CSG140 Computer Graphics. Spring 2004. Midterm Exam

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This exam is for Thursday 18 March - Closed book/notes

Question 1. Barycentric coordinates begin with the expression

$\mathbf{p}=\mathbf{a} + \beta(\mathbf{b} - \mathbf{a}) + \gamma(\mathbf{c} - \mathbf{a})$

Convert this to a symmetric form and state the constraint on the three resulting parameters as well as what the constraint means. Draw a triangle with vertices **a**, **b**, and **c** and show the points **p** resulting from special values of the parameters including having $\alpha = \beta = 1/2$, one of the parameters = 1, or = 0 and having all three parameters equal to one another.

Question 2. The following code implements the midpoint drawing algorithm. Manually evaluate it for four steps for a line starting at 0,0 and ending at 7,5.

```
y = y0
d = 2(y0 - y1)(x0 + 1) + (x1 - x0)(2y0 + 1) + 2x0y1 - 2x1y0
for x = x0 to x1 do
   draw(x,y)
   if  d < 0 then
      y = y + 1
      d = d + 2(x1 - x0) + 2(y0 - y1)
    else
      d = d +  2(y0 - y1)
```

Question 3. Write out the equation for the color, c, of a surface in terms of the reflectivity c_r, the normal vector **n**, and the direction to the light source, **l**. Draw a figure illustrating this relation.

Question 4. Phong's lighting model can be written

$c = c_l \max(0,\mathbf{e}\cdot\mathbf{r})^p$

Draw a diagram for the Phong lighting model similar to the one in Question 3, except add the additional vectors **e** and **r** and explain their role. Then discuss the meaning and use of the exponent p as well as giving typical values that are used in practice.

Question 5. The equation for a sphere can be written in the explicit form

$(\mathbf{p} - \mathbf{c}) \cdot (\mathbf{p} - \mathbf{c}) = R^2$

where **p** is a point on the surface and **c** is the center.

To solve the ray tracing equation for a line $\mathbf{p}(t) = \mathbf{e} + t\mathbf{d}$, it needs to be substituted in the equation $f(\mathbf{p}(t)) = 0$, where $f(\mathbf{p}) = 0$ is the implicit equation of the sphere (trivially derived from the explicit form).

Solve the ray tracing equation by the substitution just described and collect the powers of t to produce a polynomial who's roots are the intersection values. You do not need to solve the resulting polynomial. Hint: Each coefficient of a power of t is an inner product and the constant term is $-R^2$ (that's minus R^2).

Question 6. Discuss hard and soft shadows by drawing and explaining a few simple diagrams. If you know the meaning of *umbra* and *penumbra*, they can be useful in labeling and explaining your figures.