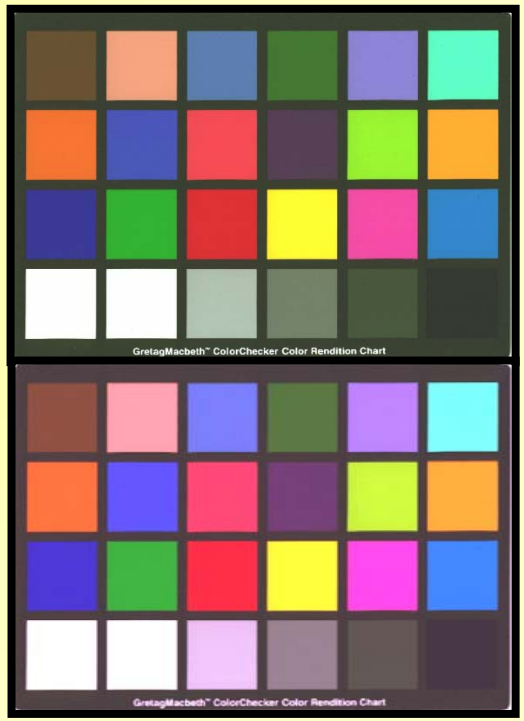
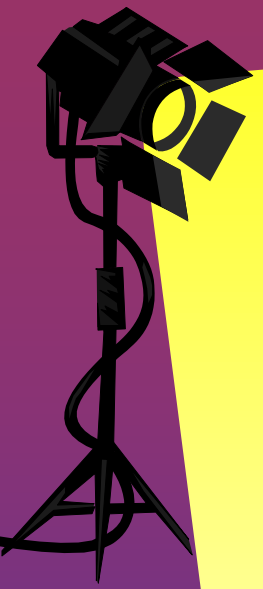
Digital Photography: Fundamentals of Light, Color, & Exposure - PART 1

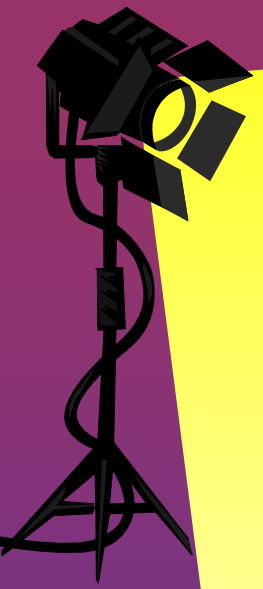


Michael J. Glagola - November 11, 2006



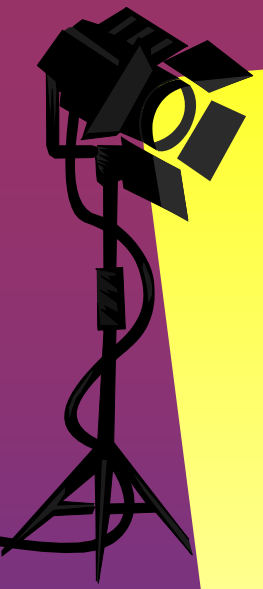
Why is Light, Color, and Exposure IMPORTANT?

- Image editing software cannot fix every image; some digital images are beyond repair! (Garbage in = Garbage out)
- Examples:
  - Image too dark; black values the same
  - Image too light; white values the same
  - White balance is off; entire image has a distinct color tint where it should not be
- A technically “good” image makes it easier to use all of the other technology of digital imaging to achieve a “great” picture



Session Goals

- To provide an understanding of the basics of:
- Light and how it effects exposure
- Color and how it effects white balance
- How to take better exposed and white balanced images
- How to deal with common problems with lighting and white balance



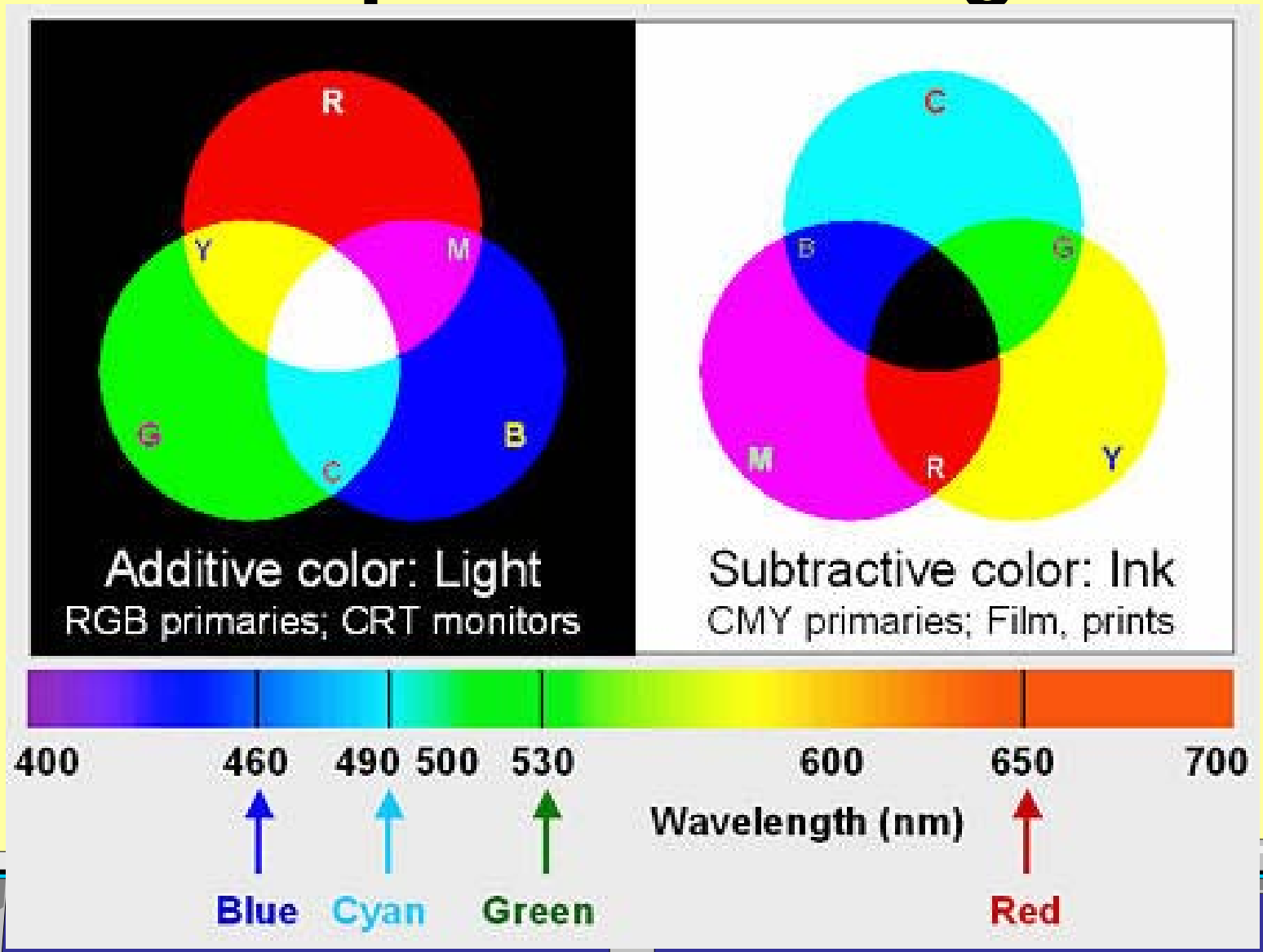
Agenda

- What is Light; What is Exposure?
- What is Color; What is White Balance?
- Digital Camera Exposure and White Balance
- Examples and Suggestions
- Q&A

What is Light and Color?

- Electromagnetic radiation with wavelengths between about 380 and 700 nanometers is known as ***light***. The eye has three classes of color-sensitive light receptors called ***cones***, which respond roughly to red, blue and green light (~ 650, 530 and 460 nm, respectively)
- A range of colors can be reproduced by one of two complimentary approaches:
  - ***Additive color:*** Combine light ***sources***, starting with darkness (black). The ***additive primary*** colors are red (R), green (G), and blue (B). Adding R and G light makes yellow (Y). Similarly, G + B = cyan (C) and R + B = magenta (M). Combining all three additive primaries makes white.
  - ***Subtractive color:*** Illuminate objects that contain dyes or pigments that ***remove*** portions of the visible spectrum. The objects may either transmit light (transparencies) or reflect light (paper, for example). The ***subtractive primaries*** are C, M and Y. Cyan absorbs red; hence C is sometimes called "minus red" (-R). Similarly, M is -G and Y is -B.

Components of Light



Photography

- Using light to make pictures
- Painting with light
- the process of recording images by exposing light-sensitive film or a digital sensor array to the light reflected off a scene

Seeing Light and Color

- The human eye compensates for both the intensity of the light and its color; regardless of the light the human eye sees color consistently
- Both film and digital arrays have varying sensitivity to the amounts of light and different light frequencies. Their response to light and color does NOT match that of the human eye.

Photographic Exposure

- Components of Exposure:
  - ISO (speed of the sensor)
  - Light controlled by:
    - Aperture (size of the lens opening)
    - Shutter Speed (duration of the exposure)
- Exposure is accomplished by measuring the light and selecting an aperture and shutter speed which will produce the desired effect for the ISO of the sensor

What is Correct Exposure?

- Correct exposure - satisfactory detail in both the deepest shadows and brightest highlights; More than a single exposure combination (f-stop/shutter speed) can produces this result
- “Minimum” exposure - good tone separation just attained in the deepest shadow
- “Maximum” exposure – good detail just retained in brightest highlight
- Exposure beyond “min” - shadow details “block up”
- Exposure beyond “max” – highlight details “flatten out”
- Range between “min & max” exposures is LATITUDE

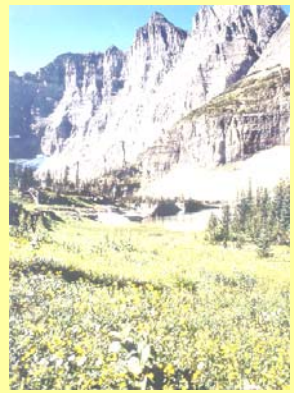
Correct Exposure Example

Acceptable



Too Dark

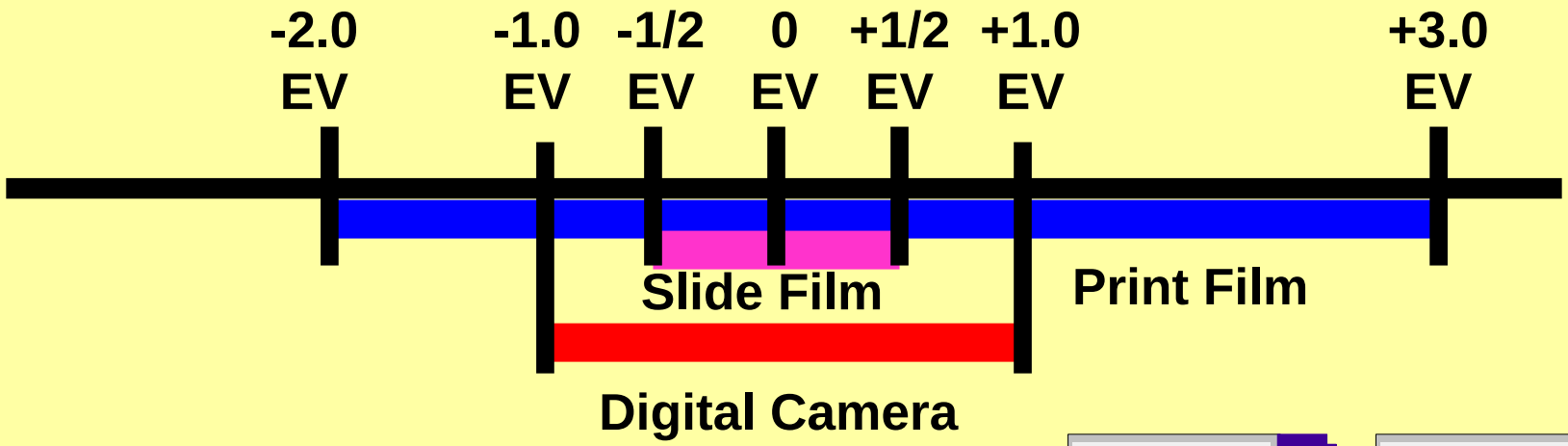
Unacceptable



Too Light

Latitude

- The exposure range at which an acceptable photograph is obtained; note acceptable in shadows AND highlights!
- Print Film: ~ 5 EV
- Slide Film: ~ 1 EV
- Digital: ~ 2 EV



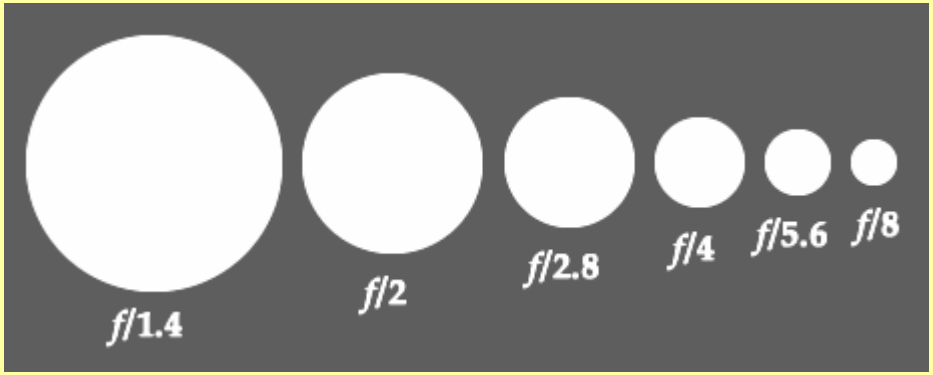
Film Speed (ISO)

- ISO - measure of sensitivity to light; bigger the number the more sensitive the film (100, 200, 400, 800, 3200)
- Each doubling of ISO = twice the sensitivity or the need for 50% less light (-1 EV)
- The larger the number usually the more grain (film) or noise (digital) in the image
- Sunny 16 Rule: On a sunny day with the aperture set at f 16 the correct shutter speed is 1/ISO (ISO of 200; 1/250 sec @ f16)

Shutter Speed

- Shutter Speed is the amount of time the shutter is open during exposure
- Measured in fractions of a second
  - 1, ½, ¼, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000, 1/2000, …
  - Usually written without the fraction, 1, 2, 4, 8, 15, 30, 60, 125, 500, …
  - Each doubling of shutter speed represents ½ the light of the previous exposure
- Typically a human can hand hold a “normal” 50mm lens at 1/60 second
- Telephoto lenses typically cannot be hand held below a shutter speed of 1/focal length of the lens (e.g. minimum hand hold shutter speed for a 200mm lens is 1/250 of a second)

Aperture

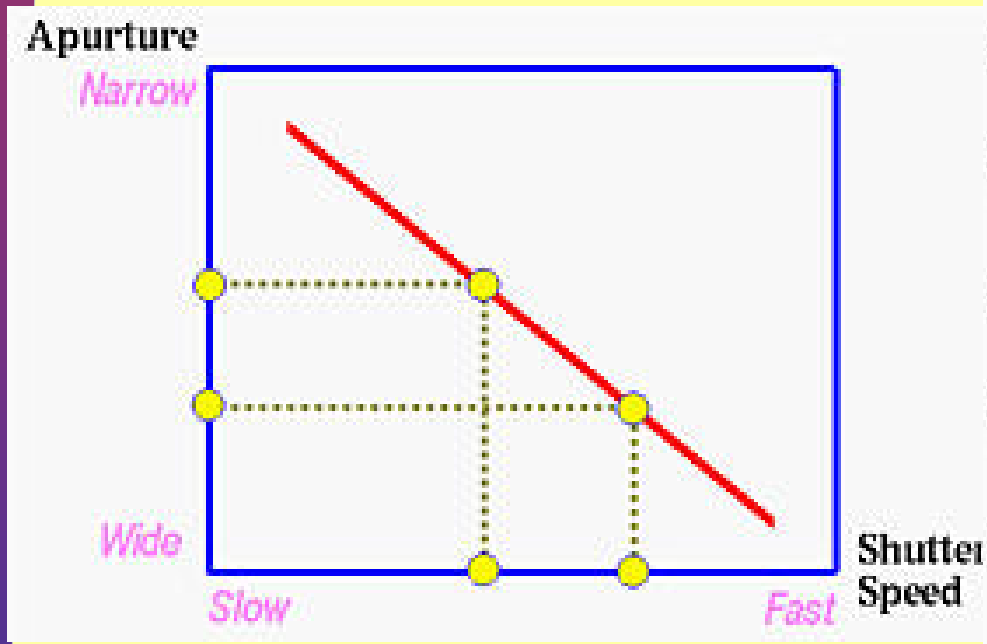


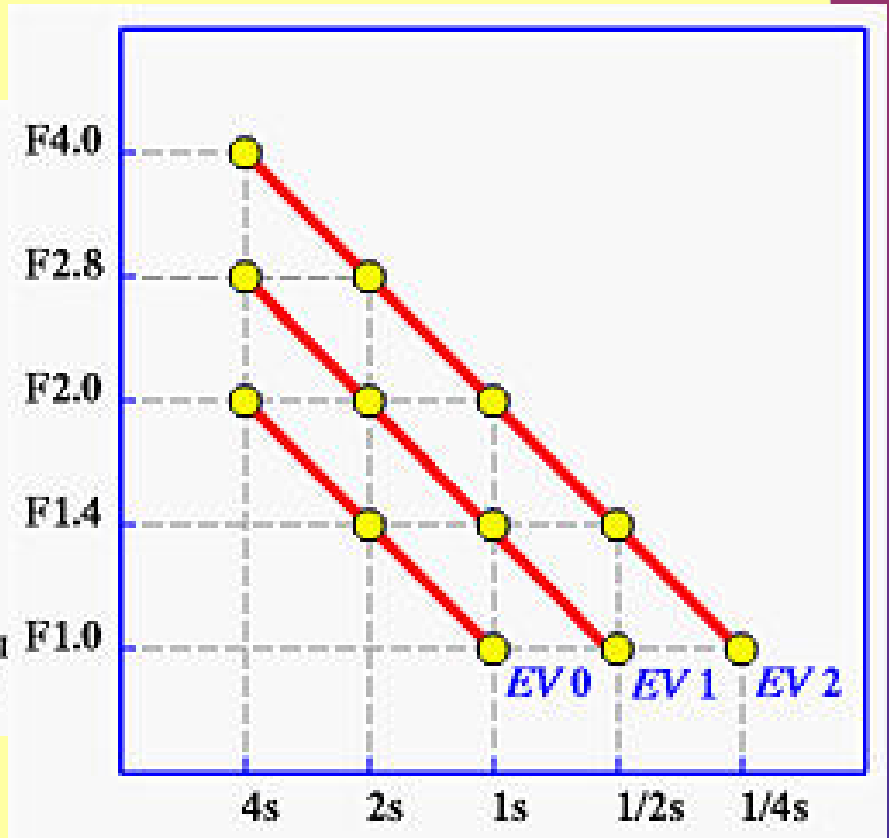
- Aperture refers to the size of the lens opening; the ratio of focal length to effective aperture diameter
- Measured in “f-stops”; the larger the number the smaller the opening and the less light that is left in. Each f-stop represents 50% less light than the preceding f-stop (1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32)
- Depth of field describes the extent to which subject matter lying closer than or farther from the actual plane of focus appears to be in focus. The smaller the f-stop (e.g. 16) the less the light and the greater the depth of field; the larger the f-stop (2.8) the smaller the depth of field.

Exposure Value

- Exposure Values are numbers which refer to combinations of lens aperture and shutter speed. A reduction of 1 EV represents 50% less light.
- A full change of one shutter speed or one f-stop while leaving the corresponding f-stop or shutter speed constant represents a change of 1 EV
- Exposure Value zero (EV 0) corresponds to exposure time of 1 second and aperture of f/1.0

Exposure Value





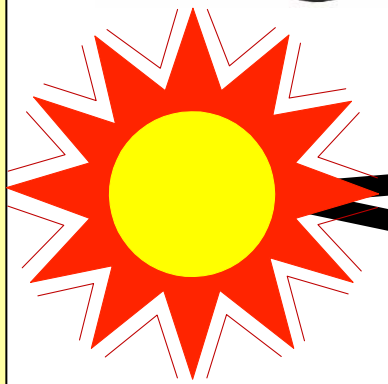
Multiple combinations of f-stops and shutter speeds can achieve the same EV

Measuring Light and Determining Exposure

- Light meters – two types: reflective or incident
- Incident meters measure the light falling on the scene
- Reflective meter measures the light reflected off of the scene
- Camera light meters are reflective light meters
- **ALL** reflective light meters assume “the world” is 12% gray (approximately 12-18% gray)
- If the scene is not 12% gray then exposure problems can occur

Measuring Light

Reflective
Measurement

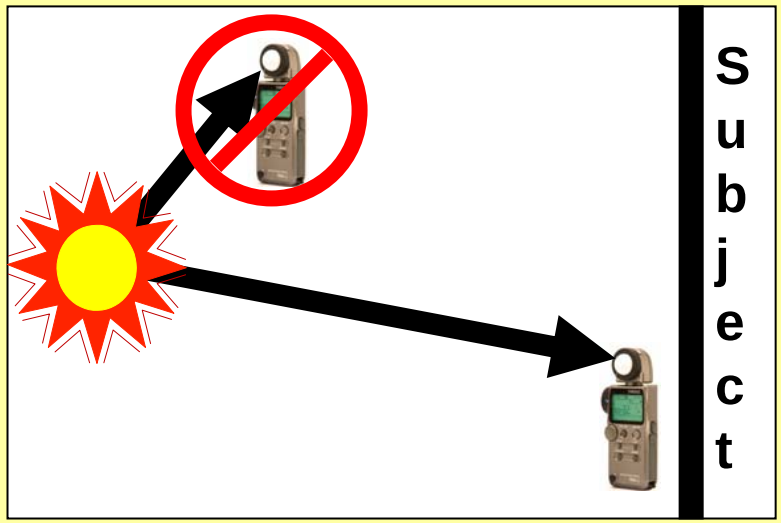


Light
Source

Incident
Measurement

Incident Light Meter

- Incident metering, when done properly, reads the intensity of light falling on the subject and give accurate and consistent results



- Incident metering to give accurate results must measure the light where it falls on the subject
- The problem with incident metering is that it is often not possible to measure light where it falls on the subject

Reflective Light Meters

Three types of reflective light meters:

- **Spot** focuses on a very small portion of the scene (typically 1°~5° angle of view); good for working with scenes containing high contrast
- **Average** takes a general metering of the entire scene; easily fooled by complex lighting
- **Matrix** divides the scene into n # of sections, meters each one independently, and using a computerized algorithm tries to determine the appropriate exposure; better than average but still fooled by large sections that are not 12% gray

Exposure Examples Test Setup

- Series of photos with a given background taken under identical light conditions with only change being about .3 EV every picture

Measuring Light with a Reflective Light Meter: Example 1 White

Question? If you used the reflective light meter of a digital camera set on Auto Exposure to take a picture of a white card, what would the picture look like?

Measuring Light with a Reflective Light Meter: Example 1 White

Answer? If you used the reflective light meter of a digital camera set on Auto Exposure to take a picture of a white card, the picture would look like this! Gray.

Measuring Light with a Reflective Light Meter: Example 1 White

Why did the photo of the white card turn gray?

The light meter which assumes the world is 12% gray reduced the light and the white card appeared gray!

Measuring Light with a Reflective Light Meter: Example 2 Gray

Question? If you used the reflective light meter of a digital camera set on Auto Exposure to take a picture of a gray card, what would the picture look like?

Measuring Light with a Reflective Light Meter: Example 2 Gray

Answer? If you used the reflective light meter of a digital camera set on Auto Exposure to take a picture of a gray card, the picture would look like this! Gray.

Measuring Light with a Reflective Light Meter: Example 2 Gray

Why did the photo of the gray card stay gray?

The light meter which assumes the world is 12% gray saw 12% gray and everything worked as it is suppose to!

Measuring Light with a Reflective Light Meter: Example 3 White Light Intensity

White Card

Exposed with light meter set on auto with exposure bias of:

-2 EV **-1 EV** **0 EV** **+1 EV** **+2 EV**

Meter on auto the result is <u>too dark</u>

Correct is +2 EV

Measuring Light with a Reflective Light Meter: Example 4 Gray Light Intensity

Gray Card

Exposed with light meter set on auto with exposure bias of:

-2 EV -1 EV 0 EV +1 EV +2 EV

Meter on auto is <u>Correct</u>

Measuring Light with a Reflective Light Meter – Example 5
Gray and White Light Intensity

White Card on top; Gray Card on bottom

Black, Gray, and White are only differences in light intensity!!!

Exposure Example 1
“Normal” Object; White Background

With a background that is brighter than 12% gray, the light meter on auto is fooled! Add light (+EV) to brighten the image

Exposure Example 2
High Contrast; White Background

With high contrast and a background lighter than 12% gray it may not be possible to add light (+EV) and find an exposure that will fit the latitude of digital. Consider bracketing and fixing in software.

Exposure Example 3
High Contrast; Gray Background

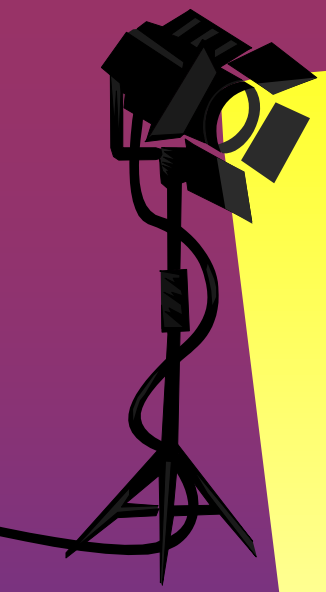
With high contrast and a background that is 12% gray should be OK especially if one fixes in software. Consider bracketing just in case latitude is a problem

Exposure Example 4
High Contrast; Black Background

With a background darker than 12% gray subtract light (-EV). With high contrast and a background darker than 12% gray it may not be possible to subtract light (-EV) and find an exposure that will fit the latitude of digital. Consider bracketing and fixing in software.

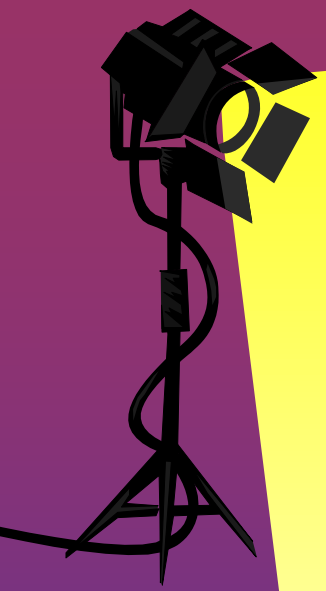
Lighting/Exposure Recap

- NO digital camera on Auto can handle all lighting situations; problem occurs when the scene is significantly darker or lighter than 12% GRAY
  - If scene is lighter than 12% gray add light (+EV)
  - If scene is darker than 12% gray subtract light (-EV)
  - Be aware that high contract in the scene may exceed the latitude of the digital sensor to such a extent that it CANNOT be fixed in software alone; consider bracketing
- Learn to recognize difficult lighting situations and experiment to find what works
- Analyze your “problem” pictures and learn from them
- Practice, Practice, Practice!!!!!!!!!!!!!



Summary

- Digital image manipulation is the equivalent of the film darkroom; it can fix a lot of problems but it is not a universal remedy. It helps to have a correctly exposed and white balanced image to start with.
- To take good images under difficult lighting conditions requires an understanding of the fundamentals of light and color.
- Strive to get as good an original image as possible; learn how to recognize and deal with difficult lighting and color situations rather than leave the camera on “auto”.



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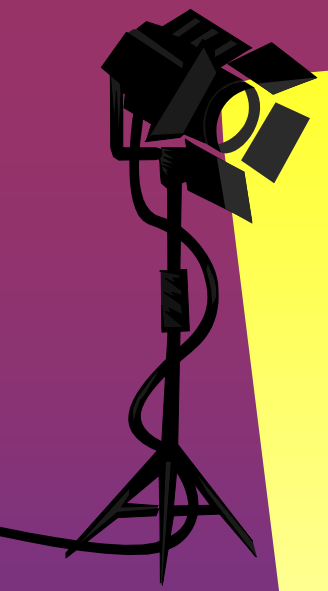

Recommended Reading; Good Photo Books

- How to Take Good Pictures (Kodak)
- Nat'l Geographic Photography Field Guide
- The Hand Exposure Meter Book
- Light – Working with Available and Photographic Lighting