Calculating Light

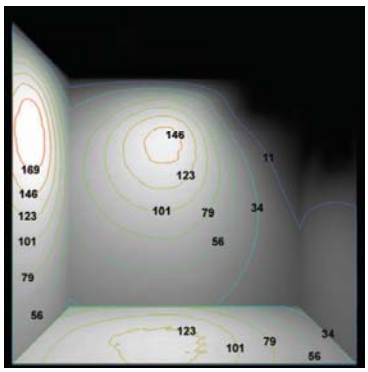
NOT SO SCARY LIGHTING MATH

Measuring Light / Light Metrics

- **Hand Calculations**
  - **Point-by-Point**
  - **Lumen Method**

1

Calculating Light



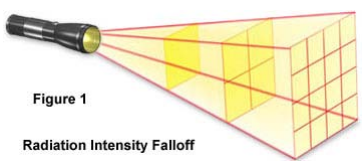


Figure 1

Radiation Intensity Falloff

The importance of Lighting Math:

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

Methods to perform Lighting Math:

- By Hand - calculates a "**quick**" estimate of light levels, and verifies qty of fixtures
- By Computer - calculates a "**detailed**" estimate of light levels, and verifies qty of fixtures

2

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,*

3

Target Illuminance / Ages

Less than 40 years old…

Can reduce the light levels up to 1/3!

Standard Age Range is 40-55 years old

Over 55 years old…

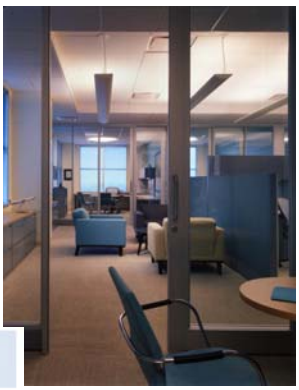
Can increase the light levels up to 2/3!

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

4

Calculating Light

IESNA Recommended Light Levels



QUALITY ISSUES FOR OFFICE LIGHTING

	Private Offices	Open-plan Offices	Office Corridor
Control of direct and reflected glare	●	●	○
Light on walls and ceilings	●	●	◐
Physical relation of fixtures to users	●	●	○
Uniformity / Reduce shadows and flicker	◐	◐	○
Room surface characteristics	◐	◐	◐
Color rendering and color temperature	◐	◐	○
Daylighting	◐	◐	○
Lighting controls	◐	◐	○
Quantity of light on task (footcandles)	40-50 fc	40-50 fc	5-10 fc

● Very Important ◐ Important ○ Somewhat Important * Adapted from the Lighting Design Guide. IESNA Lighting Handbook, 9th Edition

5

IESNA Recommended Light Levels

QUALITY ISSUES FOR SCHOOL LIGHTING

	General Classroom	Computer Classroom	School Corridor
Light on walls and ceilings 1 on photo above	●	●	◐
Control of direct and reflected glare 2	◐	●	○
Uniformity 3	◐	●	○
Daylight 4	●	○	◐
Color rendering and color temperature	◐	●	◐
Lighting controls	●	◐	○
Quantity of light (horizontal footcandles)	40-50 fc	20-40 fc	10 vert. fc

● Very Important ◐ Important ○ Somewhat Important * Adapted from the Lighting Design Guide. IESNA Lighting Handbook, 9th Edition

6

Calculating Light

IESNA Recommended Light Levels

- IESNA Light Level recommendations are for foot-candles (FC, fc) at the work plane - 2'6" AFF (30 inches)
- 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)

7

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

A= 3 fc
B = 5 fc
C = 10 fc
D = 30 fc
E = 50 fc
F = 100 fc
G = 300-1000 fc

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 (see Transportation Terminals in Section V, Transportation)																								Ch. 23
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		

8

Summary Horizontal Light Level (table 15)

TABLE 15

RECOMMENDED ILLUMINANCE VALUES

	General Lighting			Task Lighting		
Activity	Public Spaces 3 fc	Simple Orientation 5 fc	Occasional Visual Task 10 fc	Large Visual Task 30 fc	Small Visual Task 50 fc	Very Small Visual Task 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				•		

9

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 reaching a specific point
- Candlepower info needed

Lumen Method

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

10

Calculating Light

Manufactures Guides: Beam Guides

Calculite® Evolution Incandescent Adjustable Accent **C4P20A**

Page 2 of 2

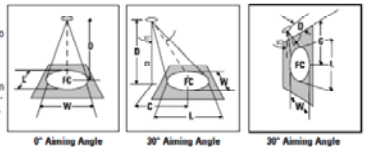
4 1/2" Aperture PAR20 / PAR16 Reflector Trim

Accent Lighting Performance Data

(FC) is initial footcandles at center of beam.Beam length **(L)** and beam width **(W)** are to where the candlepower is reduced to 50% of the center beam candlepower.

CBCP is center beam candlepower. **(C)** is distance to the center of the beam.

Lamp data shown is typical, and is based on bare lamp photometrics. Contact lamp manufacturers for availability and performance.

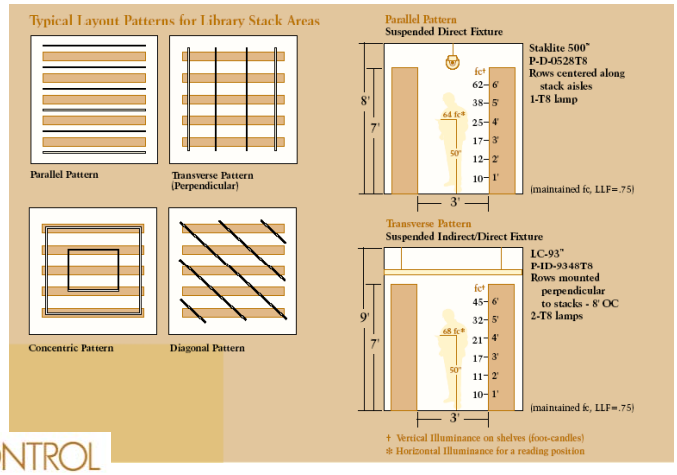


Lamps	Beam Spread (to 50% CBCP)	CBCP	Rated Life (hrs.)	0° Aiming Angle D	FC	L	W	30° Aiming Angle D	C	FC	L	W	30° Aiming Angle D	C	FC	L	W
PAR16 Halogen Line Voltage Lamps																	
60W PAR16 NSP	10°	5000	2000	6' 10' 12'	139 78 55	1.0' 1.4' 1.7'	1.0' 1.4' 2.1'	5' 7' 9' 11'	23' 40' 62' 84'	130 66 40 27	1.2' 1.6' 2.1' 2.6'	1.0' 1.4' 1.8' 2.2'	2' 3' 4' 5'	25' 52' 89' 137'	150 69 39 25	1.4' 2.1' 2.9' 3.6'	0.7' 1.0' 1.4' 1.7'
60W PAR16 NFL	30°	1500	5000	3' 5' 7' 9'	144 52 27 16	1.8' 2.7' 3.8' 4.8'	1.8' 2.7' 3.8' 4.8'	3' 5' 7' 9'	17' 29' 40' 52'	94 34 17 10	2.2' 3.7' 5.1' 6.6'	1.9' 3.1' 4.3' 5.6'	1' 2' 3' 4'	17' 35' 62' 97'	153 41 18 10	2.7' 5.5' 8.2' 10.9'	1.1' 2.1' 3.2' 4.3'
75W PAR16 NSP	10°	7500	2000	7' 10' 13' 16'	153 75 44 29	1.3' 1.7' 2.3' 2.6'	1.2' 1.7' 2.3' 2.6'	6' 9' 12' 15'	35' 60' 84' 107'	135 60 34 22	1.4' 2.1' 2.8' 3.5'	1.2' 1.6' 2.4' 3.0'	2' 3' 4' 5'	35' 73' 104' 162'	234 104 59 36	1.4' 2.1' 2.9' 3.6'	0.7' 1.0' 1.4' 1.7'
75W PAR16 NFL	30°	1900	2000	4' 6' 8' 10'	119 53 30 19	2.1' 3.2' 4.2' 5.4'	2.1' 3.2' 4.2' 5.4'	5' 7' 9' 11'	29' 49' 71' 95'	133 40 25 15	2.2' 3.7' 5.1' 6.6'	1.9' 3.1' 4.3' 5.6'	1' 2' 3' 4'	17' 35' 59' 97'	238 59 26 15	2.7' 5.5' 8.2' 10.9'	1.1' 2.1' 3.2' 4.3'
PAR20 Halogen Line Voltage Lamps																	
25W PAR20 NSP	8°	3000	2000	6' 8' 10' 12'	83 47 30 21	0.8' 1.1' 1.4' 1.7'	0.8' 1.1' 1.4' 1.7'	5' 7' 8' 11'	23' 40' 52' 84'	78 40 24 16	0.8' 1.3' 1.7' 2.1'	0.8' 1.1' 1.5' 1.8'	2' 3' 4' 5'	34' 42' 23' 15'	54 42 23 15	1.1' 1.3' 2.3' 2.8'	0.8' 0.8' 1.1' 1.4'
25W PAR20 NFL	40°	1000	2000	3' 5'	100 36	1.6' 2.7'	1.6' 2.7'	5' 7'	29' 49'	65 23	2.2' 3.7'	1.9' 3.1'	1' 2'	17' 35'	113 26	2.7' 5.5'	1.1' 2.1'

PHILIPS LIGHTOLIER

11

Manufactures Guides: Printed Literature



LITECONTROL

12

Calculating Light

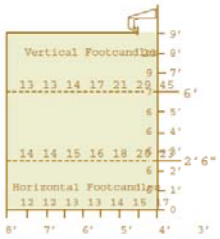
Manufactures Guides: Printed Literature

wall wash with
ample ambient lighting

sample layout

CORRIDOR
One 48" row with
one-lamp T8 fixtures

2014T8
REFLECTANCES: 80/70/20
LIGHT LOSS FACTOR: .75
POWER DENSITY: 1.12 W/ft²
AVG. MAINTAINED fc AT FLOOR: 13



LITECONTROL

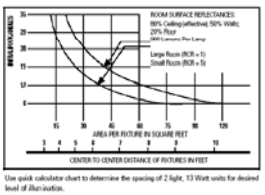
13

Manufactures Guides: Printed Literature

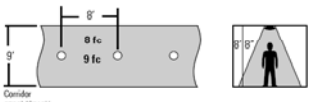
Specification Decorative Discus™ **6700MS213U**

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.



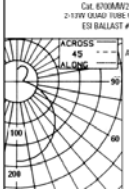
Corridor
6700MS213U
4.5 fc. average
0.44W/sf

SPACING RATIO = 1.3

CERTIFIED TEST REPORT NO. 1854FR
COMPUTED BY LSI PROGRAM "TEST-LITE"
LIGHTOLIER SURFACE UTILITY FLUORESCENT "DISCUS"
Cat. 6700MM213U 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	186		90	18	
5	188	18	95	16	18
10	185		100	16	
15	182	51	105	17	18
20	178		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

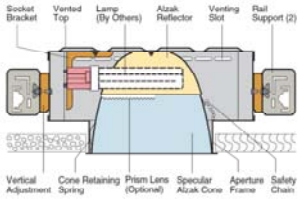


PHILIPS
LIGHTOLIER

14

Calculating Light

Manufactures Guides: Printed Literature

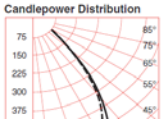


Performance Datachart

Single Unit Initial Footcandles, 30" Work Plane						Ceiling to Floor	Multiple Units Initial Footcandles, 30" Work Plane			
P632 One 26W Quad Tube lamp							Ceiling 80% Walls 50% Floor 20%			
Nadir	15°		25°		35°		Spacing is Maximum Over Work Plane			
FC	FC	Diam	FC	Diam	FC	Diam		Spacing	RCR 1	RCR 3	RCR 8
23	19	3'	15	5'	7	8'	8'	6'	28	24	16
17	13	3'	11	6'	5	9'	9'	7'	20	17	12
13	10	4'	8	7'	4	11'	10'	8'	15	13	9
10	8	5'	6	8'	3	12'	11'	9'	12	10	7
8	6	5'	5	9'	2	13'	12'	10'	9	8	5

See notes 4, 5 and 6.

Candlepower Distribution



Candelas

	0°	90°
○	1800*	1800*
0	708	708
5	691	726
10	661	677
15	673	593
20	671	582
25	626	575
30	513	519
35	416	397

Coefficients of Utilization

Ceiling	80%				70%		50%		30%		0
Wall %	70	50	30	10	50	10	50	10	50	10	0
RCR	Zonal Cavity Method - Floor Reflectance 20%										
1	.58	.56	.55	.54	.55	.53	.53	.51	.51	.50	.47
2	.55	.52	.50	.48	.51	.47	.49	.46	.48	.45	.43
3	.52	.48	.45	.43	.47	.42	.46	.42	.45	.41	.40
4	.49	.44	.41	.39	.44	.38	.42	.38	.41	.37	.36

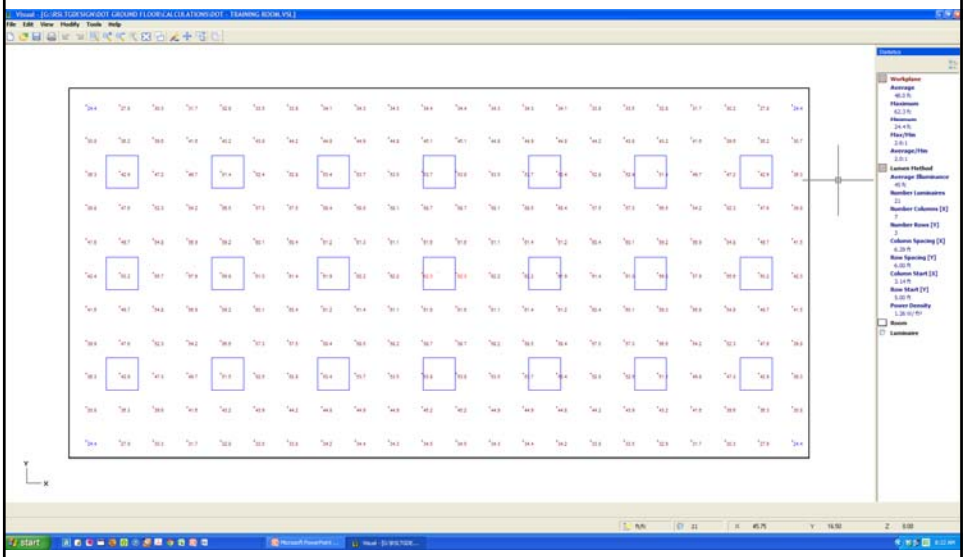
kurt versen
10 Charles Street PO Box 677 Westwood, New Jersey 07675

15

Manufactures Guides: On-Line Calculations

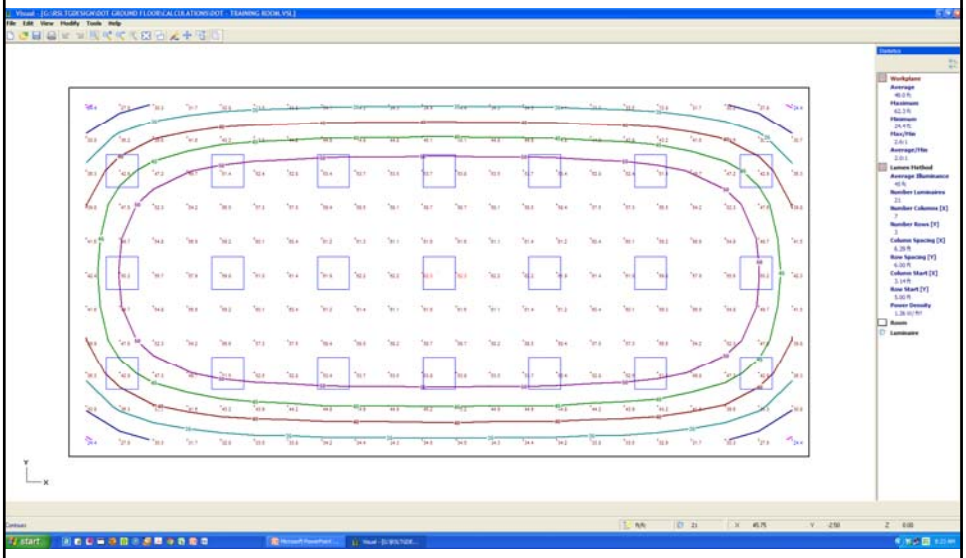
16

Computer Calculation Example



17

Computer Calculation Example



Calculating Light

Seeing Light

Illuminance: We do Not See Light Arriving

*Measures how much light is present, the light level to perform a task – **arriving** lighting energy*

Examples: emergency light level on the floor), on the desk, on a book

Measured in: Foot-Candles (US) and Lux (Metric)

Luminance: We See Brightness of Surfaces

*Measures how easy something is to see, or how bright a surface is – **emitting** or **reflected** light energy*

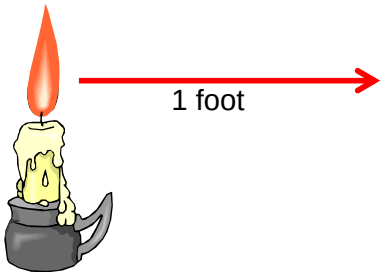
Examples: backlit signage, the moon, a glowing wall, the contrast on steps

Measured in: Foot-Lamberts (US) or Candelas per meter squared (metric)

1 Foot-Lambert = 3.426 Candelas/m2

19

Light Metric – The Foot-candle



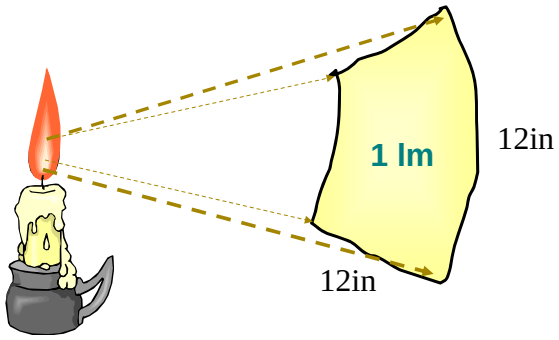
Foot-candle is known as a unit of light - direct illumination light level

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

20

Calculating Light

Light Metric – The Lumen



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

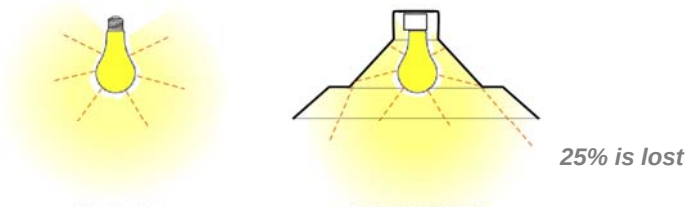
*The total amount of light energy coming out of the **candle** is approximately **13 lumens***
*The total amount of light energy coming out of **100-watt A-lamp** is approximately **1650 lumens***

NOT DEFINED BY DISTANCE

21

Efficiency vs Efficacy

- **Watts** is the amount of energy used to **Produce Light**
- Light output from **lamps** and **fixtures** be measured in units of **Lumens** and **Candelas**.
- The ratio **Lumens** emitted by a lamp or fixture measures **Efficiency** and **Efficacy**



Bare Lamp
100 watt A-lamp = 1650 Lumens

Efficacy = Lumens/Watt
= 1650/100
= 16.5 L/W

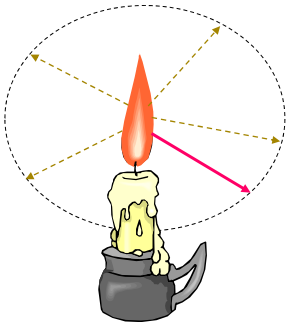
Lamp in a Fixture
Fixture = 1240 Lumens

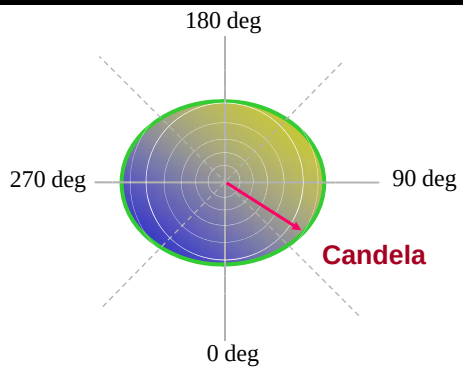
Efficiency = Fixture Lumens/Lamp Lumens
= 1240/1650
= 75%

22

Calculating Light

Light Metric – The Candela





Distribution Curve

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

23

Light Measurement

Measures the candlepower distribution of a particular lamp or luminaire.

Information is generated in a -- Photometric report

Erik is setting up a lamp for testing in the 2m integrating sphere.

Integrating Sphere

Gonio-Photometer

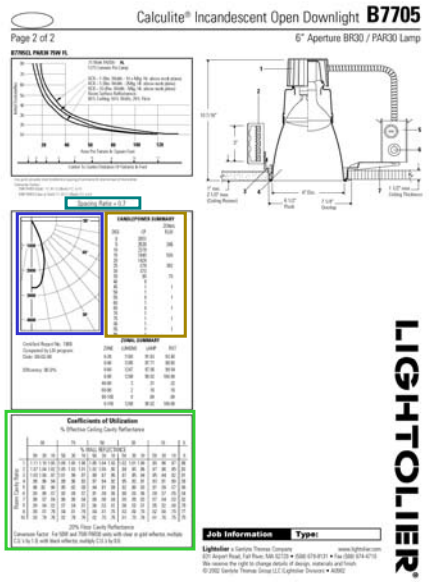
The Spectro-Radiometer

24

Calculating Light

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**



Hand Methods to Calculate Light

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

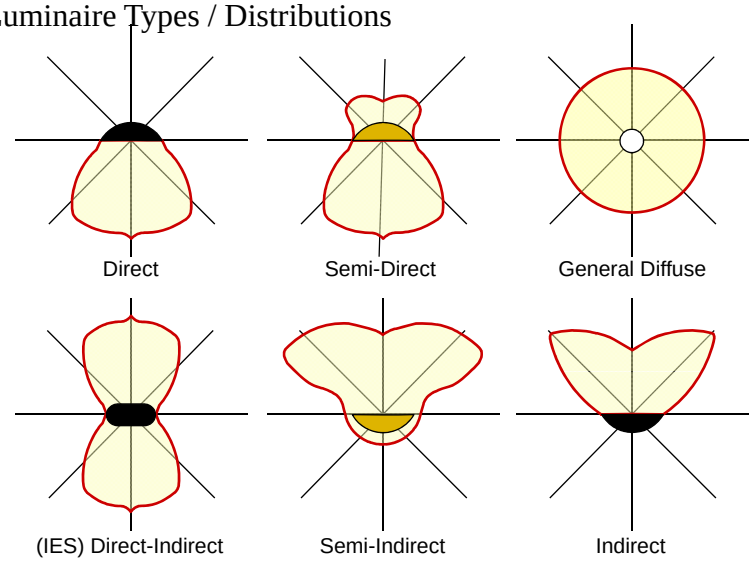
Point-by-Point
- Direct light level from a Fixture or Lamp reaching a specific point
- Candlepower info needed

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

26

Point-by-Point: FC at a Point

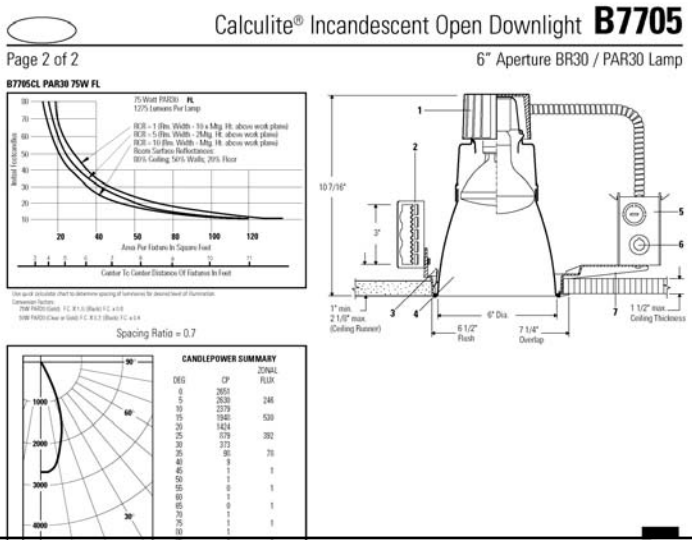
CIE Luminaire Types / Distributions



27

Photometry Reports: sample 1

- Downlight


Calculite® Incandescent Open Downlight **B7705**

Page 2 of 2

6" Aperture BR30 / PAR30 Lamp

B7705CL PAR30 75W FL

Spacing Ratio = 0.7

CANDLEPOWER SUMMARY

DEG	CP	ZONAL FLUX
0	2651	
5	2630	246
10	2379	
15	1940	530
20	1424	
25	979	392
30	373	
35	96	70
40	9	
45	1	1
50	1	
55	0	1
60	1	
65	0	1
70	1	
75	1	1
80	1	

28

Photometry Reports: sample 2

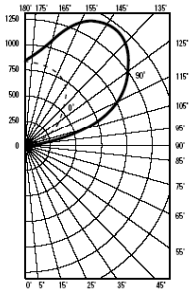
- Indirect Pendant

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 ➤ / DEG. ▼	0	22	45	67	90
	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

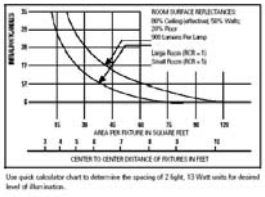
29

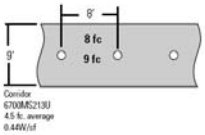
Photometry Reports: sample 3

- Ceiling Fixture

Specification Decorative Discus™ **6700MS213U**

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

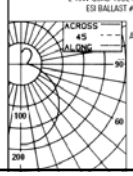




SPACING RATIO = 1.3

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-CRQ-13/TH-UNIVD. 120VAC

CANDLEPOWER SUMMARY

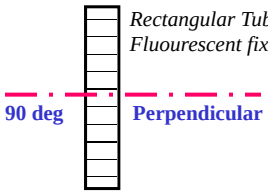


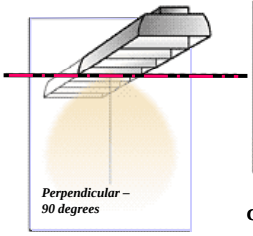
ANGLE	MEAN CP	LMS	ANGLE	MEAN CP	LMS
0	188		90	18	
5	188	18	95	16	18
10	185		100	16	
15	182	51	105	17	18
20	176		110	20	
25	169	79	115	23	23
30	161		120	26	
35	152	95	125	29	26
40	141		130	33	
45	129	100	135	36	28
50	116		140	38	
55	102	91	145	39	24

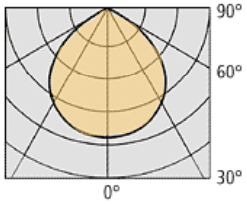
30

Point-by-Point: FC at a Point

Asymmetrical Distribution Curve

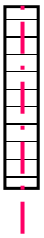


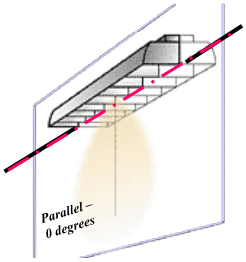


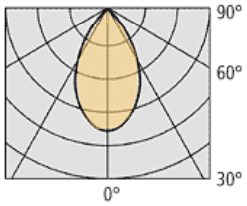


Candlepower Distribution

0 deg | Parallel





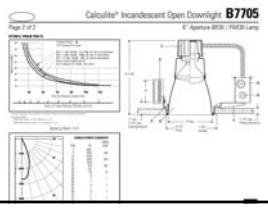


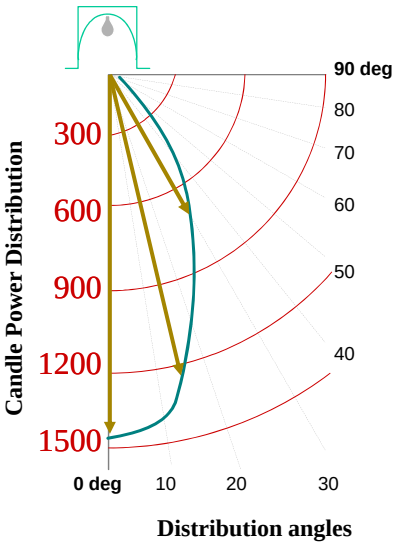
Candlepower Distribution

31

Point-by-Point: FC at a Point

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





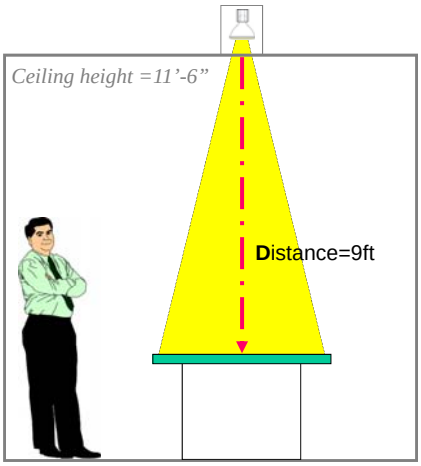
32

Calculating Light

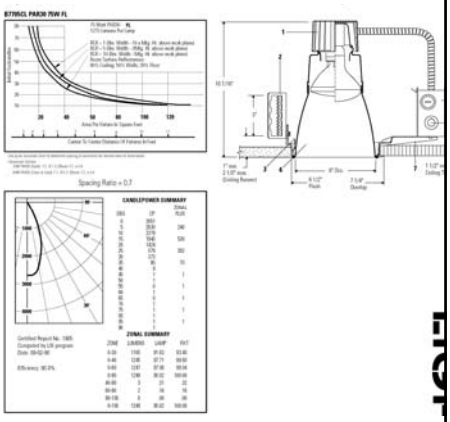
Point-by-Point

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

Calculate the Level at the Table



FC = _____*candelas* / ___*ft²*
FC = ____ *foot-candles*



33

Point-by-Point

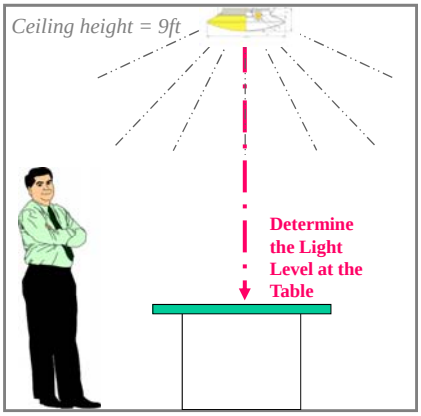
Foot-candle = $\frac{\text{Candle Power}}{\text{Distance}^2}$

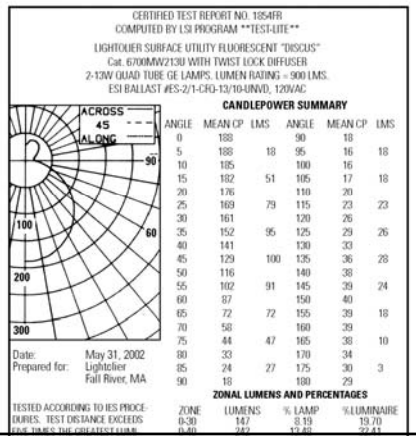
- Ceiling Fixture Example

FC = ____ *candelas* / ___ *ft²*

FC = _____ *foot-candles*

Calculate the Level at the Table




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-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	

ZONAL LUMENS AND PERCENTAGES

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

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

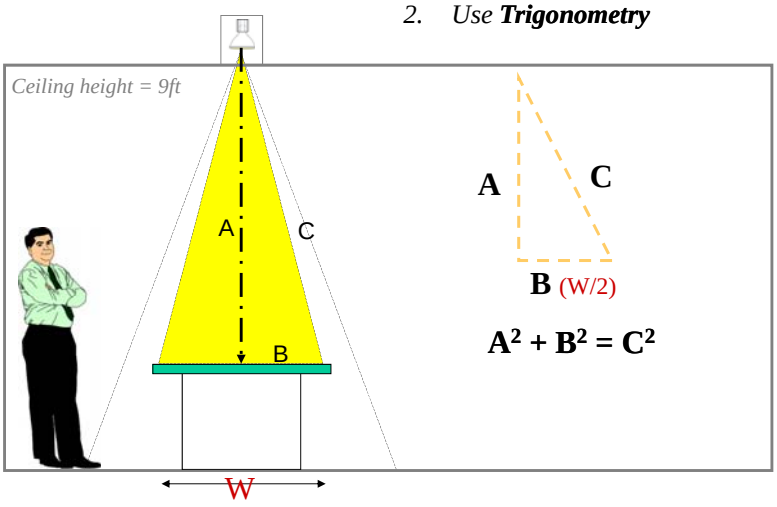
TESTED ACCORDING TO IES PROCEDURES. TEST DISTANCE EXCEEDS FIVE TIMES THE GREATEST LUMI-

Calculating Light

Beam Study

To solve for **any component**, you can:

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

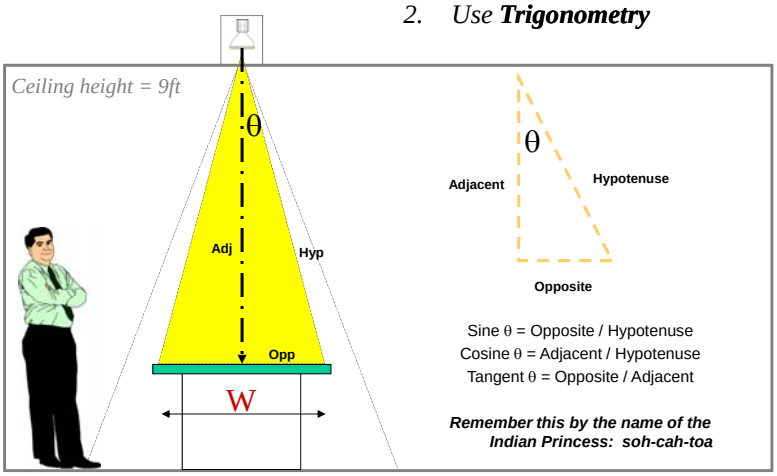


35

Beam Study

To solve for **any component**, you can:

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



36

Calculating Light

Point-by-Point

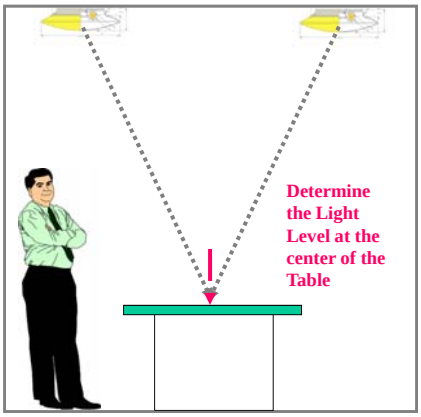
$$\text{Foot-candle} = \frac{\text{Candle Power}}{\text{Distance}^2}$$

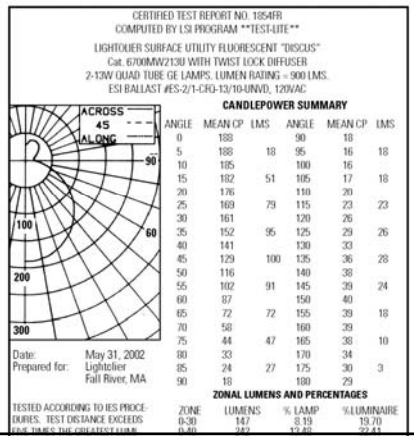
- Ceiling Fixture Example

FC = ____ *candelas* / ___ *ft²*

FC = _____ *foot-candles*

Ceiling height = 9ft




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-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
0-40	242	13.48	32.41

Hand Methods to Calculate Light

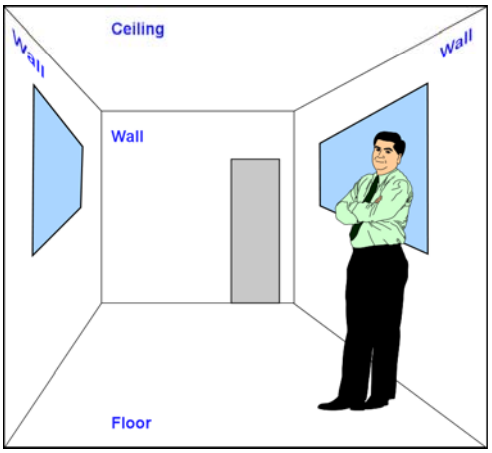
Mnfrs Guides
- Direct or Average Illumination from a Fixture or Lamp
- Recommended spacing or layout

Point-by-Point
- Direct light level from a Fixture or Lamp reaching a specific point
- Candlepower info needed

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

38

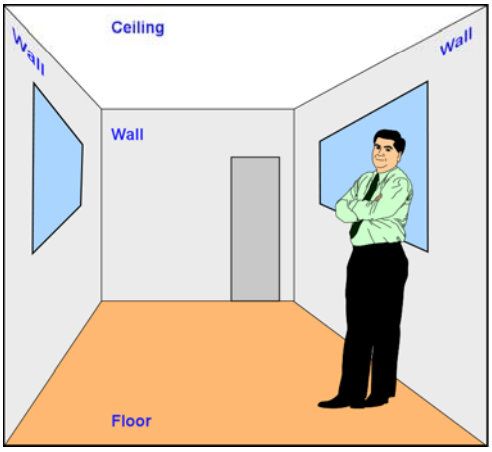
Lumen Method: Room Reflectance



- 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.

39

Lumen Method: 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

40

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).*
- *The formula 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.*

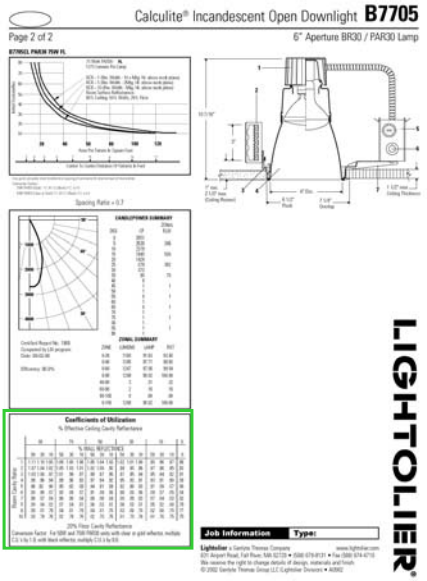
The Steps:

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!

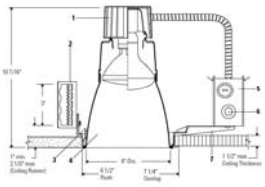
41

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**



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	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	.98	.96	.97	.96
2	1.07	1.04	1.02	1.05	1.03	1.01	1.02	1.00	.98	.99	.98	.96	.97	.96	.95	.93
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	.89	.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

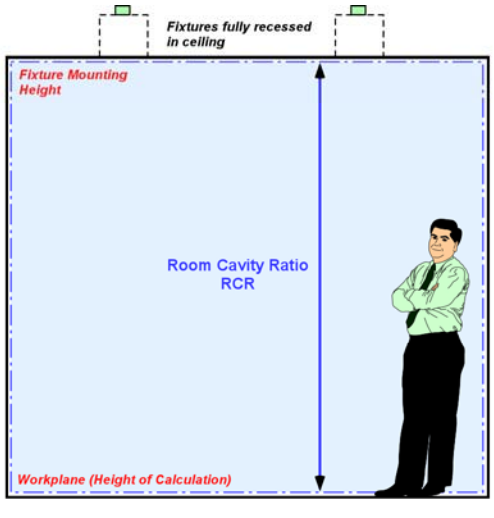
Conversion Factor: For 50W and 75W PAR30 units with clear or gold reflector, multiply C.U.'s by 1.0; with black reflector, multiply C.U.'s by 0.6.

- 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 commercial Reflectance of 80/50/20, the actual CU value is this.**

43

Step Room Cavity Ratio

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



Room Section

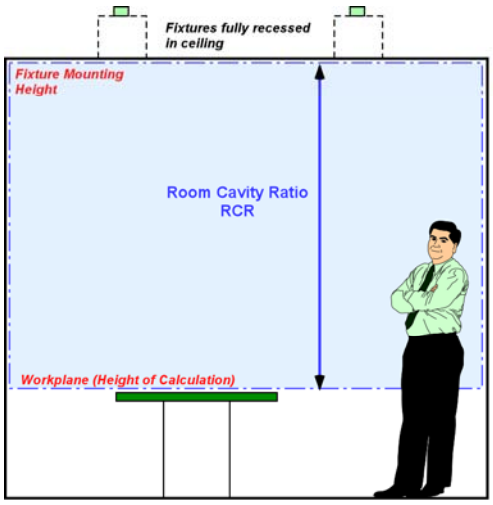
- The **RCR** can vary depending on the height you want to calculate… ***as shown here with the calculation height at the floor.***

44

Calculating Light

Room Cavity Ratio

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



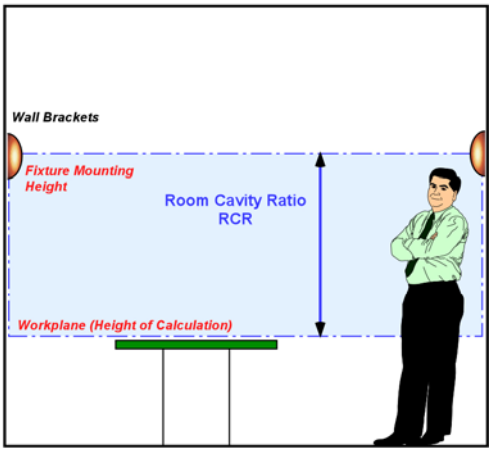
Room Section

- 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

45

Room Cavity Ratio

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



Room Section

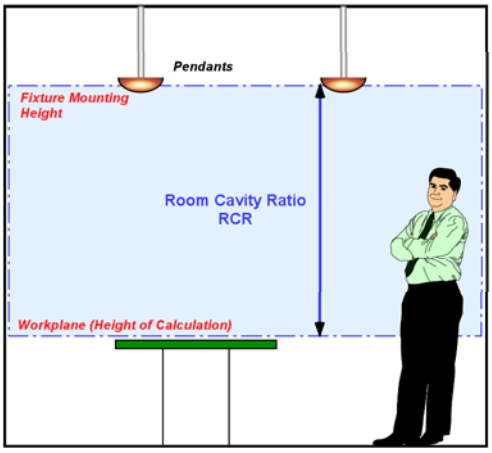
- The **RCR** can vary depending on the height of the fixture….***as shown here with Wall Brackets or Sconces.***

46

Calculating Light

Room Cavity Ratio

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



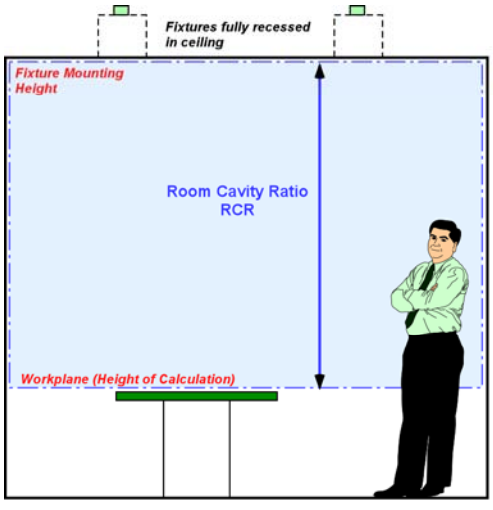
Room Section

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

47

Room Cavity Ratio

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



Room Section

Example:

Room Width: 12*ft*

Room Length: 15*ft*

Ceiling Height: 10*ft*

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

RCR =

48

Calculating Light

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:

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

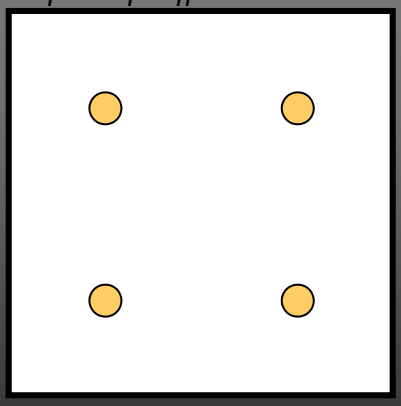
$$\text{Qty of Fixtures} = \frac{\text{FC x Area of the Room}}{\text{Number of Lamps per Fixture x Lumens per Lamp x CU}}$$

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

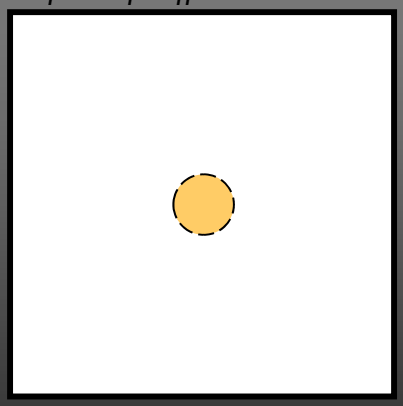
49

Layout and Pattern

10ft x 10ft Office



10ft x 10ft Office



Four Ceiling Lights:

One Pendant:

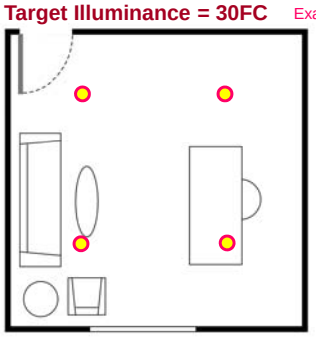
Calculating Light

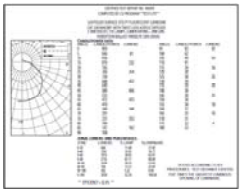
Lumen Method Example 1

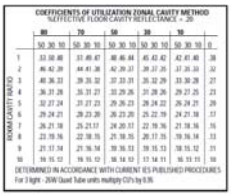
What is the resulting Foot-candle Level at table height from four ceiling lights?

Target Illuminance = 30FC

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



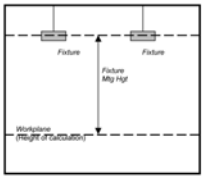




Lumen Method Calculation

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 = _____

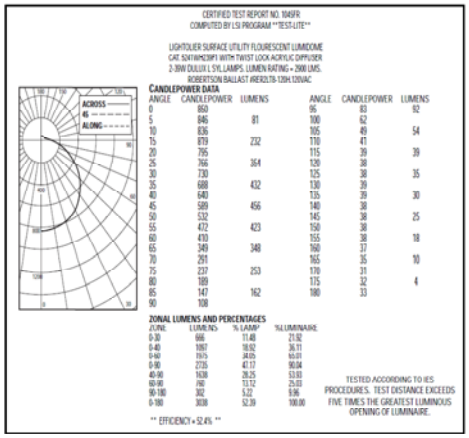
Qty of Fixtures = FC x L x W / (Lumens per Lamp) x (# of Lamps per Fixture) x CU x MF

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

Qty of Fixtures = _____

Lumen Method Example 1

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



CERTIFIED TEST REPORT NO. 1046FR
COMPUTED BY LSI PROGRAM "TEST-LITE"

LIGHTOLIER SURFACE UTILITY FLOURESCENT LUMIDOME
CAT. 5SATWM236P1 WITH TWIST LOCK ACRYLIC DIFFUSER
2-39W DULUX L SYL LAMPS. LUMEN RATING = 2900 LMS.
ROBERTSON BALLAST #5R82LTB-120H.120VAC

CANDLEPOWER DATA

ANGLE	CANDLEPOWER	LUMENS	ANGLE	CANDLEPOWER	LUMENS
0	850		95	83	92
5	846	81	100	62	
10	836		105	49	54
15	819	232	110	41	
20	795		115	39	39
25	766	364	120	38	
30	730		125	38	35
35	688	432	130	39	
40	640		135	39	30
45	589	456	140	38	
50	532		145	38	25
55	472	423	150	38	
60	410		155	38	18
65	349	348	160	37	
70	291		165	35	10
75	237	253	170	31	
80	189		175	32	4
85	147	162	180	33	
90	108				

ZONAL LUMENS AND PERCENTAGES

ZONE	LUMENS	% LAMP	%LUMINAIRE
0-30	666	11.48	21.92
0-40	1087	18.92	36.11
0-60	1575	24.65	50.01
0-90	2726	47.17	90.04
40-90	1638	28.25	53.93
60-90	1151	13.52	25.03
90-180	302	5.22	9.96
0-180	3038	52.39	100.00

TESTED ACCORDING TO IES PROCEDURES. TEST DISTANCE EXCEEDS FIVE TIMES THE GREATEST LUMINOUS OPENING OF LUMINAIRE.

** EFFICIENCY = 52.4% **

COEFFICIENTS OF UTILIZATION ZONAL CAVITY METHOD
%EFFECTIVE FLOOR CAVITY REFLECTANCE = .20

ROOM CAVITY RATIO	80	70	50	30	10	
	50 30 10	50 30 10	50 30 10	50 30 10	50 30 10	0
1	.53 .50 .48	.51 .49 .47	.48 .46 .44	.45 .43 .42	.42 .41 .40	.38
2	.46 .42 .39	.44 .41 .38	.42 .39 .37	.39 .37 .35	.37 .35 .33	.32
3	.40 .36 .33	.39 .35 .32	.37 .33 .31	.35 .32 .29	.33 .30 .28	.27
4	.36 .31 .28	.35 .31 .27	.33 .29 .26	.31 .28 .26	.29 .27 .25	.23
5	.32 .27 .24	.31 .27 .23	.29 .26 .23	.28 .24 .22	.26 .24 .21	.20
6	.29 .24 .21	.28 .23 .20	.26 .23 .20	.25 .22 .19	.24 .21 .18	.17
7	.26 .21 .18	.25 .21.17	.24 .20 .17	.22 .19 .16	.21 .18 .16	.15
8	.23 .19 .16	.22 .18 .15	.21 .18 .15	.20 .17 .15	.19 .16 .14	.13
9	.21 .17 .14	.21 .16 .14	.19 .16 .13	.19 .15 .13	.18 .15 .12	.11
10	.19 .15 .12	.19 .15 .12	.18 .14 .12	.17 .14 .11	.16 .13 .11	.10

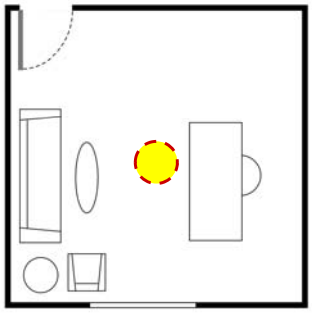
DETERMINED IN ACCORDANCE WITH CURRENT IES PUBLISHED PROCEDURES
For 3 light - 26W Quad Tube units multiply CU's by 0.95

Calculating Light

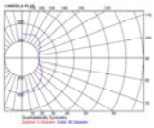
Lumen Method Example 2

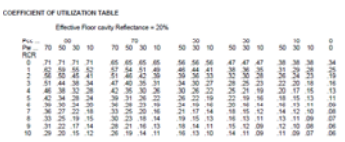
What is the resulting Foot-candle Level at table height from one pendant?

Target Illuminance = 30FC



Example:
- Room Width: 10*ft*
- Room Length: 10*ft*
- Ceiling Height: 10*ft*

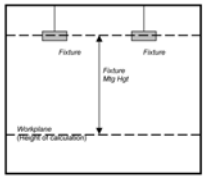




Lumen Method Calculation

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 = _____

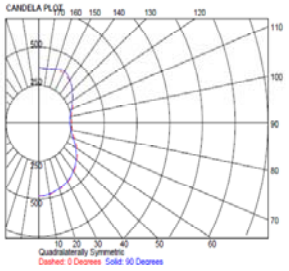
Qty of Fixtures = FC x L x W / (Lumens per Lamp) x (# of Lamps per Fixture) x CU x MF

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

Qty of Fixtures = _____

Lumen Method Example 2

What is the resulting Foot-candle Level at table height from one pendant?



SUMMARY DATA

EFFICIENCY (Total):	65.6 %
EFFICIENCY (Downlight):	34.4 %
EFFICIENCY (Uplight):	31.1 %
CIE CLASSIFICATION:	DIRECT-INDIRECT
SPACING CRITERION (0-Deg.):	1.38
SPACING CRITERION (90-Deg.):	1.37
LUMENS/LAMP:	3100
NO. OF LAMPS:	2
LUMINOUS OPENING:	VERTICAL CYLINDER
Diameter:	1.33 (Feet)
Height:	0.73
INPUT WATTS:	84
RP-1-93 VDT CONFORMANCE:	NON-CONFORMING

COEFFICIENT OF UTILIZATION TABLE

Effective Floor cavity Reflectance = 20%

Pcc ...	80				70				50			30			10		0
Pw ...	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
RCR																		
0	.71	.71	.71	.71	.65	.65	.65	.65	.56	.56	.56	.47	.47	.47	.38	.38	.38	.34
1	.62	.59	.55	.52	.57	.54	.51	.49	.46	.44	.41	.38	.36	.35	.31	.29	.28	.25
2	.56	.50	.45	.41	.51	.46	.42	.39	.39	.36	.33	.32	.30	.28	.26	.24	.23	.19
3	.51	.44	.38	.34	.47	.40	.35	.31	.34	.30	.27	.28	.25	.23	.22	.20	.18	.16
4	.46	.38	.32	.28	.42	.35	.30	.26	.30	.26	.22	.25	.21	.19	.20	.17	.15	.13
5	.42	.34	.28	.24	.39	.31	.26	.22	.26	.22	.19	.22	.19	.16	.18	.15	.13	.11
6	.39	.30	.24	.20	.36	.28	.23	.19	.24	.19	.16	.20	.16	.14	.16	.13	.11	.09
7	.36	.27	.22	.18	.33	.25	.20	.16	.21	.17	.14	.18	.15	.12	.14	.12	.10	.08
8	.33	.25	.19	.15	.30	.23	.18	.14	.19	.15	.13	.16	.13	.11	.13	.11	.09	.07
9	.31	.22	.17	.14	.28	.21	.16	.13	.18	.14	.11	.15	.12	.09	.12	.10	.08	.06
10	.29	.20	.15	.12	.26	.19	.14	.11	.16	.13	.10	.14	.11	.09	.11	.09	.07	.06