What will be on the final exam?

CS 178, Spring 2012

You should also review the material from the first half of the course. We won't emphasize it on this exam, but we might use it here and there.

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Trichromatic theory (1 of 2)

- interaction of light with matter
  - understand spectral power distributions (SPDs), multiplying illumination × reflectance wavelength-by-wavelength
- color response
  - basis for color discrimination, meaning of a metamer
  - monochromats versus dichromats, trichromats, N-chromats
  - understand the tristimulus sensitivity functions and how one computes ρ, γ, β from them and a stimulus spectrum
    - understand the linearity of light and retinal response
    - you won't need to perform calculus derivations on the exam
- 3D colorspace
  - how one plots ρ, γ, β for a spectrum or mixtures of spectra
  - understand the spectral locus and gamut of perceivable colors

Trichromatic theory (2 of 2)

- reproducing colors using primaries
  - understand how the color matching experiment works
  - understand trichromatic matching functions (including negative values) and the gamut of reproducable colors for a given set of primaries
  - effect of pure (single-wavelength) versus impure primaries, the effect of adding extra primaries
- additive versus subtractive mixing
  - when is additive mixing relevant, and when is subtractive?
  - which spectra are best for additive/subtractive primaries?
  - effect of moving the primaries around, adding extra primaries
    - don't worry about printing via the Neugebauer equations

Applications of color

- cylindrical color systems
  - linear versus circle versus rainbow, extra-spectral purples
  - meaning of scales for hue, saturation, and lightness/value
- chromaticity diagrams
  - construction and properties of the of rg(b) and xy(z) spaces
    - for xy(z), know the matching functions are all-positive
  - what is color temperature and correlated color temperature?
  - how is white balancing performed in digital photography?
    - know the gray-world method for auto white balancing
  - procedure for obtaining the xy coordinates for a real object
  - what is a device gamut, and how is gamut mapping done?
    - don't need to know the details of L*a*b*, YIQ, YCbCr, sRGB, rendering intents, but understand what they are
    - memorize the Calvin and Hobbes cartoon on color ;-)

Light and reflection

- radiometry versus photometry
  - understand the distinction, and the luminous efficiency curve
- the four measures of luminance
  - know their definitions and units (lumens, steradians, m^2)
    - don't worry about nits, lux, or footcandles
  - don't memorize the examples we gave, but be able to reason about new problems we may pose along these lines
- reflection of light
  - meaning of the terms diffuse, specular, albedo, microfacets
  - be able to reason about mirror reflections (perspective, focus)
  - be able to interpret (or sketch) a goniometric diagram
  - meaning of terms anisotropic reflection, BRDF, BSSRDF (don't worry about Fresnel equations)

Photographic lighting

- taxonomy of light sources
  - spatial versus angular extent, point versus extended sources, parallel versus diffusing sources, umbra versus penumbra
- studio lighting
  - know the terms floodlight, spotlight, barn doors, diffusers, main/key, fill, accent/rim, grazing, brightfield, darkfield
    - don't worry about the bas-relief ambiguity
- flash
  - effects of flash placement, fill-flash, flash-plus-ambient
  - relationships of flash duration, shutter speed, aperture, ISO
  - understand guide numbers, 2nd curtain sync
  - how do digital cameras meter for flash photography?
  - understand problems with flash and flash color temperature

In-camera image processing

- tone mapping
  - be able to compare gamma transform, histogram equalization
    - don't worry about details of HDR tone mapping
- denoising and sharpening
  - roughly understand bilateral filtering and unsharp masking
- compression
  - what is JPEG, EXIF, and RAW?
  - what are the steps in JPEG compression?
    - don't need to know formulas or detailed algorithms

Panoramas

- what assumption underlies panoramic mosaicing?
  - rotation around the center of perspective
- what are the steps required to stitch a panorama?
  - find correspondences, compute transformation, warp, blend
- understand perspective versus cylindrical projection
  - for perspective, reprojecting to a common picture plane simulates having had a wide-angle camera in the first place
  - for cylindrical, project onto a cylinder to create a panorama, then reproject to a plane for display

List of important formulas (will be replicated on exam sheets)

$$(\rho,\gamma,\beta) = \left(\int_{400\,nm}^{700\,nm} L_e(\lambda)\,\rho(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\gamma(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\beta(\lambda)\,d\lambda \right)$$

$$(R,G,B) = \left(\int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{r}(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{g}(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{b}(\lambda)\,d\lambda \right)$$

$$r = \frac{R}{R+G+B} \qquad g = \frac{G}{R+G+B}$$

$$(X,Y,Z) = \left(\int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{x}(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{y}(\lambda)\,d\lambda,\ \int_{400\,nm}^{700\,nm} L_e(\lambda)\,\bar{z}(\lambda)\,d\lambda \right)$$

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z}$$

List of important formulas (continued)

$$L = \rho + \gamma + \beta = \int_{400nm}^{700nm} L_e(\lambda)\, V(\lambda)\, d\lambda \qquad V(\lambda) = \rho(\lambda) + \gamma(\lambda) + \beta(\lambda)$$

$$I = \frac{P}{\Omega} \quad \left(\frac{\text{watts}}{\text{steradian}}\right) \qquad L = \frac{P}{\Omega A \cos\theta} \quad \left(\frac{\text{watts}}{\text{steradian m}^2}\right)$$

$$E = \frac{P}{A} \quad \left(\frac{\text{watts}}{\text{m}^2}\right) \qquad \text{BRDF:} \quad f_r(\theta_i, \phi_i, \theta_r, \phi_r) \quad \left(\frac{1}{sr}\right)$$

$$\text{BSSRDF:} \quad \rho(x_i, y_i, \theta_i, \phi_i, x_r, y_r, \theta_r, \phi_r) \quad \left(\frac{1}{sr}\right)$$

1 steradian of solid angle (sr) = $r^2 / 4\pi r^2$

aperture size = flash guide number / distance to subject

luminance of a CRT = voltage$^\gamma$ where $\gamma \approx 2.5$