting Fixtures Schedule for Direct System

Fixture		Luminaire	Type	Mounting	Photometric Web	# lamps & Wattage	Lamp type	LLF
CAI		ERCO Lightcast Downlight 22239.023	Size 7 Downlight, cut- off 30°	Recessed		1 x 32	GX24q-3	0.72
FBI		LITE- CONTROL Cove-25	Concealed Cove System	Cove		1 x 54	T5HO	0.60
FMI		ERCO Wall- washers	Wallwasher for Fluorescent lamps	Recessed		1 x 36	T26	0.76

## System #2: Indirect System

The indirect system will involve the use of:

- Suspended indirect fixtures to provide an even illumination for the entire space.
- Suspended indirect fixtures should be aligned orthogonally with the orientation of the desks to minimize reflected glare.
- Cove fixtures are used once again in the cove around the perimeter of the room (same as direct system).
- a row of downlights is arranged above the main floor for the major traffic flow of the room (same as direct system).

(Table 5.2 lists the luminaires used in the indirect lighting system)

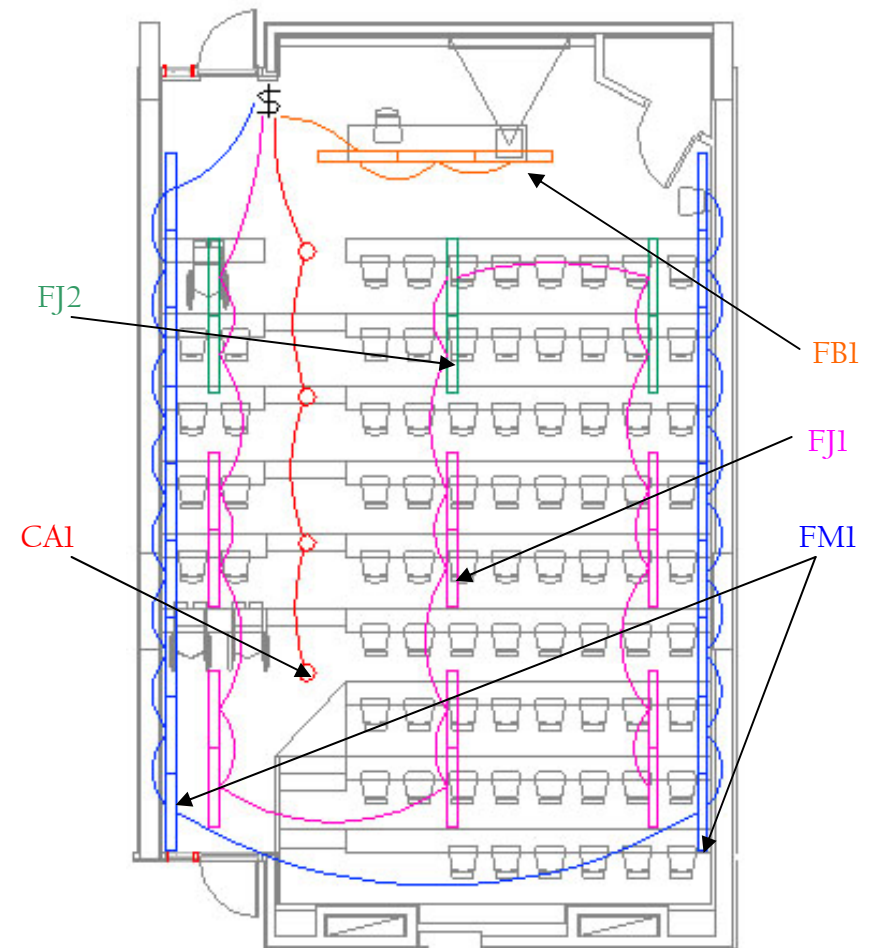
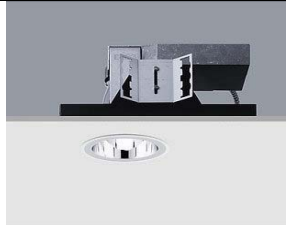
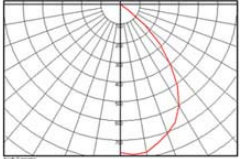

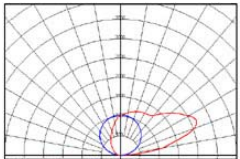

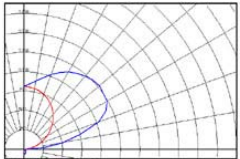

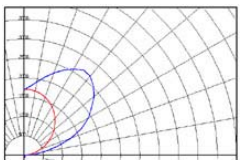
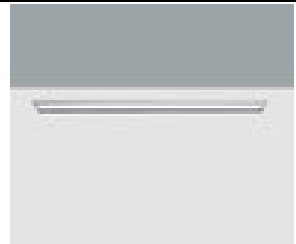
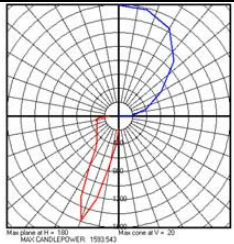


Figure 5.4 - Luminaire layout for the indirect system of Lecture Hall #1210

Table 5.2 - Lighting Fixtures Schedule for Indirect System

Fixture		Luminaire	Type	Mounting	Photometric Web	# lamps & Wattage	Lamp type	LLF
CAI		ERCO Lightcast Downlight 22239.023	Size 7 Downlight, cut- off 30°	Recessed		1 x 32	GX24q-3	0.72
FBI		LITE- CONTROL Cove-25	Concealed Cove System	Cove		1 x 54	T5HO	0.60
FJ1		LITE- CONTROL Classica	Pendant Mounted Indirect	Pendant		2 x 32	F32T8	0.55
FJ2		LITE- CONTROL Classica	Pendant Mounted Indirect	Pendant		4 x 32	F32T8	0.55

Fixture		Luminaire	Type	Mounting	Photometric Web	# lamps & Wattage	Lamp type	LLF
FMI		ERCO Wall-washers	Wallwasher for Fluorescent lamps	Recessed		1 x 36	T26	0.76

Continuation of Table 5.2 - Lighting Fixtures Schedule for Indirect System

## Light Loss Factors

The light loss factors used in the calculations of the lighting systems in the Lecture Hall are listed as follow:

### Lecture Hall

Fixture	BF	Dirt Cond.	Maintenance Category	Cln. Interv	LDD	RSDD	LLD	Total LLF
CA1	0.98	Very Clean	IV	12	0.94	0.92	0.85	0.72
FBI	1.02	Very Clean	VI	12	0.93	0.67	0.95	0.60
FJ1	0.98	Very Clean	VI	12	0.93	0.67	0.89	0.55
FJ2	0.98	Very Clean	VI	12	0.93	0.67	0.89	0.55
FMI	0.98	Very Clean	IV	12	0.94	0.92	0.89	0.76

Table 5.3 - Light Loss Factor for fixture used in the Lecture Hall



## Lighting Power Densities

The power densities for the two systems are calculated as follows:

### System #1: Direct Lighting System

Fixture	Lamp Watt	# Lamps	Input Watt	# used	Total Wattage
CA1	32	1	35	41	1435
FBI	54	1	60.8	18	1094.4
FMI	34	1	42	3	126
Total Wattage (W)					2655.4
Total Area (sf)					1442.5
Power Density (W/sf)					1.84

### System #2: Indirect Lighting System

Fixture	Lamp Watt	# Lamps	Input Watt	# used	Total Wattage
CA1	32	1	35	4	140
FBI	54	1	60.8	18	1094.4
FJ1	32	2	70	12	840
FJ2	32	4	123	6	738
FMI	34	1	42	3	126
Total Wattage (W)					2938.4
Total Area (sf)					1442.5
Power Density (W/sf)					2.04

Table 5.4 - Power density calculations for the two different lighting system designs

Even though the power density for both of the lighting design systems are over the recommended power allowance

of 1.6 W/sf (by the IESNA/ASHRAE Standard 90.1, 1999), simple changes can be made to lower the power density of both the lighting systems. One very quick and efficient way of correcting this problem is to control the different scenes of the lighting system (refer to the next section, System Control), by not having the cove lighting on during the regular lecture/note-taking scene. By doing so, it will decrease the power density greatly to an acceptable level, as shown in Table 5.5 below. Overall, **System #1** performs better regarding to the power density issues.

### System #1: Direct Lighting System (with modification)

Fixture	Lamp Watt	# Lamps	Input Watt	# used	Total Wattage
CA1	32	1	35	41	1435
FBI	54	1	60.8	0	0
FMI	34	1	42	3	126
Total Wattage (W)					1561
Total Area (sf)					1442.5
Power Density (W/sf)					1.08

### System #2: Indirect Lighting System (with modification)

Fixture	Lamp Watt	# Lamps	Input Watt	# used	Total Wattage
CA1	32	1	35	4	140
FBI	54	1	60.8	0	0
FJ1	32	2	70	12	840
FJ2	32	4	123	6	738
FMI	34	1	42	3	126
Total Wattage (W)					1844
Total Area (sf)					1442.5
Power Density (W/sf)					1.28

Table 5.5 - Power density calculations (modified)



## Lighting Circuiting Calculation

For both system #1 and system #2, only one circuit is needed to carry all the design fixture's loads.

*\*Please note that according to electrical standards commonly practiced in Canada, fluorescent fixtures are usually connected to a voltage of 347V*

### System #1: Direct Lighting System

Fixture	Input Watt	# used	Total Wattage	Total Amps
CA1	35	41	1435	4.135
FBI	60.8	18	1094.4	3.154
FMI	42	3	126	0.363
			Total Amps	7.652
			# of circuits	1

### System #2: Indirect Lighting System

Fixture	Input Watt	# used	Total Wattage	Total Amps
CA1	35	4	140	0.403
FBI	60.8	18	1094.4	3.154
FJ1	70	12	840	2.421
FJ2	123	6	738	2.127
FMI	42	3	126	0.363
			Total Amps	8.468
			# of circuits	1

## System Control

With the increased types of uses in a space, the lighting system must be able to provide different lighting scenes for different tasks and purposes. The increased flexibility in lighting control allows the user to be much more productive in the environment. Three different scenes are needed for the functions of the Lecture Hall:

- Lecture/General note-taking
- Audio/Visual (A/V) Presentation
- Unoccupied/Nightlight

### ❖ Specification of control hardware



The change in lighting scenes for the lecture room will be controlled with the use of the Lutron GRAFIK Eye present lighting control system. This system allows the user to create and recall some custom preset scenes for common room activities. This control system controls not only which fixtures will be turned on or off, but can also control the

dimming of different fixtures, providing that the fixtures are dimmable.

Two wall control panels will be placed in the Lecture Hall, one next to each door of the room. A wireless remote control will also be available for the lecturer's use in the room.

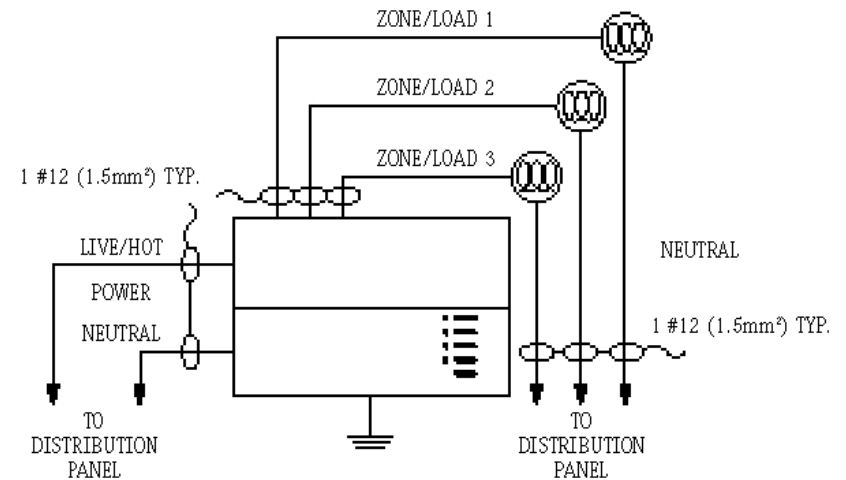


Figure 5.5 - Wiring diagram for the GRAFIK Eye control system.

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The two lighting designs of the Lecture Hall will have different luminaires responding to each of the preset scenes, as listed below:

## Direct System

- Lecture/General note-taking
  - All lights on (CA1, FB1)
- A/V Presentation
  - Only perimeter cove lights on (FB1)



- Unoccupied/Nightlight
  - Only isle downlights on (CA1)

*For switching diagram, see Figure 5.4*

## Indirect System

- Lecture/General note-taking
  - All lights on (CA1, FB1, FJ1, FJ2)
- A/V Presentation
  - Only perimeter cove lights on (FB1)



- Unoccupied Nightlight
  - Only isle downlights on (CA1)

*For switching diagram, see Figure 5.4*

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## Calculations and Renderings

The illuminance level calculations were performed by Lightscape. The target illuminance for the horizontal work plane is 30 fc and for the vertical surface of the blackboard it is also 30 fc.

System #1 - Direct System



System #2 - Indirect System



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System #1 - Direct System



System #2 - Indirect System





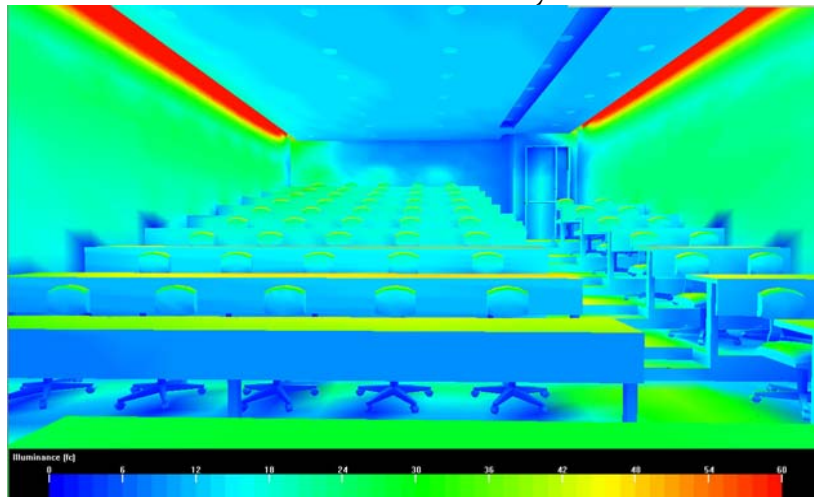
System #1 - Direct System



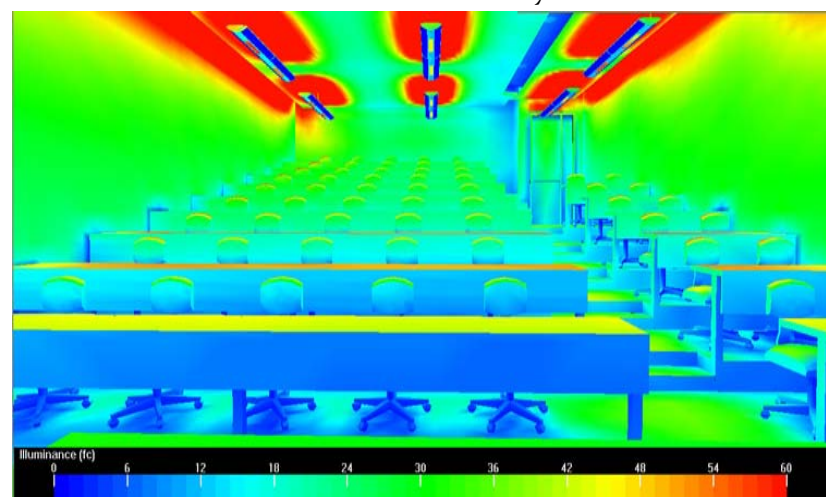
System #2 - Indirect System



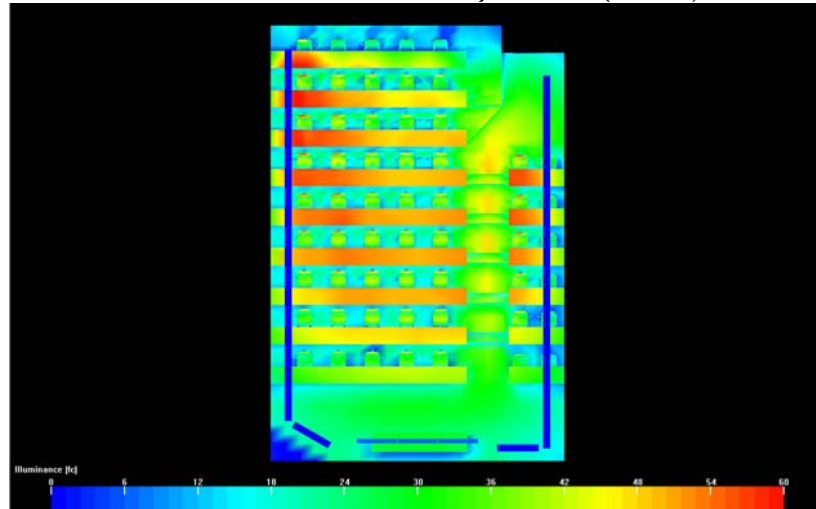
Illuminance distribution for System #1



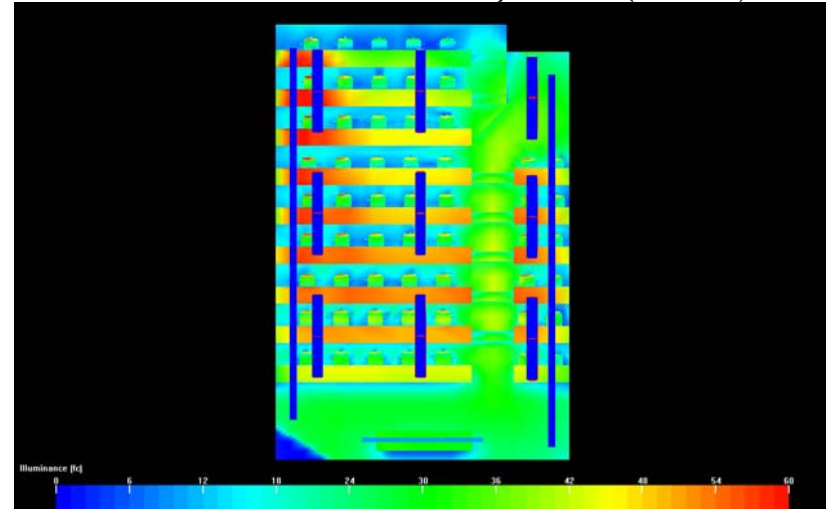
Illuminance distribution for System #2



Illuminance distribution of System #1 (Direct)



Illuminance distribution of System #2 (Indirect)



## Comparison of the two systems

The performance of the two system not only differ in the power density and control areas, but also in the illuminance levels and the general appearance of the space. Both systems were sufficient at providing the suggested 30fc recommended for general note-taking in the Lecture Hall. However, the delivery of the two systems differs, which creates two distinct visual appearances of the space.

## Walls

In system #1 (Direct System), there are patterns of light (scallops) on the surfaces of the walls around the room. In System #2 (Indirect System), the walls are much more evenly lit with no visible bright and dark variations.

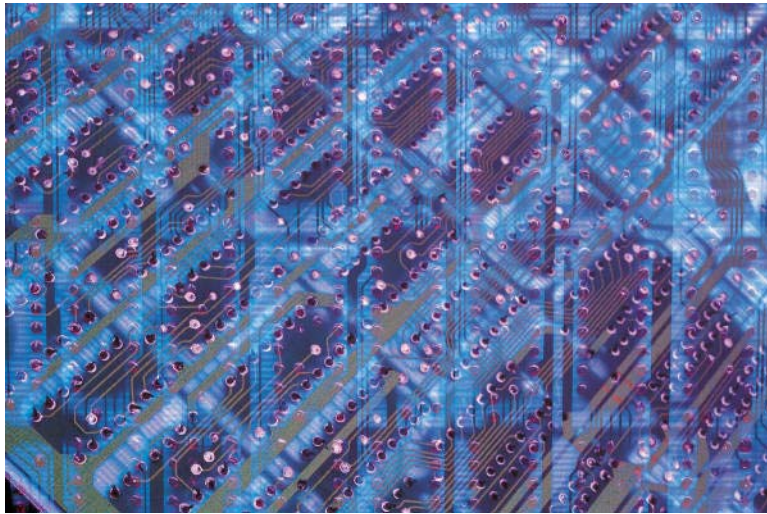
## Ceiling

Since system #1 is a direct lighting system, no lights are aimed directly at the ceiling to create any differences. The indirect fixtures in System #2 creates many hot spots on the ceiling of the Lecture Hall, creating a large contrast of bright and dark on the surface of the ceiling.



## Other Factors

Visually, the compact fluorescent downlights of System #1 (direct system) creates a more visually appealing look for the room, where the order and pattern of the downlights conforming to the project metaphor (motherboard) mentioned earlier in the Lighting Conditions section.



surface because of the longer distance that the light rays has to travel.

Visually, system #1 also performed slightly better because it conforms to the project metaphor and creating interesting scallop patterns on the walls, instead of the “washed-out” look of the indirect system (system #2).

Overall with all the factors being considered in this comparison analysis, I recommend the direct system (System #1) to be the ideal design for Lecture Hall 1210.

## Conclusion and recommendations

Both system were satisfactory at providing the recommended illumination suitable for the use in a Lecture Hall. The downlight system (System #1) performed much better in the power density component compared to the indirect system. The high ceiling of the room makes it more difficult for the light from indirect fixtures to reach the task