Today: Finish lenses

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Good digital photography reference:


Free download (ads)


Impact of focal length on framing:

As f increases (longer lens), field of view narrows

'Telephoto compression' happens too

TRY THIS NOW

FOCUS

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

\[
\frac{1}{f} = \frac{1}{0} + \frac{1}{I}
\]

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

'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?

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

**OUT OF FOCUS**

![Diagram of optical axis, FOCAL plane, image plane, sensor plane, and focus plane.]

Image plane, sensor plane, FOCUS plane

Not a point; looks like a circle; Circle of Confusion

**Depth of Field**

![Diagram of optical axis, FOCAL plane, image plane, sensor plane, and focus plane.]

Image plane, sensor plane, FOCUS plane

OK range, circles are small enough to be ignored

Improve DOF by reducing diameter: smaller hole, better depth of field

Depth Of Field = DOF

More DOF behind
Aperture (iris) mechanism made from overlapping pivoting leaves.

Aperture has impact on exposure too, how much light total hits the sensor.
Units: 1 stop = 1 EV Exposure Value = factor of 2 in area, light.
Camera adjustments in 1/3 stops

Stop used to be a metal plate with hole punched in it.

http://media.wiley.com/assets/1007/41/0-7645-9802-3_0213.jpg
http://synapticlight.com/iris-and-aperture/

2.8, 3.5, 4, 5.6, 8, 11, 16, 22, 32, 45, 64

Ansel Adams founded f/64 club. Tiniest hole, maximum DOF. Modern lenses often best sharpness at f/5.6 or design point.

4. EXPOSURE
For a given intensity, area X time shutter is open.
4. EXPOSURE
   For a given intensity, \( \approx \text{area} \times \text{time shutter is open} \)

   \[ f/8, 1/100 \text{ sec} \]
   \[ f/11, 1/25 \text{ sec} \]

   Equivalent exposures: \( f/4, 1/100 \text{ sec} \)

   Image 'density', average pixel values also depends on
   sensor gain, sensitivity: ISO (ASA historically)

   1 EV, stop = factor of 2 in ISO

   \[ f/8, 1/100 \text{ sec}, \text{ISO 400} \]
   \[ f/4, 1/200 \text{ sec}, \text{ISO 400} \]

   How to choose?
   Minute paper: list pros and cons of
   1) small aperture vs large aperture
   2) short shutter (high shutter speed) vs long (slow)
   3) high ISO vs low

   1) Aperture: large f/ = better DOF, but less light, maybe less
      sharpness overall
   2) Short shutter = freeze the flow, minimize motion blur, but
      less light
   3) High ISO adds noise

   http://upload.wikimedia.org/wikipedia/commons/3/3b/Noise_Comparison.JPG

   Usually, set ISO for overall conditions, then choose
   Av = aperture priority, let AE (auto exposure) choose
shutter
or
Tv = shutter priority, AE chooses aperture

Shutter nomenclature:
2 = 1/2 sec, 20 = 20 1/20th sec etc.
2" = 2 sec
T = time = actuate open, actuate closed
B = bulb = open as long as actuated. Rare now.

To change exposure,
lighten image, overexpose compared to AE
suggestion +++
Darken, underexpose compared to AE, -----

Other considerations of shutter speed:
Short enough to 'freeze' flow, or long enough to
get desired particle tracks.

If long shutter is needed, might be too much
light. Try a
NDF = Neutral Density Filter. Neutral = all
wavelengths equally. Gray.
NDF 1 = 1/10 light transmission.
NDF 2 = 1/100 etc. Log scale.
30 seconds. NDF 8x
Need a tripod for macros, or shutters > 1/30 sec
Full size start at $25. Highly recommended.
Several available for checkout.

Estimate motion blur in pixels to guide choice of shutter speed.

Example:
Field of view = 10 cm
Fluid moving at 0.5 m/s
10 Mpx sensor

Minute paper: what shutter speed will ‘freeze’ this flow?

Can tolerate maybe 5 px blur?
10 Mpx ~ 3750 X 2750
0.1 m / 3750 = 2.6 e-5 = 0.000026 m/px = 26 μm/px
5 px = 1.3 e-4 m = 0.00013 = 0.13 mm estimated
acceptable object displacement x
time t = x/velocity
1.3e-4 m / (0.5 m/s) = 2.6e-4 seconds
2.6e-4 sec = 1/3750 Very short. Can your camera do this?
5/3750 = 0.0013 = 0.13% of image width

Do this analysis for each image. Motion blur is surprisingly common and annoying.

Inspec demo?