Lighting Depth

Overview:

For the lighting depth, I have selected four spaces to perform detailed lighting design and analysis. These spaces were selected either for their important or impact of the function of the building, or because the space is representative of several others throughout the building (thus lending itself well to repetition of key elements).

Selected Spaces:

Exterior Space – East Entry and Façade

This is the main entrance for the building. It lies along a critical link for the campus to the main town area. In addition, this is by far the most interesting façade of the building, with pilasters, large arched windows, and extensive stonework making this a distinctive façade that needs a complementary lighting design.

Circulation Space – Frey Atrium

The east (and main) entry into the Life Sciences and Philosophy Building leads to this atrium. This acts as the circulation core for the entire building, and most everyday users and all university guests must go through this space. The unique elliptical shape, 3-story height, and many modern elements make this an interesting space for study.

Work Space – Ecology Teaching Laboratory

While not a particularly distinctive space in its own right, this laboratory is a great representative of the many other lab spaces in the building, in terms of both size and usability. As a result, it makes the most sense to perform a full lighting design analysis here, and then repeat the concepts in the other labs as appropriate.

Special Purpose Space – Bonchek Lecture Hall

This space was designed as a guest lecture space for use by both the occupying departments and Franklin & Marshall College as a whole. The space has many different design elements and parameters, including three projection screens, good-sized windows facing west, and a cove ceiling system. This space also lends itself well to breadth studies

Spatial Relationships:

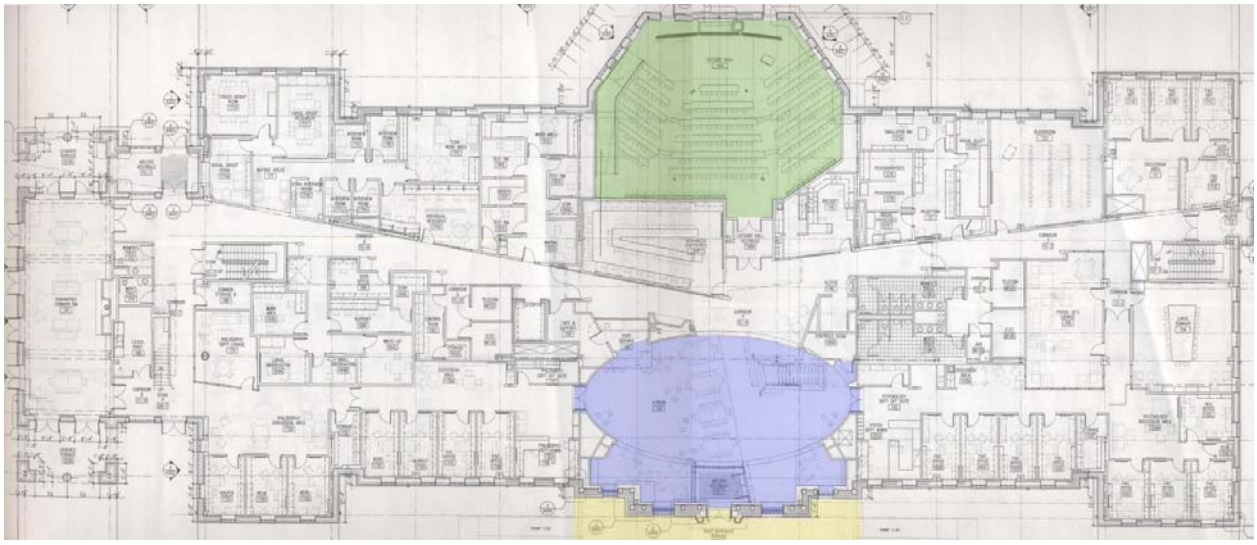


Figure 1.01 *First Floor Plan – Life Sciences & Philosophy Building*
Yellow = East Entry ; Blue = Atrium ; Green = Lecture Hall

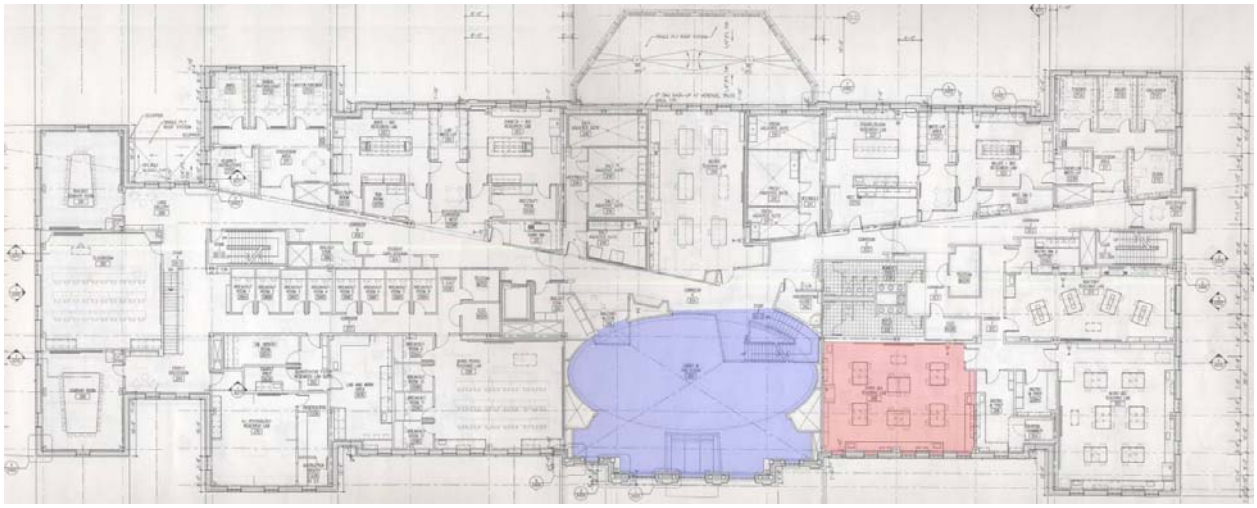


Figure 1.02 *Second Floor Plan – Life Sciences & Philosophy Building*
Blue = Atrium ; Red = Ecology Lab

East Entry & Facade

Overview:

The east entry and facade is a critical space for several reasons. First, it is the entrance that the vast majority of users and guests will use. This façade will be one of the first impressions people will get of Franklin & Marshall College, due to the building's location along the Harrisburg Pike, and because Franklin & Marshall is using photos and rendering of this façade to advertise for the university as a whole. In addition, this façade faces the football stadium and football parking, so even casual visitors will see this façade frequently. One could argue that this is the most critical façade of the entire campus, let alone for this building.

The scope of this space can be defined as the sum of three parts: the façade, the entrance, and the walkway. Each has different design criteria, but in order to be most effective, all three have to be integrated into one seamless design. This can be done by using similar finishes, similar luminaires, similar shapes, etc. The façade is a great example of Georgian revival architecture, complete with pilasters, large windows with white mullions, elaborate stonework, and overall perfect symmetry across the main entry. The entry itself is normally scaled, but the main entrance itself is very long and narrow, and is a couple of feet above ground level. The walkway is the same pink sidewalk Franklin & Marshall College uses throughout the campus. Immediately north on the walkway in the bridge that links the college to the town; not far south on the walkway are the dormitories and other college departments.

Plans:

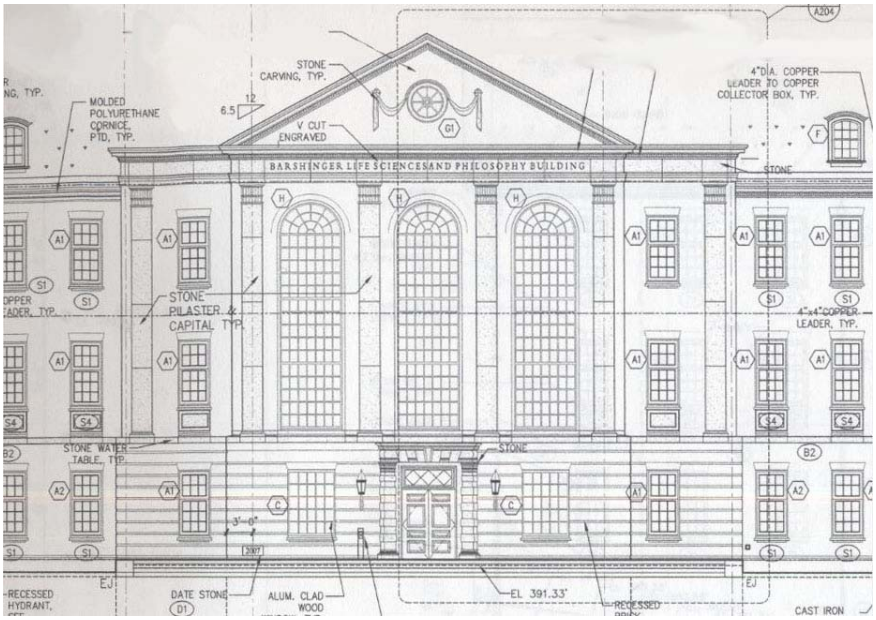


Figure 2.01 *East Elevation – Life Sciences & Philosophy Building*

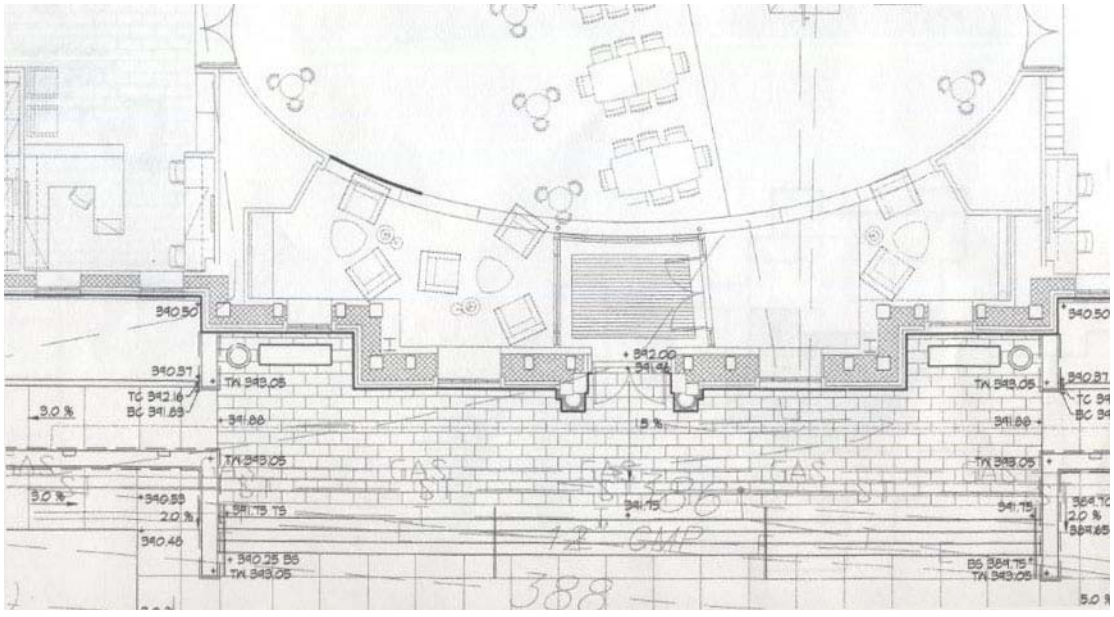


Figure 2.02 *Exterior Plan – Life Sciences & Philosophy Building*

Surface Characteristics:

Surface	Material	Color	Reflectance	Finish
Main Façade	brick	burnt red	30%	matte
Pilasters / Columns	stone	beige	40%	matte
Carvings	stone	beige	40%	matte
Cornices	polyurethane	beige	40%	semi-gloss
Ground	grass	green	18%	matte
Walkways	concrete	pale pink	40%	matte
Entry	precast concrete unit pavers	grey	20%	matte
Window / Door Trim	painted wood	white	70%	matte

Table 2.01 *Surface Characteristics - Exterior and Façade*

Illuminance Requirements:

IESNA Reference: Building Exteriors – Entrances - Active

Horizontal Illuminance: 5 fc
Vertical Illuminance: 3 fc

Analysis: This seems appropriate, though certain areas of the façade will be higher for emphasis.

Design Criteria and Goals:

Most Important:

Appearance of Space and Luminaires:

- This is the façade that Franklin & Marshall College emphasized when they marketed the building on their website. The façade should be as distinct at night as it is during the day.

Direct Glare:

- This is a security issue. Luminaires that cause glare can temporarily disable people's vision, which is effectively the same as having no light at all, and removes a person's sense of safety.

Modeling of Faces and Objects:

- In order to make people feel more secure, they must have enough light to recognize faces. They must be able to see any object that might interfere with their path and any potential threats.

Points of Interest:

- Key parts of the façade to emphasize are the pilasters, the carvings (including the building name), and the entablature. Also important to draw attention to is the entrance.

Special Considerations:

- One of my design goals is to make the exterior space more dark sky friendly. As a standard, I am shooting for a standard of "CUT-OFF" or "FULLY SHIELDED" or better.

Also Important:

Light Distribution on Surfaces:

- There should be no areas on the sidewalk or entry that appear dark, as dark is associated with unsafe. Spacing of the poles is going to have to be analyzed.

Luminance of Surfaces:

- Generally, most of the surfaces are darker than interior surfaces, and are going to have to be lit to somewhat higher levels than normal. No spot on the building can appear overly bright, as they would effectively create glare because of the dark surround.

Reflected Glare:

- Light can potentially be reflected by the glass and cause glare on people walking past the building.

Shadows:

- Fixtures must be aimed in order to keep shadowing off the walkways and entrances, in order to maintain a secure atmosphere.

Illuminance (Horizontal and Vertical):

- Good horizontal illuminance is required for the walkways and entrance. Good vertical illuminance is needed for the façade.

Luminaire Schedule

Label	Quantity	Description	Number of Lamps / Linear Feet	Lamp Type	Voltage
QQ1	6	Street "acorn" pole fixture with internal reflector to meet "Cutoff" criteria	1	150W MH	277
QQ2	6	Wall-mounted HID projector with 10 degree beam spread and 45 degree shielding	1	39W PAR30L MH	277
QQ3	2	Recessed exterior HID downlight	1	70W CMH	277
QQ4A	1	Linear LED floodlight luminaire with asymmetric optics	36	LED	277
QQ4B	2	Linear LED floodlight luminaire with asymmetric optics	19.5	LED	277
QQ5	2	Exterior wall-mounted acorn fixture at smaller scale to pole fixture	1	39W PAR30L MH	277

Table 2.02 *Compressed Luminaire Schedule for Exterior and Façade*
For Full Luminaire Schedule and Details, Please Refer to Appendix A

QQ1

QQ2

QQ3

QQ4a, QQ4b

QQ5

Ballast Schedule:

Label	Ballast / Driver Type	Power Factor	Ballast Factor	Ballast / Driver Watts
QQ1	Magnetic HID	0.90	-	173
QQ2	Electronic HID	0.95	-	45
QQ3	Electronic HID	0.90	-	79
QQ4A	24V LED Driver	-	-	505.4
QQ4B	24V LED Driver	-	-	280.8
QQ5	Electronic HID	0.95	-	45

Table 2.03 *Compressed Ballast Schedule for Exterior and Façade*
For Full Ballast Details Please Refer to Appendix A

Light Loss Factors:

Label	Maint. Cat.	Degree of Dirt	Cleaning Schedule	Distrib. Cat.	Ballast Factor	Lumin. Dirt Deprec.	Lamp Lumen Deprec.	Room Surface Dirt Deprec.	Total LLF
QQ1	V	Medium	12 mths	Direct	1.000	0.827	0.692	1.000	0.572
QQ2	VI	Medium	12 mths	Indirect	1.000	0.804	0.800	1.000	0.643
QQ3	V	Medium	12 mths	Direct	1.000	0.827	0.710	1.000	0.587
QQ4A	VI	Medium	12 mths	Indirect	1.000	0.804	0.700	1.000	0.563
QQ4B	VI	Medium	12 mths	Indirect	1.000	0.804	0.700	1.000	0.563
QQ5	V	Medium	12 mths	Direct	1.000	0.827	0.800	1.000	0.662

Table 2.04 *Light Loss Factors for Exterior and Facade*

Lighting Plan:

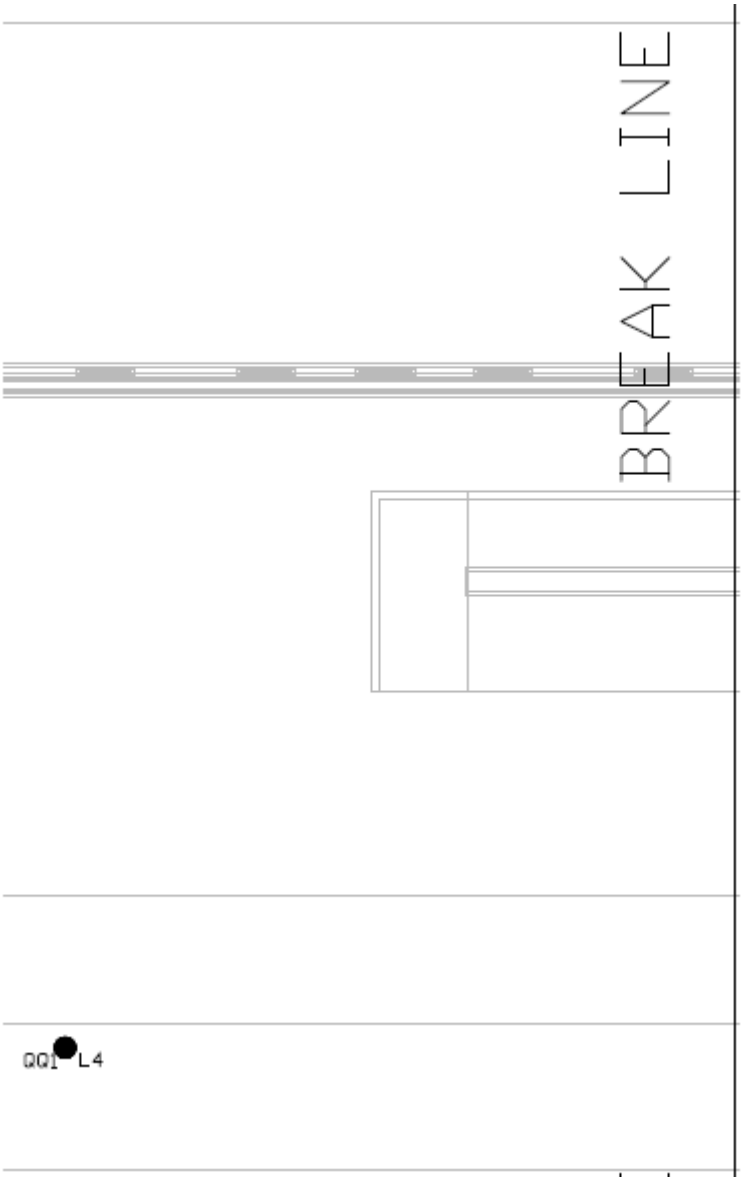


Figure 2.03 *East Entry and Façade Lighting Plan – South of Entry*

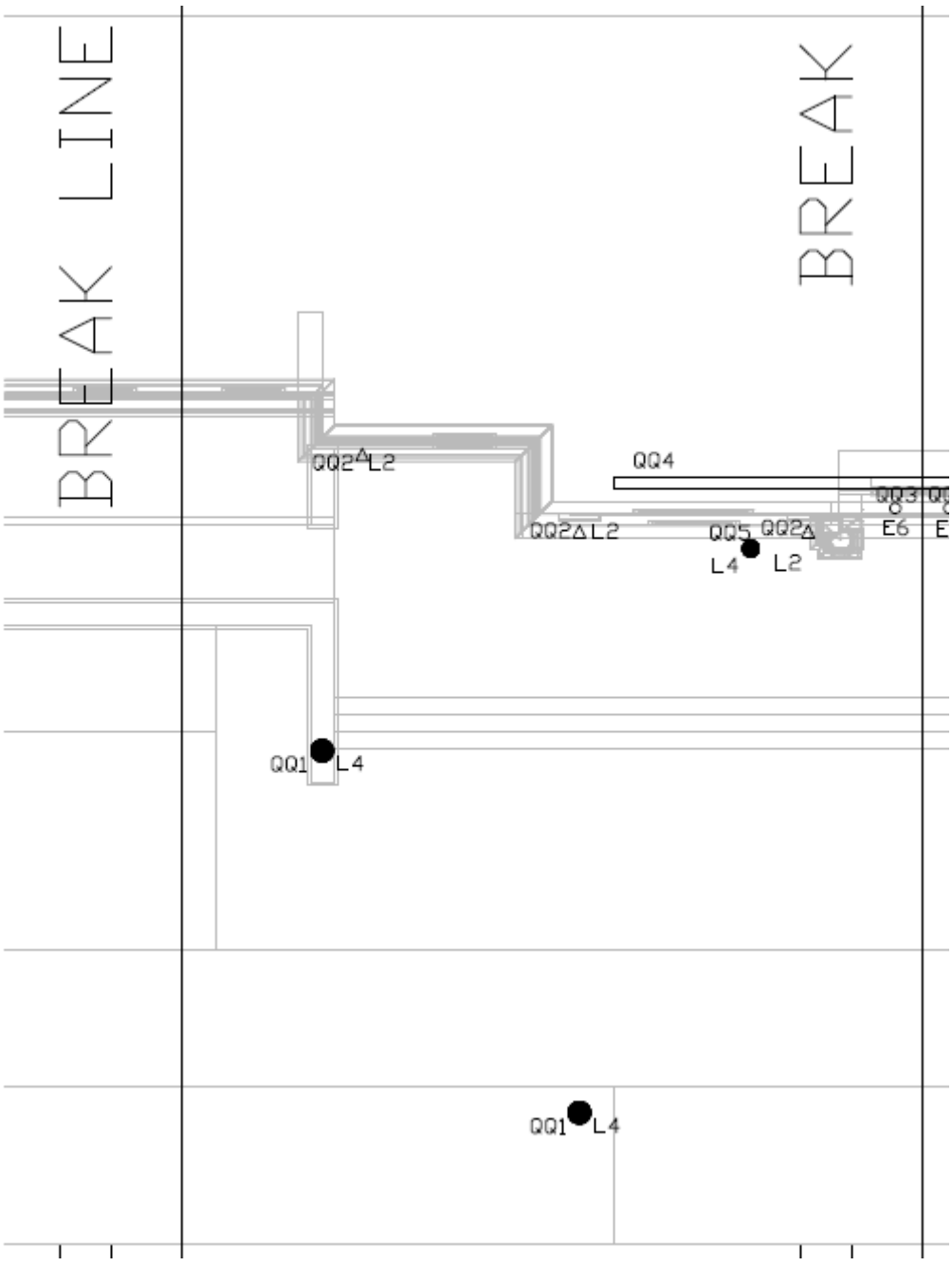


Figure 2.04 *East Entry and Façade Lighting Plan – South Side of Entry*

Note: Design is symmetrical across the main entry; therefore the north side of the plan is exactly the same as the south side.

Details:

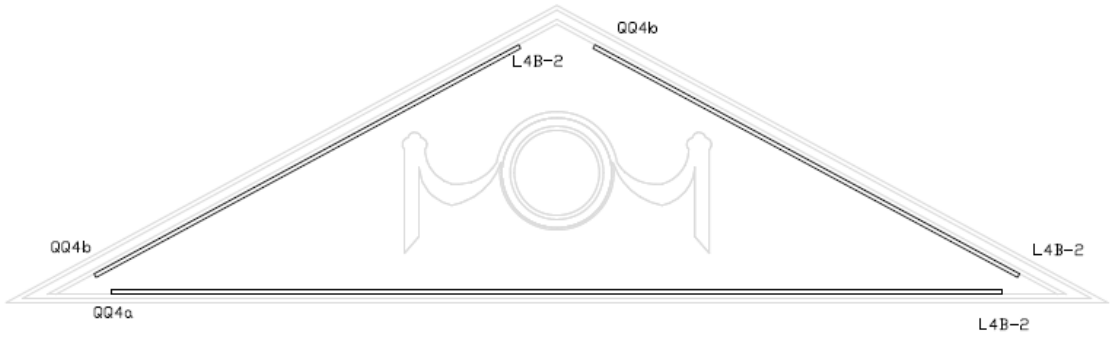


Figure 2.05 *Pediment Lighting Layout – Fixture QQ4*

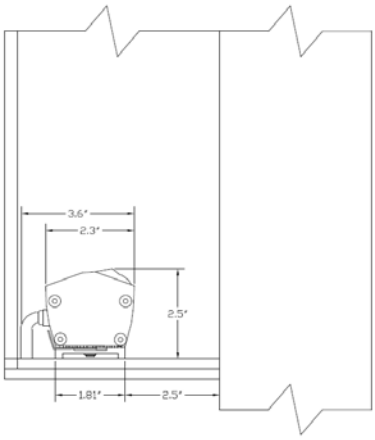


Figure 2.06 *Mounting Detail – Fixture QQ4*

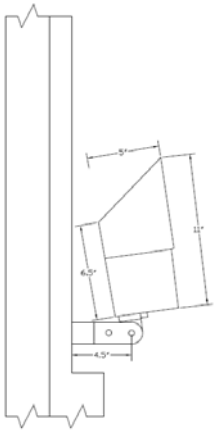


Figure 2.07 *Mounting Detail – Fixture QQ2*

Controls:

The exterior luminaires will be connected to a photocell to determine when they need to switch on. The photocell should be set so that the luminaires turn on at one hour before sunset, and turn on at one hour after sunrise. This allows the automatic shut-off requirement to be met for the exterior.

Calculations and Performance:

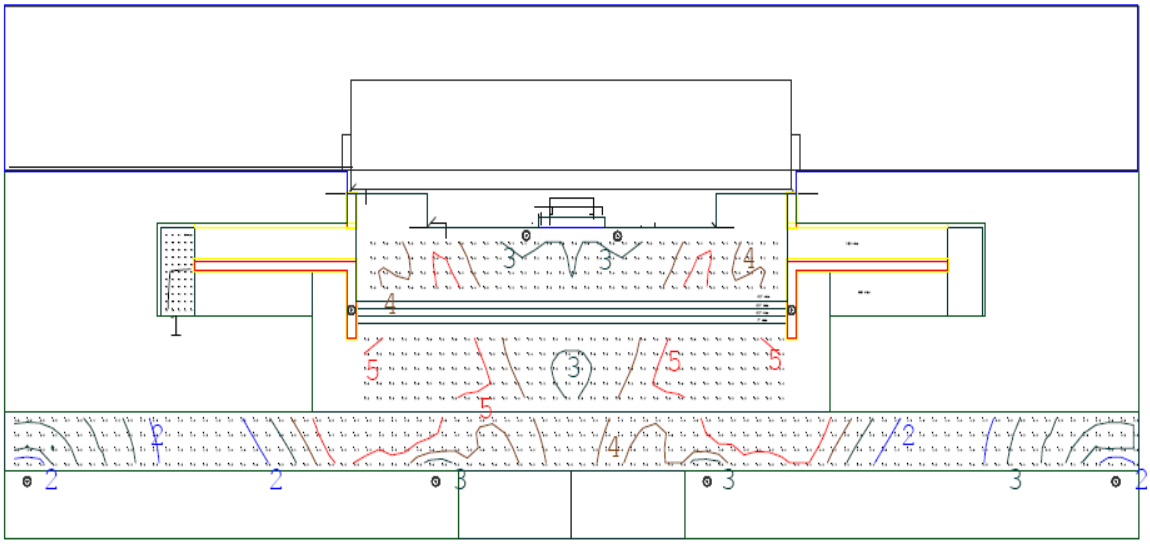


Figure 2.08 *East Entry and Façade – Plan of AGI Model with Footcandle Isolines*

Rendered Images:

Figure 2.09 *East Entry and Façade Rendering – View from Stadium*

Figure 2.10 *East Entry and Façade Rendering – Looking North on Path*

Figure 2.11 *East Entry and Façade Rendering – Main Entrance*

Power Density Calculations:

According to ASHRAE 90.1 – 2004, exterior power allowances for lighting fall into two categories: tradable and non-tradable. The façade falls into the non-tradable category, and any excess allowance not used for lighting the façade cannot be counted towards the power allowance for any other space. The rest of the exterior falls into the tradable category, and can be lumped together as one group.

Area of Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Walkway	Walkway < 10 Feet Wide	1.0 W/ft	162	-	162
Plaza	Plaza/Walkway > 10 Feet Wide	0.2 W/ft^2	-	3660	732
Stairway	Stairway	1.0 W/ft^2	-	221	221
Main Entrance	Main Entrance	30.0 W/ft	6	-	180
				Total Allowed	1295 W

Table 2.05 *Power Allowances for Exterior Tradable Areas*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
QQ1	6	173	1038
QQ3	2	79	158
QQ5	2	45	90
		Total Watts Consumed	1286 W

Table 2.06 *Power Consumed by Exterior Tradable Areas*

Area of Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Façade	Façade	0.2 W/ft^2	-	9120	1824

Total Allowed	1824 W

Table 2.07 *Power Allowance for Façade (Non-Tradable)*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
QQ2	6	45	270
QQ4a	1	505.44	505.44
QQ4b	2	280	560

Total Watts Consumed	1335.44 W

Table 2.08 *Power Consumed by Façade*

Based on the above calculation, the space meets the energy requirements set forth in ASHRAE 90.1 – 2004.

Conclusions:

This design is a slightly modern take on a simple and traditional design. Acorn pole lighting on its own is hardly cutting edge. However, what makes luminaire Type QQ1 (a version of an acorn pole luminaire) different is optics. With a reflector embedded in the glass to reflect light across the ground, this luminaire becomes a "Full-Cutoff" luminaire, and this helps dramatically reduce light pollution without reducing luminaire spacing or aesthetic appeal. All of the luminaires in this layout have some characteristic that helps to reduce light pollution. Type QQ2, lighting the pilasters, has a very narrow spot distribution and shielding that cuts off any light that missed the building. Type QQ4, highlighting the pediment, has asymmetric optics that directs all of the light towards the pediment. Even Type QQ5, a wall-mounted acorn luminaire, is "Semi-Cutoff". While I stated earlier that my goal was at least "Cut-Off" or "Fully Shielded", in order to get the scale and appearance of luminaire I wanted, the best I could accomplish was "Semi-Cutoff". However, the candelas above 90 degrees nadir are not particularly high (less than 100), and a lot of this strikes the building. The design highlights the traditional elements of the space (namely the pediment and the pilasters) in modern ways (LED optics and narrow spot metal halides), limits light pollution, and manages to come under the energy budget. I feel the design is well suited for this building.

Frey Atrium

Overview:

The Frey Atrium acts as the core of the entire Life Sciences & Philosophy Building. Most of the everyday users, and all of the university guests, enter the building from the east entrance into the atrium. It acts as a direct link to the Bonchek Lecture Hall, the Psychology and Philosophy Departments on the first floor. The open staircase is the main access path to the second and third floor of the building.

The atrium provides a great counterbalance to the east façade. Though they share many windows, including 3 two-story high arched windows, the designs are dramatically different. The exterior embodied a traditional Georgian revival, relying heavily elements of symmetry and balance. Materials used on the façade include brick and concrete, and the whole exterior was designed to look as an enhanced version of the buildings that have been on campus for decades.

The atrium, on the other hand, is a very modern design. The main shape of the space is an ellipse, which is not frequently used in traditional design. The walls are curved in the ellipse shape for all three stories, and the wood ceiling is offset from the walls about 2 feet, but retains the same shape. More noticeable is the difference in symmetry. While the basic shape of the room is symmetrical, many other elements were added to break up the sense of evenness. The balconies (themselves an uneven shape) are only on the south end of the atrium, while the 3-story open staircase dominates the north side of the shape. The first floor is divided into two areas. The seating area has a brown carpet as its floor covering, while the circulation area is a grey terrazzo. There is a clear transition between the two areas, but the division was purposely uneven (the seating area is much bigger).

Materials used here include a lot of dark wood, painted metal, and a translucent metal/frosted glass mesh that is used on the railings. A counter is provided for the café at the back end of the space. Other mobile furnishings will include couches, armchairs, and coffee tables.

Plans:

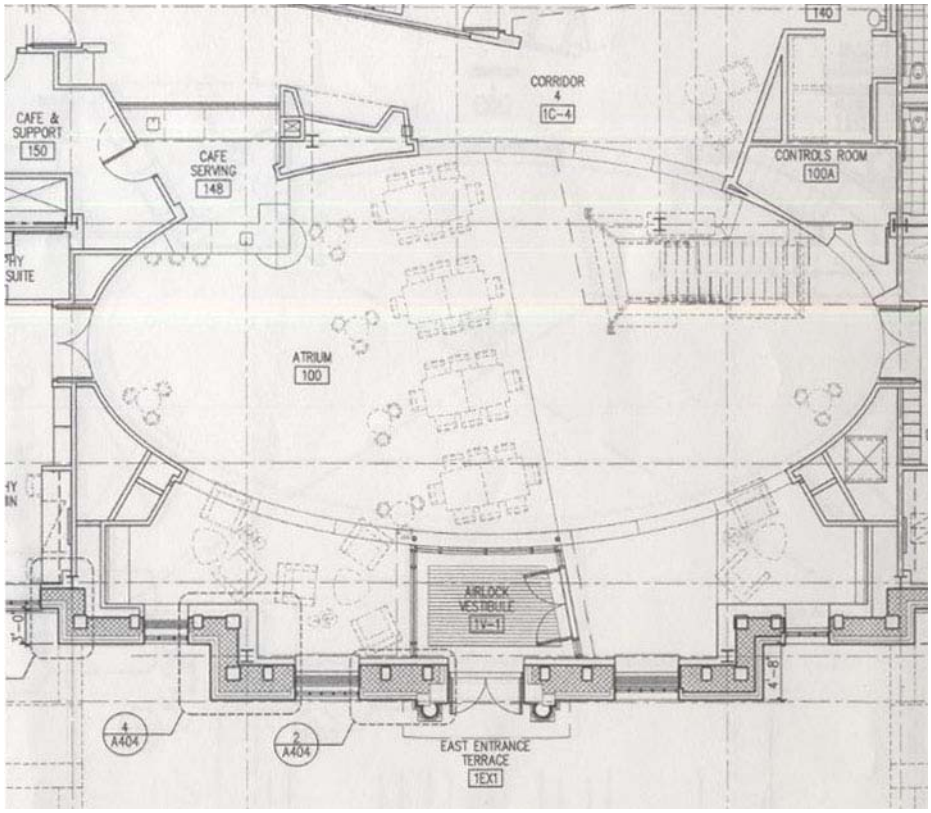


Figure 3.01 *First Floor Plan - Atrium*

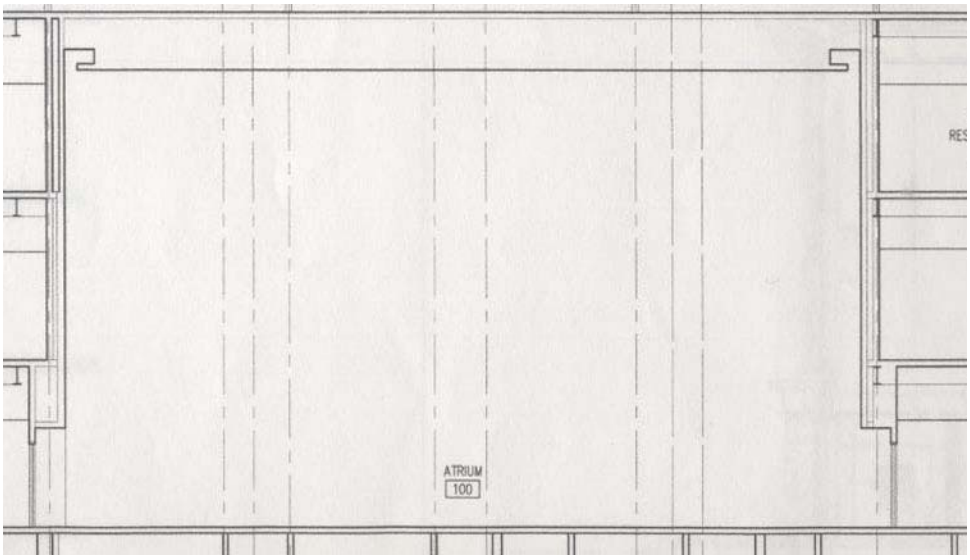


Figure 3.02 *East to West Section - Atrium*

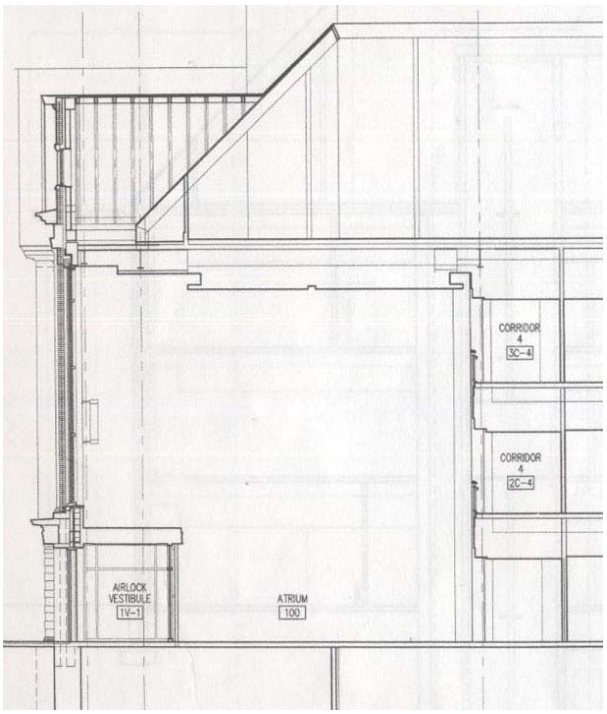


Figure 3.03 *North to South Section - Atrium*

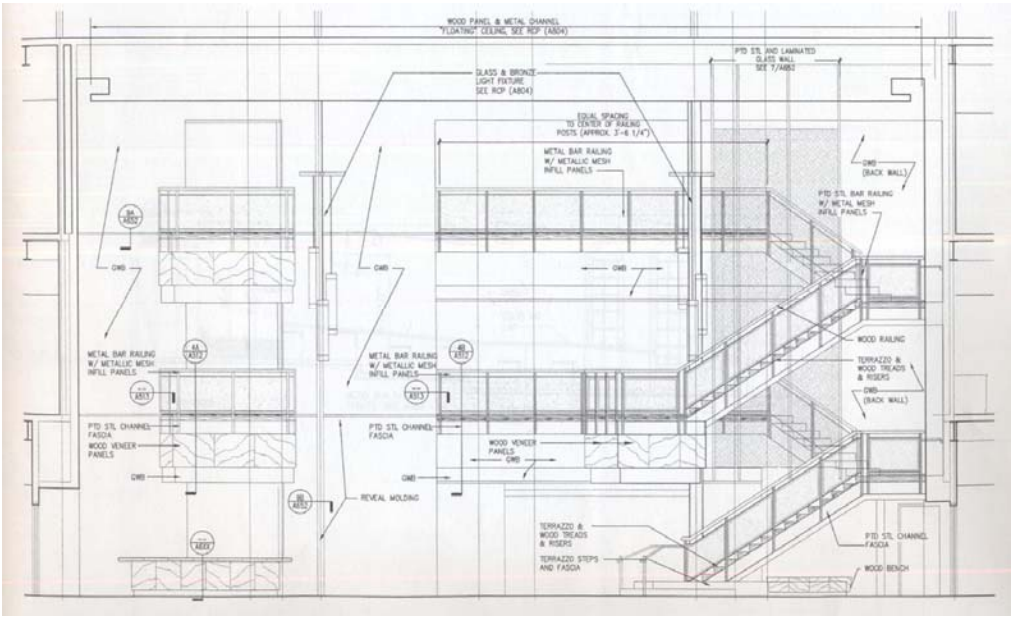


Figure 3.04 *West Elevation – Atrium*

Surface Characteristics:

Surface	Material	Color	Reflectance	Transmittance	Finish
Flat Ceiling	gypsum board	white	70%	-	matte
Acoustical Ceiling	wood slat panel	brown	15%	-	matte
Counter	bluestone	grey	15%	-	matte
Floor - Sitting	Carpet	dark grey	20%	-	matte
Floor - Circulation	terrazzo	light grey	45%	-	semi-specular
Steps	terrazzo	grey	35%	-	semi-specular
Main Walls	gypsum board	white	70%	-	matte
Benches	Wood	brown	15%	-	semi-specular
Balcony Panels	wood veneer panels	brown	15%	-	semi-specular
Decorative Wall	laminated glass	blue	5%	30%	specular
Railings	Wood	brown	15%	-	semi-specular
Rail Supports	Steel	dark grey	20%	-	matte
Rail Sides	translucent glass	clear	10%	40%	specular
Vestibule Ceiling	Wood	brown	15%	-	semi-specular
Vestibule Trim	Wood	brown	15%	-	semi-specular

Table 3.01 *Surface Characteristics - Atrium*

Daylight Elements:

Label	Quantity	Window Type	Mullion Pattern	Max Height	Max Width	Finish	Transmittance	Reflectance
A1	6	Rectangular	3X5	7'-10"	3'-8"	Clear	80%	5%
C	2	Rectangular	5X5	7'-10"	5'-4"	Clear	80%	5%
H	3	Arched Radius	7X15 + arch	25'-11"	7'-0"	Clear	80%	5%

Table 3.02 *Daylight Elements - Atrium*

Illuminance Requirements:

IESNA Reference: Hotels – Lobby – General Lighting (closest equivalent)

Horizontal Illuminance: 10 fc

Analysis: During the day, the daylighting should provide more than this by itself. At night, there are going to be task locations that require 30 fc (particularly the café cashier station and the work areas).

Design Criteria and Goals:

Most Important:

Appearance of Space and Luminaires:

- This space is the first that nearly every person entering the building will see, and this includes guests of the university. It is important that this space appears to be impressively aesthetically and also relaxing. High quality finishes were used here, so equally high-quality luminaires with pleasing aesthetics should be used.

Daylight Integration and Control:

- There is a very large amount of window area on the east wall of the space, and these have the potential to bring enough light into the space for all functions. The glass area is so large, however, that it is probable that too much light is going to enter the space, and good control of this light is critical.

Modeling of Faces and Objects:

- This is a requirement for the café area. Adequate light on faces, food, and menus is needed in order to conduct business. Also, way-finding is a critical task in this space, and being able to pick up on visual cues as to where to go requires a great deal of light on these objects.

Points of Interest:

- The open stairs and balconies are dominant elements of the space, so highlighting these areas would probably be a good idea. I'd also like to emphasize the work areas (the seating areas with tables and chairs) with more light that the general circulation areas.

Also Important:

Direct Glare:

- This relates more to the daylight entering the space. If not shielded properly, it could become impossible to do work in some areas of the spaces during certain daytime hours.

Light Patterns:

- In order to create a relaxing atmosphere, patterns of light can create bits of visual interest and help the space appear more natural.

Source/Task/Eye Geometry

- One of the tasks in this space will be casual reading. If the reading material is particularly glossy, it's going to be important to look at how the daylight is going to reflect off of the pages.

Surface Characteristics:

- The wood ceiling has some gloss to it, so a primarily indirect system would not be very effective here. The terrazzo flooring also is somewhat specular, so any high-intensity beams are going to be reflected strongly off of the floor, which could create some glare.

System Control and Flexibility:

- Daylight sensing controls may be important, as is adapting the system to both day and nighttime use. Different scenes might be good for receptions and regular work, but it's not crucial.

Daylight Study:

In order to determine whether electric light would be required during daytime hours, I performed a daylight study using AGI. The goal is to have at least 15 footcandles throughout the space at all times during the day.

Parameters:

Location: Lancaster, PA
Latitude: 40.07^{O} N
Longitude: 76.47^{O} N
Direction Building Faces: 18^{O} North of East

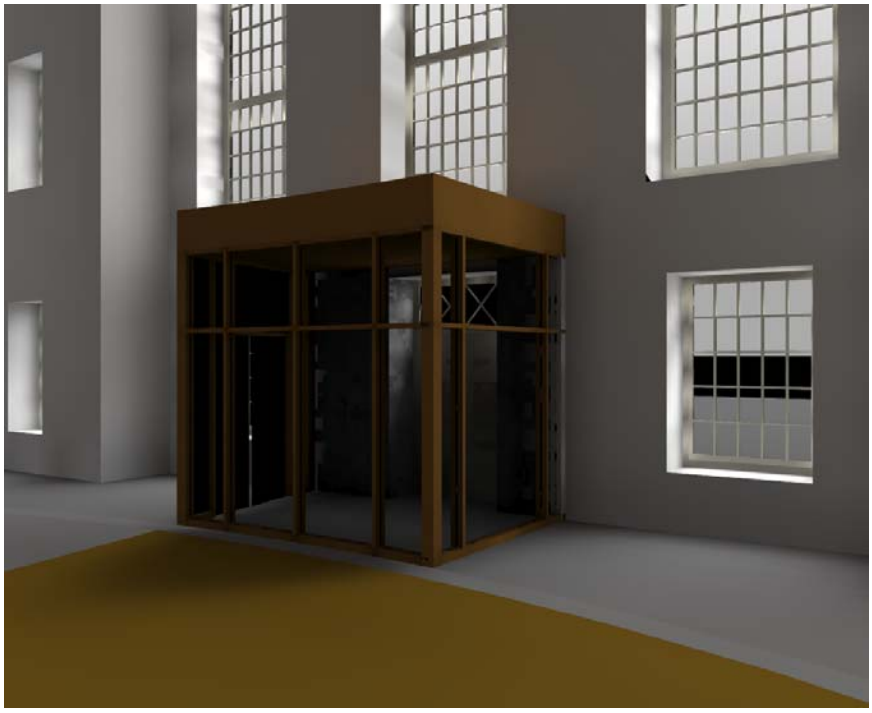


Figure 3.05 *Rendering of Atrium – March 21st, Overcast Sky, 10:00 AM*

Figure 3.06 *Rendering of Atrium – March 21st, Clear Sky, 8:30 AM*

Figure 3.07 *Rendering of Atrium – March 21st, Clear Sky, 12:00 PM*

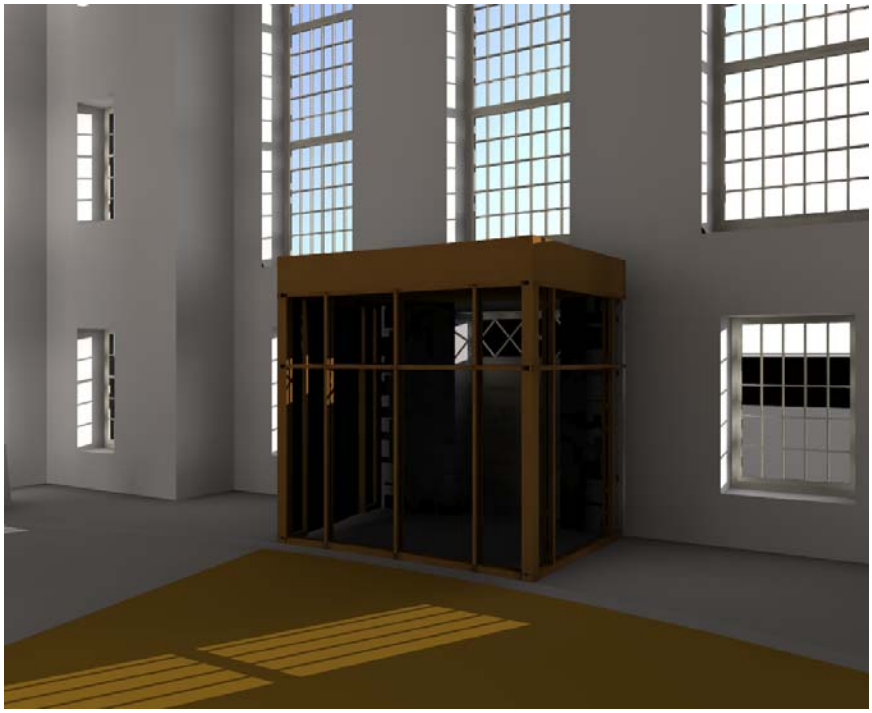


Figure 3.08 *Rendering of Atrium – December 22nd, Clear Sky, 8:30 AM*

Figure 3.09 *Rendering of Atrium – December 22nd, Clear Sky, 12:00 PM*

Figure 3.10 *Rendering of Atrium – June 22nd, Clear Sky, 8:30 AM*

Figure 3.11 *Rendering of Atrium – June 22nd, Clear Sky, 12:00 PM*

Daylight Study Results:

Month	Time	Sky	Footcandles	
			Typ.	Max.
March	8:30 AM	Clear	170	3179
March	10:00 AM	Clear	95	4220
March	10:00 AM	Overcast	23	39
March	12:00 PM	Clear	44	67
March	2:00 PM	Clear	27	35
March	4:00 PM	Clear	16	23
June	7:00 AM	Clear	98	1107
June	8:30 AM	Clear	130	3314
June	10:00 AM	Clear	100	4715
June	12:00 PM	Clear	62	99
June	2:00 PM	Clear	35	48
June	4:00 PM	Clear	25	31
December	8:30 AM	Clear	89	677
December	10:00 AM	Clear	84	1753
December	12:00 PM	Clear	38	53
December	2:00 PM	Clear	19	26
December	4:00 PM	Clear	10	13

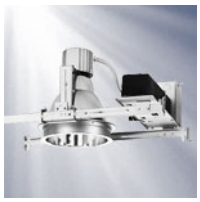
Table 3.03 *Compiled Data from Atrium Daylight Study*

As can be seen from the results above, there is more than enough natural light in the space during daytime hours. The height of the windows allows for daylight penetration all the way across the space. The values above are typical for the vast majority of the space. Therefore, I am proposed that the majority of any electric light for the space be turned off from 1 hour after sunrise until 1 hour before sunset. The café service area will require more light over the counters, and the stairs may require some additional light, so any lighting over these areas must remain on. In addition, the planned decorative pendant and other luminaires with decorative elements will likely be on for aesthetic reasons, but both of these are not going to use a tremendous amount of energy.

Luminaire Schedule:

Label	Quantity	Description	Number of Lamps / Linear Feet	Lamp Type	Voltage
SS1	34	Recessed round downlight	1	32W TRT CFL	277
SS2	14	Recessed square downlight	1	32W TRT CFL	277
SS3	14	Luminous wall sconce with brass trim	2’	T5	277
SS4	1	Decorative pendant with 4 luminous glass discs and brass trim	4	42W TRT CFL	277
SS5	1	Oval-shaped low profile linear wallwasher	6’	T5	277

Table 3.04 *Compressed Luminaire Schedule for Atrium*
For Full Luminaire Schedule and Details, Please Refer to Appendix A

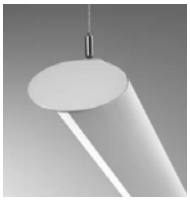


SS1

SS2

SS3

SS4



SS5

Ballast Schedule:

Label	Ballast Type	Power Factor	Ballast Factor	Ballast Watts
SS1	Electronic Rapid Start	0.98	0.98	36
SS2	Electronic Rapid Start	0.98	0.98	36
SS3	Electronic Instant Start	0.98	1.05	19
SS4	Electronic Rapid Start	0.98	0.98	184
SS5	Electronic Prog. Start	0.98	1.02	48

Table 3.05 *Compressed Ballast Schedule for Atrium*
For Full Ballast Details, Please Refer to Appendix A, p.145

Light Loss Factors:

Label	Maint. Cat.	Degree of Dirt	Cleaning Schedule	Distrib. Cat.	Ballast Factor	Lumin. Dirt Deprec.	Lamp Lumen Deprec.	Room Surface Dirt Deprec.	Total LLF
SS1	III	Very Clean	12 mths	Direct	0.980	0.924	0.841	0.965	0.735
SS2	III	Very Clean	12 mths	Direct	0.980	0.924	0.841	0.965	0.735
SS3	II	Very Clean	12 mths	Dir-Ind.	1.050	0.968	0.919	0.930	0.869
SS4	VI	Very Clean	12 mths	Dir-Ind.	0.980	0.804	0.841	1.000	0.663
SS5	III	Very Clean	12 mths	Direct	1.020	0.924	0.919	0.960	0.831

Table 3.06 *Light Loss Factors for Exterior and Facade*

Controls:

All of the lighting in the space (with the exception of the café lighting and the vestibule lighting) will be controlled off of a time clock controller. There will be two controllers. The first would be for all of the recessed lighting in the space (except as noted above). The controller will be programmed to turn those luminaires on at one hour before sunset, and turn them off at one hour after sunrise. Combined with the ample natural light entering the space during the day, this ensures that there will be adequate lighting in the space 24 hours a day without switching. The second controller will be for the decorative pendants and the sconces. That controller will be programmed to turn those luminaires on at 6:00 AM, and turn them off at 10:00 PM. This will allow the more decorative fixtures to be on during daytime hours, and to conserve energy by turning off at night. The 10:00 PM switching ensured that the lighting is not switched off during any university events that would be held here. A cutsheet of the proposed time clock controller is in Appendix A, page 222. The café lighting will be switched locally. The vestibule lighting will be on at all times for security reasons, so no switching is required. These controls allow the space to meet the automatic shut-off standard of ASHRAE 90.1-2004.

Lighting Plan – First Floor

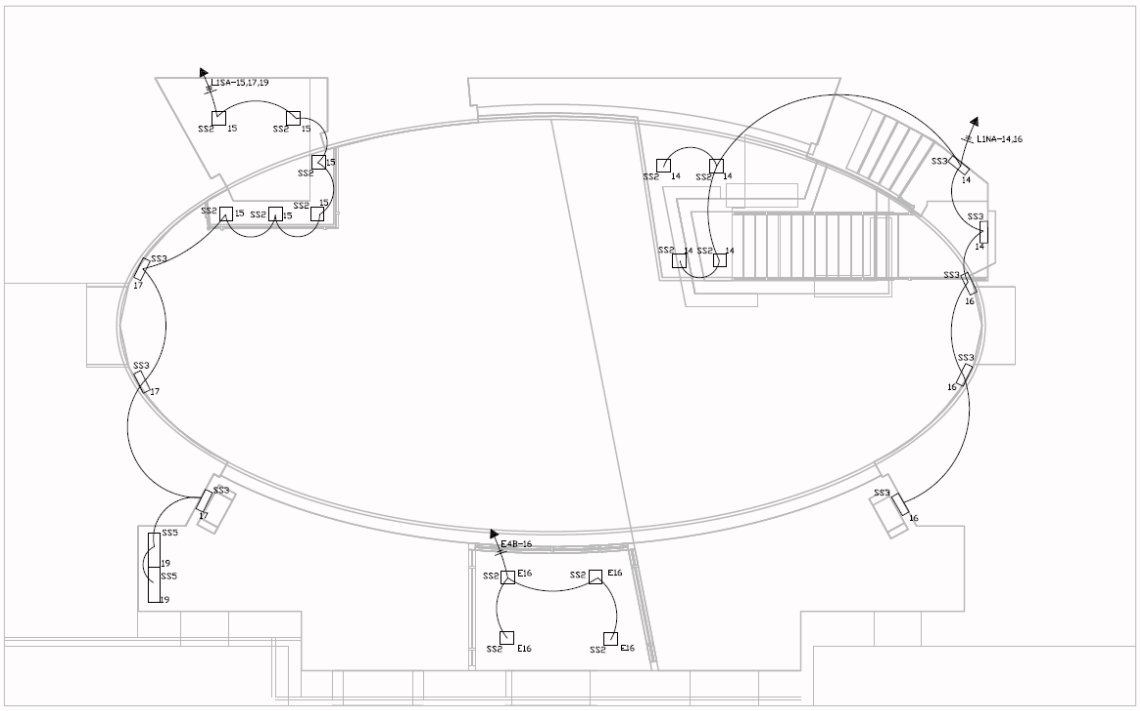


Figure 3.12 *Atrium Lighting Plan – First Floor*

Label	Number	Mounting Type	Mounting Height	Cantilever / Pendant Length	Circuit
SS2	6	Recessed	11'-6"	-	L1SA-15
SS2	4	Recessed	11'-0"	-	E4B-16
SS2	4	Recessed	11'-6"	-	L1NA-14
SS3	2	Surface	5'-0"	-	L1SA-17
SS3	1	Surface	7'-0"	-	L1SA-17
SS3	2	Surface	15'-0"	-	L1NA-14
SS3	2	Surface	5'-0"	-	L1NA-16
SS3	1	Surface	7'-0"	-	L1NA-16
SS5	1	Cantilever	8'-6"	1'-3"	L1SA-19

Table 3.07 *Mounting Details for Atrium – First Floor*

Lighting Plan – Second Floor

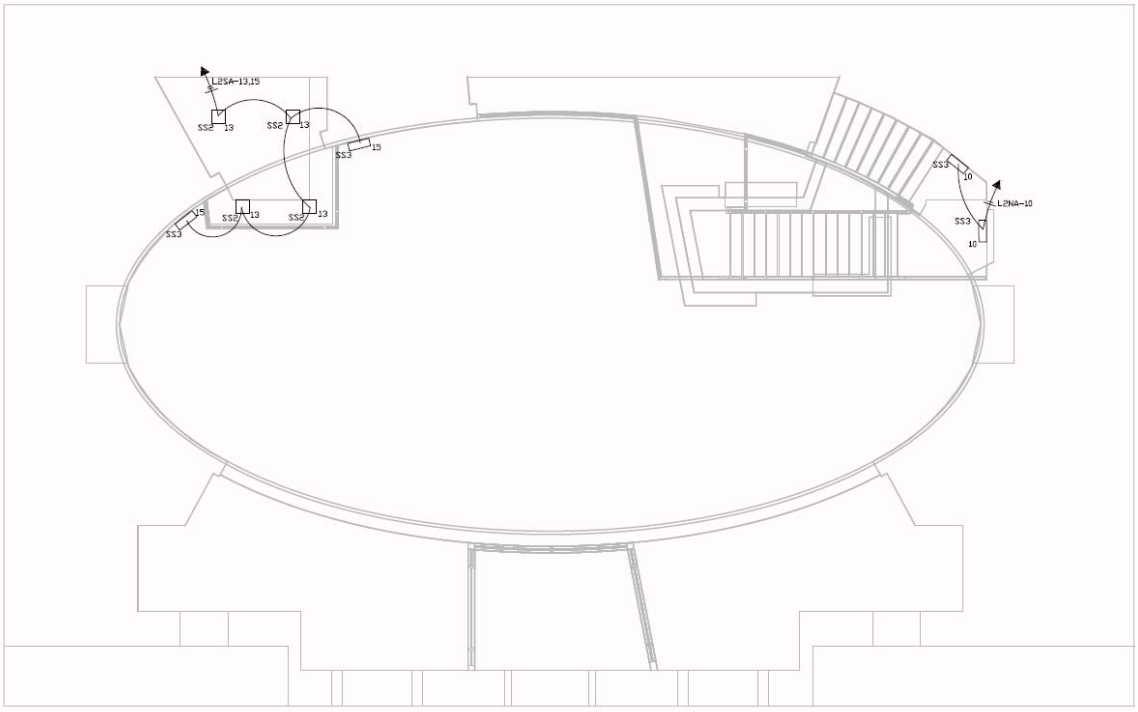


Figure 3.13 *Atrium Lighting Plan – Second Floor*

Label	Number	Mounting Type	Mounting Height	Cantilever / Pendant Length	Circuit
SS2	4	Recessed	25'-6"	-	L2SA-13
SS3	2	Surface	29'-0"	-	L2NA-10
SS3	2	Surface	20'-0"	-	L2SA-15

Table 3.08 *Mounting Details for Atrium – Second Floor*

Lighting Plan – Third Floor

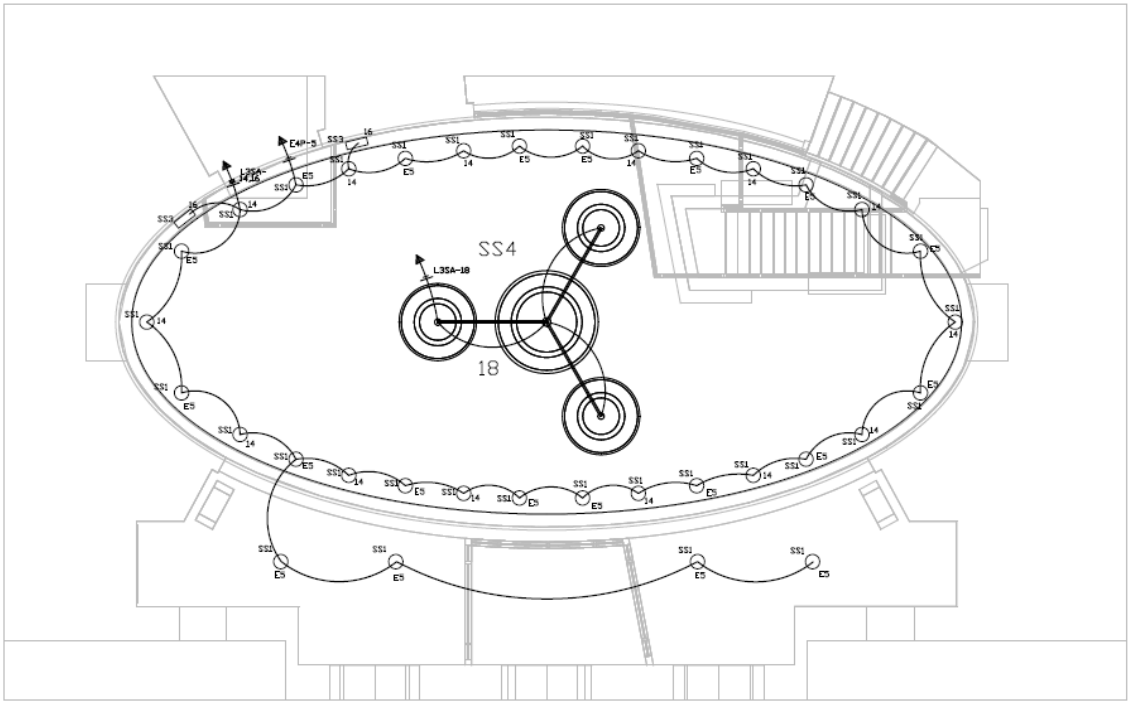


Figure 3.14 *Atrium Lighting Plan – Third Floor*

Label	Number	Mounting Type	Mounting Height	Cantilever / Pendant Length	Circuit
SS1	8	Recessed	38'-0"	-	L3SA-14
SS1	8	Recessed	38'-0"	-	L3SA-16
SS1	7	Recessed	38'-0"	-	E4P-1
SS1	7	Recessed	38'-0"	-	E4P-3
SS1	6	Recessed	38'-0"	-	E4P-5
SS3	2	Surface	34'-0"	-	L3SA-18
SS4	1	Pendant	35'-0"	3'-0"	L3SA-20

Table 3.09 *Mounting Details for Atrium – Third Floor*

Details:

I elected to design a custom pendant for the center of the space, in the hopes of creating a focal point for the atrium and enhancing the other modern design elements. I designed the pendant with the theme of "three merging into one", to reflect the original purpose of the building (bringing together the departments of psychology, philosophy, and biology in one facility). I was inspired by the concept of luminous discs of light that I saw in a couple of other pendants. I liked the use of different types of glass (clear, frosted, diffuse) that were used of the same disc, since it added both glow and interest that could not be produced with only one type of glass. The custom pendant here needed to be much larger, and it needed to match the atrium and building as a whole more. The trim and supporting elements, therefore, will be brass. Brass is considered a theme material for the building, and many of the places where metal trim was used, it was done in brass.

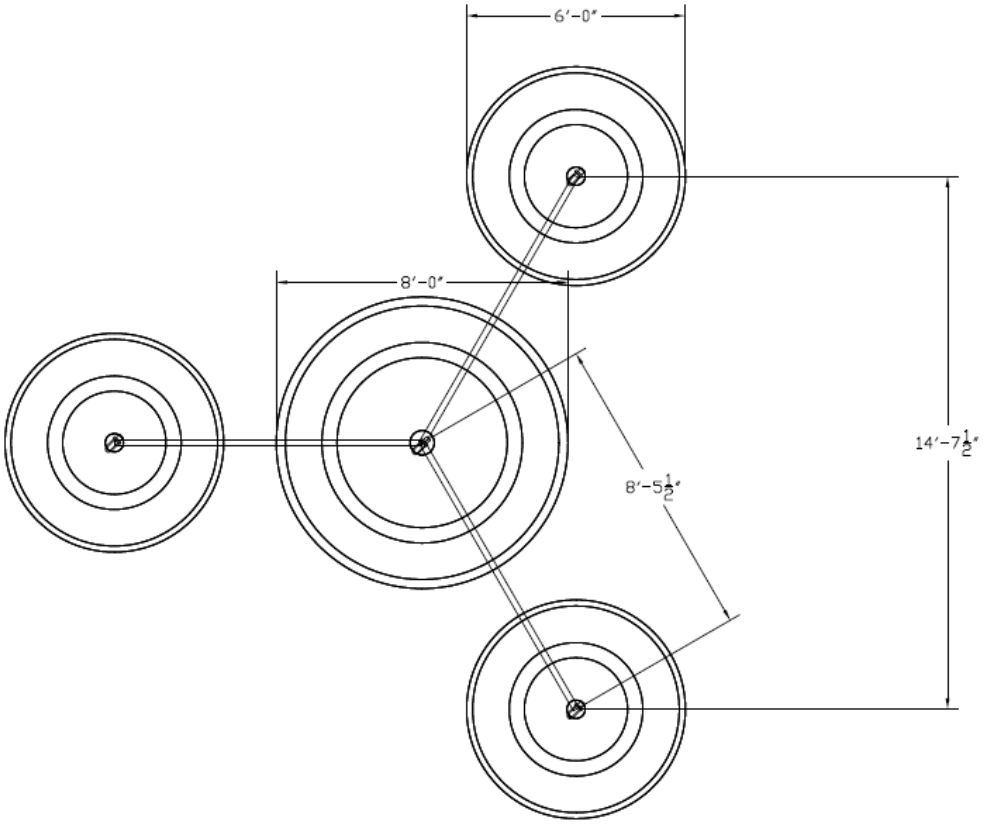


Figure 3.15 *Custom Pendant for Atrium (Type SS4) – Plan*

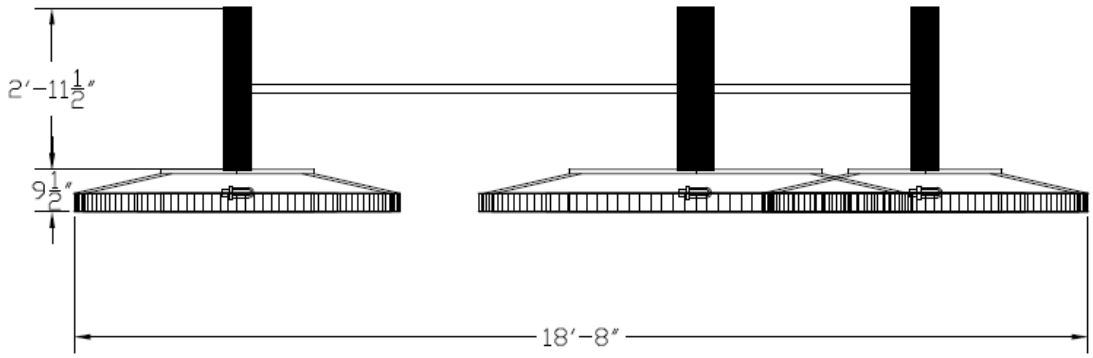


Figure 3.16 *Custom Pendant for Atrium (Type SS4) – Elevation*

Figure 3.17 *Custom Pendant for Atrium (Type SS4) – Rendered Image*

Calculations and Performance:

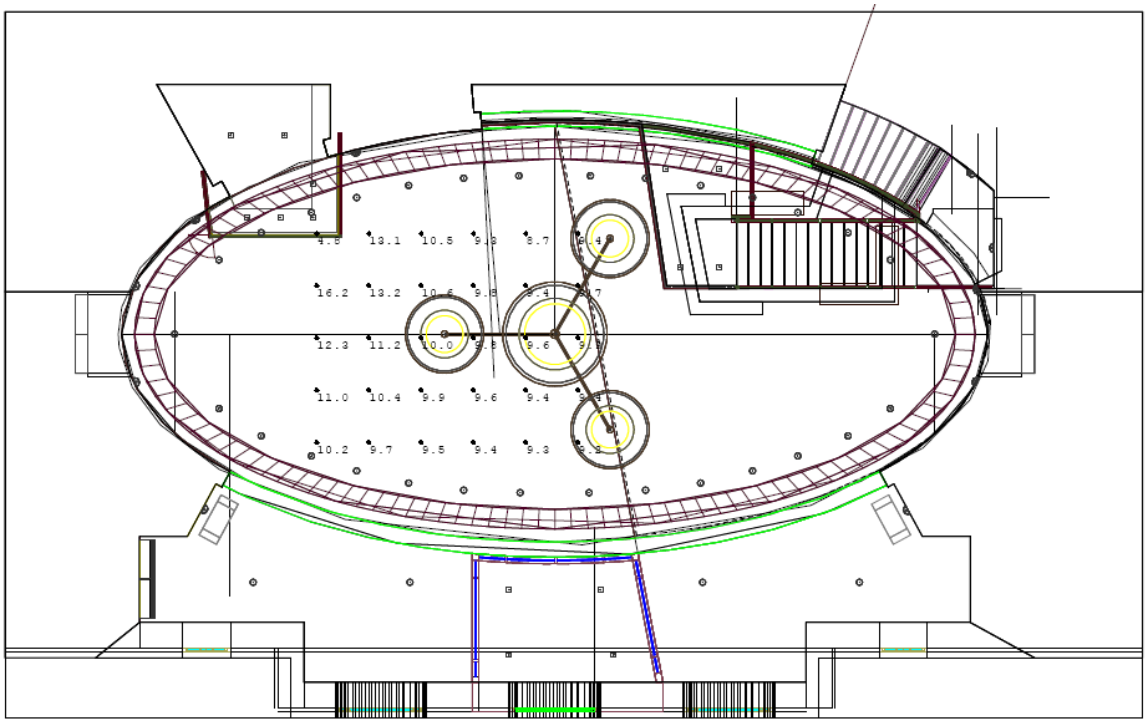


Figure 3.18 *Atrium – Plan of AGI Model with Calculation Grid*

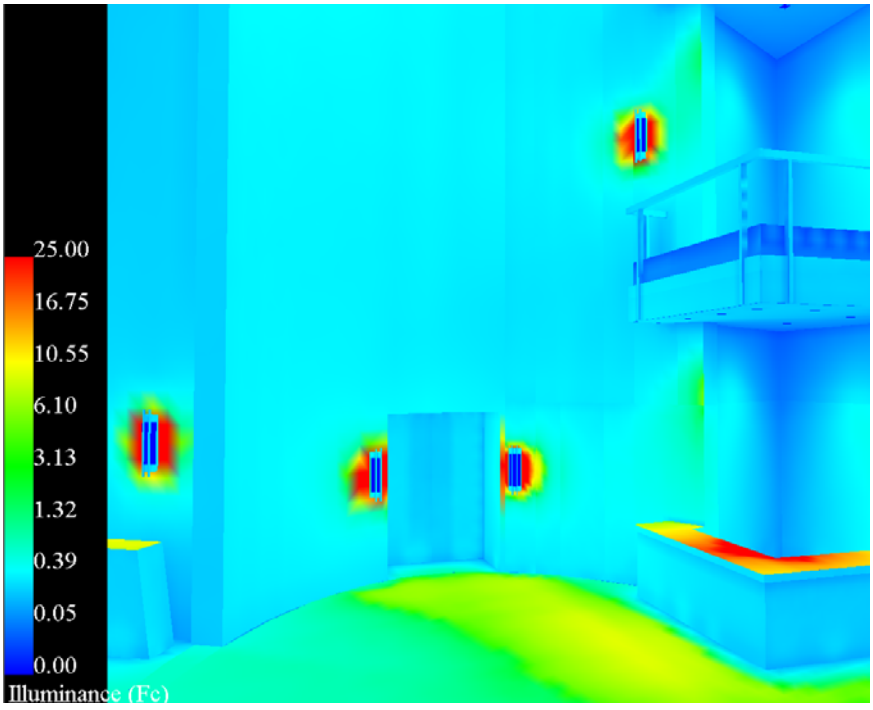


Figure 3.19 *Pseudocolor Rendering of Atrium – Facing South*

Rendered Images:

Figure 3.20 *Color Rendering of Atrium – Facing North*

Figure 3.21 *Color Rendering of Atrium – From Main Entry*

Figure 3.22 *Color Rendering of Atrium – From Balcony*

Figure 3.23 *Color Rendering of Atrium – Ceiling and Custom Pendant*

Power Density Calculations:

Because of the height, dimensions, and purpose of this space, this is by far the most difficult space to meet the power allowance in. I originally designed the space using ceramic metal halide downlights because of their high efficacy, a color that best fit the modern theme of the space, and long lamp life. The light levels were more than adequate, and would have allowed for some half-on, half-off scenarios. However, the energy consumption was nearly 1.5 Watts per square foot. Because ASHRAE 90.1 only considers connecting load, not the length of time the luminaires will be on, the 70W ceramic metal halide lamps had to be switched. I sacrificed the ability to get up to 30 footcandles at the ground. This would have been nice for some functions, but overall isn't a requirement for the atrium (10 footcandles will suffice). By switching to 32W compact fluorescent triple tube lamps, I was able to get the energy consumption low enough here to make use of the Space-by-Space procedure. Since these lamp meet illuminance goals and energy requirements, and since the lamp life is almost comparable, I feel that the overall design has not been downgraded as a result of having to design to ASHRAE 90.1-2004.

Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Atrium	Atrium - First Three Floors	0.6 W/ft^2	-	2672	1603.2
			Total Allowed		1603.2 W

Table 3.10 *Power Allowance for Atrium – Functional Lighting*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
SS1	34	36	1224
SS2	14	36	504
SS5	1	48	48
		Total Watts Consumed	1776 W

Table 3.11 *Power Consumed by Atrium – Functional Lighting*

Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Atrium	Decorative Lighting	1.0 W/ft^2	-	2672	2672
			Total Allowed		2672 W

Table 3.12 *Power Allowance for Atrium – Decorative Lighting*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
SS3	14	19	266
SS4	1	184	184
		Total Watts Consumed	450 W

Table 3.13 *Power Consumed by Atrium – Decorative Lighting*

Based on the charts above, it would appear that I have exceeded my energy budget. However, since the Space-by-Space method allows for the trading of allowable energy between spaces, I will have no difficulty meeting the standards set forth in ASHRAE 90.1-2004. I will discuss this further in the full conclusion.

Conclusions:

I like what the custom pendant brings to the space. The scale is good: large enough to be a focal point, but not so much that it covers the entire wood ceiling. It also is noticeable, but not intrusive. People can appreciate the entire space from the balconies without being blocked by the pendant. The sconces add some attention to the doors, stairs, and balconies, and the brass in them matches well with the theme materials for the space. The downlights from the wood ceiling help to emphasize the shape of the ceiling and the atrium as a whole, but still provide a relatively even distribution of light (which can be expected from a 40-foot mounting height). Despite all of this, I think it is the large windows that really allow this space to function as well as it does. The amount of daylight that penetrates the space allows most of the electric lighting to be completely off during the day, and this allows the space to have essentially two different lighting schemes for the price of one. The time clock settings allow the atrium to be alive and dynamic during the day, simple and elegant in the evening, and functional and secure at night.

Ecology Teaching Lab

Overview:

The Ecology Teaching Lab is one of fifteen throughout the second and third floors. As a result, the lighting design of this space would likely carry over to the design of the other laboratories. This laboratory is located on the second floor, immediately adjacent to (but not immediately accessible from) the atrium. The main function of this laboratory is for teaching to first and second-year students. That said, all of the labs are available to graduate students for 24-hour use. For this space, it will be important to design to both a full class of 24 students and the lone graduate student working late at night.

Major furnishings include lab stations with a workplane at 3' AFF, a podium workstation at the front of the room, sink cabinets, storage shelving, and other safety equipment. A chalkboard and a retractable projection screen will also be furnished.

Plans:

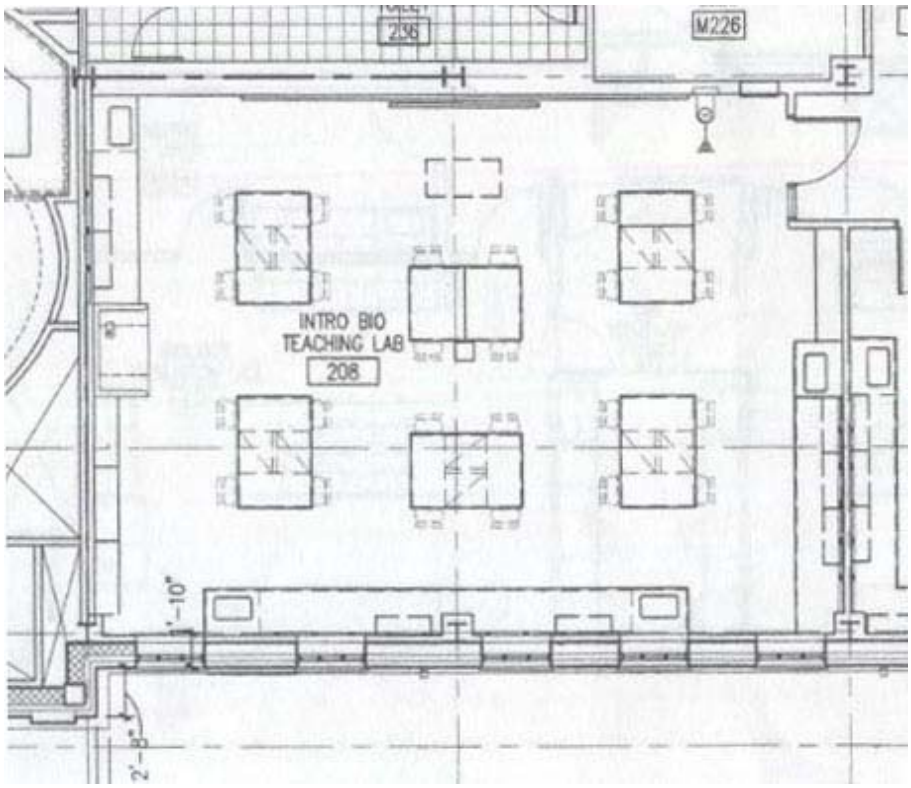


Figure 4.01 *Second Floor Plan – Ecology Teaching Lab*

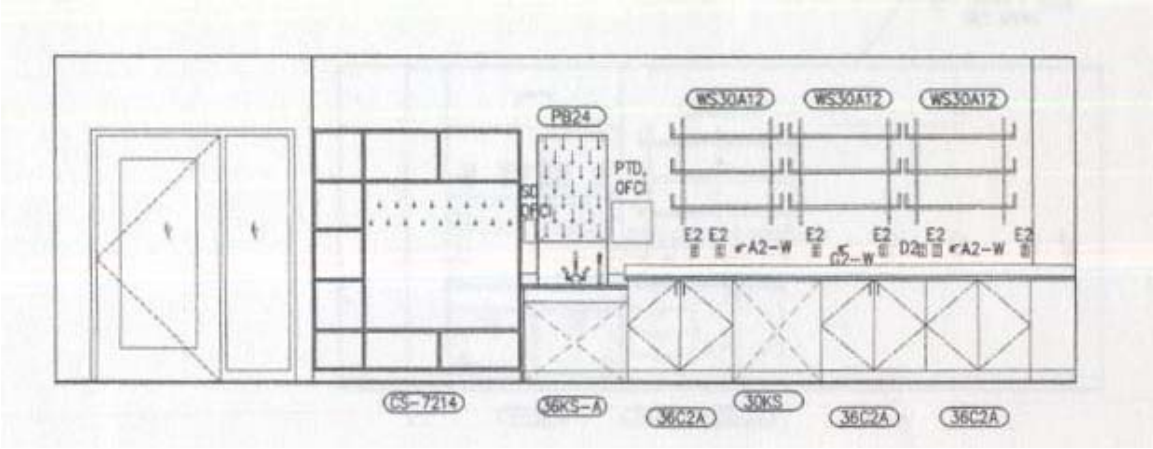


Figure 4.02 *North Elevation – Ecology Teaching Lab*

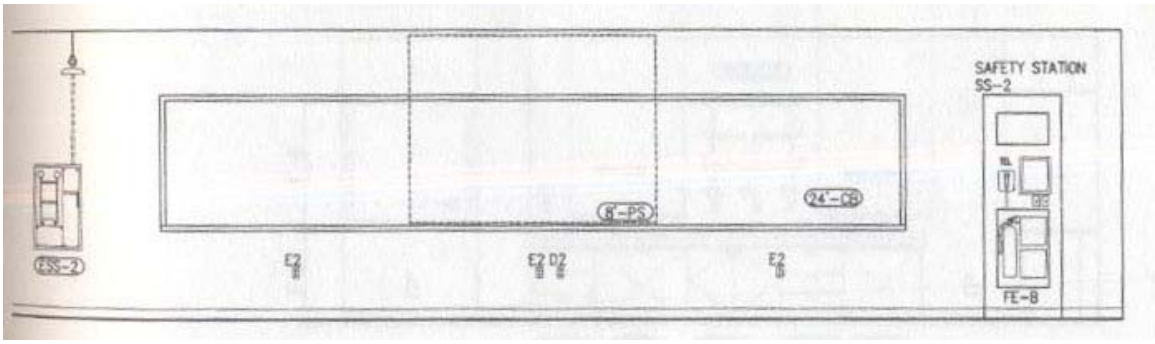


Figure 4.03 *West Elevation – Ecology Teaching Lab*

Surface Characteristics:

Surface	Material	Color	Reflectance	Finish
Ceiling	acoustical ceiling tile	white	80%	matte
Walls	gypsum board	white	70%	matte
Floor	vinyl composition tile	white	55%	semi-specular
Floor	vinyl composition tile	blue	15%	semi-specular
Cabinets	wood	tan	30%	semi-specular
Worksurface	epoxy resin	black	10%	semi-specular

Table 4.01 *Surface Characteristics – Ecology Lab*

Daylight Elements:

Label	Quantity	Window Type	Mullion Pattern	Max Height	Max Width	Finish	Transmittance	Reflectance
A1	5	Rectangular	3X5	7'-10"	3'-8"	Clear	80%	5%

Table 4.02 *Daylight Elements – Ecology Lab*

Illuminance Requirements:

IESNA Reference: Classrooms – Science Laboratories

Horizontal Illuminance: 50 fc
Vertical Illuminance: 30 fc

Analysis: Appropriate for this environment, but would like system to be capable of 75-80 fc for some experiments

Design Criteria and Goals:

Most Important:

Color Appearance and Color Contrast:

- The experiments being performed in this laboratory require the experimenter/student to be able to distinguish subtle differences in color, as well as to be able to correctly decipher color to begin with. A high CRI source would be required.

Light Distribution on Task Plane:

- In order to have a reasonably controlled environment for all experiments, it is best to have each lab station as identical to the next as possible. This includes having approximately the same illuminance and luminance levels. Also, in order to make it equally possible to learn from any place in the room, it would be practical to make the workstations as uniformly lit as possible. It is acceptable to have lower light levels over the egress areas.

Luminances of Room Surfaces:

- The chalkboard is a major task in this room, and it is imperative that the chalkboard is lit well enough to be seen.

Modeling of Faces and Objects:

- This is critical if the professor is planning on performing demonstrations in front of the class, which based on the layout of the lab, appears to be the case. The students need to be able to see distinct features of objects both at their station and the professor's. Good facial rendering is also a critical part of the learning process, as being able to see what the professor is saying both connects the professor to his/her audience and helps reinforce the information they are hearing.

Points of Interest:

- Major tasks to focus on are the chalkboard and the individual workstations. A task lighting system might be a good way to emphasize the importance of these areas.

Also Important:

Source/Task/Eye Geometry:

- Objects used during labs may be specular or glossy. If a direct lighting system is used, it is important to consider where a person is likely to sit/stand and where they are likely to view glossy objects.

Surface Characteristics:

- The major task surfaces (the workstation and the chalkboard) are very low reflectance. Generally, more light than normally required will be needed to work well in this space.

Special Considerations (VDT/Projection Screen):

- The projection screen will be over the chalkboard. Any lighting specifically for the chalkboard must be controlled separately from the rest of the space, so that people may still see to take notes during presentations. Any ambient light should be examined to make sure there isn't a significant amount striking the projection screen.

Illuminance (Horizontal and Vertical):

- Good illuminance is required to learn and to perform detailed experimentation. Appropriate horizontal illuminance is needed on the workstations, and appropriate vertical illuminance is required on the chalkboard.

Luminaire Schedule:

Label	Quantity	Description	Number of Lamps	Lamp Type	Voltage
RR1	23	Recessed direct-indirect LTT luminaire with louvers and white reflector	1	40W LTT	277
RR2	9	Recessed T8 fluorescent downlight with parabolic louver	1	32W T8	277
RR3	6	Surface mounted T8 chalkboard light	1	32W T8	277

Table 4.03 *Compressed Luminaire Schedule for Ecology Teaching Lab*
For Full Luminaire Schedule and Details, Please Refer to Appendix A

RR1

RR2

RR3

Ballast Schedule:

Label	Ballast/Driver Type	Power Factor	Ballast Factor	Ballast Watts
RR1	Electronic Ballast	0.90	1.02	40
RR2	Electronic Ballast	0.98	0.90	34
RR3	Electronic Ballast	0.98	0.90	34

Table 4.04 *Compressed Ballast Schedule for Ecology Teaching Lab*
For Full Ballast Details, Please Refer to Appendix A

Light Loss Factors:

Label	Maint. Cat.	Degree of Dirt	Cleaning Schedule	Distrib. Cat.	Ballast Factor	Lumin. Dirt Deprec.	Lamp Lumen Deprec.	Room Surface Dirt Deprec.	Total LLF
RR1	II	Very Clean	12 mths	Direct	1.020	0.968	0.908	0.973	0.872
RR2	III	Very Clean	12 mths	Direct	0.900	0.924	0.950	0.973	0.769
RR3	III	Very Clean	12 mths	Direct	0.900	0.924	0.950	0.973	0.769

Table 4.05 *Light Loss Factors for Ecology Teaching Lab*

Lighting Plan:

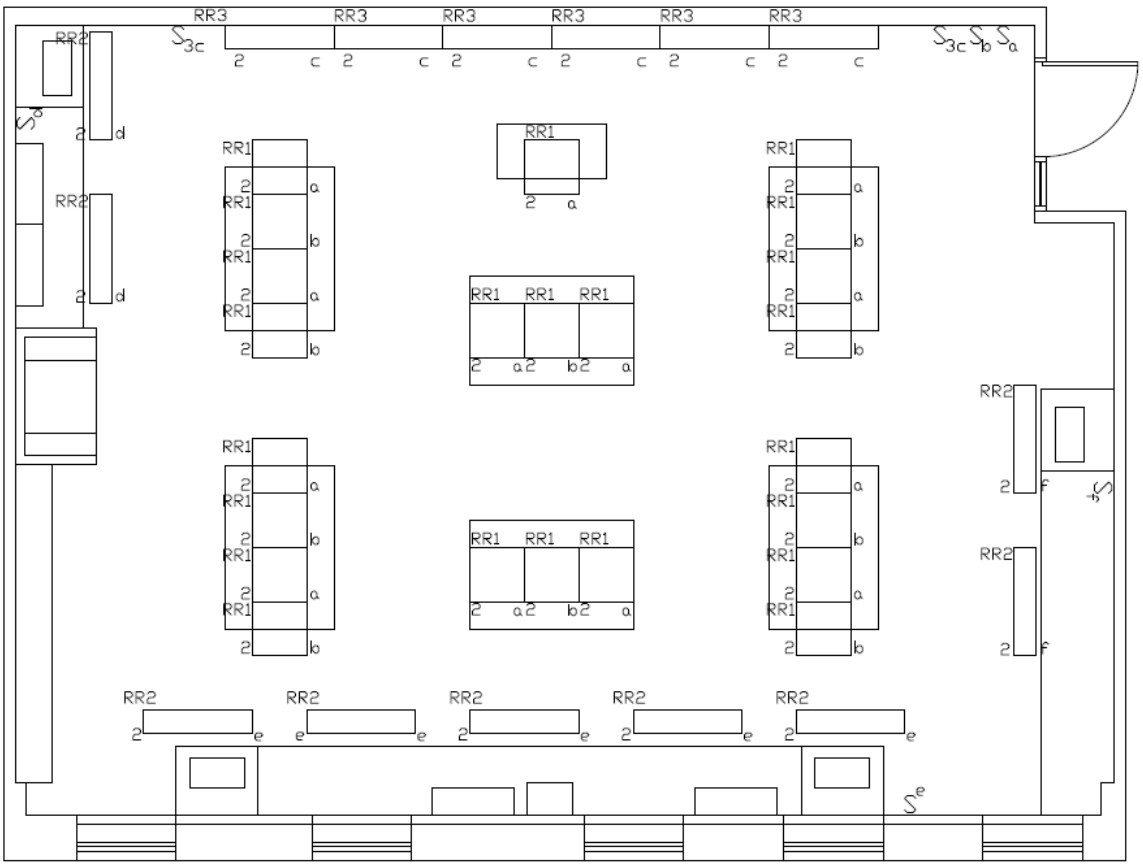


Figure 4.04 *Lighting Plan – Ecology Teaching Lab*

Controls:

For this layout, I explored two different switching options. From the beginning of the design process, I designed that I would like bi-level switching capabilities for the luminaires over the lab workstations. I also wanted localized switching for the luminaires over the side counters.

The difference between the two options is the location(s) where the second level of the bi-level switching occurs. In both systems, the first level is at the front entry, and allows for a light level of 35-40 footcandles to strike the desks.

In the first option, the second level of switching also occurs at the front entry of the room, and switches the second set of luminaires over all six lab workstations.

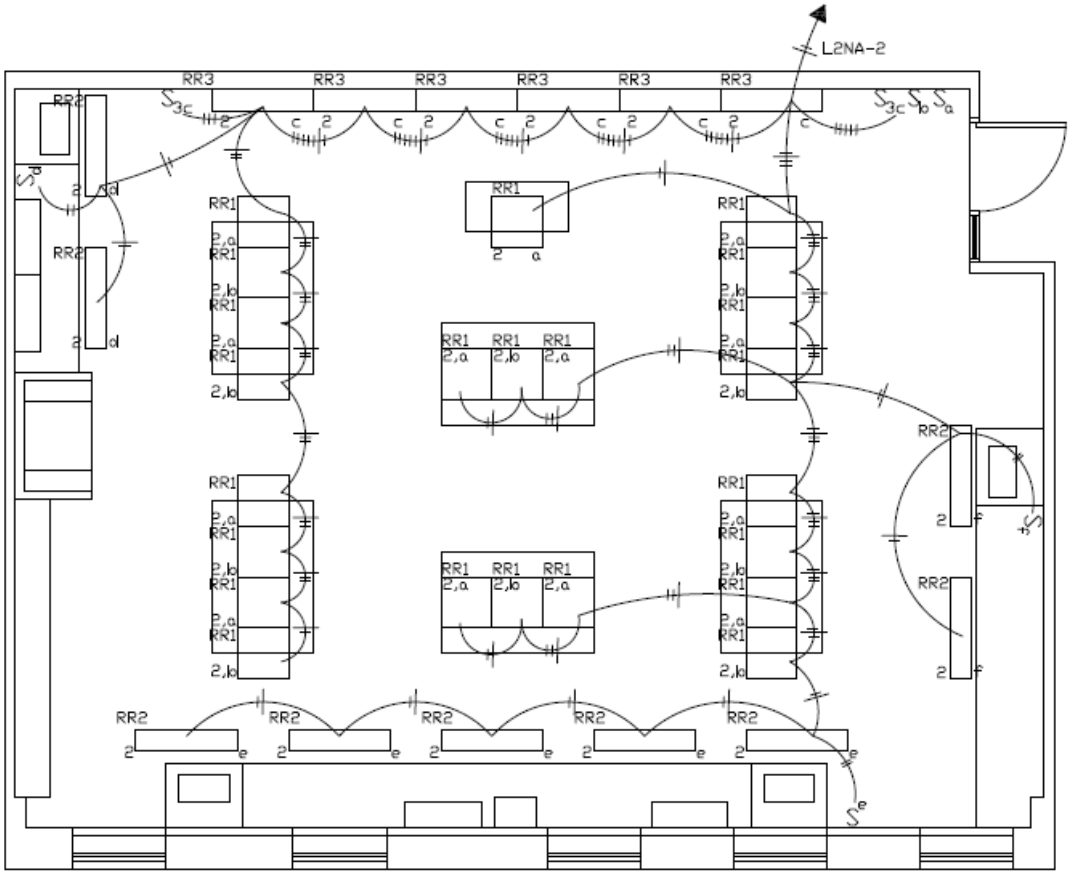


Figure 4.05 *Switching Option #1 – Ecology Teaching Lab*

The second option would allow the second light level to be switched on separately for each individual workstation. The switch would be located underneath the worksurface of the station.

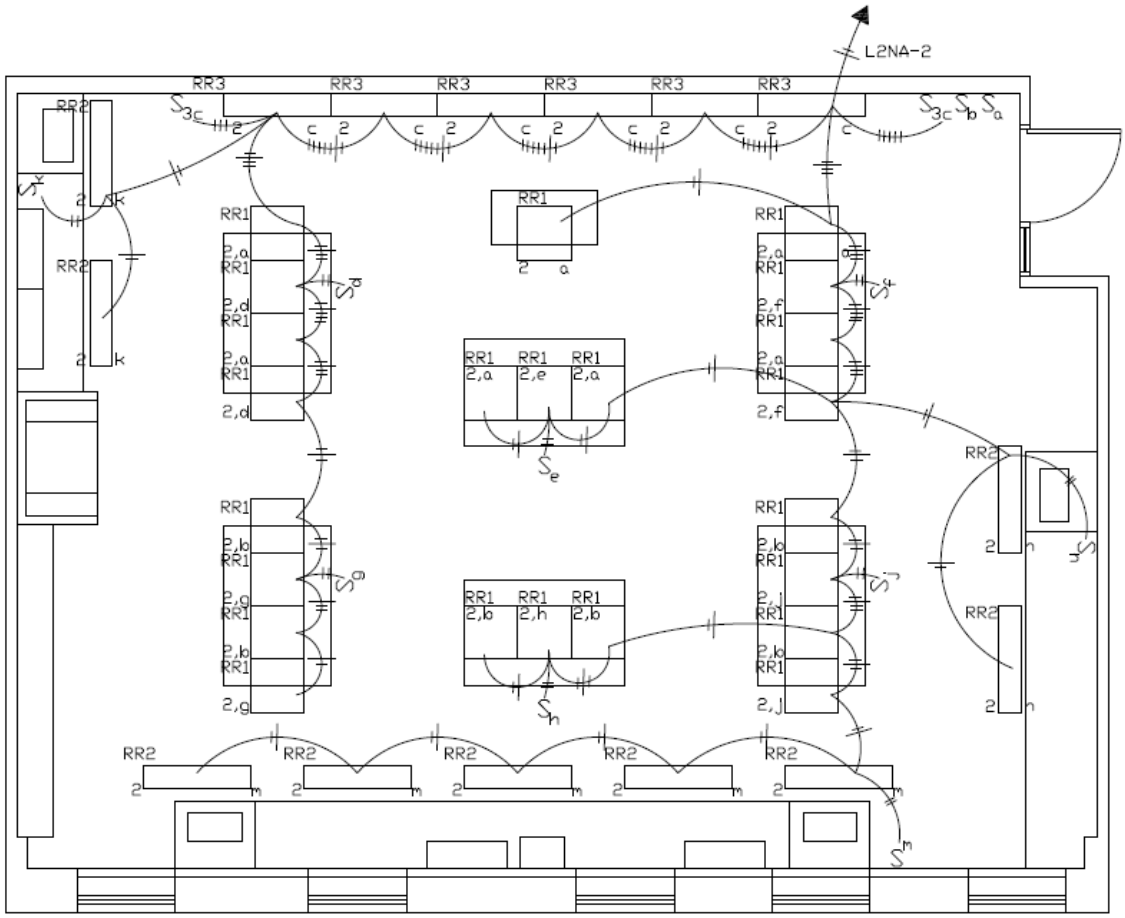


Figure 4.06 *Switching Option #2 – Ecology Teaching Lab*

While the second option would offer the most potential for energy savings, and provides the most individualized control, it has many drawbacks. Since putting a raceway of some sort through each workstation is not a viable option, wires would have to be run from the home run location through the floor to each workstation switch, then back to a wall to go up to the ceilings and the luminaires. Besides being a lot more complicated, this adds a lot more wire to the project, and therefore significantly increases the cost. For these reasons, I am recommending the first control system. With time clocks for the entire building, this space meets the requirements for automatic shut-off.

Calculations and Performance:

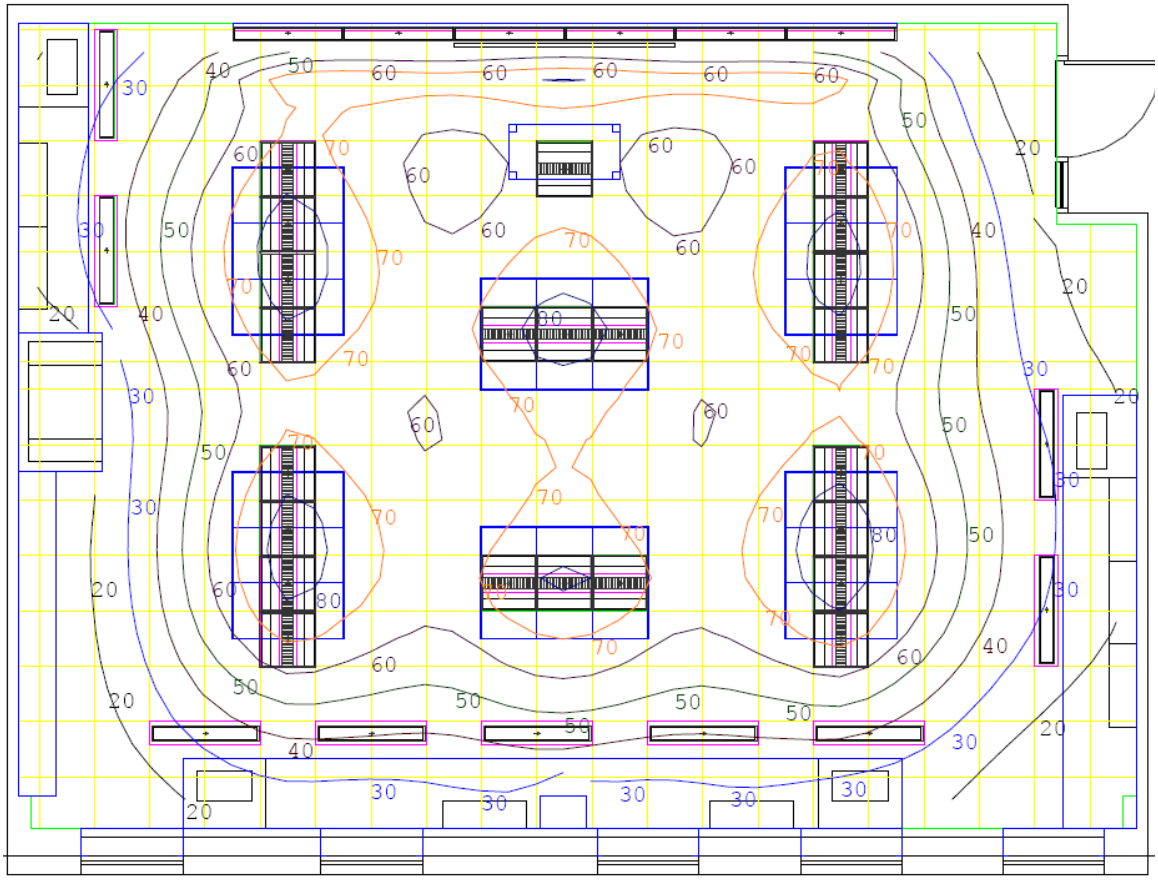


Figure 4.07 *Ecology Teaching Lab – Plan of AGI Model with Footcandle Isolines*

75.2	76.4	74.9	74.0	74.6	76.4	76.3	74.5	73.8	74.8	76.0	73.8
27.0	28.4	26.7	25.7	26.5	28.5	28.5	26.4	25.5	26.5	27.6	25.4
23.2	24.0	22.9	22.0	22.8	24.5	24.5	22.6	21.8	22.5	23.2	21.3
22.3	23.2	22.7	22.2	22.6	23.9	23.8	22.4	21.9	22.3	22.4	20.7

Figure 4.08 *Ecology Teaching Lab – Elevation of Chalkboard with Calculation Grid*

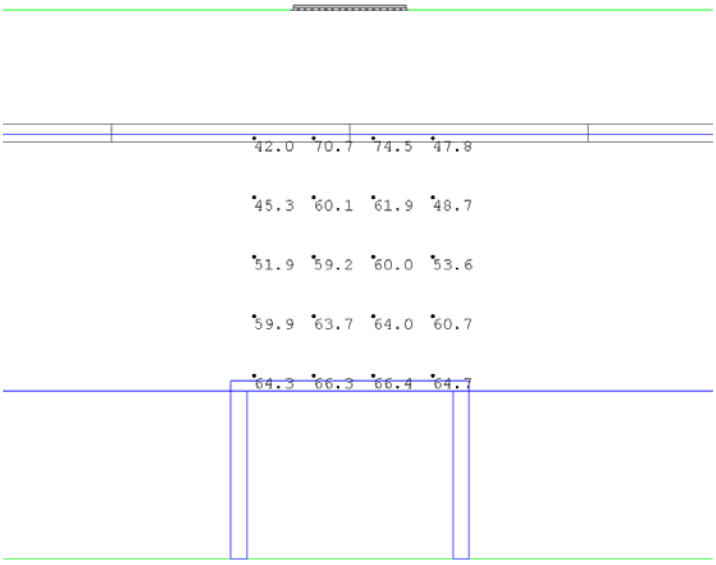


Figure 4.09 *Ecology Teaching Lab – Elevation of Lecture Area with Calculation Grid*

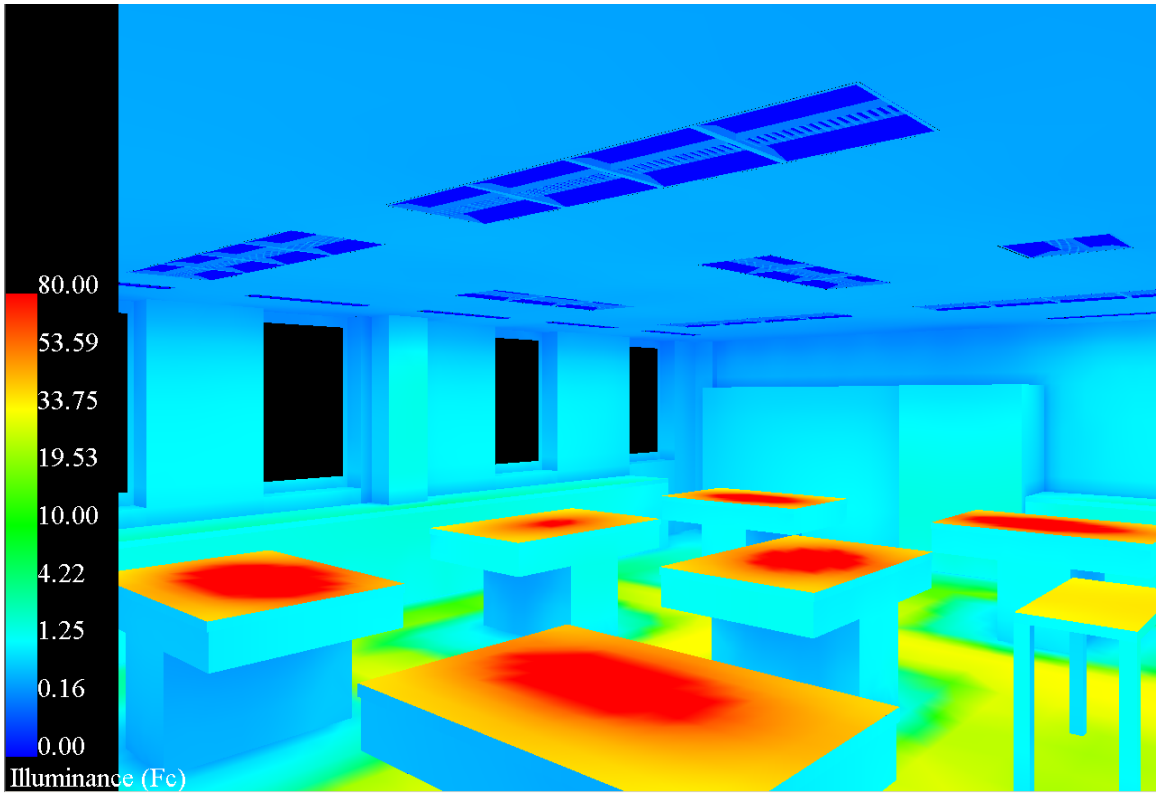


Figure 4.10 *Pseudocolor Rendering of Ecology Teaching Lab – From Entrance*

Rendered Images:

Figure 4.11 *Color Rendering of Ecology Teaching Lab – From Entrance*

Figure 4.12 *Color Rendering of Ecology Teaching Lab – From Back Workstation*

Power Density Calculations:

Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Ecology Lab	Laboratories	1.4 W/ft^2	-	1160	1624

Total Allowed	1624 W

Table 4.06 *Power Allowance for Ecology Lab*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
RR1	23	40	920
RR2	9	34	306
RR3	6	34	204

Total Watts Consumed	1430 W

Table 4.07 *Power Consumed by Ecology Lab*

Based on the above calculation, the space meets the energy requirements set forth in ASHRAE 90.1 – 2004.

Conclusions:

I feel the task-oriented approach was a very strong one for this space. First, it draws a lot of attention to the major task areas in the room: the workstations, the lecturer, and the chalkboard. This focus also has another key advantage. Since only the workstations were designed for 50 footcandles, rather than the entire space, this allowed for significant energy saving over a traditional, 2X4 or 1X4 recessed layout throughout. I also feel the switching system will be a good choice for this space. It allows the occupants of the space to use only the light they need, while allowing them enough light for any of their needs in the space. Although the layout with individualized workstation control would have been an excellent choice for function and energy savings, the room isn't properly equipped with raceways and columns, and with the much higher cost in wiring, I can't justify this option. I think I accomplished my goal of creating a layout that can be replicated throughout the other labs in the building, with similar success and energy savings.

Bonchek Lecture Hall

Overview:

This lecture hall was designed as a presentation space for guest lecturers of the departments housed in this building and for Franklin & Marshall College as a whole. Although perhaps not its original intent, the space is also now commonly used for regularly scheduled classes. Access to this space is from the atrium via a corridor width and a vestibule.

At between 9' and 13' above finished floor throughout the space, the lecture hall is not as voluminous as many lecture halls with similar footprints. There are 2 separate 1-foot step-down areas to allow a better view of the speaker and to increase the sense of spaciousness. The required handicapped ramp is at the left (south) end of the space. There is enough seating in this lecture hall for 100 attendees, plus a small number of overflow seats.

The general palette for finishes here was high-end, but simple and clean. The color in the space is restricted to the wood and to the view from the large arched windows (when the black-out shades aren't down). Aside from that, the materials remain in the white, black, and gray tones. Build-in elements include wood-trimmed laminate tables and chairs for audience members. Three projection screens (which are retractable but frequently in use) are also built-in.

Plans:

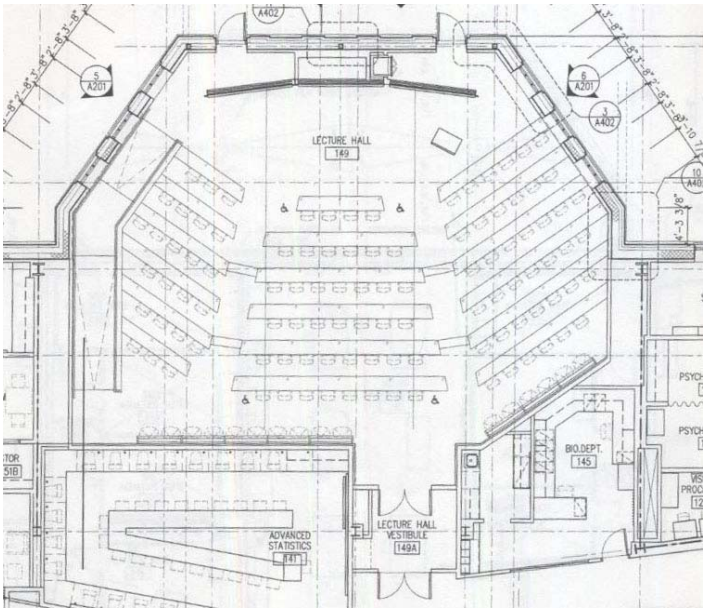


Figure 5.01 *First Floor Plan – Lecture Hall*

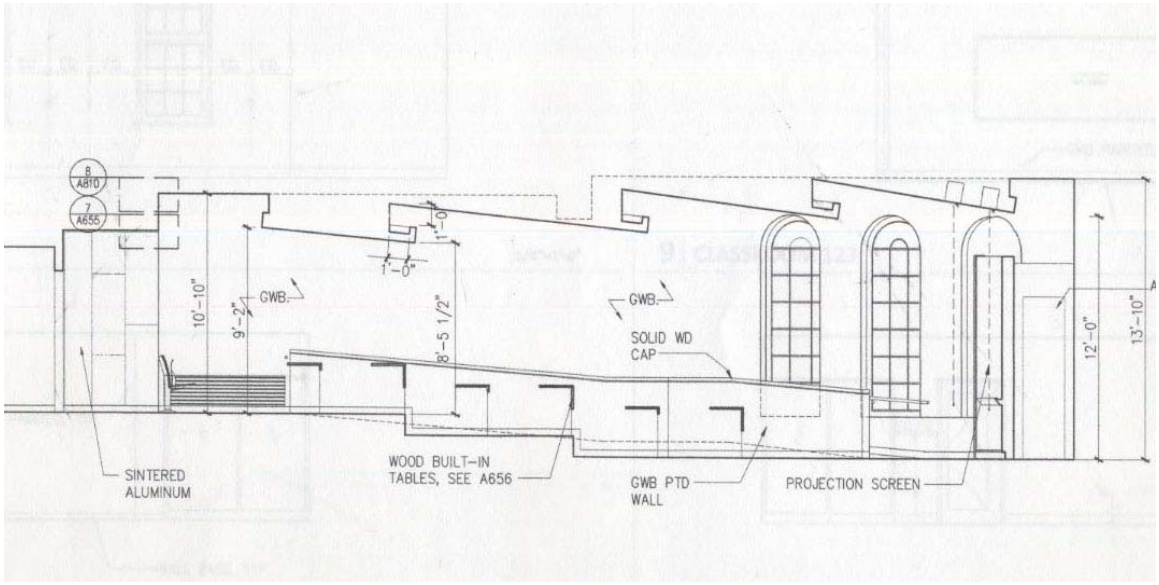


Figure 5.02 *North to South Section – Lecture Hall*

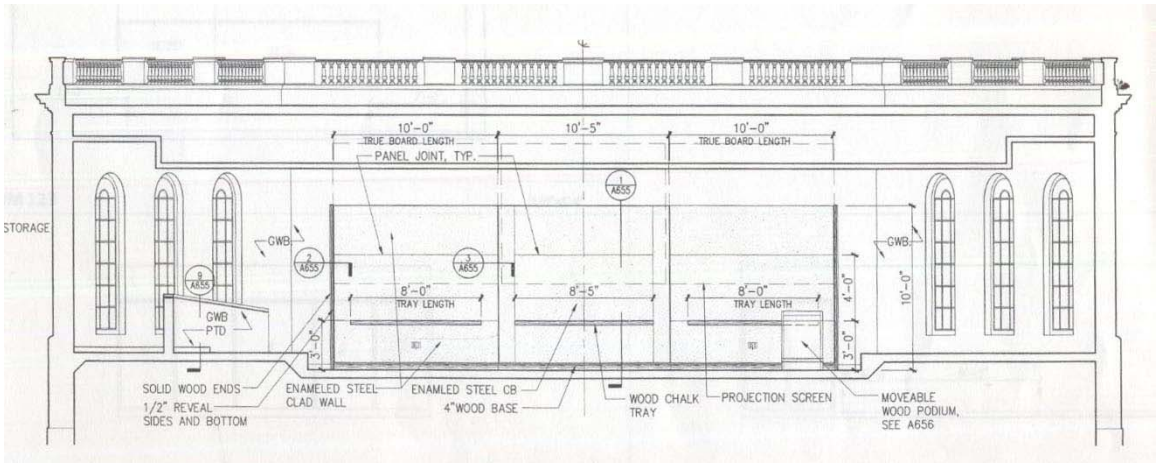


Figure 5.03 *West Elevation – Lecture Hall*

Surface Characteristics:

Surface	Material	Color	Reflectance	Finish
Side Walls	gypsum board	white	70%	matte
Back Walls	sintered aluminum panels (AWT)	silver	40%	semi-specular
Screen Walls	enamel steel clad	dark grey	10%	matte
Floor	carpet	grey	20%	matte
Desks - Trim	light wood	tan	30%	semi-specular
Desks - Top	plastic laminate	light grey	50%	matte
Railing - Top	wood	tan	30%	semi-specular
Railing - Sides	gypsum board	white	70%	matte
Ceiling - Seating	gypsum board	white	70%	matte
Ceiling - Edge	acoustical plaster	white	79%	semi-gloss

Table 5.01 *Surface Characteristics – Lecture Hall*

Daylight Elements:

Label	Quantity	Window Type	Mullion Pattern	Max Height	Max Width	Finish	Transmittance	Reflectance
J1	6	Arched Radius	3X6 + arch	9'-4"	3'-8"	Clear	80%	5%

Table 5.02 *Daylight Elements – Lecture Hall*

Illuminance Requirements:

IESNA Reference: Lecture Halls (audience/demonstration), #2 pencil/photocopies

Horizontal Illuminance: 100 fc (demonstration), 30 fc (audience)
Vertical Illuminance: 50 fc

Analysis: Vertical illuminance is appropriate, but horizontal illuminance on the demo area is way too high here (the slope of the space is not as great as many lecture halls, and vertical illuminance becomes more critical). I will design the stage area for 70 fc.

Design Criteria and Goals:

Most Important:

Appearance of Space and Luminaires:

- Many of the guest lectures and presentations for the entire university will be taking place in this room. The space should look very professional, and the fixtures should be generally recessed or aesthetically clean.

Light Distribution on Task Plane:

- Every desk in the lecture hall should be equally lit, so that there is no place in the room where it is more difficult to learn from.

Modeling of Faces and Objects:

- In presentations and demonstrations, it is critical for audience members to be able to see the presenters and details of any objects they are using. It is also critical for the faces of the audience to be somewhat lit, so that the presenter can pick up visual cues that he/she is getting their point across, and can try other things if one method is not working.

Points of Interest:

- The two major focus areas in the space are the podium and the coves, and lighting should be used to effectively accentuate these areas.

Special Considerations (VDT/Projection Screen):

- Nearly all presentations in this space will be in PowerPoint / digital format, so the projection screen is a critical task plane. Because the presentations in this room are professional in nature, it is not acceptable to simply shut off all of the lights in the room when the projection screen is being used. A high quality design will put light on the audience while limiting the illuminance on the screen to less than 5 footcandles.

System Control and Flexibility:

- At least two different scenes would be great in this space; one to be used for presentations on the projection screen, and one to be used for before and after presentations that allows more light on the stage.

Also Important:

Color Appearance and Color Contrast:

- Any demonstrations that occur as part of presentation will require reasonably good color contrast.

Shadows:

- The lighting system cannot create any shadows over the projection screen, both because of the physical fixture and the visual effects caused by the lighting system.

Illuminance (Horizontal and Vertical):

- Good horizontal illuminance is required for note taking. Good vertical illuminance is required for reading off the vertical surfaces of the space (which may include a chalkboard or whiteboard)

Ceiling Redesign:

The original ceiling for the space was a linear cove system at varying heights. One of my major goals for the lighting design here is to evenly distribute light on the work surfaces throughout the lecture hall. Because the furniture layout does not match up well with the original ceiling design, using the original ceiling would make it difficult to achieve this goal. Additional reasons for the re-design include acoustical enhancement (which is discussed in the acoustical breadth) and the opportunity to make the space more visually interesting, which will be a combination of ceiling design and lighting design.

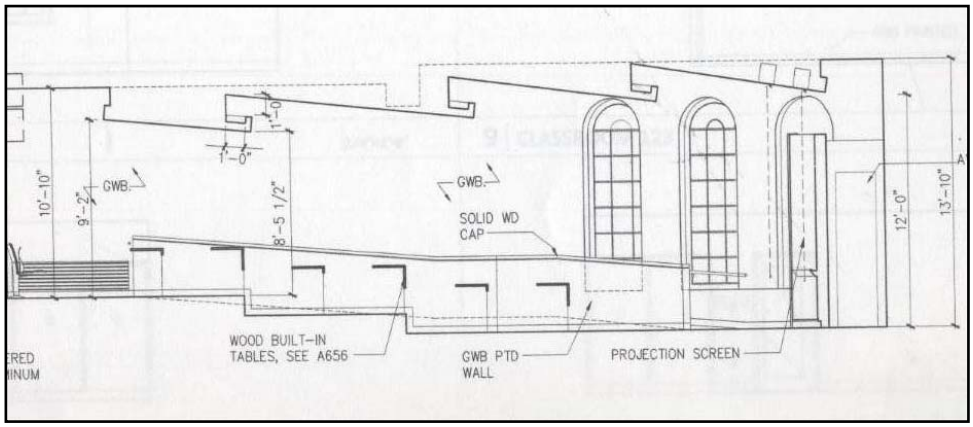


Figure 5.04 *Section of Lecture Hall – Original Cove Ceiling*

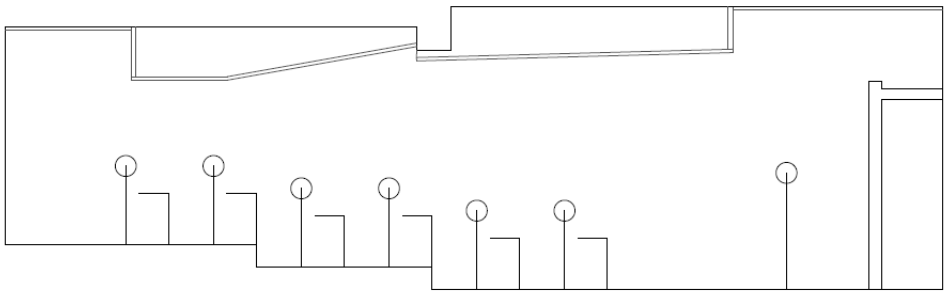


Figure 5.05 *Section of Lecture Hall – Proposed Ceiling Reflectors*

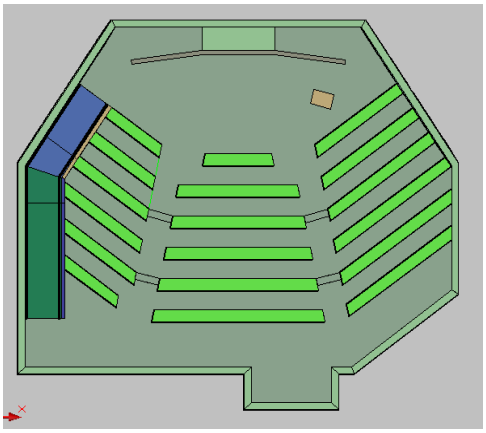


Figure 5.06 *Lecture Hall Model – Plan View*

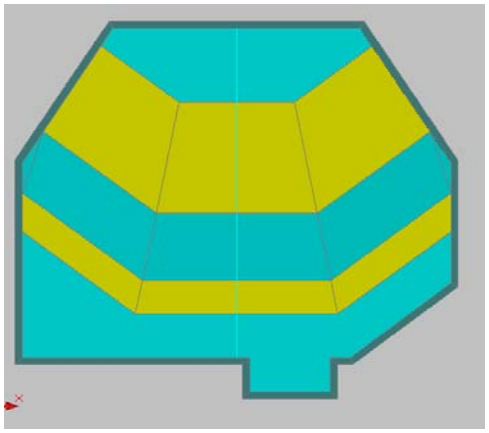


Figure 5.07 *Lecture Hall Model – Plan View of Ceiling*

Impact of New Ceiling Design on Structure:

One of the advantages of the original cove lighting systems was that it worked in very well with the structural framing for the space. The new design of the lecture hall ceiling has both a different shape (which by itself shouldn't be a huge issue) as well as lower ceiling heights in some critical areas. A key concern here was working around the bottom section of a Vierendell truss that goes across the middle of the space. Should the beam have to protrude into the space, it would interfere with the overall goals of the design (to enhance the acoustical efficiency of the space and to better match the geometry of the space and furnishing). The following diagram shows a section of the space with measurements to determine if this becomes an issue. As illustrated below, it appears that the new ceiling design will not affect the structural framing design, and vice versa.

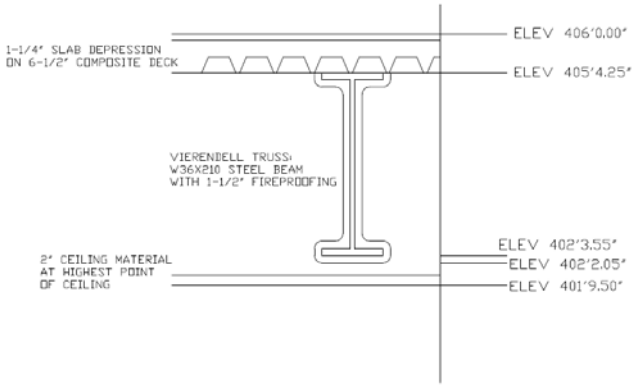


Figure 5.08 *Lecture Hall – Simplified Section of Vierendell Truss with Measurements*

Luminaire Schedule:

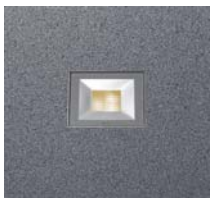
Label	Quantity	Description	Number of Lamps / Linear Feet	Lamp Type	Voltage
PP1	62	Recessed linear fluorescent downlight	4'	T5	277
PP2	14	Recessed compact fluorescent wall washer	1	42W CFL TRT	277
PP3	24	Recessed compact fluorescent downlight	1	26W CFL TRT	277
PP4	33	Floor recessed LED uplight for ramp and stairs	1	LED	277
PP5	8	Luminous wall sconce with brass trim	2'	T5	277

Table 5.03 *Compressed Luminaire Schedule for Lecture Hall*
For Full Luminaire Schedule and Details, Please Refer to Appendix A

PP1

PP2

PP3



PP4

PP5

Ballast Schedule:

Label	Ballast/Driver Type	Power Factor	Ballast Factor	Ballast Watts
PP1	Dimmable Electronic	0.98	1.00	29
PP2	Dimmable Electronic	0.99	1.00	47
PP3	Dimmable Electronic	0.98	1.05	31
PP4	24V LED Driver	1.00	-	4.2
PP5	Dimmable Electronic	0.98	1.05	19

Table 5.04 *Compressed Ballast Schedule for Lecture Hall*
For Full Ballast Details, Please Refer to Appendix A

Light Loss Factors:

Label	Maint. Cat.	Degree of Dirt	Cleaning Schedule	Distrib. Cat.	Ballast Factor	Lumin. Dirt Deprec.	Lamp Lumen Deprec.	Room Surface Dirt Deprec.	Total LLF
PP1	III	Very Clean	12 mths	Direct	1.000	0.924	0.919	0.980	0.832
PP2	III	Very Clean	12 mths	Direct	1.000	0.924	0.841	0.980	0.762
PP3	III	Very Clean	12 mths	Direct	1.050	0.924	0.841	0.980	0.800
PP4	V	Very Clean	12 mths	Indirect	1.000	0.925	0.700	1.000	0.648
PP5	II	Very Clean	12 mths	Dir-Ind	1.050	0.968	0.919	0.930	0.869

Table 5.05 *Light Loss Factors for Lecture Hall*

Lighting Plan:

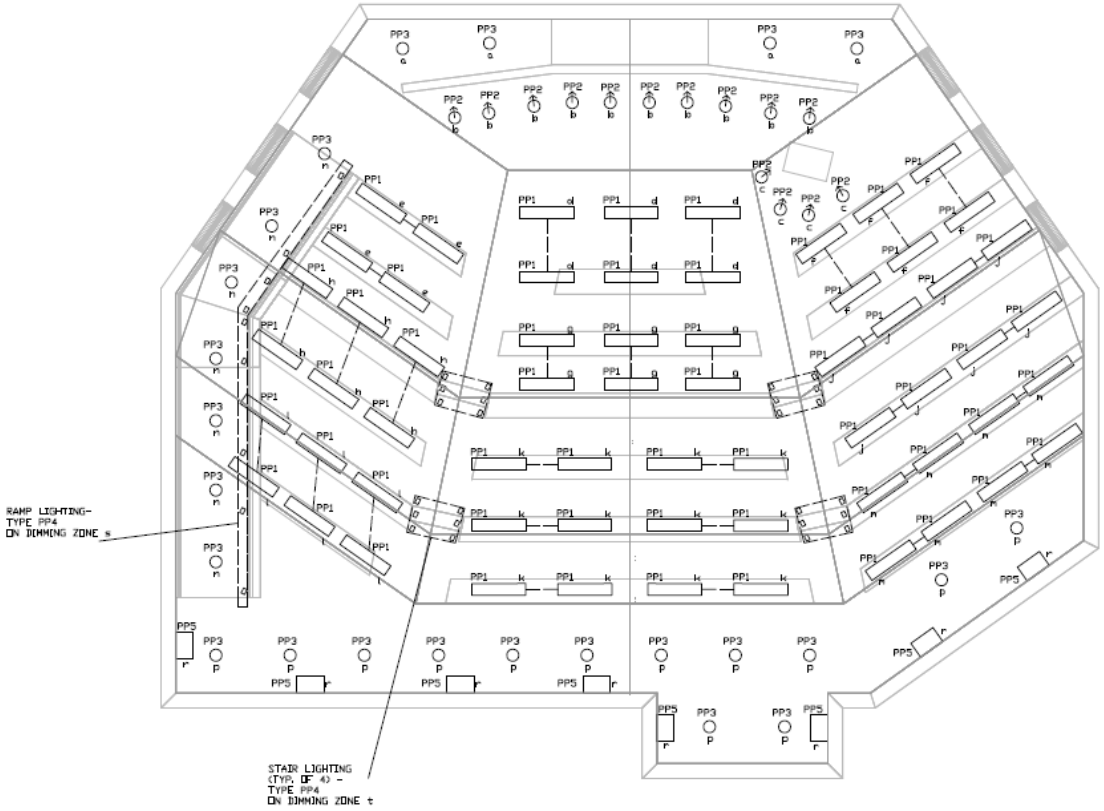


Figure 5.09 *Lighting Plan – Lecture Hall*

Controls:

Every luminaire in the lecture hall is connected to one of two dimming panels: one for normal power, and one for normal and emergency power. Since it is possible to dim every fixture in this layout, it allows this space to serve several different functions for several different effects. I am using four different scenes: LECTURE, A/V, MOVIE, and MAINTENANCE. This is in addition to an all-off scenario. In combination with time clocks for the entire building, this allows the space to meet automatic shut-off criteria.

Zone	Description	Circuit #	Fixture Load	# of Fixtures	Total Load
a	Front Exit Lighting (PP3)	EDM4P-1	31	4	124 W
b	Front Chalkboard Lighting (PP2)	DM4P-1	47	10	470 W
c	Front Speaker Lighting (PP2)	DM4P-2	47	4	188 W
d	Front Center Downlighting (PP1)	DM4P-3	29	6	174 W
e	Front Left Downlighting (PP1)	DM4P-4	29	4	116 W
f	Front Right Downlighting (PP1)	DM4P-5	29	6	174 W
g	Middle Center Downlighting (PP1)	EDM4P-2	29	6	174 W
h	Middle Left Downlighting (PP1)	EDM4P-3	29	6	174 W
j	Middle Right Downlighting (PP1)	EDM4P-4	29	8	232 W
k	Back Center Downlighting (PP1)	EDM4P-5	29	12	348 W
l	Back Left Downlighting (PP1)	EDM4P-7	29	6	174 W
m	Back Right Downlighting (PP1)	EDM4P-8	29	8	232 W
n	Ramp Downlighting (PP3)	EDM4P-11	31	7	217 W
p	Back Exit Downlighting (PP3)	EDM4P-12	31	13	403 W
q	Existing Vestibule Lighting (A17B)	EDM4P-6	34	2	68 W
r	Sconces (PP5)	DM4P-6	19	8	152 W
s	In-Ramp Lighting (PP4)	EDM4P-13	4.2	9	37.8 W
t	In-Stair Lighting (PP4)	EDM4P-14	4.2	24	100.8 W

Table 5.06 *Lecture Hall Dimming System – Zone Layout*

"LECTURE" Scene:

This is a high light-level scene that focuses a lot of light on the front stage and speaker. The desk lighting is on at 80% light output, which still provides 50 footcandles but helps to extend lamp life. The side and back lighting features are on at 40% to focus attention to the front, but to make a more pleasant condition for the speaker to look at.

Zone	Description	Percent Full Output
a	Front Exit Lighting (PP3)	100%
b	Front Chalkboard Lighting (PP2)	100%
c	Front Speaker Lighting (PP2)	100%
d	Front Center Downlighting (PP1)	100%
e	Front Left Downlighting (PP1)	80%
f	Front Right Downlighting (PP1)	80%
g	Middle Center Downlighting (PP1)	80%
h	Middle Left Downlighting (PP1)	80%
j	Middle Right Downlighting (PP1)	80%
k	Back Center Downlighting (PP1)	80%
l	Back Left Downlighting (PP1)	80%
m	Back Right Downlighting (PP1)	80%
n	Ramp Downlighting (PP3)	40%
p	Back Exit Downlighting (PP3)	40%
q	Existing Vestibule Lighting (A17B)	100%
r	Sconces (PP5)	40%
s	In-Ramp Lighting (PP4)	100%
t	In-Stair Lighting (PP4)	100%

Table 5.07 *Lecture Hall Dimming System – Zone Output Levels for "LECTURE" Scene*

"A/V" Scene:

This is a lower light-level scene that removed as much light as possible from the front of the space, while still leaving lighting on over most of the desk areas. The front desk lighting is either at 25% light output or off, and the rest of the desk lighting is on at 75% light output, which still provides around 30-40 footcandles on the desks. The side and back lighting features are on at 25% to allow for egress without distracting from the front. This layout is good for PowerPoint presentations, slide shows, and other static visual presentations.

Zone	Description	Percent Full Output
a	Front Exit Lighting (PP3)	0%
b	Front Chalkboard Lighting (PP2)	0%
c	Front Speaker Lighting (PP2)	0%
d	Front Center Downlighting (PP1)	0%
e	Front Left Downlighting (PP1)	25%
f	Front Right Downlighting (PP1)	25%
g	Middle Center Downlighting (PP1)	75%
h	Middle Left Downlighting (PP1)	75%
j	Middle Right Downlighting (PP1)	75%
k	Back Center Downlighting (PP1)	75%
l	Back Left Downlighting (PP1)	75%
m	Back Right Downlighting (PP1)	75%
n	Ramp Downlighting (PP3)	25%
p	Back Exit Downlighting (PP3)	25%
q	Existing Vestibule Lighting (A17B)	100%
r	Sconces (PP5)	25%
s	In-Ramp Lighting (PP4)	100%
t	In-Stair Lighting (PP4)	100%

Table 5.08 *Lecture Hall Dimming System – Zone Output Levels for "A/V" Scene*

"MOVIE" Scene:

This is a very low light-level scene that removed nearly all light from the room. The desk lighting is completely off, as is all lighting in the front area. The side and back lighting features are on at 10%, and the ramp and stair uplighting are still on for 100% to allow for emergency egress. This layout is appropriate for movies, video demonstrations, and other dynamic or low contrast visual presentations.

Zone	Description	Percent Full Output
a	Front Exit Lighting (PP3)	0%
b	Front Chalkboard Lighting (PP2)	0%
c	Front Speaker Lighting (PP2)	0%
d	Front Center Downlighting (PP1)	0%
e	Front Left Downlighting (PP1)	0%
f	Front Right Downlighting (PP1)	0%
g	Middle Center Downlighting (PP1)	0%
h	Middle Left Downlighting (PP1)	0%
j	Middle Right Downlighting (PP1)	0%
k	Back Center Downlighting (PP1)	0%
l	Back Left Downlighting (PP1)	0%
m	Back Right Downlighting (PP1)	0%
n	Ramp Downlighting (PP3)	10%
p	Back Exit Downlighting (PP3)	10%
q	Existing Vestibule Lighting (A17B)	100%
r	Sconces (PP5)	10%
s	In-Ramp Lighting (PP4)	100%
t	In-Stair Lighting (PP4)	100%

Table 5.09 *Lecture Hall Dimming System – Zone Output Levels for "MOVIE" Scene*

"MAINTENANCE" Scene:

This is a high light-level scene in which nearly all of the luminaires are on at 100%. The exception is the stair and ramp uplighting (which is off, to avoid any conflict with carpet-cleaning equipment). This is ideal for after-hours maintenance. I would also like this scene to be the default scene, in case of power failure reset.

Zone	Description	Percent Full Output
a	Front Exit Lighting (PP3)	100%
b	Front Chalkboard Lighting (PP2)	100%
c	Front Speaker Lighting (PP2)	100%
d	Front Center Downlighting (PP1)	100%
e	Front Left Downlighting (PP1)	100%
f	Front Right Downlighting (PP1)	100%
g	Middle Center Downlighting (PP1)	100%
h	Middle Left Downlighting (PP1)	100%
j	Middle Right Downlighting (PP1)	100%
k	Back Center Downlighting (PP1)	100%
l	Back Left Downlighting (PP1)	100%
m	Back Right Downlighting (PP1)	100%
n	Ramp Downlighting (PP3)	100%
p	Back Exit Downlighting (PP3)	100%
q	Existing Vestibule Lighting (A17B)	100%
r	Sconces (PP5)	100%
s	In-Ramp Lighting (PP4)	0%
t	In-Stair Lighting (PP4)	0%

Table 5.10 *Lecture Hall Dimming System – Zone Output Levels for "MAINTENANCE" Scene*

Calculations and Performance:

"LECTURE" Scene:

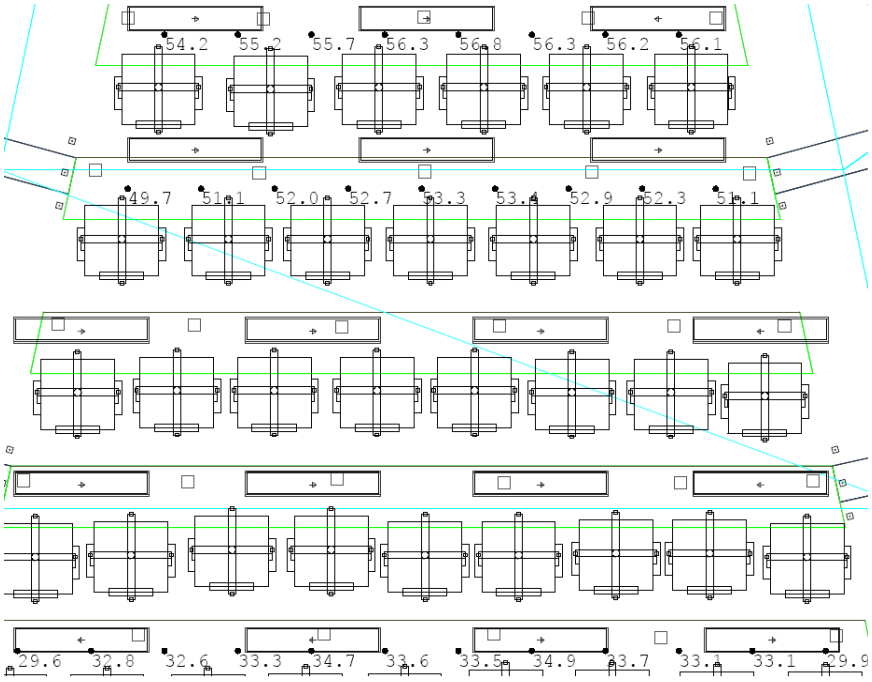


Figure 5.10 *Lecture Hall – Illuminance on Desks During "LECTURE" Scene*

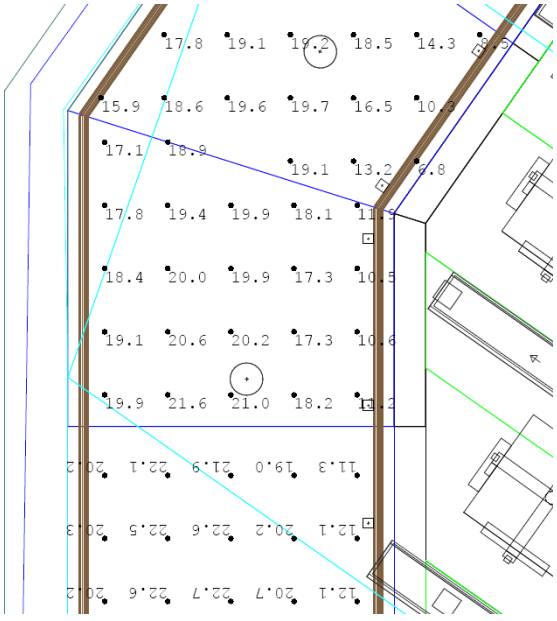


Figure 5.11 *Lecture Hall – Illuminance on Ramp During "LECTURE" Scene*

Figure 5.12 *Lecture Hall – Illuminance on Projection Screen During "LECTURE" Scene*

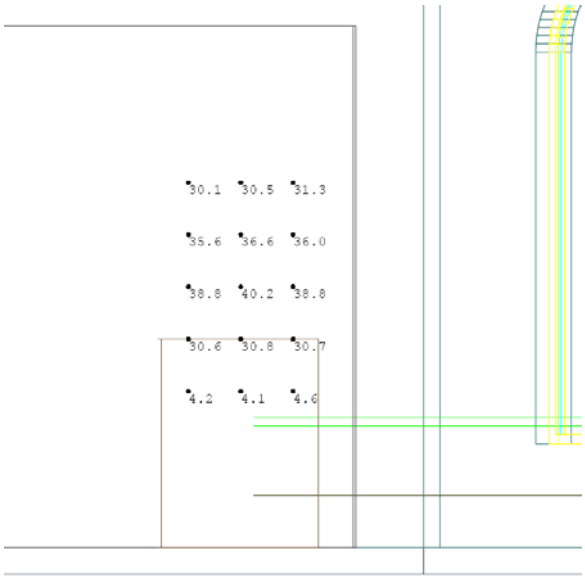


Figure 5.13 *Lecture Hall – Illuminance on Speaker During "LECTURE" Scene*

"A/V" Scene:

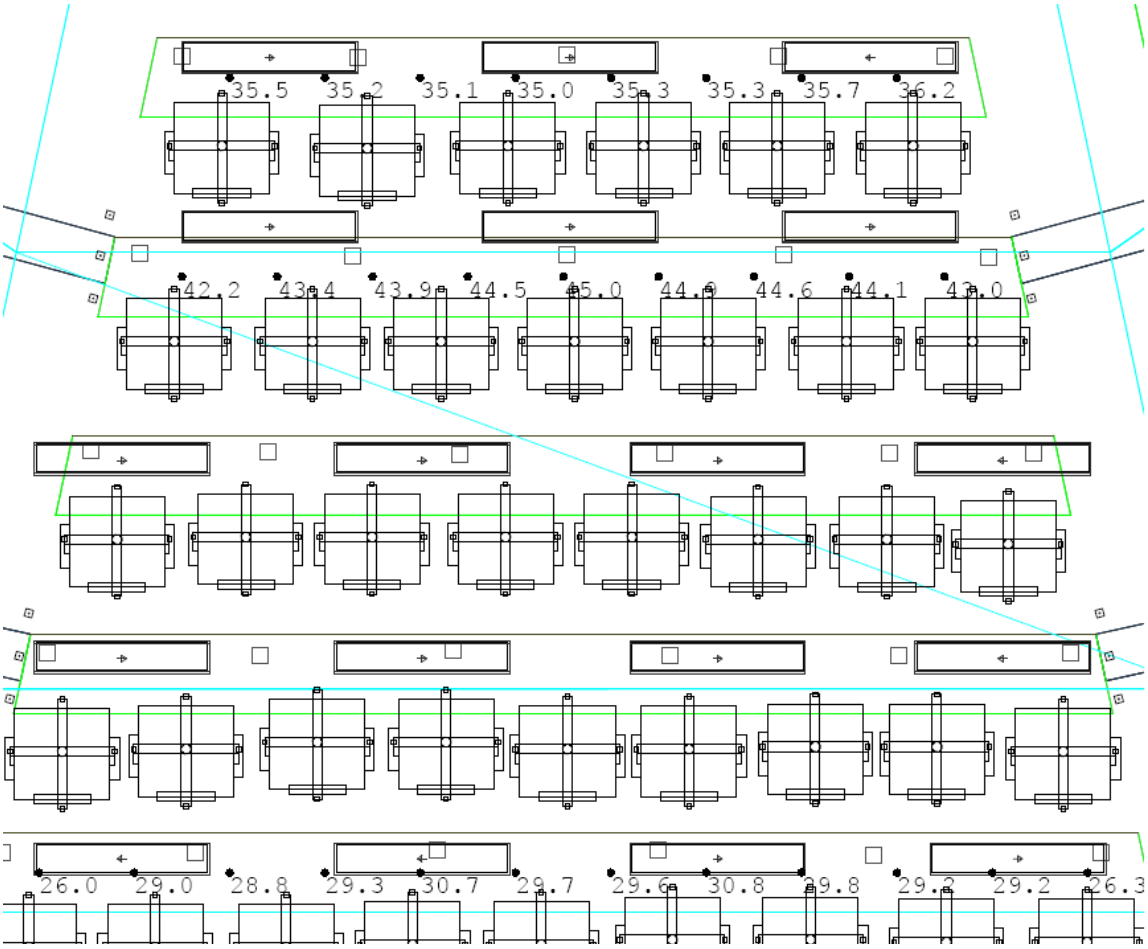


Figure 5.14 *Lecture Hall – Illuminance on Desks During "A/V" Scene*

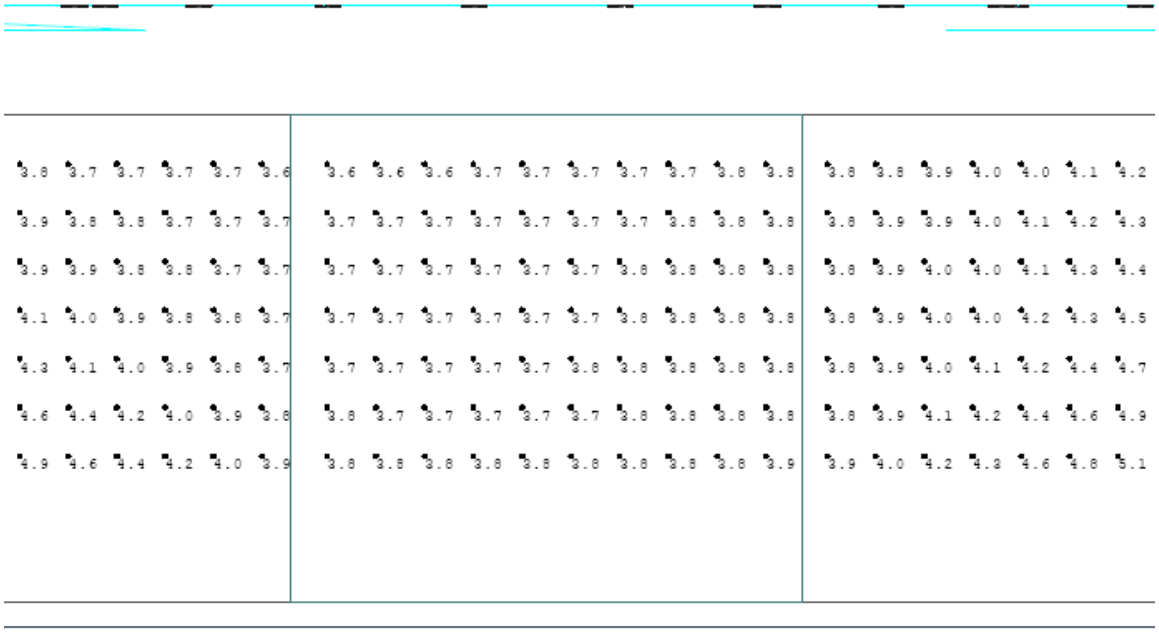


Figure 5.15 *Lecture Hall – Illuminance on Projection Screen During "A/V" Scene*

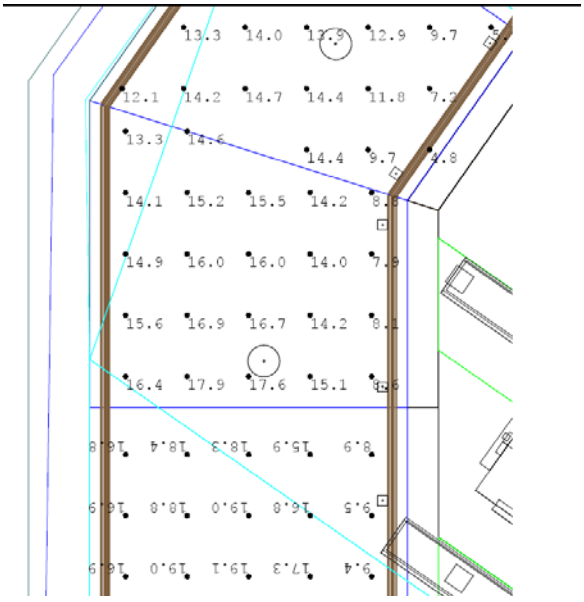


Figure 5.16 *Lecture Hall – Illuminance on Ramp During "A/V" Scene*

Rendered Images:

Figure 5.17 *Color Rendering of Lecture Hall From Back Row Seating – "LECTURE" Scene*

Figure 5.18 *Color Rendering of Lecture Hall From Speaker Podium - "LECTURE" Scene*

Figure 5.19 *Color Rendering of Lecture Hall From Back Row Seating - "A/V" Scene*

Figure 5.20 *Color Rendering of Lecture Hall From Speaker Podium - "A/V" Scene*

Figure 5.21 *Color Rendering of Lecture Hall From Back Row Seating - "MOVIE" Scene*

Figure 5.22 *Color Rendering of Lecture Hall From Speaker Podium - "MOVIE" Scene*

Figure 5.23 *Color Rendering of Lecture Hall From Back Row Seating - "MAINTENANCE" Scene*

Figure 5.24 *Color Rendering of Lecture Hall From Speaker Podium - "MAINTENANCE" Scene*

Power Density Calculations:

Space	Matching ASHRAE Category	Power Allowance	Length (ft)	Area (ft^2)	Watts Allowed
Lecture Hall	Classroom/Lecture/Training	1.4 W/ft^2	-	2500	3500

Total Allowed	3500 W

Table 5.11 *Power Allowance for Lecture Hall*

Type	Quantity	Input Watts / Luminaire	Total Watts / Type
PP1	62	29	1798
PP2	14	47	658
PP3	24	31	744
PP4	33	4.2	138.6
PP5	8	19	152

Total Watts Consumed	3490.6 W

Table 5.12 *Power Consumed by Lecture Hall*

Based on the above calculation, the space meets the energy requirements set forth in ASHRAE 90.1 – 2004.

Conclusions:

The use of all –recessed luminaires in the ceiling allows for the maximization of the height the space has. Aligning the linear luminaires with the desks, though not typically the best layout for a learning space, works out well here because of the even distribution on the desks and the shape of the ceiling. There is plenty of light on the lecture area for good rendering of facial features and chalkboard writings. The control devices created 4 scenes that are representative of all of the major functions of the space. The "A/V" scene limits to light on the projection screens to less than 5 footcandles, meeting IES recommendations, while still putting 30-35 footcandles on the desks, which is more than acceptable. The new ceiling appears to be working well with the furniture and lighting layouts; I will analyze the success of the ceiling in relation to acoustics and incorporation of air distribution in the breadth studies.