Please do your ratings for Best of Web by 5 pm

https://www.cu.edu/coltt/galloping.html
Intermediate-advanced Photoshop workshop
9-11:30 Weds Feb 26.

Today: Finish exposure, tradeoffs.
Motion blur calculation
Thursday: Intro Photoshop

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With 8 bit depth on a pixel, can count up to \(2^8=256\) =11111111 in binary = FF in hexadecimal (base 16) different brightness levels in the image

\[
\begin{array}{c|c}
0 & \text{E}1\text{T} \text{B} \text{A} \text{S} \text{E} \text{ 2} \\
\text{B} \text{A} \text{E} \text{ 1} 0 & \text{3} \text{ 5} \\
\hline
\frac{1}{2} \ & \frac{1}{4} \ & \frac{1}{8} \\
0 \ & \frac{1}{2} \ & \frac{1}{4} \ & \frac{1}{8} \ & \frac{1}{16} \ & \frac{1}{32} \ & \frac{1}{64} \ & \frac{1}{128} \\
\hline
4 \ & \frac{1}{2} \ & \frac{1}{4} \ & \frac{1}{8} \ & \frac{1}{16} \ & \frac{1}{32} \ & \frac{1}{64} \ & \frac{1}{128} \ & \frac{1}{256} \\
\hline
8 \ & \text{B} \text{Y} \text{T} \text{E} = 8 \text{ bits} \\
\end{array}
\]

With 12 bit \(2^{12}=4,096\) levels

Minute paper: Have you been taught to count in binary? When?

Minute paper: What is a pixel? What is it made of (for software purposes)?

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

On a screen, = 1 red, 1 blue, & 1 green light emitter.
Proper exposure = middle value on an average pixel

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

# bits used per pixel per color = color depth, bit depth
Cameras are often 12 bit depth, but Photoshop has limited capabilities for depths > 8 bits
In RGB color space, have 3 color channels per pixel; Red, Green and Blue subpixels each has 8 bit range
FF,FF,FF= full white, all subpixels at max
FF 00 00 = red
Values of R=G=B, (i.e. 100,100,100) should be neutral grays. If not, check your screen calibration. Calibrator is available for checkout.

3 ways to control pixel values so far

Shutter speed  Aperture  ISO
slow  big
30 = 1/30 sec  5.6
60
120
240
480
100 low sensitivity
200
400
800
1600 high sensitivity


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How to choose?

Autoexposure programs (AE)
Wide variety. Stay away if you can.
Semi-automatic programs are better.
Av = aperture priority. You choose the aperture, camera will choose shutter speed. ISO might be automatic too.
Tv = Time priority; you set the shutter speed and ISO, camera AE will choose the aperture.
M = Manual (maybe). You choose both aperture and shutter speed. Meter will tell you if exposure is OK.

![High ISO vs Low ISO](image)


$$\$\$$ in camera buys less noise at high ISO

4 ways to control pixel values

1. Deliberate over/under exposure
   - Overexposed = More light, or more sensitive ISO
     - EV = +1
     - Proper exposure = middle value on an average pixel
     - Underexposed = Less light, less sensitive
     - EV = -1

2. Shutter speed
   - slow
     - 30 = 1/30 sec
     - 60
     - 120
     - 240
     - 480

3. Aperture
   - big
     - 11
     - 8
     - 11
     - 16

4. ISO
   - 100 low sensitivity
     - 200
     - 400
     - 800
     - 1600 high sensitivity
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
  4. Deliberate over/under exposure

  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, but can use low light
  4. Need to be careful about which value gets changed to achieve what you asked for.

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

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, even at low ISO.
Try a
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.