

# Classroom Lighting Guidelines

## Best Practices for Efficiency

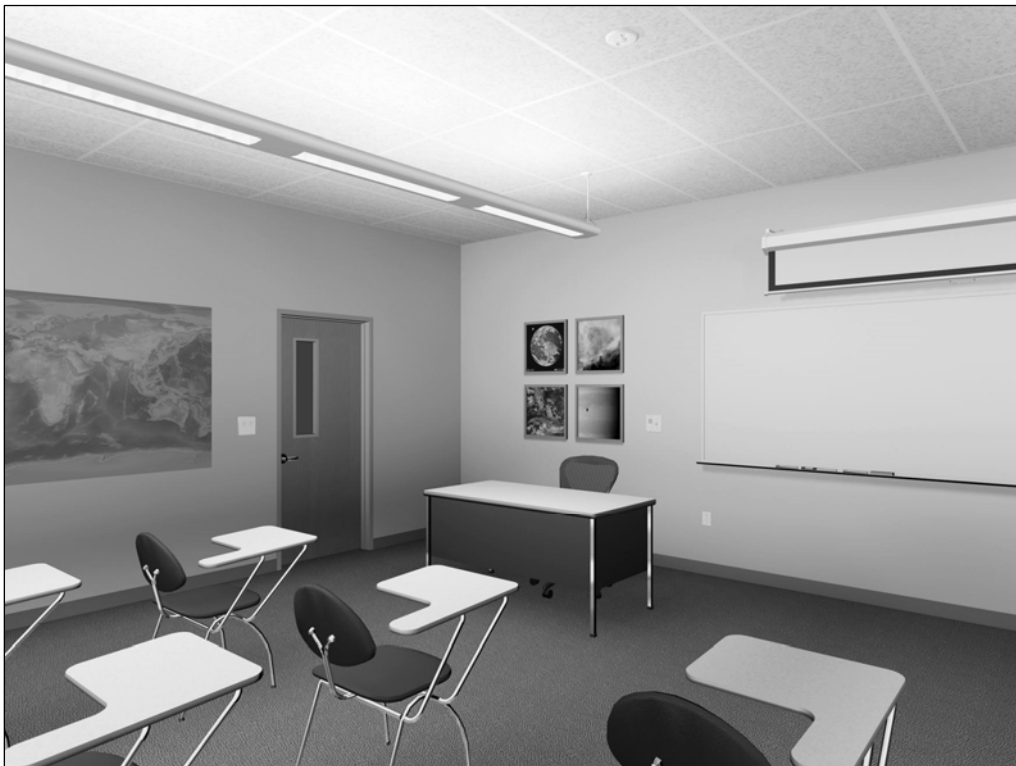
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Drafted by

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Commissioned by

UI and CL&P



## Introduction

With the growth in population and increasing numbers of children, there is an increased demand for new schools. New schools and major remodeling of existing facilities are important projects throughout the nation. Today's classrooms, however, require a major change in design criteria. As a general rule, classrooms today should be designed to employ video projections as well as more traditional teaching media. With the latest lighting technology, it's possible to have it all – energy efficient, flexible lighting systems that support many different teaching methods.

## Facilities Affected

These Guidelines are intended to be used by contractors, architects, engineers, and others responsible for designing, specifying and/or building new lighting systems, including new buildings, remodeling, and/or energy-upgrade initiatives.

In general, these Guidelines should be applied to the following:

- K-12 classrooms
- College level classrooms
- Corporate conference and training rooms
- Meeting rooms in conference centers and convention facilities.

In addition, some types of institutional buildings and similar spaces may benefit from using these Guidelines.

## Facilities Less Affected

These Guidelines are not necessarily intended to address any of the following space types.

- Auditoriums
- Video conferencing spaces
- Spaces with stages

However, the principles of cost effective, energy efficient design expressed by these Guidelines should be employed in these or other space types whenever possible.

## Implicit Considerations

These Guidelines were developed in consideration of applicable codes and standards in the U.S., including the following:

- Standards of the Illuminating Engineering Society of North America, including IESNA/ANSI RP-3-00 (reaffirmed 2006), Lighting for Educational Facilities. IESNA Standards apply in the USA, Canada and Mexico
- Findings of the California PIER research Project 4.5 report
- Standards of Underwriters Laboratories.
- Energy efficiency standards of the States of Connecticut, Massachusetts, and IESNA/ASHRAE/ANSI 90.1-2001 and 90.1-2004.

## **General Design Requirements**

All designs must comply with applicable codes and ordinances. Note that in general, the following requirements will result in lighting designs that demand less power (watts per square foot floor area) than mandated by the energy code. The energy cost savings realized by this practice will often pay back the incremental cost for the more efficient system within 3 years. Additionally, in many cases the first cost of lighting may be less than traditional designs because these Guidelines optimize the amount and type of lighting equipment than can be used.

## **Lighting Systems**

### **General Requirements**

A complete, hardwired lighting system must be installed that has an average power density of less than 0.9 watts per square foot in each classroom.

### **Compliance Documentation**

Designs shall be certified using COM-CHECK 3.1 release 1 or higher. For the Code to be used, select ASHRAE/IESNA 90.1-2004. If these guidelines are followed closely, the resulting designs should achieve approximately 25-35% better than 90.1-2004 and 40-50% better than 90.1-2001. NOTE: Achieving performance significantly better than these target values is very difficult and not recommended without design involving considerable expertise.

### **Principal Lighting Systems**

For most spaces, designers should employ either of the two pattern lighting layouts illustrated below. In general, do NOT add incandescent lighting, halogen lighting, or track lighting systems or monopoints of any kind or voltage of operation.

### **Other Lighting Systems**

In every building, there are a number of other lighting situations. Consult other Guidelines for suggestions for efficient solutions.

## **Lighting Criteria**

The lighting design should provide the following:

- Two modes of operation including (1) a normal mode for conventional classroom activities and (2) an AV mode in which a video projector and screen can be used without totally darkening the room.
- At least 30 footcandles on every desk in normal mode, with the average light level in the student desk area of 40-45 footcandles
- At least 10 footcandles on every desk in AV mode
- At least 20 footcandles on the vertical teaching surface (white board or chalkboard) in normal mode.
- No more than 5 footcandles on the AV screen in AV mode
- Integration and use of natural daylighting whenever possible

## Lamps and Ballasts

### General

The secret to achieving outstanding energy efficiency in classrooms is to use state of the art fluorescent T8 or T5 lamps and the new, efficient electronic ballasts. Dimming ballasts are not required, but they are suggested. Acceptable performance, however, can be obtained through the proper use of non dimming ballasts and reasonably priced lighting equipment and materials.

### Ballasts

There are four types of high efficiency ballasts to consider:

- Instant start single level ballasts, the least expensive and most efficient
- Program start single level ballasts, which increase lamp life but cost slightly more and are slightly less efficient than instant start.
- Multi-level ballasts, typically rapid start or program start
- Dimming ballasts

To be efficient, ballasts be the latest "efficient" type. Instant start ballasts are the most efficient and least costly, but lamp life will suffer if lamps are frequently switched; all other ballast types maintain reasonably normal lamp life with normal use. For classrooms, the on/off cycle depends on many factors. In general, choose program start, multi-level or dimming ballasts for classrooms with periodic use, and instant start, multi level or dimming ballasts when the classrooms are constantly in use for at least 3-4 hours at a time.

### T-8 versus T-5

Four-foot T-8 fluorescent lighting systems must employ "high efficiency" lamps or "high lumen" lamps. The low cost of T-8 systems is very appealing, but the slightly more expensive T-5 lamps are a reasonable alternative. As a general rule, T-8 lamps will be slightly better in open fixtures and T-5 in enclosed fixtures, but either one is still a good choice. For those concerned with cost, the long term cost of the T-5 lamp is expected to be lower than T-8. Note: Compact fluorescent lamps lack the efficacy of T-5 and T-8 systems, and can't reach the performance of these lamps.

### Controls

Provide lighting controls that permit proper use of the lighting systems. The following controls are the minimum required:

- Motion sensor to prevent operation of lights when the room is unoccupied.
- Manual on/off switch with separate switch for daylighted zone if there is one
- Teacher's Normal/AV switch
- Separate manual on/off switch for teaching board light if there is one

If dimming ballasts are used, then in addition, there must be a daylight sensor. In addition, consider the following controls:

- Motion sensor override to allow the teacher to operate lights for an hour with little movement in the room

- Manual dimmer control when dimming ballasts are used.

Dimming ballasts add considerable cost, and are slightly less efficient than non dimming ballasts. For dimming ballasts to be cost effective, they need to be dimming the lighting systems to at most 50% of normal light, average, throughout every school day. This is hard to achieve in the Upper Northeast and New England climate, especially since the school year typically does not include summer. Dimming ballasts, on the other hand, are preferable as they permit fine tuning of the lighting under all conditions. If cost effectiveness is required, only consider dimming for classrooms with good daylighting characteristics. Otherwise, only consider dimming when the budget is adequate.

## **Interior Finishes**

As a general rule, interior ceilings, structures and upper walls should be painted a light color. Ceiling reflectance is essential for lighting systems with any indirect component, so in addition to light color, a relatively flat, homogeneous surface is essential. For the suspended lighting system in Pattern 1, a minimum ceiling height of 9'-6" is necessary.

## **Pattern 1: the PIER Solution**

From 2002-2005, the California Energy Commission funded Public Interest Energy Efficiency Research (PIER) and in particular, a study of classroom lighting. The PIER 4.5 Classroom Lighting Study was charged with developing a new, high efficiency, cost effective lighting system for school classrooms. The results of this study have been accepted nationwide and are now considered the best way to light typical classrooms.

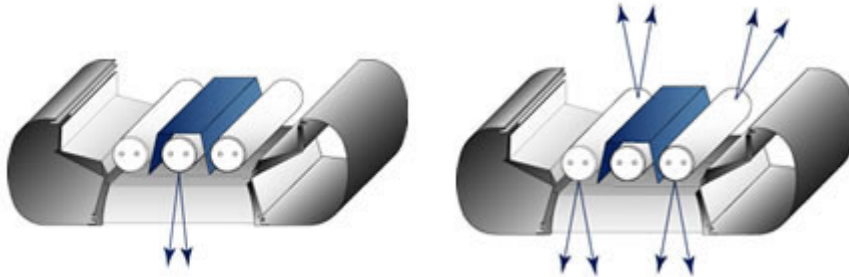
The PIER Classroom Lighting System consists of the following:

- Suspended luminaires with separate compartments for general lighting and for AV lighting
- The general lighting is semi-indirect
- The AV lighting is direct and shielded using a parabolic louver
- Smart controls that allow the system to work as intended

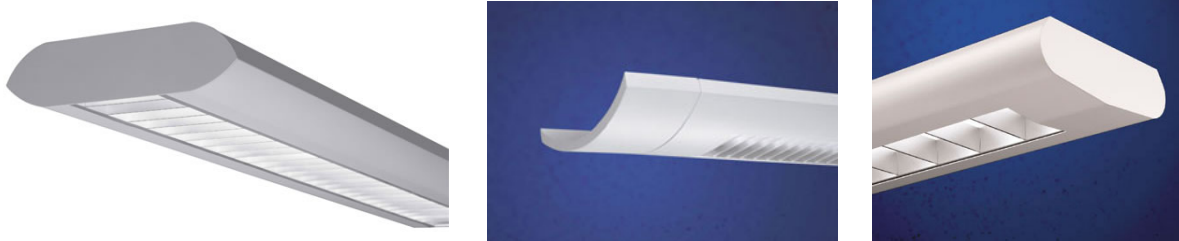
The principal advantage of this system is cost effectiveness. While the fixtures are more expensive than other possible choices, labor and additional materials are minimized through the use of continuous row luminaires with single feed points. The integral classroom lighting system (ICLS) control system is analog low voltage, eliminating line voltage switch legs. Its plug-together approach accelerates installation and prevents miswiring.

One lighting manufacturer and one controls manufacturer were part of the research team and developed commercially viable products. However, because PIER is publicly funded, any company can make similar products without royalty, and designers will find products from a number of manufacturers nationwide.

There are three basic PIER lighting systems: GOOD, BETTER and BEST. The GOOD system is the least expensive, and does not employ a separate teaching board light. The BETTER system employs a teaching board light, and in order to reduce cost, uses fewer overhead luminaires. The BEST system has a full complement of overhead lights and a teaching board light.

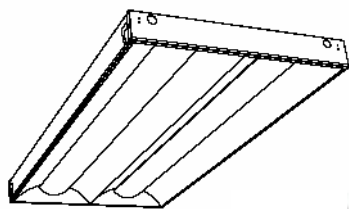


*The PIER Classroom Luminaire  
Separately switched central lamp used for AV only  
Wired for outer lamps or inner lamp only- not operated together. Many appearance options available.*



## Pattern 2: Low Ceiling Direct Lighting

Not all classrooms can enjoy 9' 6" or higher ceilings. There will be quite a few rooms in which a conventional ceiling system with lay-in lighting or surface mounted fixtures is the only practical solution. For this, use the following pattern.



The state of the art is the 2x4 T5 thin troffer. T5 lamps are particularly efficient when operated inside of a lensed chamber, so that the lamp reaches optimum temperature. As a general rule, this is one of the most efficient methods to light a space. But this efficiency has a downfall; the lighting system performs poorly in the AV mode.

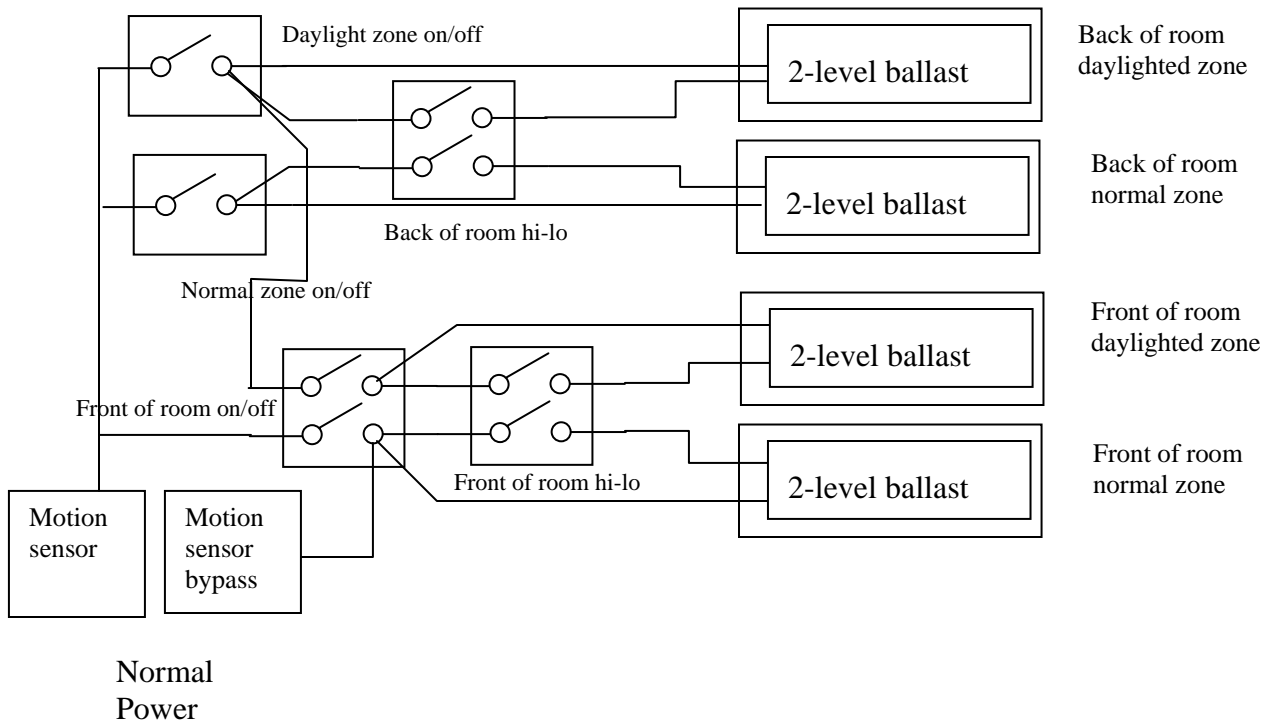
A desirable option of T-5 technology is the choice of normal light level (BF = 1.0) or high light level (BF = 1.15) two level ballasts. Two level ballasts are used for stepped dimming and provide some of the desired flexibility for AV uses of the room. They can also be used to manually adjust for daylighting. In the drawing showing Pattern 2, this lighting must be wired in a particular manner to adjust for AV uses, as follows:

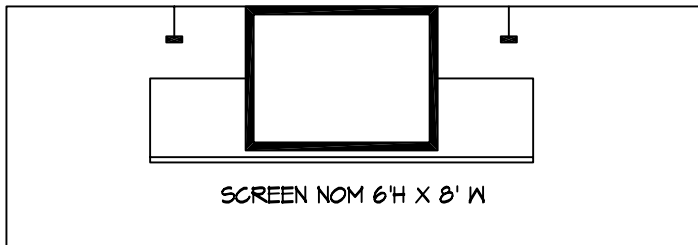
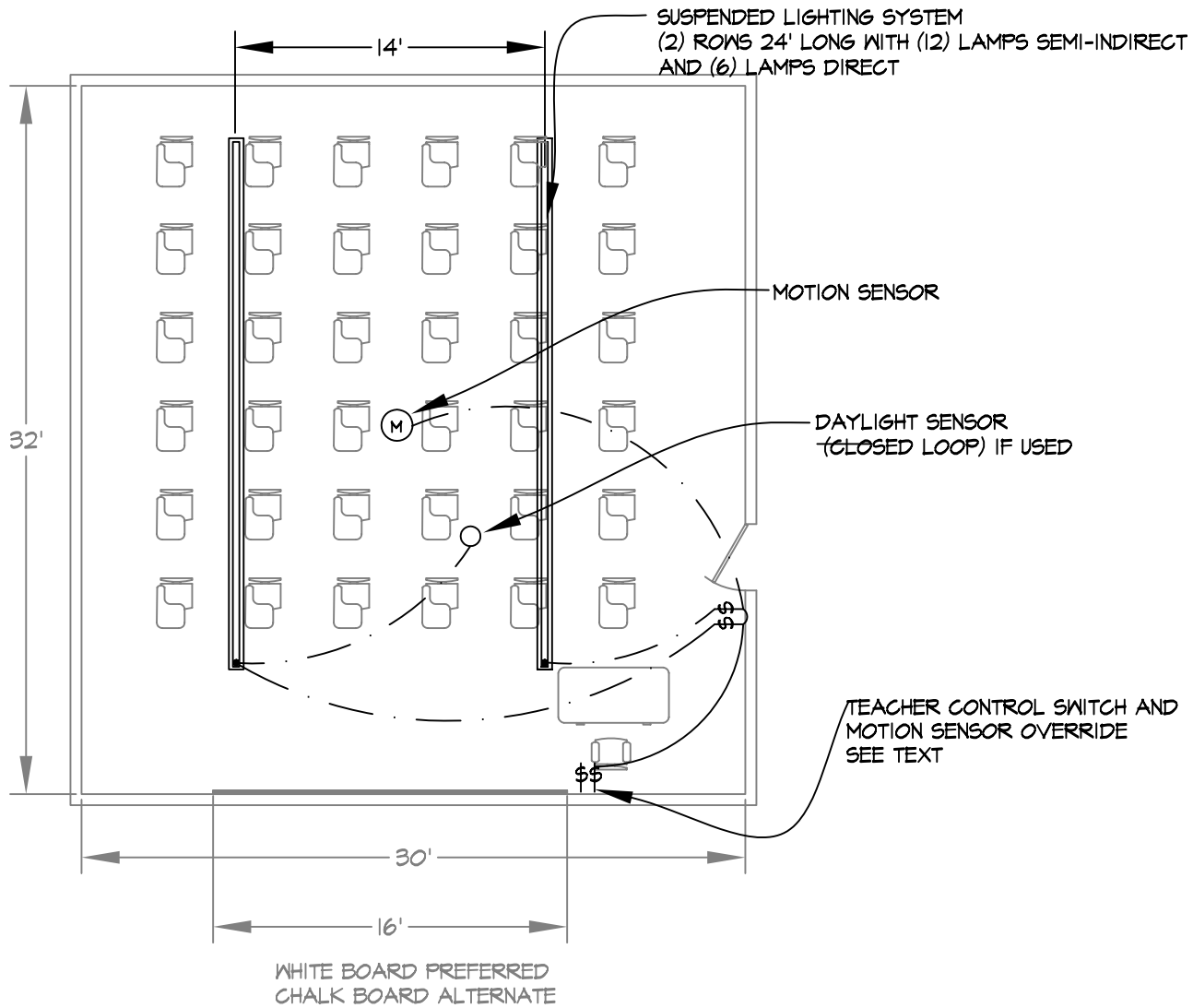
- Upon entering the room, there is an on-off switch for the daylighted part of the room, and another for the non daylighted part of the room. These are wired in series with the motion sensor. If no one is in the room, all lights go off. Otherwise, the switches operate as normal on/off switches.
- There is an additional hi-lo switch which governs all lights. When lights are turned on, this switch causes all lights to be either hi or lo.

- A third pair of switches is located at the teacher’s station at the front of the room. The teacher can turn on or off the front half of the room, with separate daylight and non-daylight zones.

The teacher will find that for normal classroom use, all lights can be turned on full, or if daylight is present, can turn off the daylight zone. Then, for AV, all lights can be turned down to low, and the front half of the room can be turned off. While not as good as Pattern 1, this scheme will permit acceptable AV performance while providing acceptable lighting for most desks.

Note that this switch may be wired in series with a daylight sensing switch





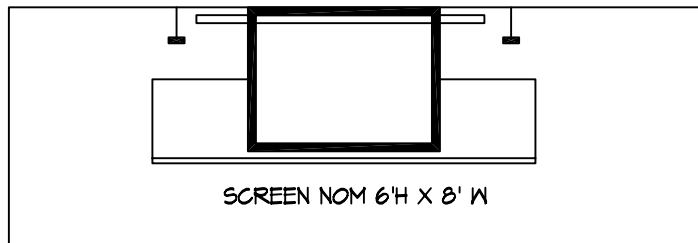
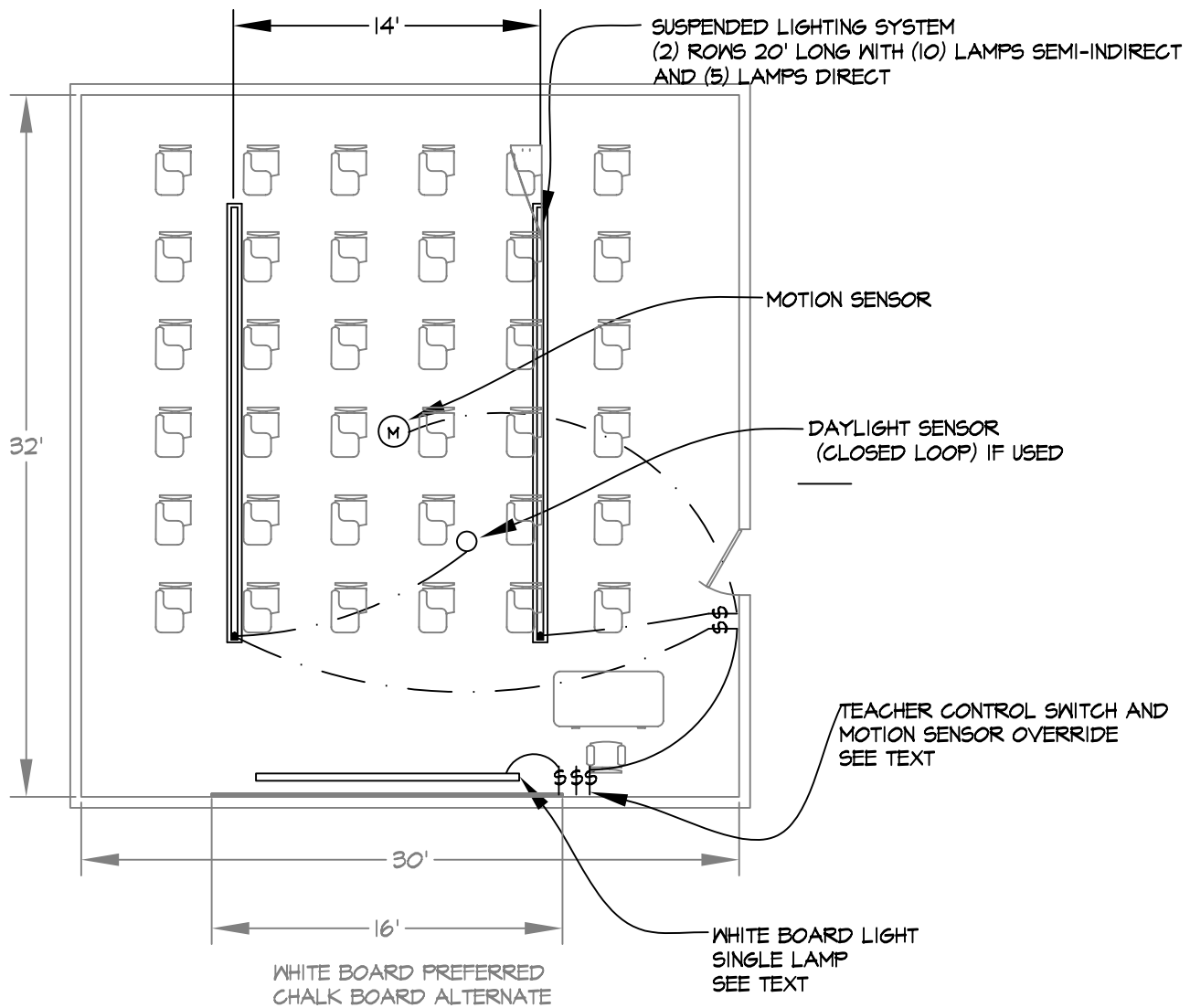
### DESIGN DATA

SEMI-INDIRECT PART OF ROW LUMINAIRE  
(24) T8 LAMPS WITH HIGH LIGHT OUTPUT  
EFFICIENT BALLASTS 0.875 W/SF

DIRECT PART OF ROW LUMINAIRE  
(12) T8 LAMPS WITH NORMAL LIGHT OUTPUT  
EFFICIENT BALLASTS 0.337 W/SF

INTERLOCK SWITCHED ONE OR THE OTHER

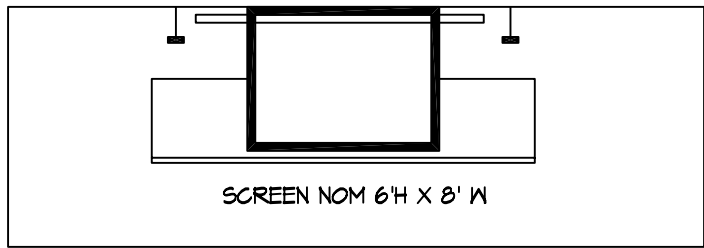
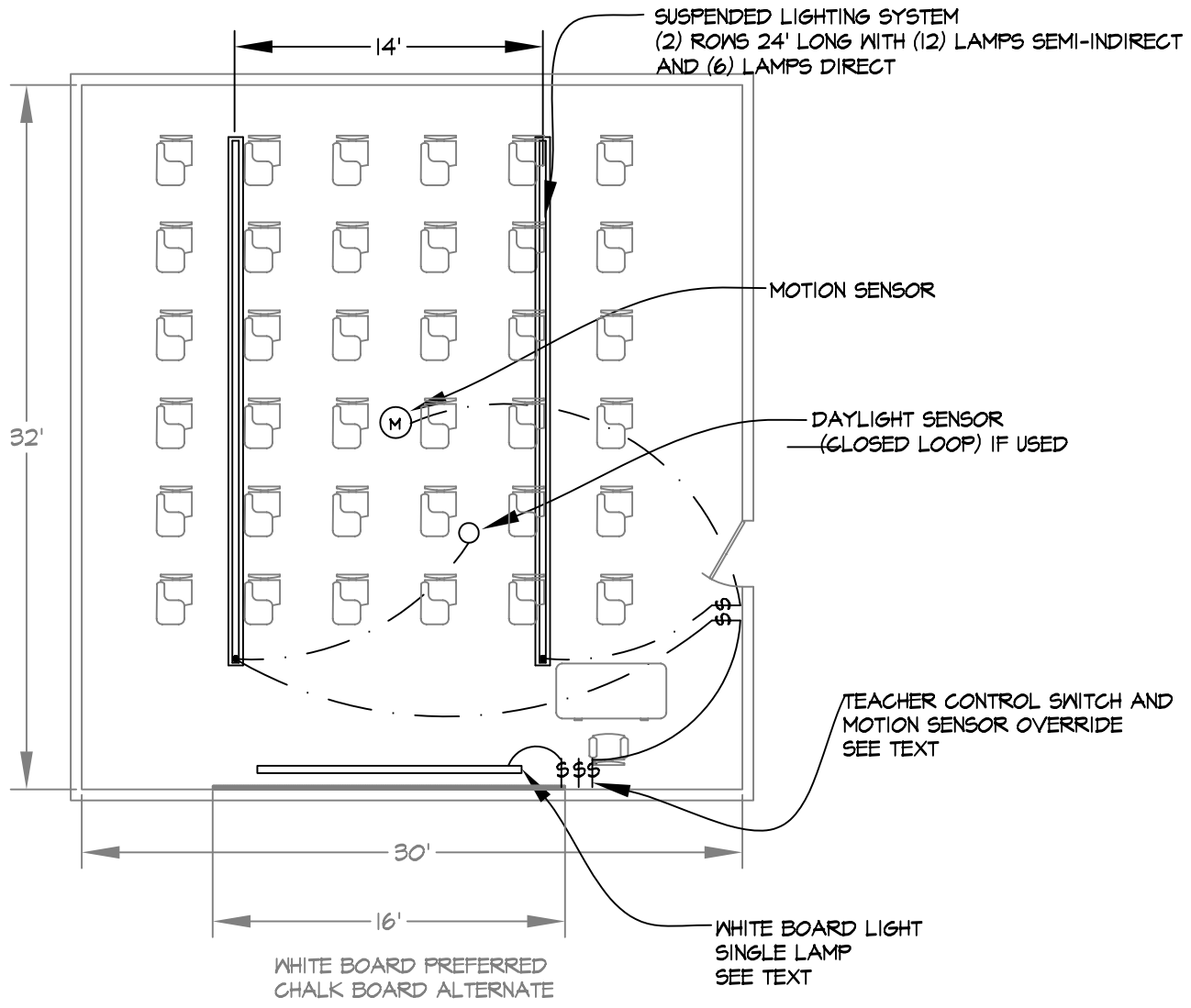
CLASSROOM LIGHTING SYSTEM: PATTERN 1 GOOD



### DESIGN DATA

SEMI-INDIRECT PART OF ROW LUMINAIRES  
 (20) T8 LAMPS WITH HIGH LIGHT OUTPUT  
 EFFICIENT BALLASTS 0.729 W/SF  
 TEACHING BOARD LIGHT NOM 12' LONG  
 (3) T8 LAMPS WITH HIGH LIGHT OUTPUT  
 EFFICIENT BALLASTS 0.109 W/SF  
 TOTAL NORMAL MODE 0.838 W/SF  
 DIRECT PART OF ROW LUMINAIRES  
 (10) T8 LAMPS WITH NORMAL LIGHT OUTPUT  
 EFFICIENT BALLASTS 0.281 W/SF  
 INTERLOCK SWITCHED SEMI-INDIRECT AND BOARD  
 LIGHT OR DIRECT LIGHT - NEVER ALL LIGHTS

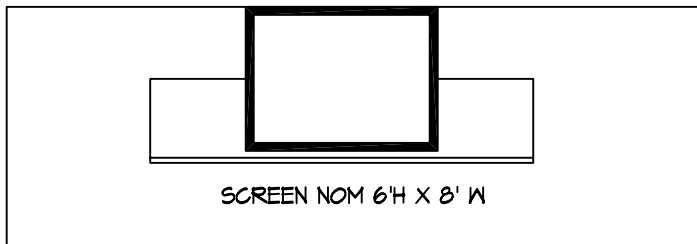
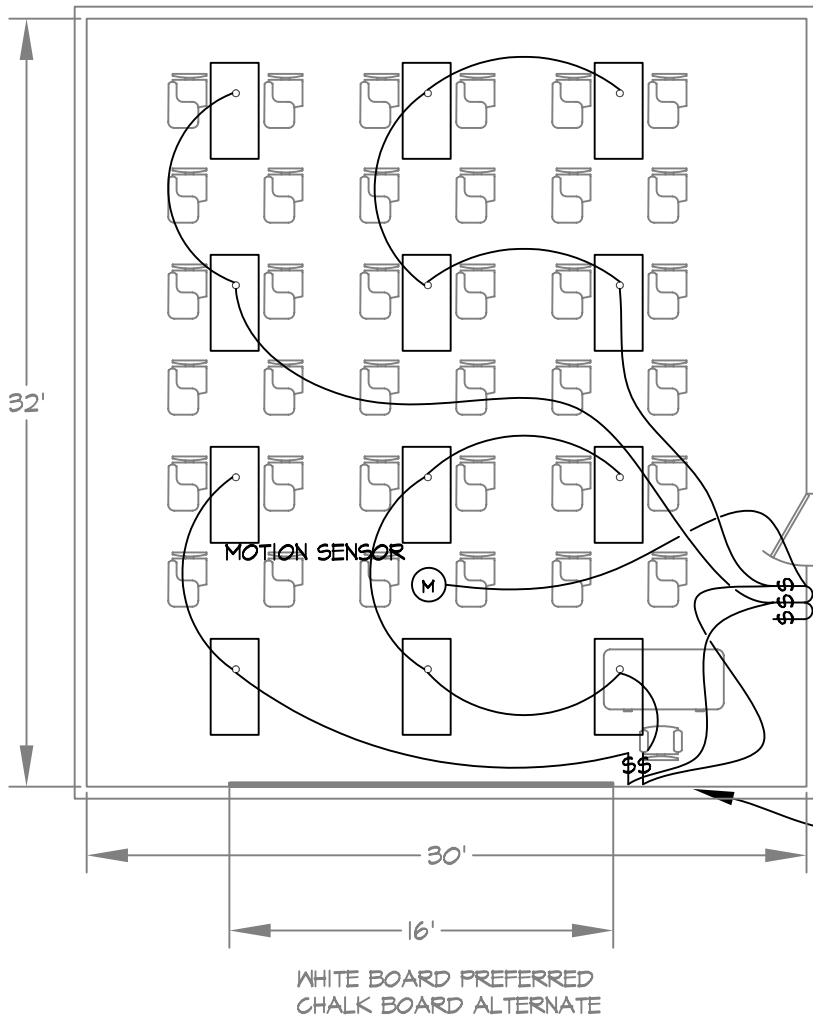
CLASSROOM LIGHTING SYSTEM: PATTERN 1 BETTER



**DESIGN DATA**

SEMI-INDIRECT PART OF ROW LUMINAIRES  
(24) T8 LAMPS WITH NORMAL LIGHT OUTPUT  
EFFICIENT BALLASTS 0.675 W/SF  
TEACHING BOARD LIGHT NOM 12' LONG  
(3) T8 LAMPS WITH HIGH LIGHT OUTPUT  
EFFICIENT BALLASTS 0.109 W/SF  
TOTAL NORMAL MODE 0.784 W/SF  
DIRECT PART OF ROW LUMINAIRES  
(12) T8 LAMPS WITH NORMAL LIGHT OUTPUT  
EFFICIENT BALLASTS 0.337 W/SF  
INTERLOCK SWITCHED SEMI-INDIRECT AND BOARD  
LIGHT OR DIRECT LIGHT - NEVER ALL LIGHTS

**CLASSROOM LIGHTING SYSTEM: PATTERN 1 BEST**



## DESIGN DATA

(12) DIRECT LUMINAIRES WITH 2-F28T5 LAMPS  
 OPTION 1: HIGH LIGHT OUTPUT 2 LEVEL BALLASTS  
 HIGH LIGHT LEVELS >50 FC AVERAGE 0.9 W/SF

OPTION #2: NORMAL LIGHT OUTPUT 2 LEVEL BALLASTS  
 NORMAL LIGHT LEVEL ~45FC AVERAGE .75 W/SF

SEE TEXT FOR SWITCHING