

a) Winkelabhängige Größe Lichtstärke Candela (lumen/sr)

$$I_v = \frac{d\Phi_v}{d\Omega}$$

Flächenabhängige Größe Beleuchtungsstärke Lux (lumen/m²)

$$E_v = \frac{d\Phi_v}{dA}$$

Verbindungsgröße Fluss

$$\Phi_v = I_v \cdot \Omega$$

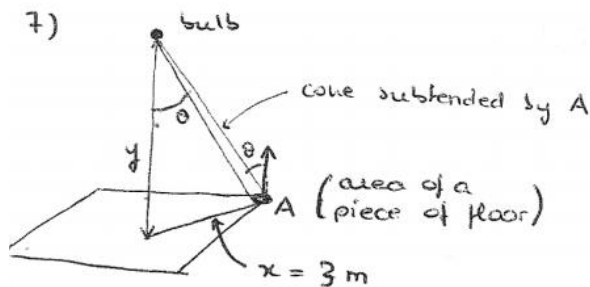
$$\Omega \approx A/(d^2)$$

$$E_v = \Phi_v / A = (I_v \cdot \Omega) / A = (I_v \cdot A) / (d^2) \cdot A$$

$$d = \sqrt{I_v / E_v}$$

$$\text{Einsetzen: } d = 1,41 \text{ m}$$

b)

Relations between quantities

A piece of floor with area A subtends a solid angle:

$$\omega = \frac{A \cos \theta}{x^2 + y^2}$$

(Think that A is not perpendicular to the cone! The angle between the normal of A and the cone is θ , which is also the angle between the cone and the vertical axis)

Since the intensity emitted by the bulb (in every direction) is $I (= 1000 \text{ cd})$, the flux emitted in direction of A is $F = I \omega$.

The illuminance received in A is $E = \frac{F}{A}$.

Therefore: $E = \frac{I \omega}{A} = \frac{I A \cos \theta}{A(x^2 + y^2)}$ where $\cos \theta = \frac{y}{\sqrt{x^2 + y^2}}$

$$E = I \frac{y}{(x^2 + y^2)^{3/2}}$$

E is maximum when $\frac{y}{(x^2 + y^2)^{3/2}}$ is maximum, therefore when

its derivative $\frac{x^2 - 2y^2}{(x^2 + y^2)^{5/2}}$ is zero, or when $2y^2 = x^2$

$$y = \frac{x}{\sqrt{2}}$$

$$y \approx 2,12 \text{ m}$$

The illuminance is $E \approx 42 \text{ lux}$

c)

$$e = h \cdot c / \lambda$$

$$e_{475} = h \cdot c / 475 \text{ nm} = 4.1848 \text{ e-19 J}$$

$$e_{650} = h \cdot c / 650 \text{ nm} = 3.0582 \text{ e-19 J}$$

$$\Phi(\lambda) = \Phi_v(\lambda) / V(\lambda) \cdot (683 \text{ lm/W})$$

$$\Phi(\lambda_{475}) = \Phi(\lambda_{650}) = 1 \text{ lm} / 0.1 \cdot (683 \text{ lm/W}) = 14,6 \text{ mW}$$

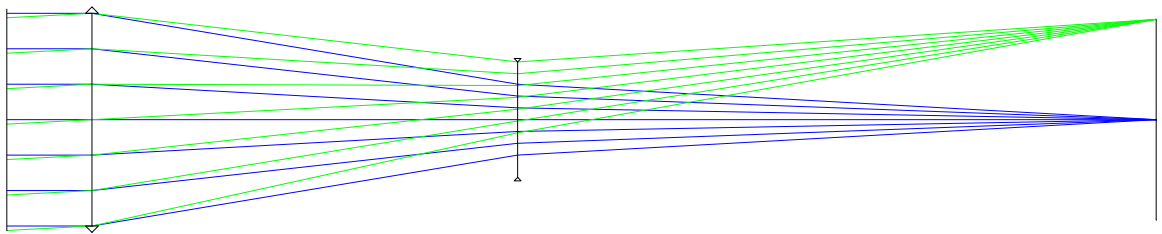
Energie in einer Sekunde für beide Wellenlängen: $14,6 \text{ mW} \cdot 1 \text{ s}$
 $= 14,6 \text{ mJ}$

$$\text{Anzahl Photonen} = \text{Gesamtenergie} / \text{Einzelenergie}$$

$$N_{475} = 14,6 \text{ mJ} / 4.1848 \text{ e-19} = 3.488 \text{ e16}$$

$$N_{650} = 14,6 \text{ mJ} / 3.0582 \text{ e-19} = 4.774 \text{ e16}$$

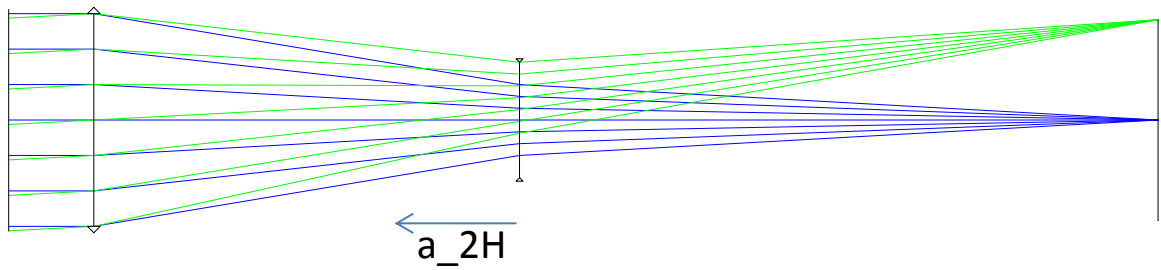
d)



$$1/f_{\text{ges}} = 1/f_1 + 1/f_2 - d/(f_1 \cdot f_2)$$

$$f_{\text{ges}} = f_1 \cdot f_2 / (f_1 + f_2 - d) = -1800 / -10 = 180 \text{ mm}$$

d)



$$a_{2H} = -f_{\text{ges}} \cdot d / f_1 = -120$$

$$\text{Relativ zu Linse 1: } -120 + d = -80 \text{ mm}$$

e)

Gesamtbrennweite: 180 mm, Lage der
bildseitigen Hauptebene 80mm vor der
ersten Linse -> Rest = 100 mm

f)

400 μm Objekt entspricht $50 \times 400 \mu\text{m} = 20 \text{ mm}$ im Zwischenbild =
Sehfeldzahl

$$\tan(w) = y/f$$

$$f = y / \tan(w) = 10 \text{ mm} / \tan(20^\circ) = 27,47 \text{ mm}$$