Today: Finish resolution

HOMEWORK: due after T2 critique
1) Measure the best F/ for sharpness
2) Evaluate one of your images for time resolution. Motion blur?
3) Test: image a gray card. At low ISO, see how many stops of underexposure will make it black, and how many of overexposure will make it white. Probably a total range of 6-9. What happens at high ISO?

Homework: F/ for best sharpness. Resolution of GW image from previous years

Best f/	Sensor size
10	DSLR
7.1	DSLR
6.3	DSLR
Around 8	Full frame
12	DSLR
3.5	Small camera
8	mirrorless

Motion Blur: sides of streak will be in focus. Just being out of focus will be an overall blur

GW time/space resolved?	Reason why not
7 said yes 15 no	Pixelization Motion blur /// Hard to tell due to diffusion in subject Focus: limited DOF //// Chromatic aberration

Time Resolution continued:

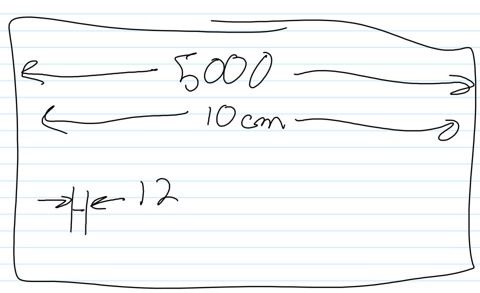
Motion Blur Example:
Field of view = 10 cm
Fluid moving at 0.5 m/s
18 Mpx sensor
Minute paper: what shutter speed will 'freeze' this flow?

5000 px wide
Allow a smear of how many px?

1/2000 shutter = 12.5 px

$\left(\frac{10\ cm}{0.5\ m/s}\right)$ time to cover 5000 px

$\frac{1}{5}$ sec for



$\Rightarrow$ 50 000 px / m

Speed = 0.5 m/s
= 25 000 px/s
#ps to tolerate
= 1 / seconds

$\frac{.2\ sec}{5000}$ = time for 1 px smear = 0.2/5000=0.0 = 40 μs

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? 1/10,000 sec is fast electronic shutter. To go faster/shorter need strobe.
5/3750 = 0.0013 = 0.13% of image width

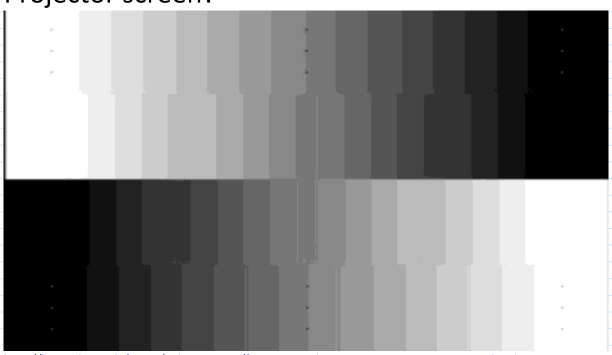
Do this analysis for each image; put in your report. Motion blur is surprisingly common and annoying.

Resolution in the Measurand: Light

Part 1: Dynamic range

Human eye sensitivity, dark adapted ~ 800 ISO
http://clarkvision.com/imagedetail/eye-resolution.html
Human contrast range detection: 24 EV, but is dynamic.
http://www.luminous-landscape.com/columns/eye-camera.shtml

Sheet of paper: at most 7 EV (factors of 2 in brightness) from black to white.
Projector screen?



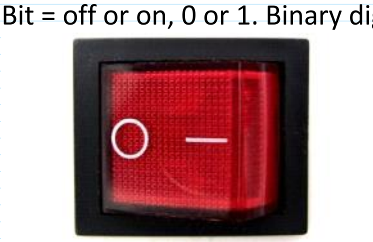
http://hometheaterhifi.com/volume_13_2/feature-article-contrast-ratio-5-2006-part-1.html

What can your camera detect?
Test: image a gray card. At low ISO, see how many stops of underexposure will make it black, and how many of overexposure will make it white. Probably a total range of 6-9. What happens at high ISO?

Part 2: Resolution=Bit Depth

This total dynamic range then gets *quantized*/digitized into steps. The more steps, the finer the resolution. (http://www.peachpit.com/articles/article.aspx?p=1709190&seqNum=2. Nice discussion of dynamic range vs bit depth)

Part 2B: Counting steps
Bit = off or on, 0 or 1. Binary digit.



Binary= numbers in base 2, a series of bits. 0 1 1 0 = 6 in base 10
8 4 2 1
$2^3\ 2^2\ 2^1\ 2^0$

Binary= numbers in base 2, a series of bits. 0 1 1 0 = 6 in base 10

8 4 2 1

$2^3\ 2^2\ 2^1\ 2^0$

nibble

With 4 bits, can count to 2^4=16

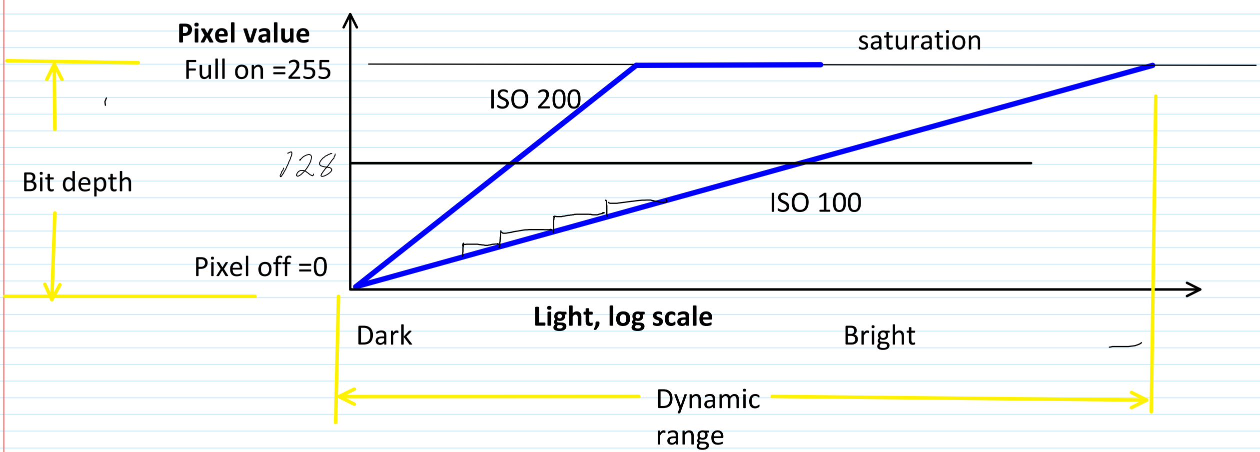
With 8, can count to 256 = one byte

Hexadecimal: single digit goes up to 16: 0-9, then A B C D E F

16^2=256 , so can express full range of a byte in two digits.

9F

Camera A/D is likely 10-24 bits. That's the number of different levels possible but not the range of brightnesses



HDR = High Dynamic Range

Take multiple images with varied (bracketed) exposures of the same scene, some under exposed, some over exposed. In-camera or post-processing algorithm assembles them together to provide additional measurand (light) resolution in highlight and shadow areas. Can make nighttime images look like daylight.

Here is an HDR image (made with 5 images from -3 to +3 EV) by Phil Nystrom 2018.

The word *pixel* is based on a contraction of *pix* ("pictures") and *el* (for "element");

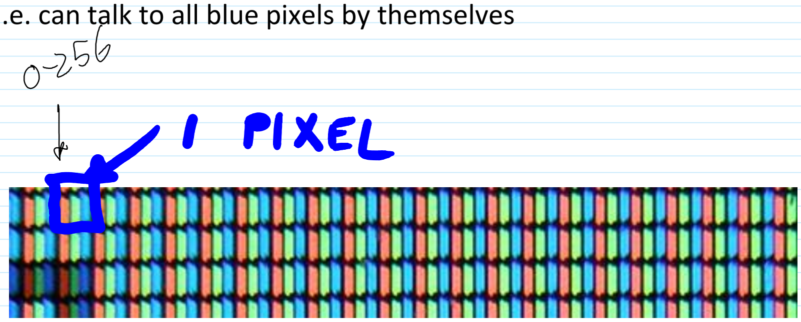
Pasted from <http://en.wikipedia.org/wiki/Pixel>

On a screen, = 1 red, 1 blue, & 1 green light emitter.

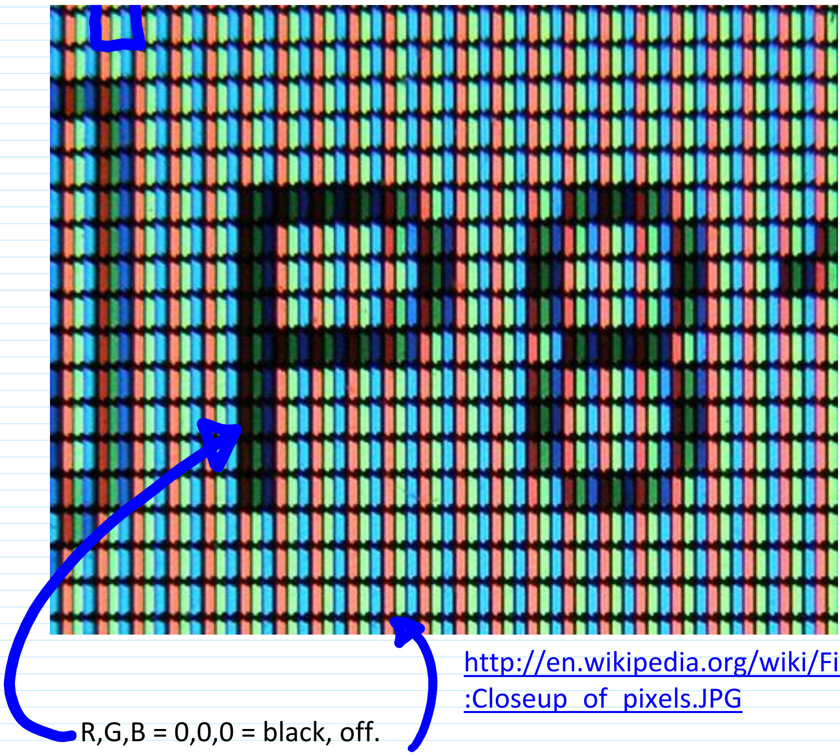
In Photoshop, access them separately in *color channels*

i.e. can talk to all blue pixels by themselves

CYMK

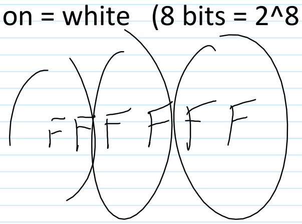


RGB is a common color space, good for screens. CMYK (Cyan, Magenta, Yellow and blacK is another color space, good for printing blacK is another color space, good for printing



http://en.wikipedia.org/wiki/File:Closeup_of_pixels.JPG

R,G,B = 0,0,0 = black, off.
R,G,B, = 255, 255, 255 = all full on = white (8 bits = 2^8 = 256 possible levels)
R,G,B = 0,0, 256 = blue



FFFFFF = full white
0000FF= blue
808080=gray

Color channels

Red channel: Can address just the red elements in all the pixels. See histograms, adjust range and contrast

SPECIFIC FV techniques

Lectures will next focus on specific FV techniques, starting with boundary techniques.
Boundary between 'seeded' and unseeded fluid is what we perceive.

Choice depends on physics desired
I DYES Today. Mostly in water.
2 Aerosols Particles. Mostly in air for boundary effect.

In this class, often visualization technique determines physics examined, but usually physics are determined by system under study, and FV technique applied should not disturb the flow/physics

I) Dye Considerations:

1)Want dye to NOT disturb flow
2)Want dye to show up - HIGH VISIBILITY
3) Special techniques

Minute paper results: How to not disturb flows? Will continue this after T2 critiques

Match dye density to medium density
Avoid changes in momentum: inject at local velocity and direction