Name:_____

ECSE-4750 Computer Graphics, Fall 1998
Handout 22*
Final Exam

April 27, 1999

Rules

1. You may have two 2-sided 8.5 inch x11 inch note sheets, which may be mechanically printed.
2. You may have your blank paper, calculator, pens, etc.
3. You may not communicate with anyone, except Giampiero or me.
4. Answer all questions. Brief, concise, answers are preferred.
5. Spend time on a question proportional to its number of points.
6. Note that the last page is number **22–12**.
7. Start immediately. You have until 2 pm.
8. Try to write legibly.
9. Write your NAME on top of this page.
10. Try to write your answers on these question sheets, tho extra paper is allowed. If an answer is on an extra sheet, say so in the normal space on this sheet.
11. Leave the small oval boxes blank; they're for our grade.

Exam

Geometry Warmup

1. In 3D, consider the X-axis and the point $(3, 2, 1)$.

   (a) ____/[2] What is the equation of the plane thru the both of them, in the form $ax + by + cz + d = 0$?

Intro

2. ____/[1] Portability has at least one disadvantage, other than making it easier for your competitor to copy your program. Name it.

Algorithms

3. I described 2 fill algorithms, called *polygon fill* and *seed fill*.

   (a) ____/[1] Which one would a vector drawing program like *xfig* be more likely to use?

(b) ____/[1] Which one would a raster paint program like *xpaint* be more likely to use?

4. ____/[2] One step along the way towards the Bresenham line algorithm has the program looking like this:

```
m=y1/x1;
d=0;
pixel(0,0);
y=0;
for(x=1;x<=x1;x++)
{  d+= m;
   if (d>= 1/2)
   {  d -= 1;
      y++;  }
   pixel(x,y);
}
```

Then I "Scale up m and d by 2x" to create the next version of the code. Why?

5. ____/[1] What property of many modern CPUs makes *if* statements undesirable in tight loops?

6. ____/[2] Which of the following 3 methods will draw the most accurate circle $y = \sqrt{100 - x^2}$

over the interval $0 \leq x \leq 71$, given the same number of terms in the approximation? Which method will be second best?

(a) a Taylor expansion about $x = 0$.

(b) a Taylor expansion about $x = 35$.

(c) a Chebyshev expansion over the interval $[0, 71]$.

7. ____/[2]

In this version of the Bresenham circle algorithm, look at the comment.

```
y=r;
d= -r;
pixel(0,r);
for(x=1;x<r/sqrt(2);x++)
{  d+= 2x-1;
   if (d>=0)
   {  y--;
      d -= 2y; /* Must do this AFTER y-- */
   }
   pixel(x,y);
}
```

Would we still get the right answer if we ignored the comment, and swapped the two statements thus:

```
...
   if (d>=0)
   {  d -= 2y; /* Must do this AFTER y-- */
      y--;

   }
...
}
```

Why (not)?

8. ____/[1] Are *bitmapped* or *outline* fonts more suitable to a low-res terminal?

9. ____/[1] Are *bitmapped* or *outline* fonts more suitable to a 1200 DPI printer?

10. Characters are normally typeset by assuming a rectangle around each char, and placing the rectangles adjacent to each other. That works well in most cases, such as this: **ABCDEFGHIK**. However, sometimes it causes apparent gaps, like between A and V here:
AVXAVXAVXAVX.

    (a) ____/[1] What's the name of the fix in PostScript?

11. This is about the Sutherland-Hodgman paper and patent.

    (a) ____/[2] Draw an example of a polygon and a clip window, where the clipped polygon will have twice as many vertices as the original one.

Hardware

12. ____/[1] Which hardcopy device might remind you of the movie *Animal House*?

13. Computer monitors tend to use an RGB color space, but color NTSC TVs do not.

(a) ____/[1] What space do they use?

(b) ____/[1] How does the choice of first axis make color NTSC more compatible with something or other?

14. ____/[1] What limits the practical resolution of color CRT monitors? (2 words)

15. ____/[2] Suppose that your video game generates a narrow horizontal white line on your TV. The line may appear to flicker at 30Hz even though other parts of the image, such as large rectangles, look stable. Why? How do high quality computer graphics displays prevent this problem? (Not playing video games, and not displaying narrow lines, are not acceptable answers.)

16. ____/[1] What is the operating principle of the Polhemus 3D location device? Pick one: optical, mechanical, magnetic, electrostatic, psychic, chemical.

Transformations

17. Our vector formula for rotating a point p about an axis a is this:

$$p' = a \cdot p\, a + (p - a \cdot p\, a)\cos\theta + a \times p \sin\theta$$

(a) ____/[1] Does p need to be normalized?

(b) ____/[1] Does a need to be normalized?

18. Consider the following matrix, which is a 3-D rotation:

$$\begin{bmatrix} 0.9023689270 & -0.1910440617 & 0.3863062075 \\ 0.3863062075 & 0.7559223176 & -0.5285347327 \\ -0.1910440617 & 0.6261658057 & 0.7559223176 \end{bmatrix} \quad (1)$$

(a) ____/[1] What is the cosine of the angle of rotation?

(b) ____/[1] What is the axis of rotation? You don't need to normalize it.

19. ____/[1] Give a homogeneous coordinate matrix for scaling any given homogeneous vector (x, y, z, w) to half its cartesian length.

20. ____/[2] Rotate the 3D point (2,0,0) about the axis (0.577, 0.577, 0.577) by 180 degrees.

21. ____/[2] Consider the function $F(p) = (a \cdot p)a$, where a and p are 3-D Cartesian vectors, and $a = \begin{pmatrix} 0 \\ 2 \\ 3 \end{pmatrix}$. Find a 3x3 matrix M, such that $F(p) = Mp$.

Projection

22. ____/[2] One advantage of homogeneous coordinates is that points at ∞ can be represented. What is the homogeneous coordinate representation for the point at ∞ on the line $y = 2x + 2$? (Might require thinking.)

23. ____/[2] Name 2 other advantages of homogeneous coords.

24. ____/[2] Find the 4x4 homogeneous matrix for a perspective projection from the origin to the projection plane with cartesian equation $4x + 3y + 2z = 1$.

25. ____/[3] With that projection, what Cartesian points would these Cartesian points project onto:

(a) (1,0,0)
(b) (1,1,0)
(c) (1,1,1)

26. ____/[1] What point would the infinite homogeneous point (1,2,3,0) project onto?

Color

27. ____/[1] Should you use *additive* or *subtractive* colors to do color mixing on a CRT?

28. ____/[1] Should you use *additive* or *subtractive* colors to do color mixing on a sheet of paper?

Visible Surface Determination

29. ____/[2] Draw an arrangement of polygons that the painters algorithm would not be able to handle, w/o some modification, such as splitting one polygon into two parts.

30. ____/[2] Give 2 ways that antialiasing can be added to ray tracing without increasing the time by a factor of, say, 16?

Illumination and Shading

31. ____/[2] Suppose you wish to make a virtual trip all around through a to-be-built building,

and would like reasonable shading. Would ray-tracing or radiosity be your primary shading method? Why?

32. ____/[1] If you want to model a scene with lots of transparent glass balls, is ray-tracing or radiosity better?

33. For Phong and Gouraud shading, which

(a) ____/[1] represents highlights better?

(b) ____/[1] is faster to execute, or similarly, uses less HW to implement?

34. ____/[2] What is bump mapping? Why is it useful?

Misc

35. ____/[2] Name 2 specific ways, other than using a table, to display Math in HTML.

36. ____/[1] What is a *texel* (2 words)?

37. ____/[1] Which company owns the Jan 1999 patent on style sheets?

Total: 60 points
End of exam

Notes

1. Grades should be ready in 2 weeks. We'll email them, or you may phone Giampiero or me.
2. You may examine your graded exam, but not keep it (you may have a copy if you want). We will gladly correct solid, definite, unambiguous, grading errors.
3. You're welcome to ask me graphics, or other, questions, in the future (if you can find me). I might even have answers.
4. Have a good summer.
5. I might also be willing to sign off on independent reading courses on this next fall. The way that this works is that you do all the work on your own, then you write a report on what you did, and get a grade.