

Name: _____

EE 193-03 Homework 1

Due in class, 17 September 2019

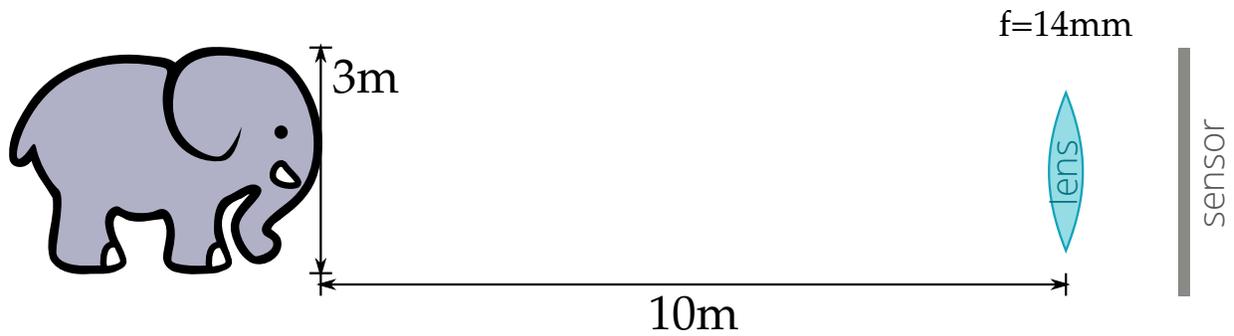
Notation

For everyone's sanity, let's define some notation:

- s_i image distance (from lens to in-focus image plane)
- s_o object distance (from lens to in-focus object plane)
- f focal length
- N F-number
- D Diameter of the aperture
- A Area of the aperture
- NA Numerical aperture (We're not using this, just don't confuse it with N and A .)

Problem 1: Elephants

Suppose I take a picture of an 3 m-tall elephant from 10 m away with a 14 mm lens.



Assuming the elephant is focused on the image sensor, how large will the image of the elephant be?

Problem 2: Further away

I'm actually scared to get that close to an elephant, so suppose I stand 30 m away instead. What focal length should I use to achieve the same image size?

Problem 3:

Below are two images captured with the focal lengths from the previous two problems, captured from approximately 10 and 30 m away. Which one is which? Use some equations and/or diagrams to support your conclusion. The F-number is the same for both shots.



Problem 4: Cell phone camera

I take a picture with my cell phone ($f = 3.7\text{mm}$, $1/3''$ sensor = $4.8\text{mm} \times 3.6\text{mm}$, $N = 2.8$) of a scene with an average luminance of $2 \times 10^4 \text{ cd m}^{-2}$. What will be the average illuminance on the sensor? *Hint: One approach to this problem is to calculate the flux going through the lens, and then divide this by the sensor area.*

Problem 5: Tradeoffs

Let's designate the average sensor illuminance from the previous problem as B . What is the illuminance (as a function of B) in each of the following scenarios?

1. The luminance of the scene doubles (to $4 \times 10^4 \frac{\text{cd}}{\text{m}^2}$).
2. The focal length doubles, but the aperture diameter remains the same.
3. The focal length doubles, and the f-number remains the same.
4. We quadruple the sensor dimensions (both width and height), and quadruple the focal length while keeping the f-number the same. *This is essentially what would happen if you used equivalent settings on a much larger camera.*

Problem 6: Desk lighting

I'm a big fan of LEDs, so I decide to install a large LED strip (specifically the Bridgelux BXIB-L1092A-35E3000-A-13, datasheet posted on the website) underneath my bookshelf to illuminate my otherwise dark desk.¹ What will be the illuminance of the surface of my desk?



You'll need to make some assumptions (and probably approximations) to solve this problem; just make sure to document what those assumptions are.

¹I've since moved offices, and my desk is anything but dark. Come see me in Halligan 202c!