

Cameras 1

Cameras

Cameras 2

Observations about Cameras

- They record a scene on an image sensor
- Good cameras need focusing, cheap ones don't
- Many cameras have zoom lenses
- Some cameras have bigger lenses than others
- They have ratings like focal length and f-number

Cameras 3

6 Questions about Cameras

- Why does a camera need a lens?
- Why do most camera lenses need focusing?
- Why are lenses telephoto or wide-angle?
- Why do fancy lens's have internal apertures?
- Why is a good camera lens so complex inside?
- How does the image sensor respond to light?

Cameras 4

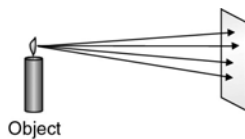
Question 1

- Why does a camera need a lens?

Cameras 5

Light from an Object

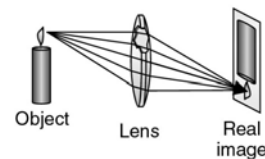
- An illuminated object reflects or scatters light
 - You see the object via reflected or scattered light
 - The object's light produces diffuse illumination
 - You can't tell what the object looks like from this diffuse illumination



Cameras 6

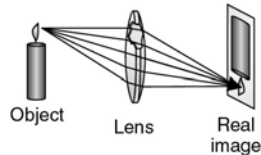
Converging Lenses

- A converging lens bends light rays via refraction
 - Light rays that were spreading now converge
 - Rays from a common point on an object converge to a common point on the far side of the 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

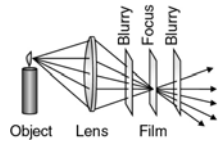


Question 2

- Why do most camera lenses need focusing?

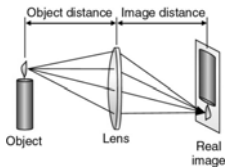
Lenses and Image Sensor

- The sensor records the pattern of light it receives
- If you put the sensor in a real image, it will record a pattern of light that looks just like the object
- For a good photograph, the real image should be sharply focused on the image sensor and its size should match the image sensor.



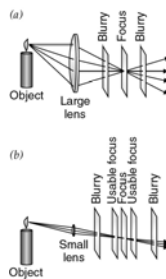
Focusing

- The farther the object,
 - the less diverging its light as that light enters the lens
 - the more converging that light after it leaves the lens
 - and the nearer to the lens the real image forms.
- Different objects form real images at different distances from the lens.
- Lens-to-sensor distance must match lens-to-image distance.



Lens Diameter and Focusing

- Larger lens gathers more light
 - so the image is brighter
 - but focus is more critical
 - and there is less depth of focus.
- Smaller lens gathers less light
 - so the image is dimmer
 - but focus is less critical
 - and there is more depth of focus.

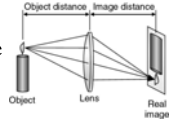


Question 3

- Why are lenses telephoto or wide-angle?

Focal Length

- Focal length measures lens's converging ability
 - Long focal length: weak lens, long image distance
 - Short focal length: strong lens, short image distance
 - Behavior accurately described by the lens equation:
- Larger image distance, then bigger image
 - Long focal length: big dim image
 - Short focal length: small bright image



Wide Angle vs Telephoto

- Wide-angle lens converges rays strongly,
 - so they focus close to the lens
 - and form a bright, small image near the lens.
 - Small diameter lenses are usually adequate.
- Telephoto lens converges rays weakly,
 - so they focus far from the lens
 - and form a dim, large image far from lens.
 - Large diameter lenses are usually necessary.

Question 4

- Why do fancy lenses have internal apertures?

Aperture or f-number

- f-number is focal length over lens diameter
 - and characterizes the brightness of the image.
- A large f-number lens produces a dim image
 - with a large depth of field/focus (focus is forgiving).
- A small f-number lens produces a bright image
 - with a small depth of field/focus (focus is critical).
- Fancy lenses have adjustable f-numbers,
 - to control both image brightness and depth of focus.

Question 5

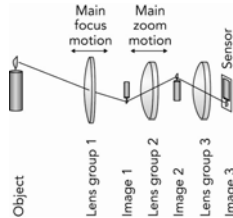
- Why is a good camera lens so complex inside?

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

Zoom Lenses

- A zoom lens typically has three images overall
- Its first lens group produces the first image
- Its second and third lens groups project a resized real image onto the image sensor.



Question 6

- How does the image sensor respond to light?

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 lowers threshold to 2 silver atoms
- Development turns 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 yield 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 : cyan, blue : yellow, green : 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
- Each photon causes a charge transfer in its pixel
- After exposure, the pixels retain a charge image
- Charge is shifted out of pixels using MOSFETs
- Camera obtains and saves image

Summary about Cameras

- They use converging lenses to form real images
- Lens focal length sets image size
- Lens f-number sets image brightness
- The image sensor records the pattern of light