70001 Spring 2023 Assignment 2
due Mon 20, 2023, 2pm
(please complete submission before class)

(Parts 1 and 2 implementation by Team member #1)

- **Part 1: Generate plots of Fresnel reflectance**
  - Write your own code to generate plots (e.g., in GNUPlot, Python or MATLAB) of Fresnel reflectance for a dielectric material. Choose the index of refraction of the material $\eta_t = 1.45$ 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 1^{st} part as the R_0 parameter.

- **Part 2: Generate MC 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 each 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.
  - For the 256 samples case, also save another EM showing only the selected samples with their RGB values. For illustration, again set a 5x5 window around the selected pixel to this value. Set all other pixels to black. Save the output (.pfm) also as an LDR image (.ppm) with appropriate scaling and gamma correction.

Prepare a detailed report on Parts 1 & 2 (Word or PDF) providing as much description of each result in the report as possible.

(Parts 3 and 4 implementation by Team member #2)

- **Part 3: Generate samples on an EM using Median Cut**
  - Write your own code to load the Grace Cathedral environment map (.pfm) in latitude-longitude format and generate samples on it according to the Median Cut algorithm. Here, you should recursively partition the EM into two halves with equal energy. Note that the partition is done across the longest dimension in each iteration! You should compute the energy 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 θ = 0 – PI.
  - Write out the EM (.pfm) after each iteration of the algorithm with the partition(s) drawn with **White.** Inside each partition, mark the pixel position corresponding to the centroid of the partition in **Blue**. For illustration, you should really set a 5x5 or 9x9 neighborhood around the chosen pixel (centroid) to blue (0,0,1) and mark the partition with a similar thickness in white (1, 1, 1).
  - Repeatedly write out the EM with 2, 4, 16, and 64 partitions (including their marked centroids) and save the outputs (.pfm) as LDR images (.ppm) with appropriate gamma correction.
  - For the 64 partitions case, also save another EM showing only the centroids representing the total RGB radiance within each partition. For illustration, again set a 5x5 window around the centroid to this value. Set all other pixels to black. Save the output (.pfm) also as an LDR image (.ppm) with appropriate scaling and gamma correction.

- **Part 4: Render a sphere lit by Grace EM using PBRT**
  - Install and compile PBRT 2.0 renderer
  - Use PBRT, with the example scene file provided, to render a diffuse sphere with albedo ρ_d =1.0 in the Grace Cathedral lighting environment with 8, 16, 32 and 64 samples drawn from the EM. This is a very simple task requiring just running PBRT with different sample counts.
    (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 a detailed report on Part 3 and 4 (Word or PDF) providing as much description of each result in the report as possible.

- Prepare the joint assignment report for the team by combining the two individual reports into one file. Include all LDR images (.ppm) generated for the assignment in the report along with the settings used. Submit your joint report document including the .ppm images and all the generated images (.pfm and the .ppm versions) of the results and your code (individual folders) as one zipped file.

- IMPORTANT: Please write a good report with sufficient explanation of your implementation and the results obtained for each part as the GTA will grade your assignment based only on the report and the data submitted, not based on examination of the code (which will be only checked to verify implementation). We reserve 10% of the marks for the quality of the report. The quality of each sub-part of the report will be marked separately.