CompSci 373 S1 C 2013
Computer Graphics and Image Processing

Mid Term Test – Monday, 6th May 2013, 6.30 pm – 7.30 pm

VERSION CODE 00000001

Instructions:

1. Enter your *name*, *student ID* and the *version number* shown on the top left into the teleform sheet supplied. Your name should be entered left aligned. If you have a middle initial, enter it under MI. If your name is longer than the number of boxes provided, truncate it.
2. Use a dark pencil to mark your answers on the teleform sheet supplied. If you spoil your sheet, ask the exam supervisor for a replacement. Writing on this question book will **NOT be marked**.
3. If you want to change your answer **erase the previously filled in box completely** using an eraser.
4. All questions must be answered in the multiple choice answer boxes on the teleform sheet corresponding to the respective question number. There is only one correct answer for each question.
5. **Questions total 50 Marks**. Each question is worth 2 marks.
6. Attempt **ALL** questions.
7. The test is for 60 minutes.
8. This is a **closed book** test.
9. Calculators and electronic devices are **NOT** permitted.
10. This test is worth 20% of your final marks for CompSci373 S1 C

Question 1:

The dot product of $\mathbf{u} = \begin{pmatrix} -1 \\ 2 \\ -3 \end{pmatrix}$ and $\mathbf{v} = \begin{pmatrix} 1 \\ 4 \\ 1 \end{pmatrix}$ equals

(a) -1
(b) 4
(c) 12
(d) 8
(e) None of the others

Question 2:

The cross product of $\mathbf{u} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\mathbf{v} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$ equals

(a) $\begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}$

(b) 0

(c) $\begin{pmatrix} -8 \\ -2 \\ 4 \end{pmatrix}$

(d) $\begin{pmatrix} 4 \\ 2 \\ -8 \end{pmatrix}$

(e) None of the others

Question 3:

The orthogonal projection of vector $\mathbf{b} = \begin{pmatrix} -1 \\ 0 \\ 3\sqrt{2} \end{pmatrix}$ onto vector $\mathbf{a} = \begin{pmatrix} 0 \\ \sqrt{2} \\ \sqrt{2} \end{pmatrix}$ is equal to:

(a) $2\begin{pmatrix} 0 \\ \sqrt{2} \\ \sqrt{2} \end{pmatrix}$

(b) 2

(c) $\begin{pmatrix} 0 \\ -2 \\ 6 \end{pmatrix}$

(d) $\begin{pmatrix} -1 \\ -\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}$

(e) None of the others

Question 4:

Assume square matrix $M=\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$

Which of the following statement about the inverse matrix M^{-1} of matrix M is *true*?

(a) $M^{-1}=\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$

(b) $M^{-1}=\frac{1}{4}\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$

(c) $M^{-1}=\frac{1}{4}\begin{pmatrix} -1 & 1 \\ -1 & 1 \end{pmatrix}$

(d) M has no inverse

(e) None of the others

Question 5:

Given a sphere defined by the equation $(x-1)^2 + (y-2)^2 + (z-3)^2=1$, what are the coordinates of the normalized vector **n** orthogonal to the sphere surface at point $P = \begin{pmatrix} 1 \\ 3 \\ 3 \end{pmatrix}$?

(a) $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

(b) $\begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix}$

(c) $\begin{pmatrix} -\frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ -\frac{1}{\sqrt{3}} \end{pmatrix}$

(d) There is no such vector **n**

(e) None of the others

Question 6:

What equation below defines the plane containing the points $A = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$, $B = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$, and $C = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$?

(a) x+y+z = 0
(b) x-y+z = 1
(c) x+y+z = 1
(d) x-y-z = 1
(e) None of the others

Question 7:

Given is a plane defined by the normal $\mathbf{n}=\begin{pmatrix}1\\1\\-1\end{pmatrix}$ and the point $P=\begin{pmatrix}1\\0\\0\end{pmatrix}$. What is the distance of the point $Q=\begin{pmatrix}2\\1\\1\end{pmatrix}$ to this plane?

(a) 0 (i.e. point Q is on the plane)

(b) $\frac{1}{\sqrt{3}}$

(c) 2

(d) $3-\sqrt{3}$

(e) None of the others

Question 8:

What is the distance between the plane defined by equation $x+z=\sqrt{2}$ and the origin:

(a) 0 (the origin is on the plane)
(b) 1
(c) $\sqrt{2}$
(d) 2
(e) None of the others

Question 9:

Given the following affine transforms: rotation **R**, Scaling **S** and translation **T**, which of the statements below is always *true*?

(a) $ST = TS$
(b) $(RT)^{-1} = R^{-1}T^{-1}$
(c) $R^{-1} = R = R^{T}$
(d) $S^{-1} = -S$
(e) None of the others

Question 10:

Which of the following statements on Phong illumination is true?

(a) The diffuse reflection is influenced by the reflection direction and the angle at the reflection point between the light source and the viewing direction
(b) The diffuse reflection intensity depends on the "shininess" parameter of the material
(c) The diffuse reflection is independent of the viewing angle
(d) The diffuse reflection intensity at the reflection point depends on the distance to the light source
(e) None of the others

Question 11:

A point **p** is element of a plane P with unit normal **n** at a distance *a* from the origin if it fulfills the equation $\mathbf{p}\cdot\mathbf{n} - a = 0$. Given a ray passing through point *eye* and point **m,** defined by its parametric equation (parameter **t**), which expression about the value of ***t*** for the intersection between the ray and the plane is true?

(a) $t = \dfrac{a + (\mathbf{m} - \mathbf{eye})\cdot\mathbf{n}}{\mathbf{eye}\cdot\mathbf{n}}$

(b) $t = \dfrac{a + \mathbf{eye}\cdot\mathbf{n}}{\mathbf{eye}\cdot\mathbf{n}}$

(c) $t = \dfrac{a - (\mathbf{m} - \mathbf{eye})\cdot\mathbf{n}}{\mathbf{eye}\cdot\mathbf{n}}$

(d) $t = \dfrac{a - \mathbf{eye}\cdot\mathbf{n}}{(\mathbf{m} - \mathbf{eye})\cdot\mathbf{n}}$

(e) None of the above

Question 12:

What is the (closest to $eye = \begin{pmatrix} -2 \\ -1 \\ -1 \end{pmatrix}$), intersection point $p(t_0)$ of the ray $p(t) = \begin{pmatrix} -2 \\ -1 \\ -1 \end{pmatrix} + t\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$ with the sphere of equation $x^2+y^2+z^2=1$?

(a) There is no intersection point

(b) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = 1$

(c) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \sqrt{2}$

(d) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = 0$

(e) None of the others

Question 13:

What is the (closest to $eye = \begin{pmatrix} 0 \\ 0 \\ -10 \end{pmatrix}$), intersection point $p(t_0)$ of the ray starting from *eye* in direction vector $\begin{pmatrix} 0 \\ 5 \\ 5 \end{pmatrix}$ with the cylinder defined by the equation $\begin{cases} x^2 + z^2 = 1 \\ -10 \le y \le 10 \end{cases}$?

(a) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \frac{9}{5}$

(b) There is no intersection point

(c) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \frac{11}{5}$

(d) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \frac{7}{5}$

(e) None of the others

Question 14:

Given is a world coordinate window with the coordinates x_{left}=0.0, x_{right}=2.0, y_{bottom}=0.0, y_{top}=3.0, and a window on the screen (the viewport) with width = 400 pixels, height = 600 pixels, and top-left corner at the pixel (100,300) on the screen.
What is the homogeneous matrix **M** for the world-to-viewport mapping?

(a) $\mathbf{M} = \begin{pmatrix} 200 & 0 & 100 \\ 0 & -200 & -300 \\ 0 & 0 & 1 \end{pmatrix}$

(b) $\mathbf{M} = \begin{pmatrix} 200 & 0 & 100 \\ 0 & -200 & 300 \\ 0 & 0 & 1 \end{pmatrix}$

(c) $\mathbf{M} = \begin{pmatrix} 200 & 0 & 100 \\ 0 & 200 & 300 \\ 0 & 0 & 1 \end{pmatrix}$

(d) $\mathbf{M} = \begin{pmatrix} 200 & 0 & 100 \\ 0 & 200 & -300 \\ 0 & 0 & 1 \end{pmatrix}$

(e) None of the others

Question 15:

What is the most suitable display mode for an OpenGL window showing an animated 3D scene using coloured partially transparent objects?

(a) `glutInitDisplayMode(GLUT_SINGLE|GLUT_RGBA|GLUT_DEPTH);`

(b) `glutInitDisplayMode(GLUT_DOUBLE|GLUT_RGBA|GLUT_DEPTH);`

(c) `glutInitDisplayMode(GLUT_SINGLE|GLUT_RGB|GLUT_DEPTH);`

(d) `glutInitDisplayMode(GLUT_DOUBLE|GLUT_RGB);`

(e) None of the others

Question 16:

Given is the following code drawing a line segment:

```
glBegin(GL_LINES);
glColor3f(0.5, 1.0, 1.0);
glVertex3f(0.0, 1.0, 1.0);
glColor3f(1.0, 0.5, 0.0);
glVertex3f(x, y, z);
glEnd();
```

The point (1, 1.5, 0.5) of the above line segment has the colour (0.75, 0.75, 0.5).
What are the values of (x, y, z) in the code above?

(a) x=2.0, y=2.0, z=0.0
(b) x=0.75, y=0.75, z=0.5
(c) x=1.0, y=0.5, z=0.0
(d) x=1.0, y=2.0, z=2.0
(e) None of the others

Question 17:

Which of the following statements is *false*?

(a) A solid cone can be drawn using two triangle fans.
(b) A solid cube can be drawn using one quad strip with four quadrilaterals and one quad strip with two quadrilaterals.
(c) A convex polygon can be drawn using one triangle fan.
(d) Every quadstrip can be drawn using a triangle strip.
(e) A solid cube can be drawn using six quadrilaterals.

Question 18:

Given is a triangle with the vertices A, B and C, and a point P inside the triangle. What are the Barycentric coordinates (α, β, γ) of the point P?

(a) $\alpha = \frac{\text{Area of the triangle } \overline{PAB}}{\text{Area of the triangle } \overline{ABC}}, \ \beta = \frac{\text{Area of the triangle } \overline{APC}}{\text{Area of the triangle } \overline{ABC}}, \ \gamma = \frac{\text{Area of the triangle } \overline{ABP}}{\text{Area of the triangle } \overline{ABC}}$

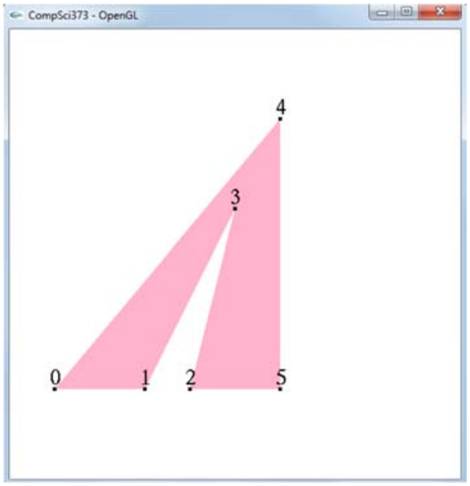
(b) $\alpha = \frac{\text{Area of the triangle } \overline{ABP}}{\text{Area of the triangle } \overline{ABC}}, \ \beta = \frac{\text{Area of the triangle } \overline{PBC}}{\text{Area of the triangle } \overline{ABC}}, \ \gamma = \frac{\text{Area of the triangle } \overline{APC}}{\text{Area of the triangle } \overline{ABC}}$

(c) $\alpha = \frac{\text{Area of the triangle } \overline{PAB}}{\text{Area of the triangle } \overline{ABC}}, \ \beta = \frac{\text{Area of the triangle } \overline{PAC}}{\text{Area of the triangle } \overline{ABC}}, \ \gamma = \frac{\text{Area of the triangle } \overline{PBC}}{\text{Area of the triangle } \overline{ABC}}$

(d) $\alpha = \frac{\text{Area of the triangle } \overline{PBC}}{\text{Area of the triangle } \overline{ABC}}, \ \beta = \frac{\text{Area of the triangle } \overline{PAC}}{\text{Area of the triangle } \overline{ABC}}, \ \gamma = \frac{\text{Area of the triangle } \overline{PAB}}{\text{Area of the triangle } \overline{ABC}}$

(e) None of the others

Question 19:



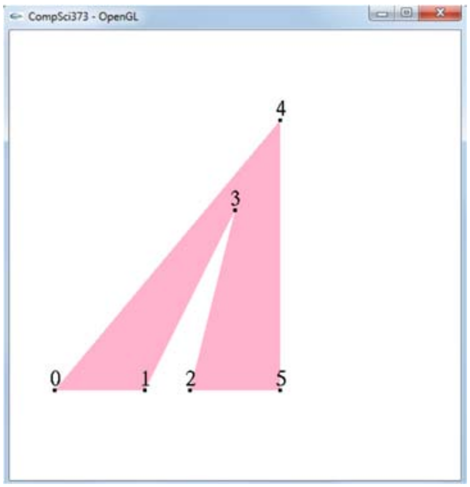
Given are the vertices

```
const int numVertices=6;
const float vertices[numVertices][2] =
   {{50,100},{150,100},{200,100},
    {250,300},{300,400},{300,100}};
```

Which calling sequence of these vertices (using `glVertex2fv`) results in the shape on the right if we use the OpenGL commands `glBegin(`**`GL_TRIANGLE_STRIP`**`)` and `glEnd()`?

(a) 0, 1, 3, 2, 5, 4
(b) 0, 4, 1, 3, 2, 5
(c) 0, 1, 3, 4, 2, 5
(d) 0, 1, 4, 3, 5, 2
(e) None of the above

Question 20:



Given are the vertices

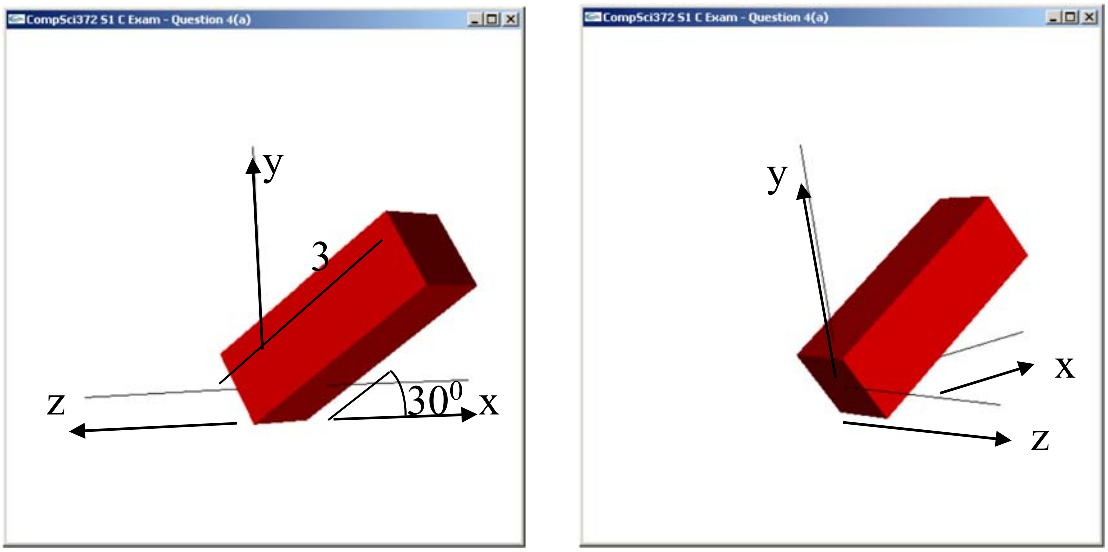
```
const int numVertices=6;
const float vertices[numVertices][2] =
   {{50,100},{150,100},{200,100},
    {250,300},{300,400},{300,100}};
```

Which calling sequence of these vertices (using `glVertex2fv`) results in the shape on the right if we use the OpenGL commands `glBegin(`**`GL_TRIANGLE_FAN`**`)` and `glEnd()`?

(a) 0, 1, 2, 3, 4, 5
(b) 0, 4, 5, 2, 3, 1
(c) 3, 1, 2, 5, 4, 0
(d) 3, 0, 1, 2, 5, 4
(e) None of the above

Question 21:

Given is a function `drawCube()` which draws an axis-aligned unit cube with side length 1 centred at the origin. Which code segment below transform the unit cube into the cuboid shown below? The cuboid has a length of 3 units, a unit square cross section and it forms an angle of 30 degree with the x-axis.



(a)
```
glPushMatrix();
glRotatef(30,1,0,0);
glTranslatef(1.5,0,0);
glScalef(3,1,1);
drawCube();
glPopMatrix();
```

(b)
```
glPushMatrix();
glTranslatef(0.5,0,0);
glScalef(3,1,1);
glRotatef(30,0,0,1);
drawCube();
glPopMatrix();
```

(c)
```
glPushMatrix();
glRotatef(30,0,0,1);
glScalef(3,1,1);
glTranslatef(0.5,0,0);
drawCube();
glPopMatrix();
```

(d)
```
glPushMatrix();
glTranslatef(0.5,0,0);
glScalef(3,1,1);
glRotatef(30,1,0,0);
drawCube();
glPopMatrix();
```

(e) None of the above

Question 22:

What is the Modelview matrix **M** defined by the code segment below?

```
glMatrixMode( GL_MODELVIEW );
glLoadIdentity();
glRotatef(90, 0, 0, 1);
glTranslatef(5, 1, 0);
```

(a) $\mathbf{M} = \begin{pmatrix} \cos\frac{\pi}{2} + 5 & -\sin\frac{\pi}{2} + 1 & 0 & 5 \\ -\sin\frac{\pi}{2} & -\cos\frac{\pi}{2} & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(b) $\mathbf{M} = \begin{pmatrix} \cos\frac{\pi}{2} & -\sin\frac{\pi}{2} & 0 & 5 \\ \sin\frac{\pi}{2} & \cos\frac{\pi}{2} & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

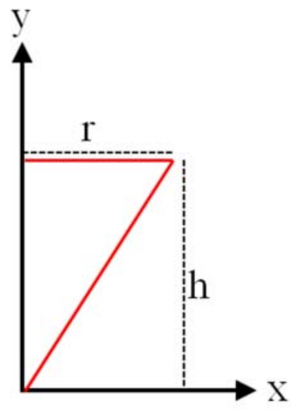
(c) $\mathbf{M} = \begin{pmatrix} \cos\frac{\pi}{2} & \sin\frac{\pi}{2} & 0 & 5 \\ -\sin\frac{\pi}{2} & \cos\frac{\pi}{2} & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

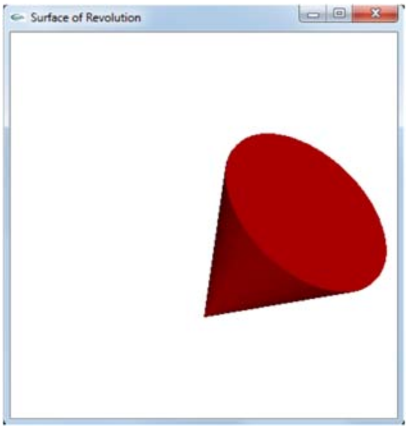
(d) $\mathbf{M} = \begin{pmatrix} \cos\frac{\pi}{2} & -\sin\frac{\pi}{2} & 0 & 5\cos\frac{\pi}{2} - \sin\frac{\pi}{2} \\ \sin\frac{\pi}{2} & \cos\frac{\pi}{2} & 0 & 5\sin\frac{\pi}{2} + \cos\frac{\pi}{2} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(e) None of the others

Question 23:

The surface of revolution below on the right is created by revolving the profile curve **c**(t)=(x(t), y(t), z(t)) in the image below on the left around the y-axis.





What is the equation of the section of the profile curve starting at **c**(0) = (0,0,0) and ending at **c**(0.5) = (r,h,0)?

(a) $\boldsymbol{c}(t) = \begin{pmatrix} 2rt \\ 2ht \\ 0 \end{pmatrix}$

(b) $\boldsymbol{c}(t) = \begin{pmatrix} 2rt \\ 2h(1-t) \\ 0 \end{pmatrix}$

(c) $\boldsymbol{c}(t) = \begin{pmatrix} r(t+1) \\ 2h(1-t) \\ 0 \end{pmatrix}$

(d) $\boldsymbol{c}(t) = \begin{pmatrix} rt \\ ht \\ 0 \end{pmatrix}$

(e) None of the others

Question 24:

What is the equation of the normal $\mathbf{n}(s, t)$ of the surface-of-revolution $\boldsymbol{p}(s,t) = \begin{pmatrix} x(\mathrm{t})\cos(2\pi s) \\ x(\mathrm{t})\sin(2\pi s) \\ z(\mathrm{t}) \end{pmatrix}$?

(a) $\boldsymbol{n}(s,t) = \begin{pmatrix} z'(\mathrm{t})\cos(2\pi s) \\ z'(\mathrm{t})\sin(2\pi s) \\ x'(\mathrm{t}) \end{pmatrix}$

(b) $\boldsymbol{n}(s,t) = \begin{pmatrix} x'(\mathrm{t})\cos(2\pi s) \\ x'(\mathrm{t})\sin(2\pi s) \\ z'(\mathrm{t}) \end{pmatrix}$

(c) $\boldsymbol{n}(s,t) = x(t)\begin{pmatrix} x'(\mathrm{t})\cos(2\pi s) \\ x'(\mathrm{t})\sin(2\pi s) \\ -z'(\mathrm{t}) \end{pmatrix}$

(d) $\boldsymbol{n}(s,t) = x(t)\begin{pmatrix} z'(\mathrm{t})\cos(2\pi s) \\ z'(\mathrm{t})\sin(2\pi s) \\ -x'(\mathrm{t}) \end{pmatrix}$

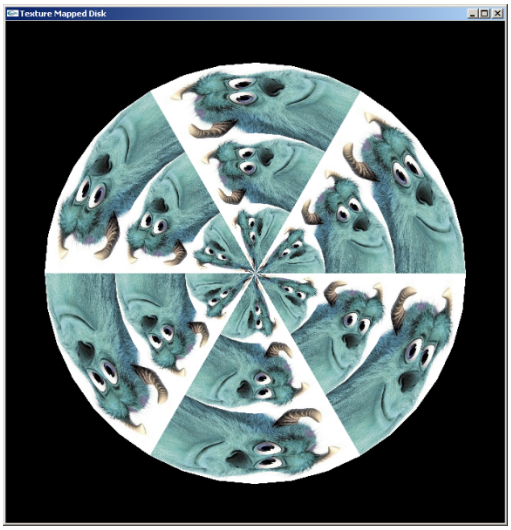
(e) None of the others

Question 25:

A disk with radius 1 can be described by the parametric equation

$$\mathbf{p}(s,t) = \begin{pmatrix} s\sin t \\ s\cos t \\ 0 \end{pmatrix}$$

where the parameter s lies within the interval $[0,1]$ and the parameter t lies within the interval $[0,2\pi]$.



The disk is texture mapped with the texture image above on the left resulting in the image shown above on the right.

The rendering code contains the following code fragment:

```
for(i=0;i<nStacks;i++)
{
   glBegin(GL_QUAD_STRIP);
   for(j=0;j<=nSegments;j++)
   {
      s=(float) i/(float) nStacks;
      t=(float) j/(float) nSegments;
      <MISSING LINE>
      glVertex3f(s*cos(t*2*Pi),s*sin(t*2*Pi),0);
      s=(float) (i+1)/(float) nStacks;
      <MISSING LINE>
      glVertex3f(s*cos(t*2*Pi),s*sin(t*2*Pi),0);
   }
   glEnd();
}
```

What code do you need to insert into the lines marked by "**`<MISSING LINE>`**" in order to get the texture mapped disk shown in the image above?

(a) `glTexCoord2f(cos(t*2*Pi), sin(t*2*Pi));`
(b) `glTexCoord2f(3, 6);`
(c) `glTexCoord2f(s, t);`
(d) `glTexCoord2f(3*s, 6*t);`
(e) None of the others

Rough Working – This page will not be marked