1. You are attempting to find paint for a room that exactly matches the colour of an object. You scrape off a sample of the object and take it to the paint shop. You put some paint on a card and hold it up next to your sample and the colours look identical. When you get home and start painting, you discover that the paint doesn't actually match so well. Give an explanation as to what possibly happened.

2. The *Portable Gray Map* (PGM) image format (described at `https://netpbm.sourceforge.net/doc/pgm.html`) is an extremely simple image format.

   (a) Notice that the width and height are included in the header. Explain the purpose of this information. Do both dimensions need to be present?

   (b) If the maximum grey level is 2047 (i.e., 2048 shades of grey including white) how much memory would you need to store a decoded 800×600 pixel PGM image if the intensity data for each pixel is to be **packed as densely as possible**?

   (c) Notice that if the data is packed densely, pixel boundaries may occur in the middle of a byte. Why might this be undesireable? Propose a different way of storing the data in memory that makes accessing the intensity at a particular pixel simpler.

   (d) Write some pseudocode to extract the intensity value for the pixel at (220,140) using the storage scheme you proposed in part (c). You can assume that the image data is stored in a contiguous block of memory in the form of an array of bytes.

3. Virtual reality headsets provide two separate displays, one for each eye. Why is this necessary? When playing a 3-D game (e.g., Fortnite) on a regular monitor one is still able to perceive depth in the virtual world. How is this possible?

4. What is the value of the ray parameter s at the intersection points between the ray $[-4, -4, -4] + s[1, 1, 1]$ and the sphere centred at the origin with radius 2?

5. When using a pinhole camera with an extremely small aperture every object appears in focus and shadows are crisp. As the aperture size increases, objects get blurry and shadows get softer. Explain, with the help of a diagram, why this happens.

6. What is the effect of applying each of the following 4×4 transformation matrices to a 3-D object with vertices given in homogeneous coordinates?

$$\begin{bmatrix} -3 & 0 & 0 & 0 \\ 0 & -3 & 0 & 0 \\ 0 & 0 & -3 & 0 \\ 0 & 0 & 0 & -2 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 4 \\ 0 & 1 & 0 & -2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$