CPSC 641 – Computer Graphics
Assignment 2 **due 10/24/17**

This assignment emphasizes two areas – Color reconstruction and BRDFs.

You should begin with a basic ray tracer that allows you to trace at least six spheres. There will be some code provided to help you perform the ray tracing calculations, or you may use your own code. Only very basic calculations are needed: enough to trace a single ray per pixel from the eye to the scene, with no reflection/refraction rays, etc. The idea is that each pixel (in which a sphere is hit) should give you a 3D point on the sphere, so that you have a varying view vector, normal, and light vector. DO NOT COMPUTE REFLECTIONS OR SHADOWS for the spheres – just use the ray tracer to get the values for the intersection point and thereby the needed vectors.

Essentially, your goal is to write a function that is given a view vector, surface normal, and single light vector, along with a surface identifier, and then uses that to calculate an RGB value. You should have a scene with six (or possibly a few more if you wish) spheres and no extraneous scenery that will make it difficult to determine how well the computation has worked.

You are to do the following on your assignment:

1. You should perform the computation by sampling the spectrum of light. Use at least 5 frequency samples (preferably more – it is better to use 20-60).
2. You are to find a chart of spectral irradiance from a light source. This could be from sunlight, from an incandescent light, from a fluorescent light, from a gas discharge light, or from an LED light. You should be able to find a variety of charts/tables giving irradiance values for various light sources (see below). For sunlight, the distribution on the surface of the earth (rather than in space) is preferred. Your spectral data should be based on measurement, rather than an analytic function.
3. You should compute both a diffuse and a specular term. The specular term should be very clearly visible (that is the main consideration, here), demonstrating that your computation worked.
4. You are to compute the color value for the spheres based on a BRDF computed from a statistical microfacet distribution model (see the Cook and Torrance paper). Use a Beckman distribution.
5. Each of the six spheres should have a different surface property. Three of the spheres should be of a single type of material with three different surface roughness calculations. The other three spheres can be of your own choosing – you could make more levels of roughness (don't make all 6 just varying roughness – that's not as interesting), different materials, or a slightly modified function. You can also use a different light spectrum to provide variation for one or more of the spheres.
6. You should perform the reflectance computation using the index of refraction (and sometimes extinction coefficient) for a real-world material. Use a table of measured values of n and k, or of reflection at normal incidence, across the spectrum of light. See below for some links.

7. Compute the color as an XYZ value. You can find tables giving the values for the XYZ color matching functions at:
   http://www.cvrl.org/cmfs.htm
   You can use any of the XYZ functions there that you wish – the 1931 2 or 5 degree functions are fine.
8. Convert your XYZ value to RGB. You may either find the x,y values and the white point for some monitor/projector/display, or use a conversion to some standard like sRGB.

For help with this assignment, the following are the best places to look:

- The recommended textbook (Computer Graphics: Principles and Practice), particularly chapters 26-28
- The Cook&Torrance paper: https://dl.acm.org/citation.cfm?doid=357290.357293
- Hall's paper on spectral color computation; http://ieeexplore.ieee.org/document/773962/
- Charles Poynton's Color FAQ at: http://poynton.ca/ColorFAQ.html
- For the light source spectra, you may need to manually read the values off of a chart (usually the spectral irradiance is shown in a graph, and not as often in a table). Some places you can find irradiance data includes:
  - For sunlight, there are a variety of sources. Here are some:
    - http://rredc.nrel.gov/solar/spectra/am1.5/ASTMG173/ASTMG173.html
    - http://iopscience.iop.org/article/10.1088/0508-3443/15/8/310/pdf (see table 2)
    - http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/18607/McCartney_and_Unsworth_Q_J_R_Met_Soc_1978.pdf?sequence=1 (see table 1)
  - For other light sources, you can sometimes find tables at company websites, such as:
    - http://assets.sylvania.com/assets/documents/faq0041-0800.83f1d8de-3fe1-4d24-a209-d95f6cac74b9.pdf
    - https://assets.newport.com/webDocuments-EN/images/Light_Sources.pdf
- You can find tables that will give you the index of refraction and coefficient of extinction (for metals) at various places. Here are a few sites you can use to find them (many will let you download tables):
  - https://refractiveindex.info/
  - http://photonics.byu.edu/tabulatedopticalconstants.phtml
  - http://people.csail.mit.edu/jaffer/FreeSnell/nk.html

You are to turn in the following:

1. On ecampus, turn in your code. It is likely a single file, but if you need multiple files, you can zip them together.
2. In class, turn in a short writeup. Include in this writeup:
   a. What your spectral samples are
   b. What light source you used:
      i. Where did you get your spectrum information from
      ii. How did you determine specific values
   c. what each of the 6 spheres is:
      i. What is the material?
      ii. Where did you get your reflectance or n/k information for the material?
      iii. What roughness parameter did you use?
      iv. What fraction of the light is diffuse, and what fraction specular?
      v. If there are any other details needed for a particular sphere, state them.
   d. Which color matching functions did you use, specifically?
   e. What did you use for conversion from XYZ to RGB? Where did you get your values from?
   f. Provide a summary of any problems you encountered or nonstandard solutions you had to use. If you used any outside libraries, state that.