Problem 1: Image formats

1. Suppose a PC is connected digitally to a 1600 by 1200 pixel color LCD display. The display is operating at 60Hz, has a gamma of 2.2, and always takes 8 bits per color channel per pixel.

   (a) What data rate is flowing across the cable to the display?
   (b) How much of the graphics card’s memory is occupied by the framebuffer for each of the following pixel formats:
      i. 16 bits per pixel (4 red, 5 green, 4 blue)?
      ii. 8 bit RGB?
      iii. 8 bit RGB with 8 bit alpha?

2. The image on the screen was computed by a ray tracer that (like the Ray I assignment) stores the RGB image it is computing as an array of double-precision floating point numbers, with the value of 1.0 corresponding to the maximum displayable intensity $I_{max}$, and lower values mapping linearly to fractions of that intensity.

   (a) How much of the PC’s main memory is occupied by the image?
   (b) What processing has to be done to the pixels before they are written into the framebuffer? Give a specific expression that could appear in the code used to do the processing.
   (c) Suppose the software thinks the display gamma is 1.5. Would the displayed image look darker or lighter than it should?
   (d) Assuming a black level of 1% of $I_{max}$, what will be the observed intensities corresponding to the five darkest gray values that can be sent to the display? Which steps are visibly different from one another?
   (e) Suppose the display is linear (i.e. its gamma is 1.0), and answer the previous two questions.

3. The same image is to be printed on a black-and-white laser printer that has a resolution of 600 dots per inch. It will appear on the page at the size 8 inches by 6 inches. There are two steps of processing that have do be done on the image before it can be printed.

   (a) What are the two steps? Give a specific expression for the first step, and name a general class of algorithms for the second step.
(b) How much data needs to be transmitted over the network to the printer if:
   i. both steps are done in the computer?
   ii. one step is done in the computer and one in the printer?
   iii. both are done in the printer?

Assume no data compression is used (this is rather unrealistic for option (a)).

Give data sizes in kilobytes, megabytes, or gigabytes as appropriate; give data rates in kilobits, megabits, or gigabits per second. Recall that these units traditionally refer to multiples of 1024, not multiples of 1000.