

Cameras

Question:

If you're building a camera and want to make a larger image (a telephoto lens) you should:

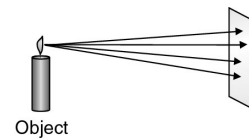
1. increase the diameter of the lens
2. decrease the diameter of the lens
3. increase the curvature of the lens
4. decrease the curvature of the lens

Observations About Cameras

- They record the light from a scene on a film or sensor
- Good cameras have to focus, cheap ones don't
- They sometimes have zoom lenses
- Some cameras have bigger lenses than others
- Cameras have ratings like focal length and f-number

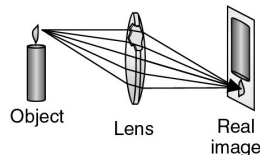
Light from an Object

- An illuminated object reflects or scatters light
- You see object via this reflected or scattered light
- The object's light forms diffuse illumination
- You can't tell what object looks like from this diffuse illumination



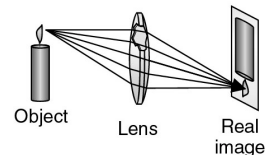
Converging Lenses

- A converging lens uses refraction to bend light rays
- Light rays converge after passing a converging lens
- Rays from a common point on an object converge to a common point on far side of the converging lens



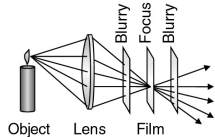
Real Images

- An image forms in space on far side of the lens
- The image is a pattern of light in space that exactly resembles the object, except for size and orientation
- The image is "real" – you can put your hand in it



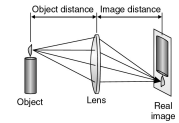
Lenses and Film

- Film records the pattern of light it's exposed to
- If you put film in a real image, it will record a pattern of light resembling the object
- For a good photograph, the real image should be sharply focused on the film and have the right size



Focusing

- Light reaching the lens from an object is diverging
- The nearer the object, the more its light diverges
- Converging lens has trouble with diverging light
 - Real image of nearby object forms farther from lens
 - Real image of distant object forms closer to lens

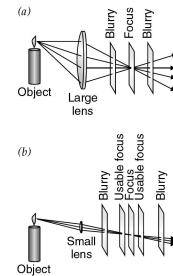


Focal Length

- Focal length measures the lens' converging ability
 - Long focal length: weak convergence, long image distance
 - Short focal length: strong convergence, short image distance
- The larger the object distance, the bigger the image
 - Long focal length: big images
 - Short focal length: small images

Lens Diameter

- Larger lens
 - converges more light
 - brighter image
 - focus becomes more critical
 - less depth of focus
- Smaller lens
 - dimmer image
 - focus becomes less critical
 - more depth of focus



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Wide Angle vs Telephoto

- Wide angle lens
 - Highly curved to converge rays quickly and focus close
 - Bright, small image forms near lens
 - Small diameter lenses are usually adequate
- Telephoto lens
 - Weakly curved to converge rays slowly and focus far
 - Dim, large image forms far from lens
 - Large diameter lenses are usually necessary

Aperture or f-number

- Aperture characterizes the diameter of the lens
- F-number is lens focal length divided by lens diameter
- Large f-number
 - Dim image
 - Large depth of field/focus (focus is forgiving)
- Small f-number
 - Bright image
 - Small depth of field/focus (focus is critical)

Lens Flaws

- Dispersion → different colors focus differently
 - Use low-dispersion glass (fluoride glasses)
 - Use multi-piece lenses or “achromats”
- Reflections → fog in photographic images
 - Use antireflection coatings
- Spherical aberration → imperfect focus
- Poor focusing off axis → coma distortions
- Spherical focus projected on flat film → Astigmatism
 - Use aspheric lenses

Black and White Film

- Light exposure creates a latent image
 - Silver bromide grains absorb photons (a silver salt)
 - Photon energy separates salt into silver and bromine
 - If a 4 atom silver cluster forms → grain will develop
 - Gold sensitization reduces threshold to 2 silver atoms
- Development converts exposed salt grains to silver
- Silver particle is misshapen and appears black
- Film forms a negative image of exposing object

Color Film

- Sensitizers and filters produce three latent images
 - Sensitizers and filters are built into the film
 - Latent images are sandwiched together in the film
 - Layers record red, green, and blue light respectively
- During development, colored dyes are produced
 - Spent developer causes dye molecules to form
 - Red layer: cyan, blue layer: yellow, green layer: magenta
- Dyes form a negative image of exposing object

Digital Cameras

- Instead of film, use CCD imaging chip
- Chip is divided into tiny squares or pixels
- Photon causes charge transfer in pixel
- After exposure, pixels retain charge image
- Charge is shifted out of pixels using MOSFETs
- Camera obtains and saves image