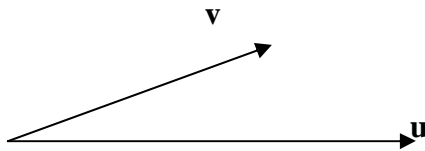


4) True or false, there must be tight synchronization between a raster monitor's framebuffer, phosphor persistence, and refresh rate? Define these terms and explain.

5) A pixel of a liquid crystal display could be described as a layer of liquid-crystal material sandwiched between two layers of polarizing material. Explain how this pixel is able to control screen illumination. Draw the three layers of the pixel and label the flow of light.

Mathematical Foundations

- 6) Given the unit vector $[\mathbf{u}_x, \mathbf{u}_y, \mathbf{u}_z]$ and another vector $[\mathbf{v}_x, \mathbf{v}_y, \mathbf{v}_z]$, what two useful quantitative measures does the dot product of \mathbf{u} and \mathbf{v} represent? Label the diagram.



- 7) If the vectors, \mathbf{u} and \mathbf{v} from the previous example are coplanar with this sheet of paper, does the cross product $\mathbf{v} \times \mathbf{u}$ extend towards the reader or away?

OpenGL

- 8) What do `glPushMatrix()` and `glPopMatrix()` do. Why would you use them?

Rasterization

9) Below is a copy of the simple line drawing algorithm from class. What family of lines does it rasterize poorly?

```
void lineSimple(int x0,int y0,int x1,int y1,Color color) {
    int pix = color.getRGB();
    int dx = x1 - x0;
    int dy = y1 - y0;

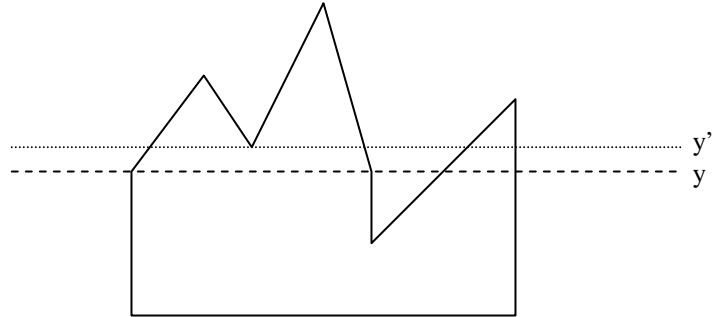
    raster.setPixel(pix, x0, y0);
    if (dx != 0) {
        float m = (float) dy / (float) dx;
        float b = y0 - m*x0;
        dx = (x1 > x0) ? 1 : -1;
        while (x0 != x1) {
            x0 += dx;
            y0 = Math.round(m*x0 + b);
            raster.setPixel(pix, x0, y0);
        }
    }
}
```

10) Bresenham's line drawing algorithm improves the efficiency of the above code. Edit the code to eliminate the use of the `round()` function and to simplify the computation of $m*x0 + b$ (use difference equation) in the while loop.

11) What's a simple change you could make to `lineSimple()` so it worked for all lines (including those from answer)?

12) What is the definition of a concave polygon?

13) In edge walking polygon rasterization, the algorithm moves across a scanline and performs a quick check to determine if each pixel is inside or outside the polygon. Explain how this checking works. In particular, consider the scan lines y and y' below that intersect edges at their endpoints.



Clipping

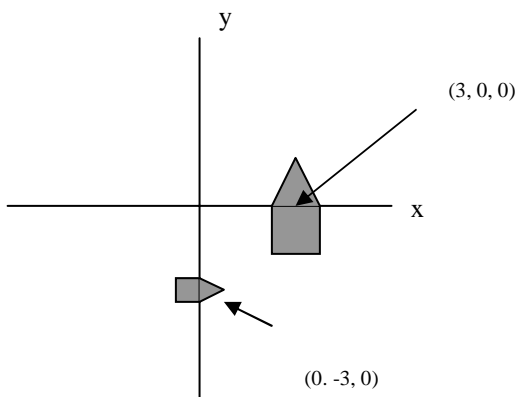
14) When is it preferable to use Cohen-Sutherland line clipping?

15) In Liang-Barsky line clipping, we clip a line to four planes. If a line is parametrically defined by two points \mathbf{p}_0 and \mathbf{p}_1 : $\mathbf{p}(t) = \mathbf{p}_0 + t(\mathbf{p}_1 - \mathbf{p}_0)$, and a plane is defined by a point \mathbf{q}_0 and a normal \mathbf{N} facing towards the outside, how do you solve for the point on the line that delineates the clipping boundary? Compute t .

Geometric Transformations

- 16) Calculate a chain of 4x4 matrices (don't multiply them together) that will rotate points about the vector $A = [(.5)^{1/2}, 1.73, (.5)^{1/2}]$. Show your work.
Helpful trig evaluations: $\tan(60 \text{ deg}) = 1.73$; $\tan(45 \text{ deg}) = 1.0$

- 17) Calculate a chain of 4 x 4 matrices that, when post-multiplied by the vertices of the house, will translate and rotate the house from $(3, 0, 0)$ to $(0, -3, 0)$. The transformation must also scale the size of the house by half.



Viewing in 3-D

18) How is the homogeneous coordinate, (x, y, z, w) converted into an (x, y, z) tuple?

19) Given a camera position P , a vector normal to the image plane N , and an up vector V_{up} , describe how to convert a point W in world coordinates to a point in camera coordinates. You do not need to worry about translating the world origin to the camera position for this problem. For each of the axes of the camera's coordinate system listed below, write the corresponding vector in world space. I've done one of the axes for you.

X:

Y:

Z: $-N / \|N\|$

20) What is a 4x4 viewing matrix M_{ort} that will transform homogeneous coordinates to points on the x-y plane at $z = 0$?

Color and Light

21) Define *metamers*.

21) Can a computer monitor produce all the colors we see in the world? Why or why not?

22) How would you select intensity values for each of 10 pixels arranged in a row so that the increase in brightness (from initial value of 0 to max of 99) looked smooth?

23) Define:

Hue:

Saturation:

Value:

24) Write the equation we use to model the diffuse illumination of a surface?

$I_d =$

25) Given:

an incoming light intensity, I

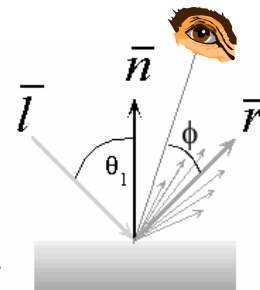
a surface normal, \mathbf{N}

a vector from the surface to the light source, \mathbf{L}

a vector from the surface to the viewer's eye, \mathbf{V}

specular constant, k_s

define the vector \mathbf{r} from the image, in terms of these variables.



26) Define Mach banding, indicate the lighting model the frequently causes the effect, and describe why we perceive the effect.

27) Name three common problems with the shading techniques we discussed in class. Draw examples when appropriate.

28) For radiosity, we discussed Form Factors. Describe how many form factors there are and what a form factor is.

(Extra Credit) If a film of me running down the street were shot (on film, not digitally). Would I appear to be running faster if the film were shown in the United States or in England? Why?