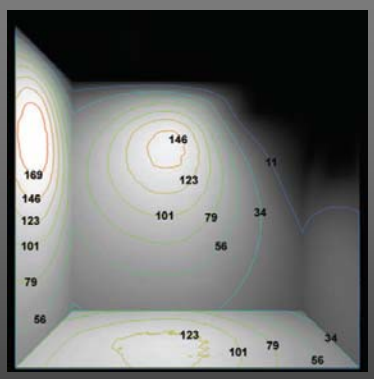
Lighting Math

NOT SO SCARY LIGHTING MATH

NOT SO SCARY LIGHTING MATH



The importance of Lighting Math:

- Calculations can determine the light levels
- Calculations can determine the required quantity of fixtures
- Calculations can verify layout

Methods to perform Lighting Math:

- By Hand
- By Computer

Lighting Math

Target Illuminance / Light Levels

Who Defines Light Levels?

- IES of North America
  - Recommended Practices
  - Defines light levels and quality of illumination by task and application
- Codes and Regulations
- The Owner

Definitions: ***Task*** *= the work performed*

Applications *= the project type (i.e. School, Commercial etc,*

- IESNA Light Level recommendations are for Foot-candles at the work plane (2'6" AFF)
- They have limited significance to us when we interpret the actual environment.
- Such factors as lighting walls, brightness accents, shadows, sparkle, and color have a greater influence on emotional reaction.

- **IESNA's recommend light levels are for an age range of 40 – 55 years old**

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.

A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)

Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.

D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)

Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.

G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

Lighting Math

Ages

Standard Age Range is 40-55 years old

Less than 40 years old…

Can reduce the light levels up to 1/3!

Over 55 years old…

Can increase the light levels up to 2/3!

Babies require 3 times more light than a 20 year old!

IESNA Recommended Light Levels

IESNA Lighting Design Guide Interior-1

I. INTERIOR LOCATIONS AND TASKS — Very Important / Important / Somewhat important / Blank = Not important or not applicable

Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Accounting (see Offices)																								Ch. 11
Air Terminals																								Ch. 23
(see Transportation Terminals in Section V, Transportation)																								
Armories																				C		A		
Art Galleries (see Museums)																								Ch. 14
Auditoriums																								
Assembly																				C				
Social activity																				B		A		
Banks (see Reading)																								Ch. 11
Lobby																								
General																		(1)		C		A		
Writing area																		(1)		D		A		
Tellers' stations																		(1)		E		A		

Lighting Math

Summary Light Level (table 15)

TABLE 15

RECOMMENDED ILLUMINANCE VALUES

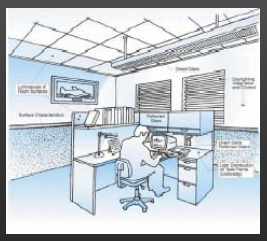
	General Lighting			Task Lighting		
Activity	Public Spaces	Simple Orientation	Occasional Visual Task	Large Visual Task	Small Visual Task	Very Small Visual Task
	3 fc	5 fc	10 fc	30 fc	50 fc	100 fc
GENERAL						
Circulation						
Corridors		•				
Elevators		•				
Lobbies			•			
Stairs		•				
Service						
Toilets and washrooms		•				
Storage						
Active			•			
Inactive		•				
HOSPITALITY FACILITIES						
Bathrooms, for grooming				•		
Bedrooms, for reading				•		
Cleaning			•			
Dining			•			
Kitchen, critical seeing					•	
Laundry				•		

Measuring Light

Luminance

- *Measures how easy something is to see, or how bight a surface is – emitting light energy*
- Examples: backlit signage, a full moon, glowing wall
- *Measured in:* Foot-Lamberts (US) or Candelas per meter squared (metric)

  1 Foot-Lambert = 3.426 Candelas/m2

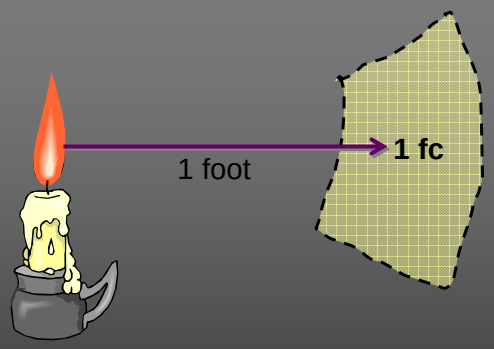


Illuminance

- *Measures how much light there is to see by, the light level to perform a task – arriving lighting energy*
- Examples: emergency light level on the floor),
- *Measured in:* Foot-Candles (US) and Lux (Metric)

Lighting Math

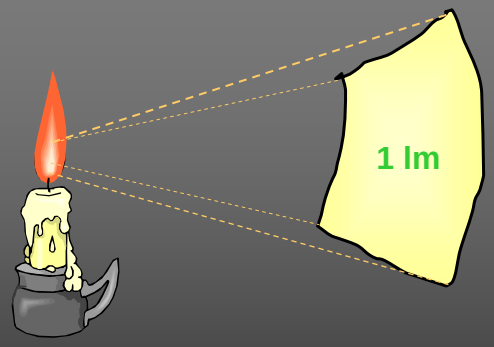
Light – The Foot-candle



Foot-candle is known as a unit of light - direct illumination light level

Derived from one candle placed at a distance of one foot from a surface is defined as a **foot-candle**
(abbreviation = fc or FC)

Light – The Lumen



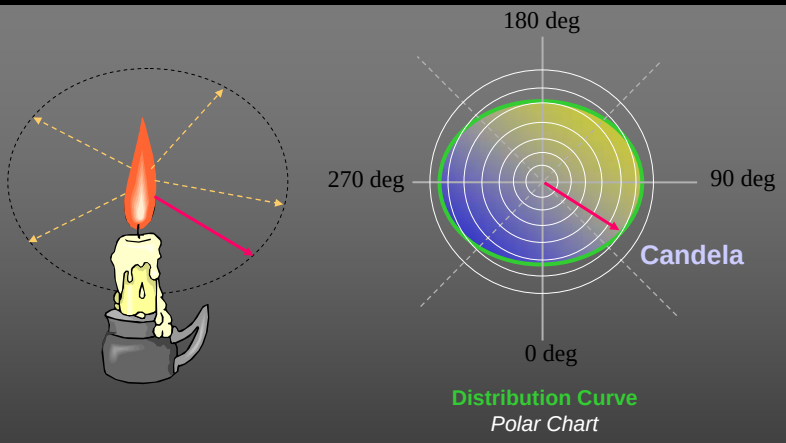
The energy of light from a candle falling on a one foot square **area** is **One Lumen** (abbreviation = lm)

*The total amount of light energy coming out of the **candle** is approximately **13 lumens***
*The total amount of light energy coming out of **100-watt A-lamp** is approximately **1650 lumens***

NOT DEFINED BY DISTANCE

Lighting Math

Light – The Candela

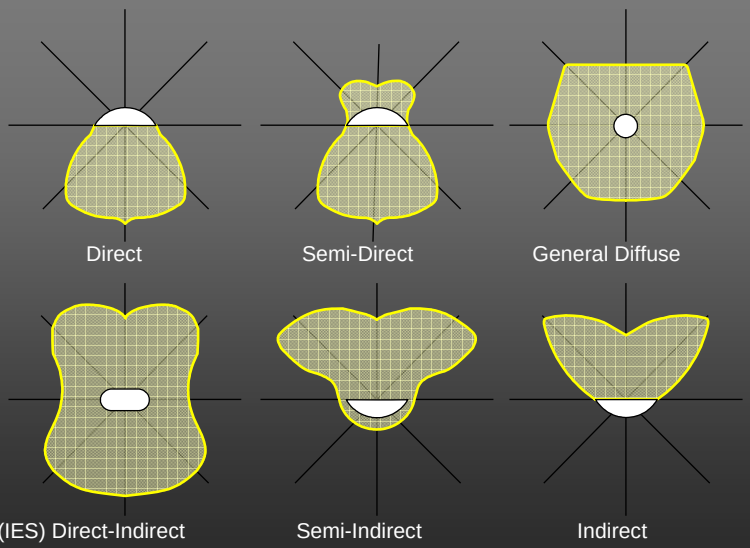


Distribution Curve
Polar Chart

Candle Power is the intensity value at any given direction.
(unit is Candela, abbreviated as cp)

Distribution Curve represents the total light intensity pattern produced by a source

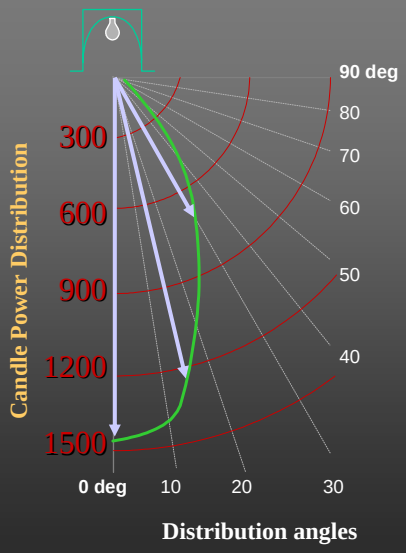
CIE Luminaire Types / Distributions



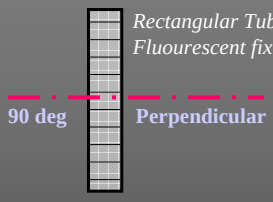
Lighting Math

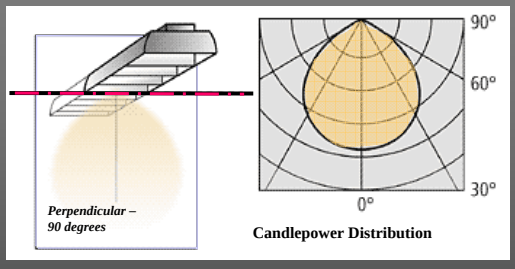
Candlepower Distribution Curve

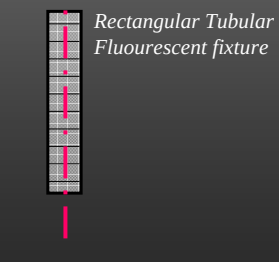
- **Candlepower distribution curves** provides intuitive information on how a **luminaire** will perform
- **Candela** values are used in calculations to predict light levels

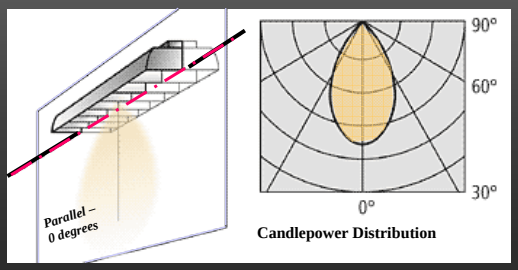


Asymmetrical Distribution Curve









Lighting Math

Light Measurement

Measures the candlepower distribution of a particular lamp or luminaire.

Information is generated in a -- Photometric report

Integrating Sphere

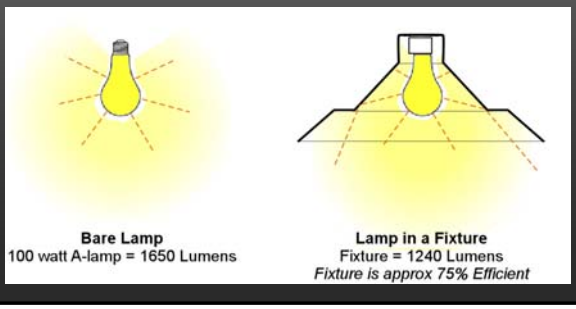
Gonio-Photometer

The Spectro-Radiometer

Lumens versus Candelas

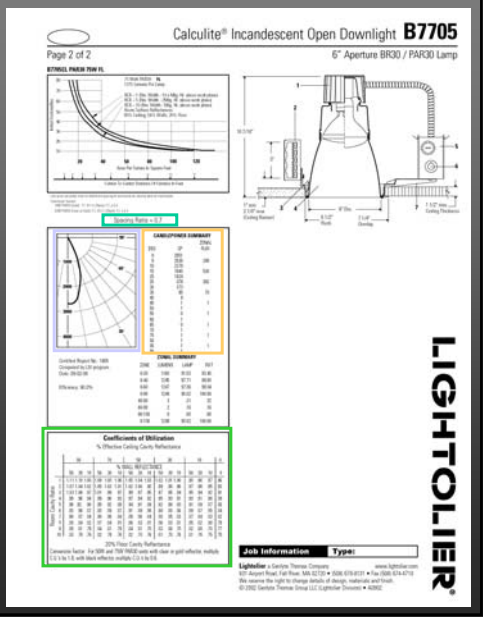
- Lumen is an amount of ENERGY
- Candela is an amount of INTESITY

- Light output from lamps and fixtures be measured in Lumens and Candelas.
- Fixtures alter Lumen and Candela output (Their values can only be found in Photometry Reports)



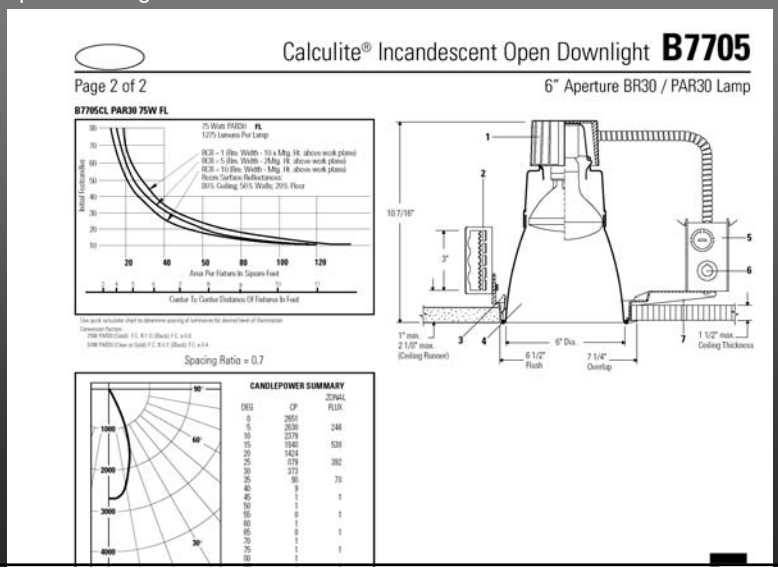
Photometry Reports

- Plot of candlepower values
- Summary of candlepower values in different planes
- Fixture Efficiency
- Lumen Summary
- Luminance summary
- Spacing criteria (SC) or Spacing/Mounting Height (S/MH) for uniformity
- Coefficient of Utilization Table
- Guides



Photometry Reports: sample 1

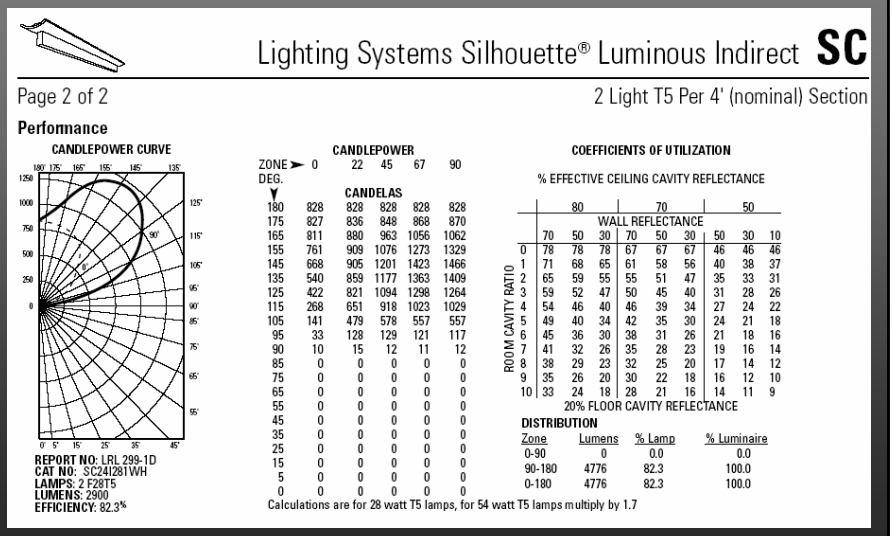
- Open Downlight



Lighting Math

Photometry Reports: sample 2

- Indirect Pendant



Lighting Systems Silhouette® Luminous Indirect **SC**

Page 2 of 2 — 2 Light T5 Per 4' (nominal) Section

Performance

CANDLEPOWER CURVE

REPORT NO: LRL 299-1D
CAT NO: SC24I281WH
LAMPS: 2 F28T5
LUMENS: 2900
EFFICIENCY: 82.3%

CANDLEPOWER

ZONE ➤	0	22	45	67	90
DEG. ▼	CANDELAS				
180	828	828	828	828	828
175	827	836	848	868	870
165	811	880	963	1056	1062
155	761	909	1076	1273	1329
145	668	905	1201	1423	1466
135	540	859	1177	1363	1409
125	422	821	1094	1298	1264
115	268	651	918	1023	1029
105	141	479	578	557	557
95	33	128	129	121	117
90	10	15	12	11	12
85	0	0	0	0	0
75	0	0	0	0	0
65	0	0	0	0	0
55	0	0	0	0	0
45	0	0	0	0	0
35	0	0	0	0	0
25	0	0	0	0	0
15	0	0	0	0	0
5	0	0	0	0	0
0	0	0	0	0	0

Calculations are for 28 watt T5 lamps, for 54 watt T5 lamps multiply by 1.7

COEFFICIENTS OF UTILIZATION

% EFFECTIVE CEILING CAVITY REFLECTANCE

	80			70			50		
WALL REFLECTANCE									
ROOM CAVITY RATIO	70	50	30	70	50	30	50	30	10
0	78	78	78	67	67	67	46	46	46
1	71	68	65	61	58	56	40	38	37
2	65	59	55	55	51	47	35	33	31
3	59	52	47	50	45	40	31	28	26
4	54	46	40	46	39	34	27	24	22
5	49	40	34	42	35	30	24	21	18
6	45	36	30	38	31	26	21	18	16
7	41	32	26	35	28	23	19	16	14
8	38	29	23	32	25	20	17	14	12
9	35	26	20	30	22	18	16	12	10
10	33	24	18	28	21	16	14	11	9

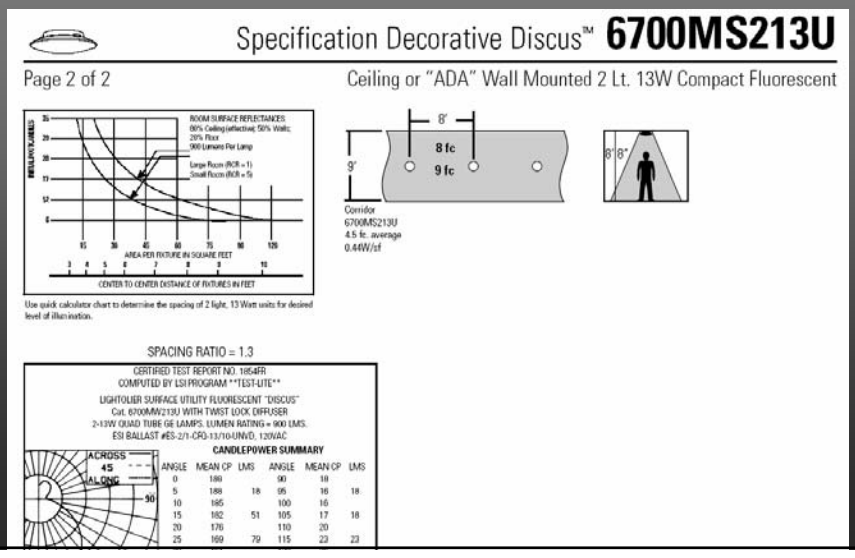
20% FLOOR CAVITY REFLECTANCE

DISTRIBUTION

Zone	Lumens	% Lamp	% Luminaire
0-90	0	0.0	0.0
90-180	4776	82.3	100.0
0-180	4776	82.3	100.0

Photometry Reports: sample 3

- Ceiling Fixture



Specification Decorative Discus™ **6700MS213U**

Page 2 of 2 — Ceiling or "ADA" Wall Mounted 2 Lt. 13W Compact Fluorescent

Use quick calculator chart to determine the spacing of 2 light, 13 Watt units for desired level of illumination.

SPACING RATIO = 1.3

CERTIFIED TEST REPORT NO. 1854FR
COMPUTED BY LSI PROGRAM **TEST-LITE**
LIGHTOLIER SURFACE UTILITY FLUORESCENT "DISCUS"
Cat. 6700MW213U WITH TWIST LOCK DIFFUSER
2-13W QUAD TUBE GE LAMPS. LUMEN RATING = 900 LMS.
ESI BALLAST #ES-2/1-CFQ-13/10-UNVD, 120VAC

CANDLEPOWER SUMMARY

ANGLE	MEAN CP	LMS	ANGLE	MEAN CP	LMS
0	189		90	18	
5	188	18	95	16	18
10	185		100	16	
15	182	51	105	17	18
20	176		110	20	
25	169	79	115	23	23

Lighting Math

Hand Methods to Calculate Light

Mnfrs Guides
- Direct or Average Illumination from a Fixture or Lamp
- Recommended spacing or layout

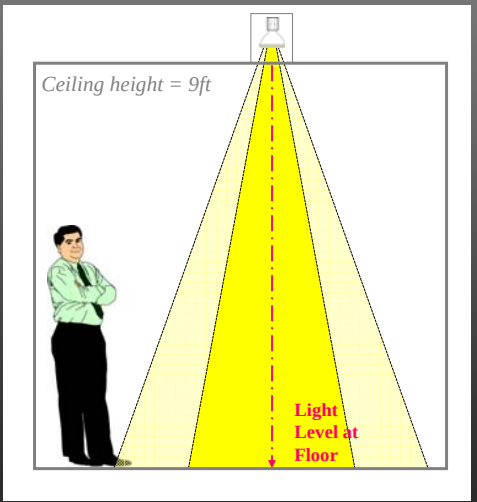
Point-by-Point
- Direct light level from a Fixture or Lamp

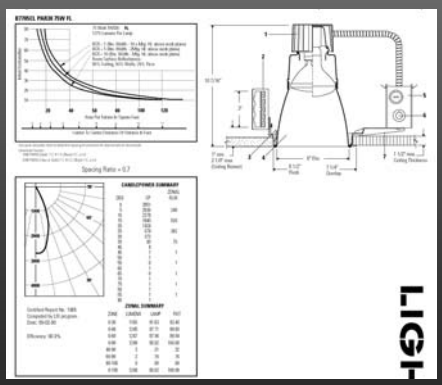
Lumen Method
- Average Light Level in a Room from a Fixture
- Can be used to determine quantity needed

Point-by-Point

$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2}$$

FC = 2651*candelas* **/ 9***ft*^{2}
FC = 2651 / 81
FC = 32.7 ***foot-candles***





Lighting Math

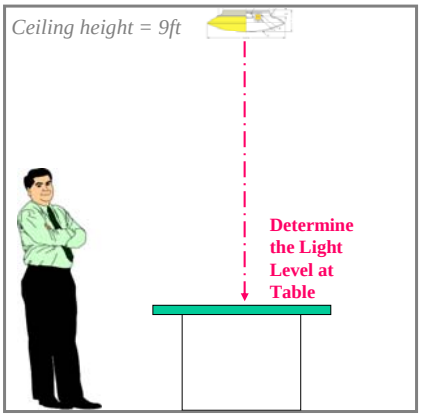
Point-by-Point

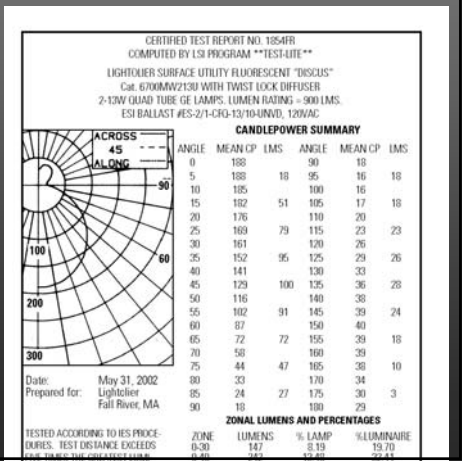
Foot-candle = $\frac{\text{Candle Power}}{\text{Distance}^2}$

- Ceiling Fixture Example

FC = ____ *candelas* / ___ ft^2

FC = _____ *foot-candles*




CERTIFIED TEST REPORT NO. 1854FR
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LIGHTOLIER SURFACE UTILITY FLUORESCENT "DISCUS"
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2-13W QUAD TUBE GE LAMPS. LUMEN RATING = 900 LMS.
ESI BALLAST #ES-2/1-CFG-13/10-UNVD, 120VAC

CANDLEPOWER SUMMARY

ANGLE	MEAN CP	LMS	ANGLE	MEAN CP	LMS
0	188		90	18	
5	188	18	95	16	18
10	185		100	16	
15	182	51	105	17	18
20	176		110	20	
25	169	79	115	23	23
30	161		120	26	
35	152	95	125	29	26
40	141		130	33	
45	129	100	135	36	28
50	116		140	38	
55	102	91	145	39	24
60	87		150	40	
65	72	72	155	39	18
70	58		160	39	
75	44	47	165	38	10
80	33		170	34	
85	24	27	175	30	3
90	18		180	29	

ACROSS 45 ALONG 90 60 100 200 300

Date: May 31, 2002
Prepared for: Lightolier
Fall River, MA

ZONAL LUMENS AND PERCENTAGES

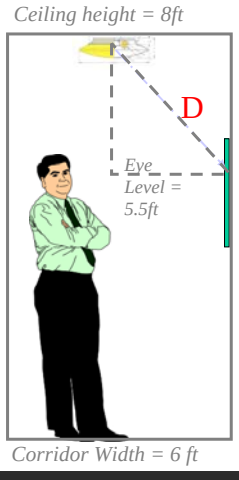
TESTED ACCORDING TO IES PROCEDURES. TEST DISTANCE EXCEEDS FIVE TIMES THE GREATEST LUMI

ZONE	LUMENS	% LAMP	%LUMINAIRE
0-30	147	8.19	19.70

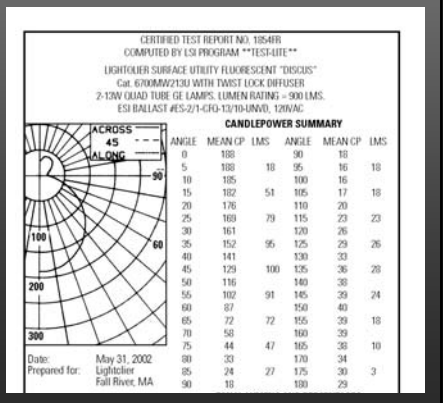
Point-by-Point

Foot-candle = $\frac{\text{Candle Power}}{\text{Distance}^2}$

- Ceiling Fixture Example



Determine the Light Level at the Wall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20	176		110	20	
25	169	79	115	23	23
30	161		120	26	
35	152	95	125	29	26
40	141		130	33	
45	129	100	135	36	28
50	116		140	38	
55	102	91	145	39	24
60	87		150	40	
65	72	72	155	39	18
70	58		160	39	
75	44	47	165	38	10
80	33		170	34	
85	24	27	175	30	3
90	18		180	29	

ACROSS 45 ALONG 90 60 100 200 300

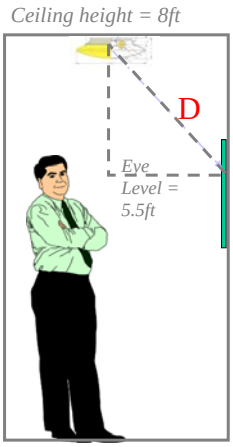
Date: May 31, 2002
Prepared for: Lightolier
Fall River, MA

Lighting Math

Point-by-Point

$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2}$$

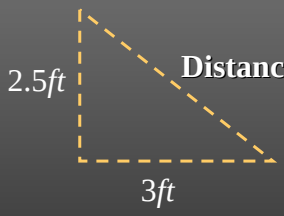
- Ceiling Fixture Example



Determine the Light Level at the Wall

To solve for **D**, you can:

1. *Scale the Drawing, or*
2. *Use **Trigonometry***



$A^2 + B^2 = C^2$

$2.5^2 + 3^2 = C^2$

$6.25 + 9 = C^2$

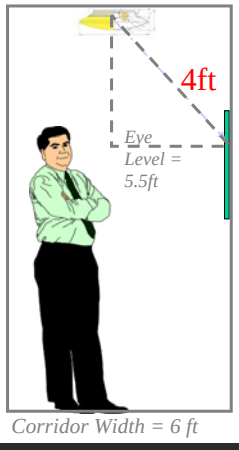
$C = \sqrt{(6.25 + 9)}$

$C = 3.9$ (approx4ft)

Point-by-Point

$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2}$$

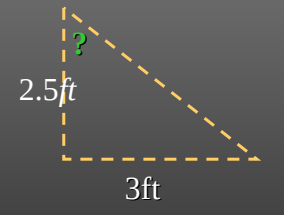
- Ceiling Fixture Example



Determine the Light Level at the Wall

To solve for **Angle**, you can:

1. *Scale the Drawing, or*
2. *Use **Trigonometry***



***Tan* (Angle) = Opp / Adj**

Angle = Tan^{-1} (Opp / Adj)

Angle = Tan^{-1} (3 / 2.5)

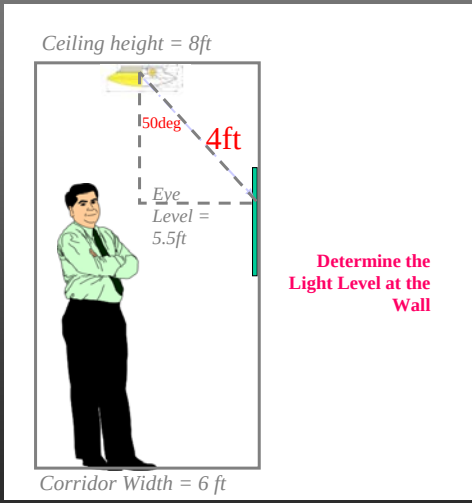
Angle = 50 *degrees*

Lighting Math

Point-by-Point

$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2}$$

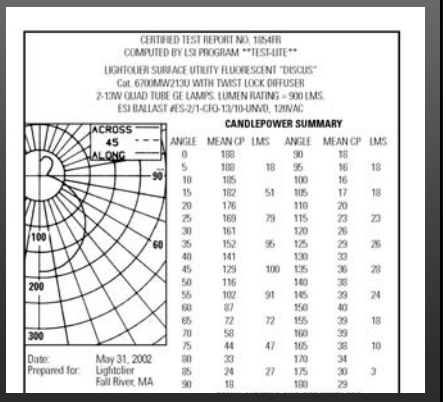
- Ceiling Fixture Example



Determine the Light Level at the Wall

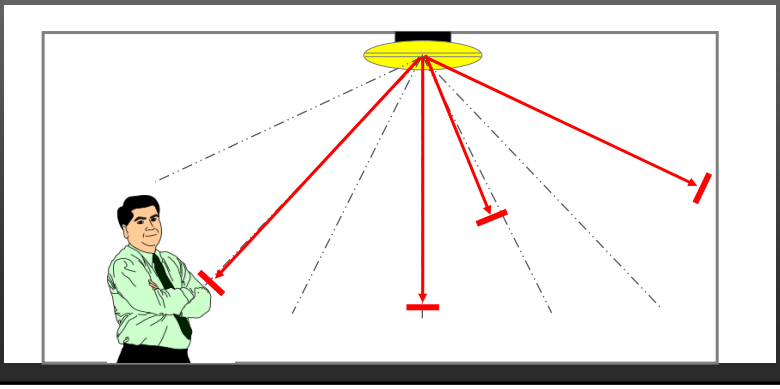
FC = ____ *candelas* / ___ *ft²*

FC = ____ *foot-candles*



Point-by-Point Factors

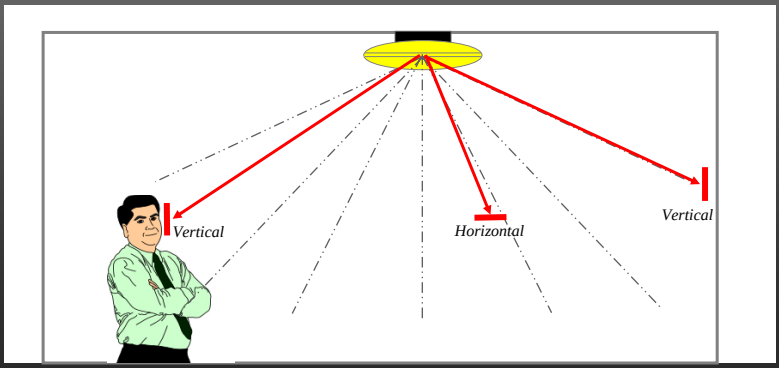
- Calculated Levels are Facing the Light Fixture
  - *With the exception of directly below*



Lighting Math

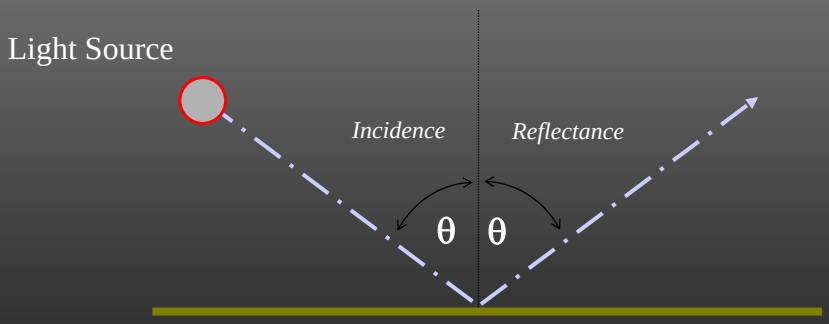
Point-by-Point Factors

- You need to factor an adjustment if you want levels at other angles (IE Horizontal, Vertical Angles)
  - **COSINE Adjusted!!**



COSINE Adjustments

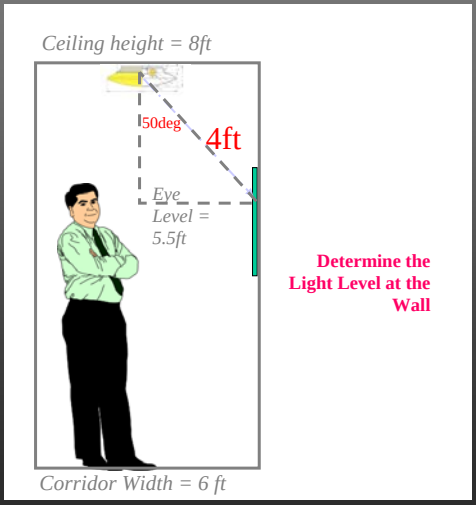
$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2} \times \text{COS(Angle of Incidence)}$$



Lighting Math

Point-by-Point… with COSINE Adjustment

- Ceiling Fixture Example



Determine the Light Level at the Wall

FC = CP/D^2 x COS(angle)

What is the Angle of Incidence?

FC = 7.25 x COS (___ *deg*)

FC = ____ *foot-candles*

Methods to Calculate Light

Point-by-Point

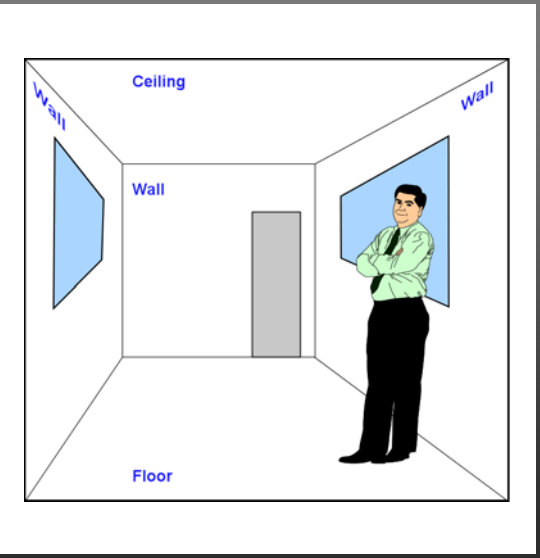
- Direct Illumination from a Fixture or Lamp
  - You need….
    - Photometry
    - Distances from Fixture or Lamp

Lumen Method

- Average Light Level in a Room from a Fixture
  - You need….
    - Photometry
    - Room Dimensions and Surface Reflectance's

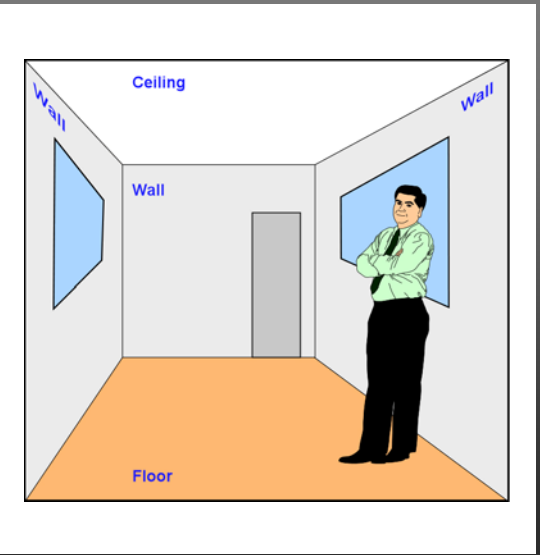
Lighting Math

Room Reflectance



- Room comprised of Walls, Ceiling, and Floor.
- Walls typically have Doors and Windows
- All surfaces have a reflectance value to bounce light.
- Light from Light Fixture bounces off of all surfaces.

Room Reflectance



- Surfaces with less reflectance will bounce less light
- Typical Reflectance Values:
  - **75%-90%** White, Off White, Grey, Light tints of Blue or Brown
  - **30%-60%** Medium Green, Yellow, Brown, or Grey
  - **10%-20%** Dark Grey, Medium Blue
  - **5%-10%** Dark Blue, Brown. Dark Green, and many wood finishes

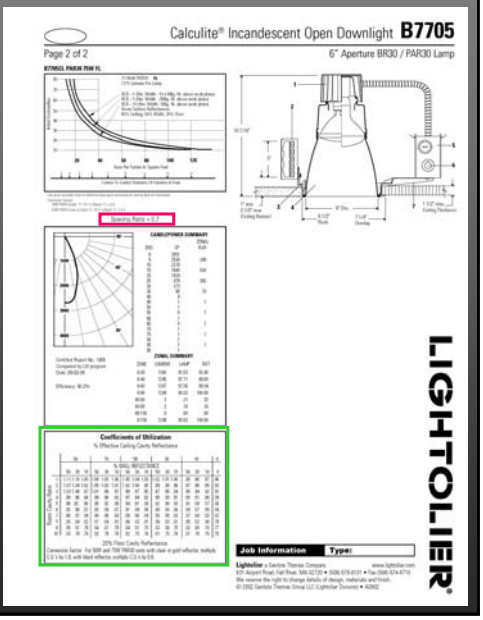
Calculations using Lumens

- Lumen Method Calculation
  - *Calculates the Average Illumination for a room.*
  - *Takes into account the room surface reflectance's – but assumes the surfaces are diffuse (not shiny!).*
  - *Assumes an empty room (without furniture).*
  - *Can also be used to determine the required Quantity of Fixtures needed for a target light level.*
  - *Does not determine light fixture layout or location – you must following mnfrs spacing criteria.*

1. You need Room Dimensions and the Fixture Mounting Height.
2. You need to select a Light fixture
3. Determine the rooms Room Cavity Ratio (RCR).
4. Look-up the fixtures Coefficient of Utilization for the RCR.
5. Calculate!

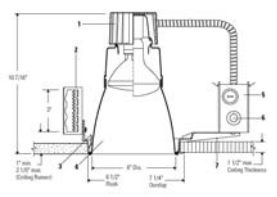
Photometry Reports

- **Plot of candlepower values**
- **Summary of candlepower values in different planes**
- **Fixture Efficiency**
- **Lumen Summary**
- **Luminance summary**
- **Spacing Criteria (SC) or Spacing/Mounting Height (S/MH) for uniformity**
- **Coefficient of Utilization Table**
- **Guides**



Lighting Math

Coefficient of Utilization



Coefficients of Utilization

% Effective Ceiling Cavity Reflectance

Room Cavity Ratio	80			70		50			30		10		0
	% WALL REFLECTANCE												
	50	30	10	50	30	10	50	30	10	50	30	10	0
1	1.11	1.10	1.08	1.09	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.00	.96
2	1.07	1.04	1.02	1.05	1.03	1.01	1.02	1.00	.98	.99	.98	.96	.93
3	1.03	1.00	.97	1.01	.99	.97	.99	.97	.95	.97	.95	.94	.91
4	.99	.96	.94	.99	.96	.93	.97	.94	.92	.95	.93	.91	.89
5	.96	.92	.90	.95	.92	.89	.94	.91	.89	.92	.90	.88	.86
6	.93	.90	.87	.93	.89	.87	.91	.89	.86	.90	.88	.86	.84
7	.90	.87	.84	.90	.86	.84	.89	.86	.84	.88	.85	.83	.82
8	.88	.84	.82	.87	.84	.81	.86	.83	.81	.86	.83	.81	.79
9	.85	.81	.79	.84	.81	.79	.84	.81	.76	.83	.80	.78	.77
10	.83	.79	.76	.82	.79	.76	.82	.78	.76	.81	.78	.76	.75

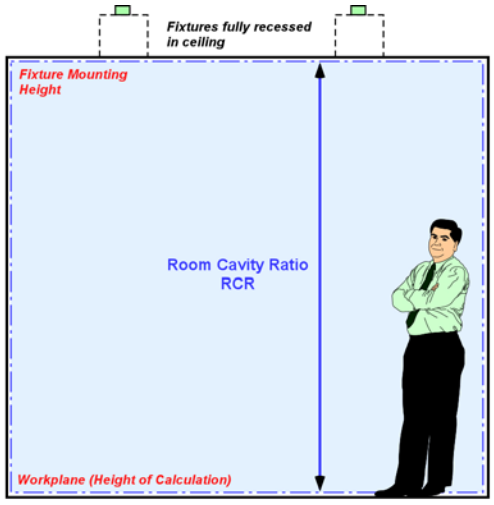
20% Floor Cavity Reflectance

Conversion Factor: For 50W and 75W PAR30 units with clear or gold reflector, multiply C.U.'s by 1.0; with black reflector, multiply C.U.'s by 0.6.

- Also known as **CU**
- Defines the percentage of light output that is expected from a fixture
- The value is determined by a CU table
- **For commercial Reflectance of 80/50/20, the actual CU value is this.**

Room Cavity Ratio

$$RCR = \frac{5xMHx(L+W)}{\text{Room Area}}$$



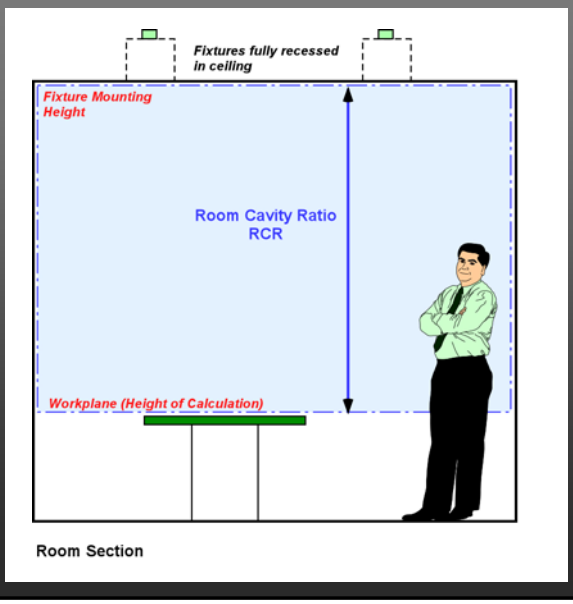
Room Section

- The **RCR** can vary depending on the height you want to calculate…***as shown here with the calculation height at the floor.***

Lighting Math

Room Cavity Ratio

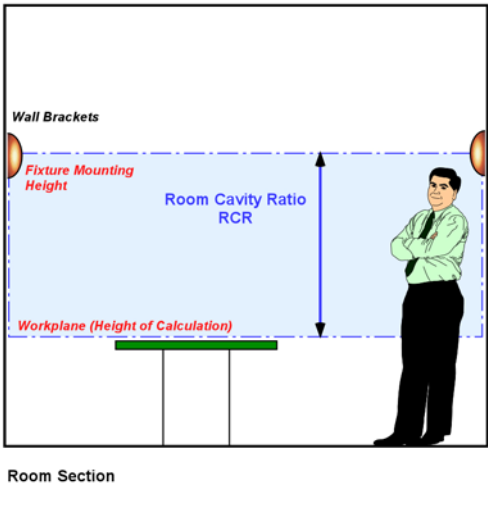
$$RCR = \frac{5xMHx(L+W)}{\text{Room Area}}$$



- Room Cavity Ratio (aka **RCR**) is the volume between the **Fixture** and **Height of Calculation**
- Workplane height is typically 30-inches above the floor
- A rooms RCR will always be between 1 and 10

Room Cavity Ratio

$$RCR = \frac{5xMHx(L+W)}{\text{Room Area}}$$

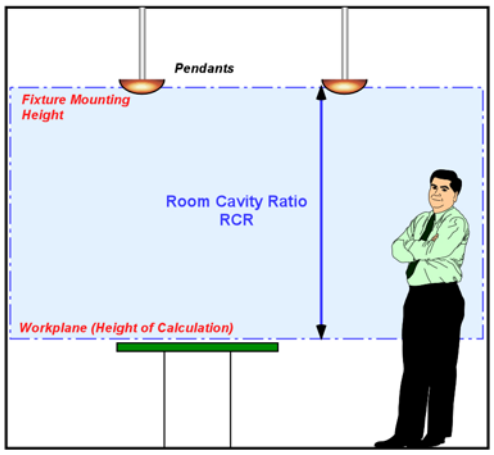


- The **RCR** can vary depending on the height of the fixture….***as shown here with Wall Brackets or Sconces.***

Lighting Math

Room Cavity Ratio

$$RCR = \frac{5xMHx(L+W)}{\text{Room Area}}$$

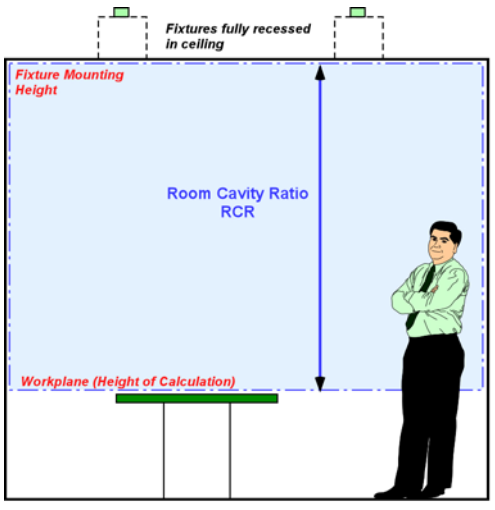


Room Section

- The **RCR** can vary depending on the height of the fixture….***as shown here with Pendants.***

Room Cavity Ratio

$$RCR = \frac{5xMHx(L+W)}{\text{Room Area}}$$



Room Section

Example:

Room Width: 12*ft*

Room Length: 15*ft*

Ceiling Height: 10*ft*

$$RCR = \frac{5 \times (\_\_\_) \times (\_\_\_ + \_\_\_)}{(\_\_ \times \_\_)}$$

RCR =

Lighting Math

Lumen Method Formula

To Calculate Foot-candle level:

$$FC = \frac{\text{Qty of Fixtures x Number of Lamps per Fixture x Lumens per Lamp x CU}}{\text{Area of the Room}}$$

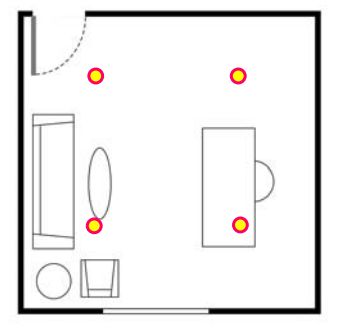
To Calculate number of Fixtures:

$$FC = \frac{\text{Total Lumens in the Room x CU}}{\text{Area of the Room}}$$

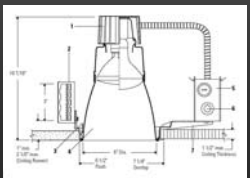
$$\text{Qty of Fixtures} = \frac{\text{FC x Area of the Room}}{\text{Number of Lamps per Fixture x Lumens per Lamp x CU}}$$

$$\text{Qty of Fixtures} = \frac{\text{FC x Area of the Room}}{\text{Total Lumens in the Room x CU}}$$

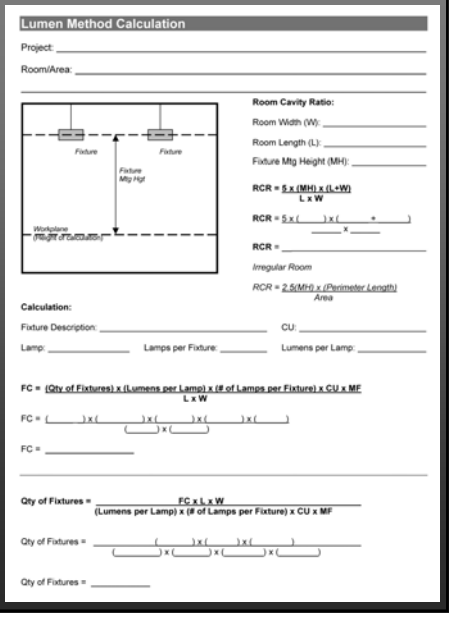
Lumen Method Example 1



What is the resulting Foot-candle Level at table height from four downlights?

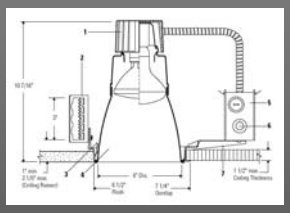


Example:
Room Width: 12*ft*
Room Length: 15*ft*
Ceiling Height: 10*ft*



Lighting Math

Coefficient of Utilization



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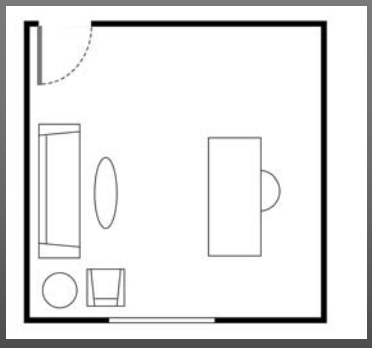
3	1.03	1.00	.97	1.01	.99	.97	.99	.97	.95	.97	.95	.94	.95	.94	.92	.91
4	.99	.96	.94	.99	.96	.93	.97	.94	.92	.95	.93	.91	.93	.91	.90	.89
5	.96	.92	.90	.95	.92	.89	.94	.91	.89	.92	.90	.88	.91	.89	.87	.86
6	.93	.90	.87	.93	.89	.87	.91	.89	.86	.90	.88	.86	.89	.87	.85	.84
7	.90	.87	.84	.90	.86	.84	.88	.86	.84	.88	.85	.83	.87	.84	.83	.82
8	.88	.84	.82	.87	.84	.81	.86	.83	.81	.86	.83	.81	.85	.82	.80	.79
9	.85	.81	.79	.84	.81	.79	.84	.81	.78	.83	.80	.78	.82	.80	.78	.77
10	.83	.79	.76	.82	.79	.76	.82	.78	.76	.81	.78	.76	.81	.76	.75	.75

20% Floor Cavity Reflectance

Conversion Factor: For 50W and 75W PAR30 units with clear or gold reflector, multiply C.U.'s by 1.0; with black reflector, multiply C.U.'s by 0.6.

- Also known as **CU**
- Defines the percentage of light output that is expected from a fixture
- The value is determined by a CU table
- **For our example:**
- **RCR_ _____…**
- **the CU is _____**
- **For commercial Reflectance of 80/50/20, the actual CU value is this.**

Lumen Method Example 2

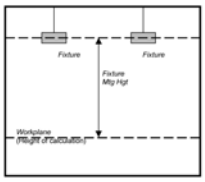


How many fixtures do I need to achieve 30-foot-candles at table height?

Lumen Method Calculation

Project: _____

Room/Area: _____



Room Cavity Ratio:

Room Width (W): _____

Room Length (L): _____

Fixture Mtg Height (MH): _____

RCR = 5 x (MH) x (L+W) / L x W

RCR = 5 x (____) x (____ + ____) / ____ x ____

RCR = _____

Irregular Room

RCR = 2.5(MH) x (Perimeter Length) / Area

Calculation:

Fixture Description: _____ CU: _____

Lamp: _____ Lamps per Fixture: _____ Lumens per Lamp: _____

FC = (Qty of Fixtures) x (Lumens per Lamp) x (# of Lamps per Fixture) x CU x MF / L x W

FC = (____) x (____) x (____) x (____) x (____) / (____) x (____)

FC = _____

Qty of Fixtures = FC x L x W / (Lumens per Lamp) x (# of Lamps per Fixture) x CU x MF

Qty of Fixtures = (____) x (____) x (____) x (____) / (____) x (____) x (____) x (____)

Qty of Fixtures = _____