Electric Lighting Calculations

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Two kinds of calculations

Task Lighting
(point source or line source method)

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Task Lighting
(point source or line source method)

Ambient Lighting
(lumen or zonal cavity method)

Point Source Method

For the basic point source formula, the source can exceed 10% of the distance between the source and the reference point.

The basic formula is: \( \text{I} = \frac{\text{E}}{\pi d^2} \)
Line Source Method

Find the illuminance from a point or line source…

...need drawings…

...measure D = 26 ft. and \( \theta = 60^\circ \)…

Photometric

How to read Candlpower Distribution Curve

...and a photometric curve…
For multiple point and line sources:

If you have more than one point source in a room calculate the Fc from each source by either:

\[ \text{total } Fc = Fc_1 + Fc_2 + \ldots + Fc_n \]

Warning: assumes IRC = 0

Lumen Method

Suitable for luminous ceilings or evenly-spaced lighting grids...

...rooms with ambient lighting or uniform lighting...

Zonal cavity method is same except it figures in floor reflectivity...
...but in real rooms light is reflected & absorbed by surfaces, this factor is labeled the coefficient of utilization (CU).

So the formula becomes:

\[ fc = \frac{\text{lumens} \times \text{CU}}{\text{area}} \]

...also the fixture and other installation details reduce the light, this is labeled light loss factor (LLF).

So solving for lumens:

\[ \text{lumens} = \frac{fc \times \text{area}}{\text{LLF} \times \text{CU}} \]

...the number of lumens in the room is determined by the number of fixtures, lamps per fixture, and lumens per lamp.

\[ \text{lumens} = \frac{\# \text{fixtures} \times \text{lamps/fixture} \times \text{lumens/lamp}}{\text{area}} \]

...since the two previous formulas are solved for lumens, they can be combined to give:

\[ \frac{\# \text{fixtures} \times \text{lamps/fixture} \times \text{lumens/lamp} = \frac{fc \times \text{area}}{\text{LLF} \times \text{CU}}}{\text{area}} \]
...we can solve this for either the number of fixtures (black)...
...or the amount of light in FC (green)...

\[
\# \text{ fixtures} = \frac{\text{FC} \times \text{Work Surface Area}}{\text{LIF} \times \text{CU} \times \text{Lamps/Luminaries} \times \text{Luminous Flux}}
\]

\[
\text{FC} = \frac{\# \text{ fixtures} \times \text{LIF} \times \text{CU} \times \text{Lamps/Luminaries} \times \text{Luminous Flux}}{\text{Work Surface Area}}
\]

# fixtures for a new design

FC for an existing design

EXAMPLE

Try this for a simple room:

- 20’ x 40’ office space
- 12’ ceiling
- requires ~50 fc

The room size (20’ x 40’ = 800 sqft)
and illuminance requirement (50 fc)

Give us the numerator for our formula...

\[
\# \text{ fixtures} = \frac{\text{FC} \times \text{800 sqft}}{\text{whatever}}
\]

...the denominator isn’t so simple...
...pick a luminaire...

<table>
<thead>
<tr>
<th>Typical Luminaire</th>
<th>Distribution and Luminous Efficacy</th>
<th>Coefficients of Utilization for Effective Cavity Resistance</th>
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Requirements:
- Requires two fluorescent tubes...

...pick a lamp...

...calculate the room cavity ratio...

\[ \text{SCR} = \frac{\text{Area of cavity visible above work plane}}{\text{Area of work plane}} \]

\[ \frac{2 \times (7.5 \times 10)}{2 \times (10.5 \times 9)} = \frac{150}{190} = 0.789 \]

\[ \text{SCR} = 0.789 \]

...key to finding CU...
...need to know RCR, ceiling and wall reflectivity...

...interpolate CU = 0.54...

...plug in lamp, fixture, and CU info...

# fixture = \( \frac{50 \times 800 \text{ sq ft}}{.50 \times .54 \times 2 \text{ lamps/million lumens/x 2770 lumens}} \)

\[ \text{LLF} = \frac{\alpha \times \beta \times x \times \gamma \times d \times x \times f \times g \times L \times D}{\text{luminance dirt depreciation}} \]

...this alphabet soup of factors is described in MEEB 12 p 730...

Or you can approximate LLF = .65 for good, .55 for average, or .45 for poor conditions MEEB 12 p. 738
...then lay out the fixtures on reflected ceiling plan...
...hey is this 5 x 5 grid ok?...

Fixture manufacturers provide the data needed for either type of calculation.
So, how did the professionals do?

“Clerestory-like backlit panels”

“Indirect ambient lighting and LED task lights”
“T-5s behind a base of frosted glass panels (box office).”

“Vibration and buzz-free lighting for orchestra rehearsal”

Grand Staircase