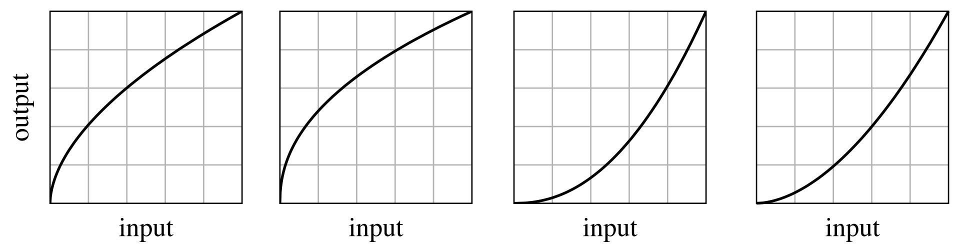
CS 465 Final Exam

Friday 16 December 2005—2.5 hours

Problem 1: Gamma correction (10 pts)

Consider these graphs of several transfer functions:



Match each graph with the description of the device or operation that uses that transfer function:

a Transfer function of a monitor with $\gamma = 1.8$.

b Gamma correction curve for $\gamma = 1.8$.

c Transfer function of a monitor with $\gamma = 2.2$.

d Gamma correction curve for $\gamma = 2.2$.

(This is a one to one matching.)

Problem 2: Triangle meshes (10 points)

The following indexed triangle set has a problem with it. What is the problem, and how can you tell?

vertices		triangles	
0	(0, 0, 0)	0	(0, 2, 1)
1	(1, 0, 0)	1	(1, 2, 3)
2	(0, 1, 0)	2	(0, 3, 2)
3	(0, 0, 1)	3	(1, 0, 3)

Problem 3: 3D Rotations and Viewing (18 points)

Assume that you have a triangle in object space with vertices: $(1, 0, 0)$, $(0, 1, 0)$ and $(0, 0, 1)$.

1. The triangle undergoes the following transformations in order to move to world space.
   (a) Scaling along the x axis and y axis by $\sqrt{2}$
   (b) Rotation about the z axis by $45°$
   (c) Translation by the vector $(1, -1, 1)$

   Give the modeling transformation matrix (as a single matrix) and calculate the positions of the three vertices in world space.

2. The camera is placed at $(5, 0, 0)$ looking at the origin. The camera up vector is the y axis. Give the viewing matrix, and calculate the positions of the three vertices in eye space.

3. If the projection matrix is:

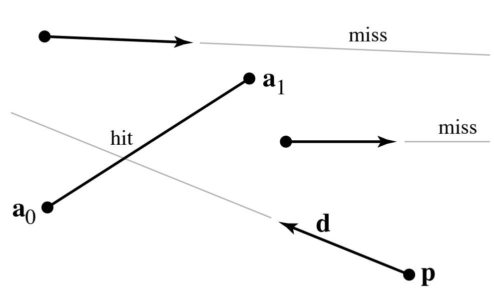
$$\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & -2 & -6 \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

   What are the near and far planes? We are using the 2-unit cube convention for the view volume in clip space.

4. The triangle's vertices after transformation by the modeling, viewing, and projection matrices are: $(-3, 0, 0, 3)$, $(-3, 0, 4, 5)$ and $(-6, -3, 2, 4)$. Will part of the triangle be clipped during rasterization, or is it all visible? If it will be clipped, which side(s) of the view volume is it clipped by?

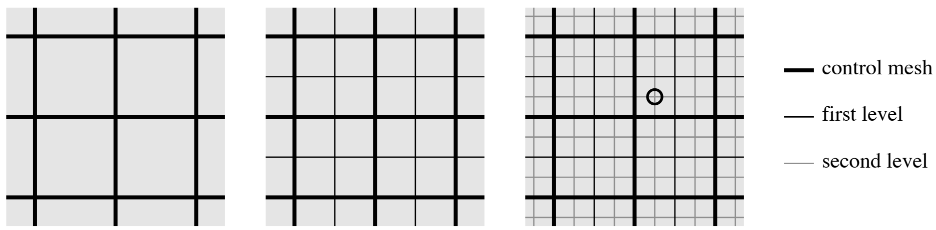
Problem 4: Ray intersection (18 points)

We have extensively discussed ray-triangle intersection in 3D; the 2D analog is intersecting a ray with a line segment in the plane. Give pseudocode that takes as input the two endpoints $\mathbf{a}_0$ and $\mathbf{a}_1$ of a line segment and the point $\mathbf{p}$ and direction $\mathbf{d}$ defining a ray, and returns a ray parameter t at which the intersection takes place, or $+\infty$ if the ray misses the line segment.

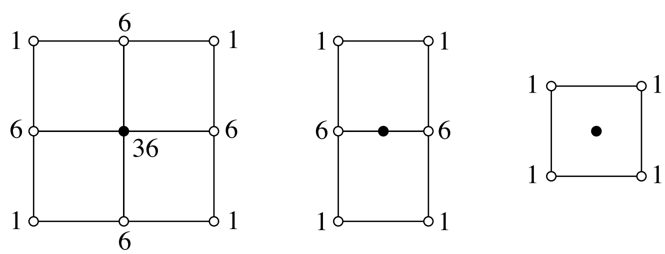


Problem 5: Subdivision (16 points)

In the homework we derived two-level subdivision masks, which express the vertex positions after two subdivision steps as weighted sums of the control vertices, for the Loop rules on triangle meshes. Here we will do the same for the Catmull-Clark rules. Recall that these rules apply to quadrilateral meshes and split each face into four by adding a vertex for each edge and a vertex for each face:



The vertex positions are computed using different masks for existing vertices, new vertices on edges, and new vertices at face centers:

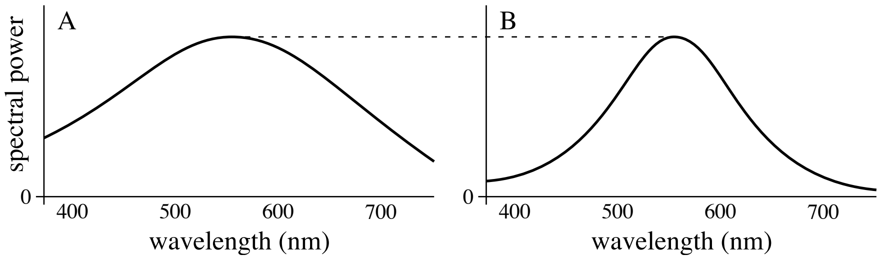


(Note that these masks are written with implied denominators of 64, 16, and 4 respectively.)

Compute the two-level subdivision mask for the point at the second subdivision level that is circled in the upper diagram. This is a mask that applies to the control mesh and expresses the second level vertex position as a weighted sum of the control vertices' positions. *Hint*: You can check your arithmetic by making sure the weights sum to 1.

Problem 6: Color (12 points)

Consider the following spectra, A and B:



1. Which spectrum has higher luminance (brightness), or are they about the same? How can you tell?
2. Which spectrum has higher saturation (colorfulness), or are they about the same? How can you tell?
3. Are the hues of the two spectra different, or are they about the same? How can you tell?

Problem 7: Splines (16 points) Assume you have Bézier spline arranged as shown in the figure below. Control points 0, 2, and 3 remain fixed, but point 1 can be moved up and down. For what value of h does the spline become tangent to the line $y = 1$? At what value of the spline parameter t is the tangent point?