CO 417 Spring 2017 HW 2

due Thursday Feb 23, 2017, 9am

- **Part 1: Generate plots of Fresnel reflectance**
  - Write your own code (e.g., in GNUPlot or MATLAB) to generate plots of Fresnel reflectance for a dielectric material. Choose the index of refraction of the material η_t =1.4 and plot out reflectance values (Y-axis) for incidence angles ranging from 0 – 90 degrees of incidence (X-axis). Plot curves for both the parallel and perpendicular polarized components. Report the reflectance of both components at normal incidence ($\theta = 0$ degrees) and the Brewster's angle for such an air-material interface.
  - Do the same for a ray exiting the material into air ($\eta_t = 1.0$). Report the Critical angle for such a material.
  - Plot the curve for Schlick's approximation of Fresnel reflectance for such a material using the reflectance value at normal incidence from 1st part as the R_0 parameter.

- **Part 2: Generate samples according to an Environment Map**
  - Write your own code to load the Grace Cathedral environment map (.pfm) in latitude-longitude format and generate samples according to the 2D PDF and CDF of the EM. Here, you should create one 1D CDF across rows to select one specific row, and separately create one 1D CDF for every row of the EM to select a specific pixel within that row. Note that you should create the CDFs based on the intensity (luminance) of each pixel **I = (R+G+B)/3**. And the intensity of each pixel needs to be scaled by the solid angle term **sin(θ)** (in order to reduce the importance of the poles) where the latlong map varies from the top to bottom $\theta = 0 – PI$.
  - Write out the EM (.pfm) with the pixels corresponding to the chosen sample directions set to **Blue**. For illustration, you should really set a 5x5 or 9x9 neighborhood around the chosen pixel to blue (0,0,1).
  - Do this for 64, 256 and 1024 samples and save the output (.pfm) as LDR images (.ppm) with appropriate gamma correction.
  - Also save the drawn samples (direction $\boldsymbol{\omega_i}$ and RGB radiance $L_i(\omega_i)$) along with the probability of drawing these samples from the EM: $p(x,y) = p(y) * p(x)$, in a separate file for Part 3.

- **Part 3: Render a sphere with sampled Environment Map**
    - Write your own code to render a sphere with the 64, 256 & 1024 samples drawn from the Grace Cathedral EM in part 2. Assume a diffuse BRDF with ρ_d =1.0. Sum up the contributions of the samples according to MC importance sampling equation for EM sampling discussed in class. Note that this is similar to ray-tracing except that you do not need to trace any rays as visibility $V(\omega_i) = 1$. Assume an orthographic camera with view vector $\omega_o = (0,0,1)$. Set the rendered image resolution to 511x511. Then every pixel inside the projected circle of the sphere corresponds to a different direction (surface normal) similar to HW1.
    - For each pixel on the sphere, compute the shading as follows:
      $L_r(\omega_o) = 1/N\ \Sigma_{j=1toN}\ (\rho_d/\pi * \cos\theta * L_i(\omega_i))/p(x,y)$
      Here, $\cos\theta = \mathbf{n} \cdot \boldsymbol{\omega_i}$, where **n** is the surface normal, and p(x,y) is the probability of selecting that specific lighting direction $\boldsymbol{\omega_i}$.
    - Note that in a typical Monte Carlo renderer, you would have to draw new set of random samples for every pixel in your image. For this assignment, you can use just one set of drawn samples from the EM for rendering the entire sphere. This means that your image will **not** have the typical Monte Carlo variance (noise) but will actually have bias! However, with increasing number of samples, the rendered image should converge more towards the correct solution.
    - Save the rendered images as both .pfm and as LDR .ppm images with appropriate gamma setting.

- **Part 4: Render a sphere lit by Grace EM using PBRT**
    - Use PBRT to render a diffuse sphere with albedo ρ_d =1.0 in the Grace Cathedral lighting environment with 8, 16, 32 and 64 samples. (NOTE - The images rendered with PBRT **will** have MC variance (noise) that should reduce with increasing sample count.)
    - Save the rendered images as both .pfm and after converting them into LDR format (.ppm).

- Prepare homework as a WORD or PDF document, and include all images (LDR) and plots generated for the assignment. Again, note that 10% marks are reserved for a detailed and well written report! Submit the document and all images (.pfm and .ppm) on CATE as a zip file.