RASNIK

Depth of Field

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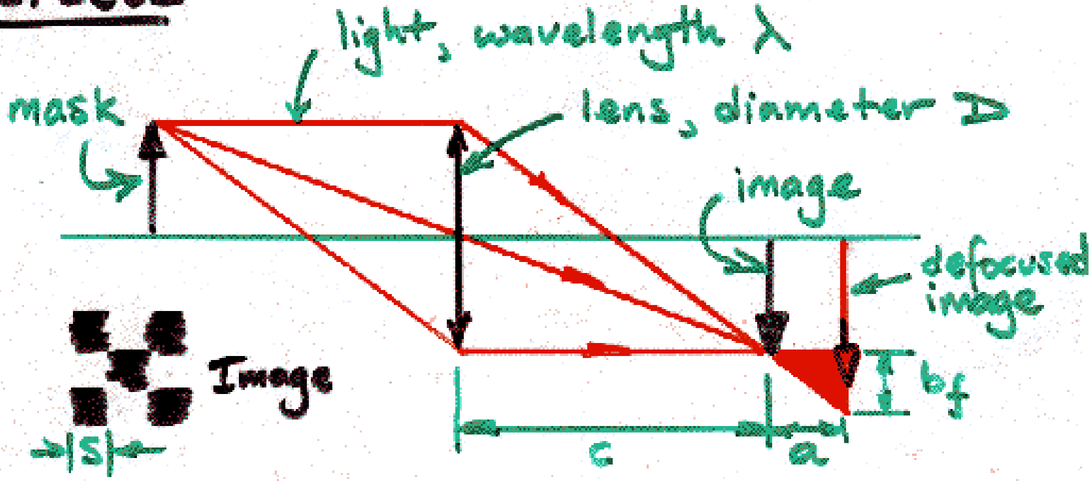
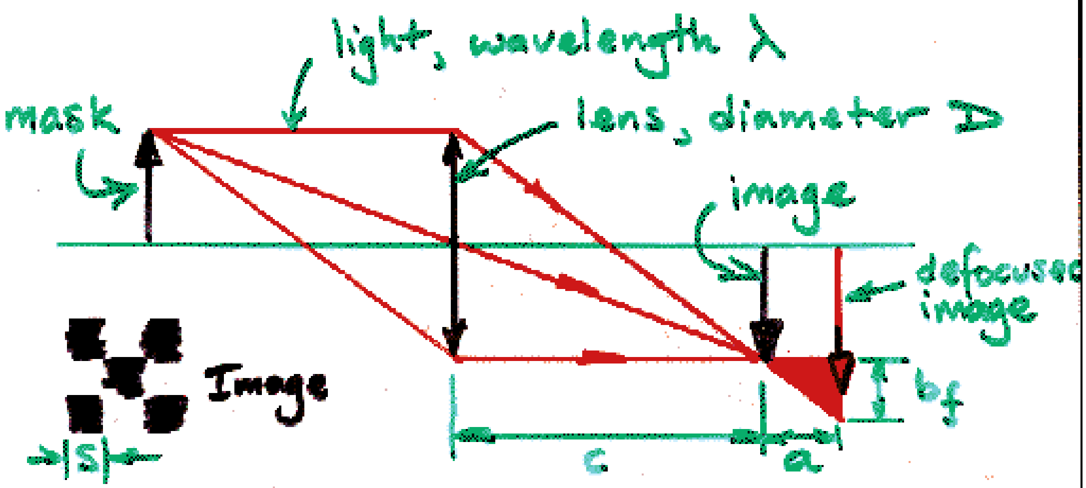
DEFOCUS



c = lens to perfect image distance
D = lens diameter
a = out of focus distance
λ = light wavelength
s = image square width
b_f = defocus blurr diameter
b_d = diffraction blurr diameter

DIFFRACTION



Similar Triangles:

$$b_f/a = D/c \Rightarrow b_f = aD/c$$

Aperture Diffraction:

$$b_d = (4\lambda/\pi D)c = 4\lambda c/\pi D$$

Empirical Dimensionless Limit:

$$(b_d/s \leq 1) \Leftrightarrow (b_d \text{ acceptable})$$

Evidence for Dimensionless Limit:

For $a = 0$, D minimized, always observe $b_d \sim s$ and cannot increase s.

Postulate:

$$(b_f/s \leq 1) \Leftrightarrow (b_f \text{ acceptable})$$

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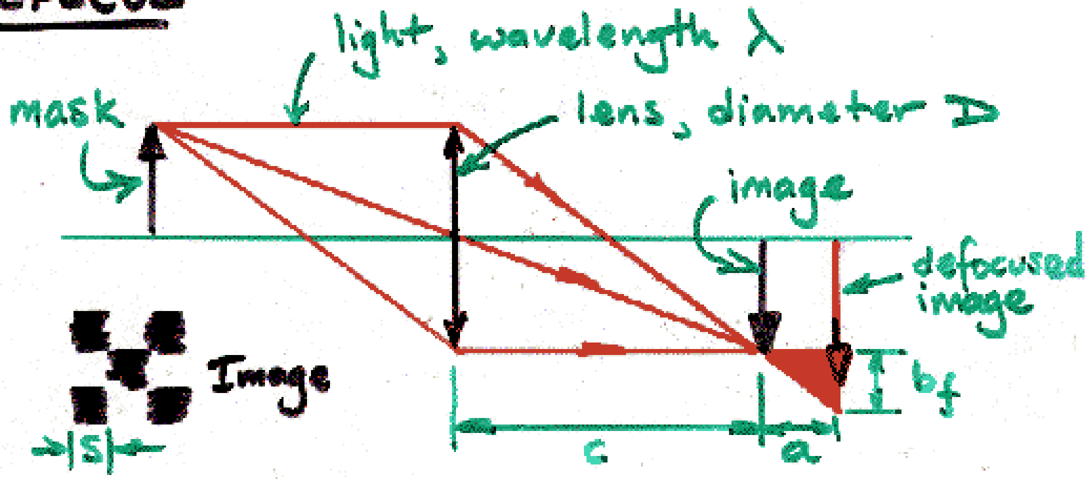


$$b_f = aD/c, \quad b_f/s \le 1 \quad \Big\} \quad D \le \frac{cs}{a}$$

$$b_d = 4\lambda c/\pi D, \quad b_f/s \le 1 \quad \Big\} \quad D \ge \frac{4\lambda c}{\pi s}$$

or, $$\frac{4\lambda c}{\pi s} \le D \le \frac{cs}{a}$$

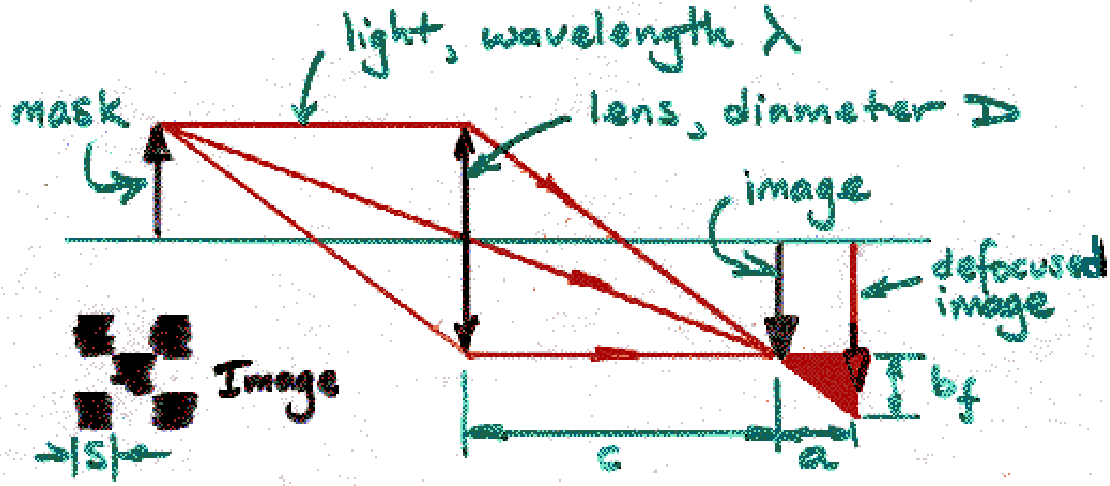
must have, $$\frac{4\lambda c}{\pi s} \le \frac{cs}{a}$$

or,

$$a \le \pi s^2 / 4\lambda$$

and

$$D = 4\lambda c/\pi s$$



- In tests, we observed that for $D = 4\lambda c/\pi s$ we had usable range $a \le s^2/2\lambda$ instead of $a \le \pi s^2/4\lambda$.
- Our analysis ignored the addition of the two blurrs.
- Use following critical values:

$$D_c = 4\lambda c/\pi s \qquad a_c = s^2/2\lambda$$

λ (nm)	c (cm)	s (μm)	D_c (mm)	a_c (mm)	
850	400	85	50	4	RASNIK (8m long)
850	400	170	25	17	
850	400	240	18	34	
850	20	170	1.3	17	Proximity Sensors (40cm long)
850	20	240	0.9	34	
600	20	240	0.6	48	
1000	20	240	1.0	29	

Conclusion

- Reduce diameter of lens until diffraction blurring is only just tolerable, then the depth of field is maximized
- Depth of field for diffraction-limited RASNIK is a function only of square size and wavelength, increasing as the SQUARE of the size.
- Size of CCD limits size of squares that can be used, and therefore the depth of field. Depth of field $\propto$ CCD area.