Today:

- Lenses
  - Lens laws
  - Typical lenses
  - Focal lengths
  - Aperture, depth of field

JH Bring to class:
- Closeup lenses
- Extension tubes
- Iris
- View camera

Please make a table tent with your name on it

PHOTOGRAPHY FUNDAMENTALS

1) Framing
2) Camera
3) Lenses
4) Exposure Control
5) Resolution

3) LENSES

Minute paper. What are the numbers on your lens? What do they mean?

```
4.5-90.0 mm | 1:3.5-6.8 | 20 x IS
focal length  aperture  optical zoom
```

```
Image Stabilization
```
Lenses are defined by **FOCAL LENGTH** and **APERTURE** and **Diameter**

\[ f = \text{focal length} = \text{distance from center of lens system to sensor when focused} \]
\[ \text{at infinity} \]

\[ \text{Aperture defined as} \quad \frac{f}{D} = f/ = f\text{ number} = f\# \]
\[ \text{INVERSELY related to diameter.} \]
\[ \text{Nondimensional. More about aperture later.} \]

Variable focal length = **ZOOM lens**.
Now is default. Non-zoom are called 'prime' lenses.

10 years ago, 35 mm film cameras were standard, and the
standard lens was 50 mm. \( f > 50 \text{ mm} = \text{telephoto} \)
\( f < 50 \text{ mm} = \text{wide angle} \)

\[ \text{As f increases (longer lens), field of view narrows} \]
\[ \text{'Telephoto compression' happens too} \]

PHDs have small sensors, so focal lengths and diameters
are smaller:
Common values for PHD cameras:
\[ f = 5 - 60 \text{ mm}, \quad f/ = 4 - 8 \]
\[ 28-336 \text{ mm equivalent to} 35 \text{ mm, i.e. same FOV} \]
\[ w = \text{wide} \quad T = \text{tight, or telephoto} \]
\[ 18-55 \quad 16-200 \quad 18-135 \]

For DSLR, bigger sensors, up to 'full frame' 35 mm
\[ f = 18-60 \text{ mm, } f/ 1.8 - 22 \]

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**Impact of focal length on framing:**
As \( f \) increases (longer lens), field of view narrows
'Telephoto compression' happens too
Near object, same size in both images

Long focal length telephoto, narrow FOV

Short focal length, wide angle

FOCUS

'In focus' when all collected light from a point on the object shows up at a single point in the image.

Dead website 9/2/15
Lens laws:
1) light through center of lens is undeflected
2) light parallel to axis goes through focal point
3) all light entering lens at a given direction ends up at the same point in the focal plane

\[
\frac{1}{f} = \frac{1}{Ob} + \frac{1}{Ii}
\]

As object moves closer, lens moves away from sensor plane. Mechanical limit defines near focus distance.

Extension tubes (for DSLR) allow lens to move further out and focus closer. $75 set of 3

"Reverse macro" adapters let you turn the lens around, or put a reversed lens at the end of your normal lens. $15.

Caution, interior lens element is now exposed, easily scratched.
'Close up' lenses allow close focus by changing system f.
Long f lens, threads on to the outer end of main lens
(threads standard, but need to match diameters).
Lower quality, though. Each additional lens element can lose 10% of light, introduce aberrations.
PHD cameras often lack threads. Just hold it out in front, or mount to cardboard tube. Check focus often.
Inexpensive, $6 for set of 4

Spec'd in 'diopters' = 1/f in meters. Typically +1, +2, +4

\[
\frac{1}{f_{\text{TOTAL}}} = \frac{1}{f_1} + \frac{1}{f_2}
\]

PHD cameras often have 'macro mode' = Flower Button. Does yours?

Exercise: Can you get the most magnification by zooming out and moving close, or by zooming in and moving back? At which extreme can you focus closest?

For DLSRs, prime and zoom 'macro' lenses are available. Expect high price, hope for quality.

More Magnification with
Wide, focus close

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<th>PHD</th>
<th>DSLR</th>
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\[
\frac{3}{4} \quad 2'' \quad 4\cdot5''
\]

\[
\frac{1}{2} \quad 2\cdot3''
\]

OUT OF FOCUS

FOCAL plane

optical axis
Improve DOF by reducing diameter: smaller hole, smaller circles of confusion, better depth of field

Depth of Field

\[ \frac{\theta}{\delta} = \frac{f \delta}{D} \]

LensBaby: lets you angle the lens axis compared to the camera body axis. Effectively makes the object plane not parallel to the sensor plane

http://lensbaby.com/lenses

OK range, circles are small enough to be ignored