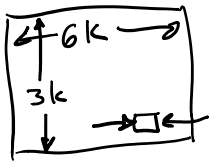
Motion Blur Example:
Field of view = 10 cm
Fluid moving at 0.5 m/s
18 Mpx sensor

Minute paper: will 1/1000 sec shutter speed 'freeze' this flow?

Flow = .5 m/s

$.5\ m/s \times \frac{1}{1000}\ sec = .0005\ m$

.05 cm = streak length



$\frac{6000\ px}{10\ cm}$ $\quad \frac{10\ cm}{6000\ px} = 1.67e^{-7}\ cm/px$

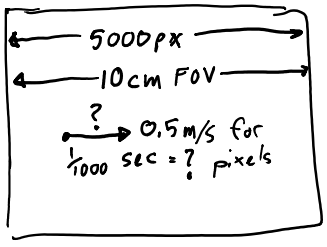
$\frac{.05\ cm}{1.67\ e^{-7}\ px} = 30\ px$ $\quad \frac{30\ px}{6000\ px} = \frac{1}{200}$ of image

18 MPx ⇒ 5184 x 3456 px

In flow, particle will move
0.5 m/s x 1/1000 sec = .5/1000=0.0005 m = .05 cm
How many pixels will ↗ cover?

$\frac{5000\ px}{10\ cm} = \frac{?\ px}{.05\ cm}$

.05*5000/10=25.0 px = smear length.



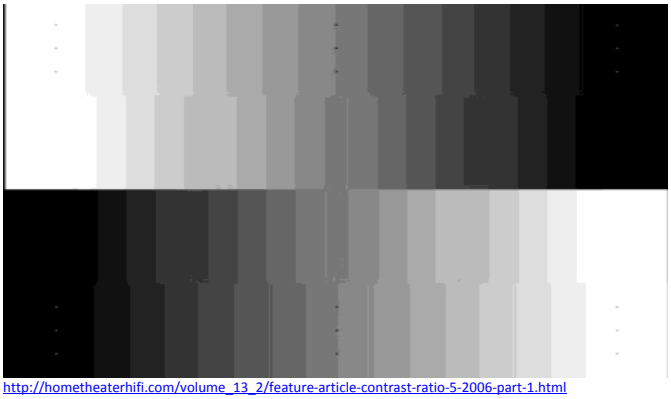
Do this analysis for each image; put in your report. Motion blur is surprisingly common and annoying.

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: 14 to 24 EV, but is dynamic.

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. Best cameras can do 14.

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

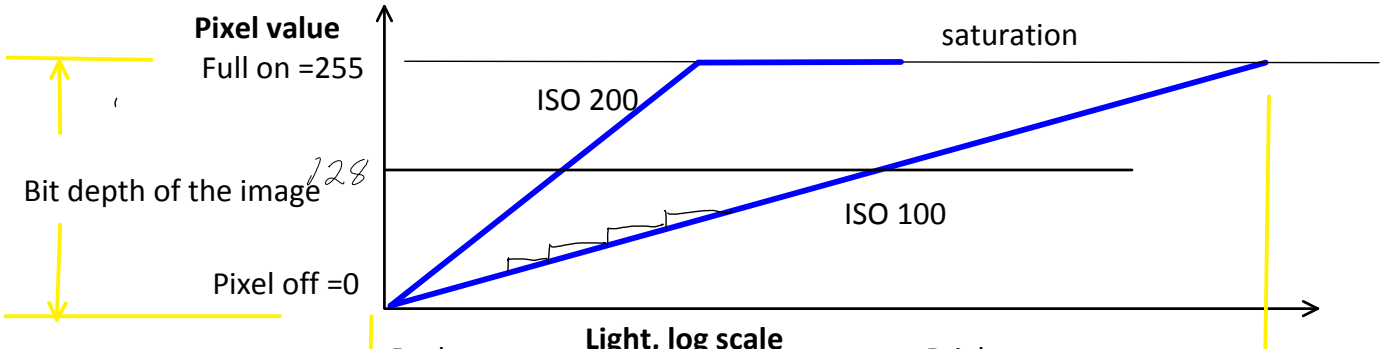
$2^3\ 2^2\ 2^1\ 2^0$

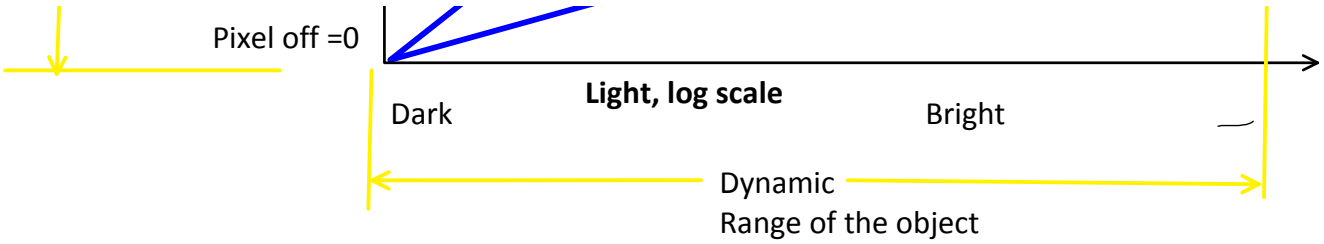
nibble

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.

9 F

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





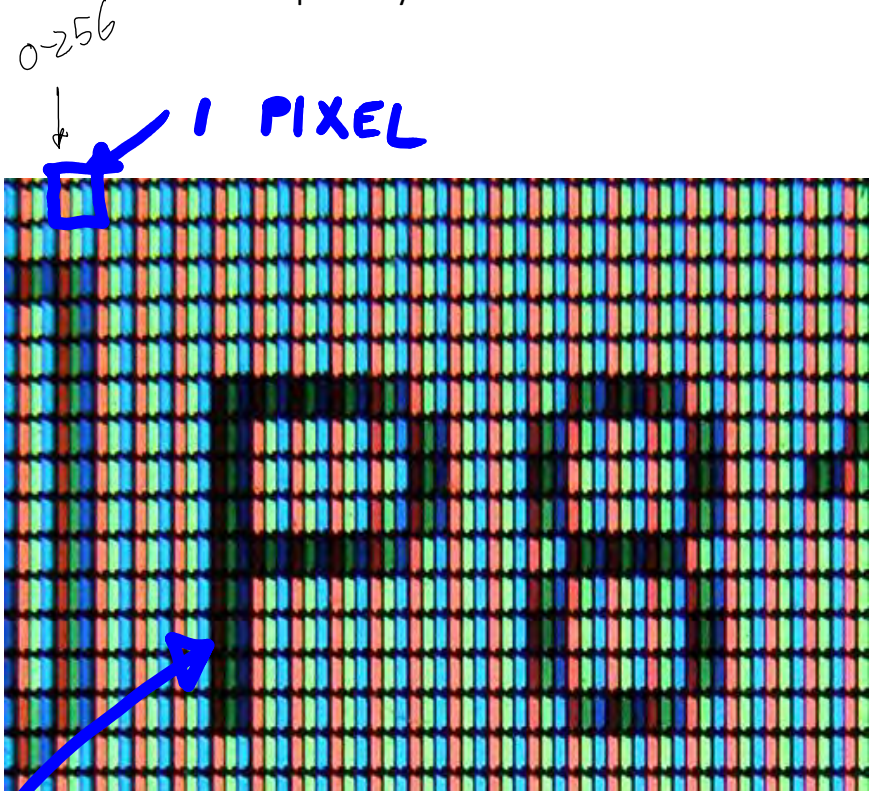
HDR = High Dynamic Range
Take multiple images with varied (bracketed) exposures of the same scene, some under exposed, some over exposed. In-camera or post-processing algorithm assembles them together to provide additional measurand (light) resolution in highlight and shadow areas. Can make nighttime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

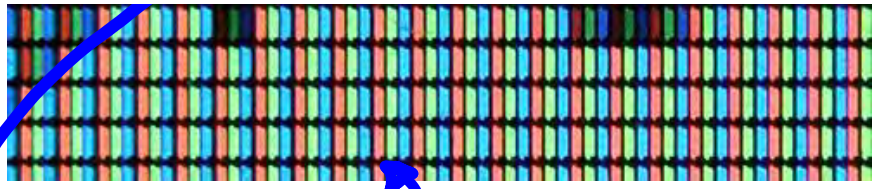
Pasted from <http://en.wikipedia.org/wiki/Pixel>

On a screen, = 1 red, 1 blue, & 1 green light emitter.
In Photoshop, access them separately in *color channels*
i.e. can control 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



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 in hexadecimal, one digit can count to 16; 0-9, then a-f
0000FF= blue
808080=gray

Color channels

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

1. Test the dynamic range of your camera: take images of 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?