For a point source (i.e. lightbulb)

luminous flux

$\Phi = 4\pi I$; I is luminous intensity in candela
Φ is luminous flux in lumens

Illumination

$E = \Phi / A$ lumens / meters^2 => lux
$= I / r^2$

but since $I = \Phi / 4\pi$,
$E = \Phi / 4\pi r^2$

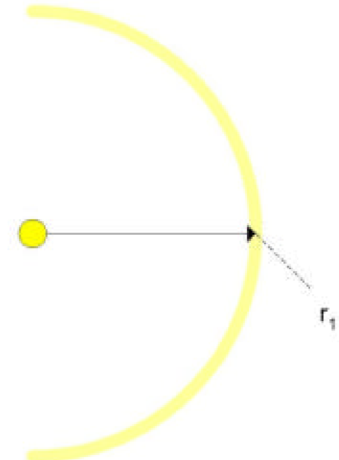
For a non-point source (i.e. spotlight or LED)

$\Phi = 2\pi (1 - \cos \phi_1) I$; I is luminous intensity in candela
Φ is luminous flux in lumens
ϕ_1 is ½ the viewing angle

$E = \Phi / A$ lumens / meters^2 => lux
$= I / r^2$

but since $I = \Phi / 2\pi (1 - \cos \phi_1)$,
$E = \Phi / 2\pi (1 - \cos \phi_1) r^2$

Spherical spreading (inverse square law)



$E = E_o e^{-(a+b)r}$; a = absorption coefficient
b = scattering coefficient

Scattering and absorbtion loss $= E_o - E$
$= E_o - E_o e^{-(a+b)r}$
$= E_o (1 - e^{-(a+b)r})$

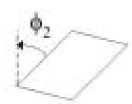
Absorption & Scattering

E_o = Original illumination

E_{r1} = Illumination at radial distance r_1

$E_{r1} = \Phi_0 / 2\pi r_1^2 (1 - \cos \phi_1) - E_o (1 - e^{-(a+b)r1})$

$E = I \cos(\phi_2) / r^2$



For a plane tilted away from light perpendicular

But due to rotated flat surface,

$E_{r1} = [\Phi_0 \cos(\phi_2)] / [2\pi r_1^2 (1 - \cos \phi_1)] - E_o (1 - e^{-(a+b)r1})$

$\Phi_1 = E_{r1} * d^2$

Illumination at target

so it follows that,

$E_{r2} = \Phi_1 / [2\pi r_2^2 (1 - \cos \phi_1)] - E_1 (1 - e^{-(a+b)r2})$

Illumination at lens

Reflected light from a cube of edge length d, with 100% reflective surface