DELFT UNIVERSITY OF TECHNOLOGY
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Computer Graphics (in2770)
28 October 2003, 9.00 - 11.00 h.

N.B.: This examination contains 30 questions
Total number of pages: 11

Instructions for filling in the Multiple Choice answer form:

- Fill in the form preferably with ballpoint or lead-pencil. Do not use red ink. Do not cross out. Erasing, when using lead-pencil, is allowed.

- Do not forget to fill in your **name**, **branch of science** and **student number**.

- Fill in your **student number** in the student number area **in cipher** and also **by filling in the squares** (check carefully).

Question 1

An image for which Gouraud shading was used is not so realistic (high quality) as an image for which Phong shading was used. Why not?

a. With Gouraud shading the approximation of the light sources is not so good.
b. With Gouraud shading colors, instead of normal vectors, are interpolated.
c. With Gouraud shading no specular reflections are calculated.
d. With Gouraud shading the ambient component is not accounted for.

Question 2

The transformation matrix for a 3D scaling (in homogeneous coordinates) with scale factors s_x, s_y and s_z relative to a point F = (x_F, y_F, z_F) is called S_F. The image P' of a point P under this transformation can be determined from $P' = S_F \cdot P$
What does matrix S_F look like?

a. $S_F = \begin{pmatrix} s_x & 0 & 0 & (1-s_x)x_F \\ 0 & s_y & 0 & (1-s_y)y_F \\ 0 & 0 & s_z & (1-s_z)z_F \\ 0 & 0 & 0 & 1 \end{pmatrix}$

b. $S_F = \begin{pmatrix} s_x & 0 & 0 & -s_x x_F \\ 0 & s_y & 0 & -s_y y_F \\ 0 & 0 & s_z & -s_z z_F \\ 0 & 0 & 0 & 1 \end{pmatrix}$

c. $S_F = \begin{pmatrix} s_x & 0 & 0 & s_x x_F \\ 0 & s_y & 0 & s_y y_F \\ 0 & 0 & s_z & s_z z_F \\ 0 & 0 & 0 & 1 \end{pmatrix}$

d. $S_F = \begin{pmatrix} s_x & 0 & 0 & x_F \\ 0 & s_y & 0 & y_F \\ 0 & 0 & s_z & z_F \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Question 3

Consider the following statements about a general 3D viewing system with a perspective projection.

(I) When projecting a scene on a projection plane, an object that is between the projection plane and the Center Of Projection (COP) is projected smaller than the same object that is placed behind the projection plane relative to the COP.
(II) The viewing frustum (viewing pyramid) is determined completely by the Center Of Projection, the View Reference Point and the near plane and far plane.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 4

3D models of objects are stored in a computer as a list of polygons. For every polygon an ordered list of vertices is stored.
Often, also the coefficients of the plane equations of the polygon planes are stored. Why do we do this last thing?

a. because otherwise, the generation of images of the 3D object will take more computer time.
b. because otherwise, the 3D object is described ambiguously, i.e. for one model there may be more than one valid object.
c. because otherwise, the 3D object is not described completely, i.e. from one model the shape of the intended object can not always be derived.
d. because otherwise, only line drawings of the 3D object can be made, as a result of the lack of information that is needed to calculate a color for the visible polygons.

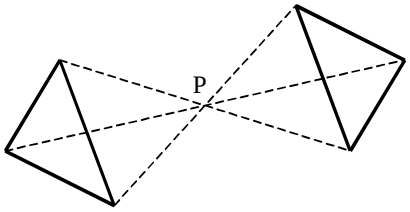
Question 5

A y-direction shearing transformation relative to the line x=0 maps the point P(3, 4) on P'(3, 16). What is the shear parameter for this shearing?

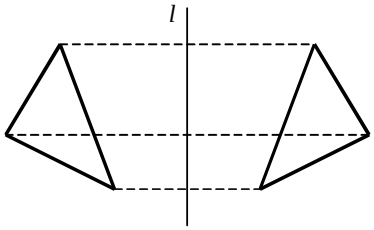
a. 2
b. 4
c. 8
d. 12

Question 6

The figure below shows the difference between a *point mirroring* and a *line mirroring (reflection)* operation.



point mirroring relative to a point P



line mirroring relative to a line l

Consider the following 2D transformation matrices:

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

How many of these transformation matrices represent a *point mirroring* operation?

a. 1
b. 2
c. 3
d. 4

Question 7

We want to color the interior of a circle with a fill algorithm. The boundary of the circle is already in the frame buffer. The background of the circle in the frame buffer has one color, and this color is different from both the color of the boundary and the fill color.
Consider the following statements:

(I) Every circle that is correctly colored with the 4-connected boundary fill algorithm, will also be correctly colored with the 8-connected boundary fill algorithm.
(II) Every circle that is correctly colored with the 8-connected boundary fill algorithm, will also be correctly colored with the 4-connected boundary fill algorithm.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 8

Consider the following statements about texture mapping.

(I) For a bilinear mapping, straight lines (in an arbitrary direction) in texture space are mapped on straight lines in screen space.
(II) For a perspective mapping, straight lines (in an arbitrary direction) in texture space are mapped on straight lines in screen space.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 9

Which statement describes the operation of the `glutMainLoop()` function from the OpenGL Utility Toolkit in the best way?

The function `glutMainLoop()` creates a loop in which repeatedly

a. the next graphical output primitive is displayed on an output device.
b. all event procedures, defined in the program, are executed.
c. is waited for an event to occur, whereafter the callback function of that event is executed.
d. is waited until the user chooses the Close menu option to close a display window.

Question 10

Which graphical input device is most practical to adopt data from a map into a computer?

a. touch panel
b. joystick
c. tablet with pen
d. mouse

Question 11

The depth sorting algorithm for hidden surface removal sorts a polygon list. It determines repeatedly for pairs of polygons, whether these polygons are in the right order in the polygon list and if not, then these polygons are swapped (like in a "normal" sorting algorithm). During sorting the situation may occur that two polygons, which have already been swapped, must be swapped again later, for instance because the first polygon overlaps the second and the second overlaps the first. How can this problem be solved?

a. Record whether the polygons have already been swapped and if so then do not swap the polygons the next time.
b. Record whether the polygons have already been swapped and if so then next time split one of the polygons into two new polygons on the intersection line of the two polygon planes.
c. Two polygons can be swapped more than once, but after some time these polygons will not be tested any more and swapping will stop.
d. The polygons are removed from the polygon list (temporarily), and after the sorting process has ended the removed polygons are inserted again on the right place in the list with an extra sorting step.

Question 12

A line through the points A and B with $A=(x_A, y_A)$ and $B = (x_B, y_B)$ can be represented with
(I) a *line equation* $y = ax + b$ with $a = (y_B - y_A) / (x_B - x_A)$ and $b = (x_B y_A - x_A y_B) / (x_B - x_A)$.
(II) a *parameter representation* $(x, y) = (x_A, y_A) + u (\Delta x, \Delta y)$ with $\Delta x = x_B - x_A$ and $\Delta y = y_B - y_A$

How does the Liang and Barsky line clipping algorithm clip a line segment AB?

a. The algorithm calculates, starting from the *equation* $y = ax + b$, the intersections of all extended window boundaries with the line and next it determines whether these intersections are on the boundary of the window and in-between the points A and B.
b. The algorithm starts from the *parameter representation* of the line and determines the parameter interval $[u_1, u_2]$ for the part of the line that is inside the window. By substituting u_1 and u_2 in the parameter representation the end points of the clipped line are determined.
c. The algorithm starts to determine 4-bits codes for the end points and calculates, only if the line cannot be directly rejected or accepted, with use of the *parameter representation*, intersections of the window boundaries with the line segment.
d. The algorithm starts to determine 4-bits codes for the end points and calculates, only if the line cannot be directly rejected or accepted, with use of the *equation* $y = ax + b$, intersections of the window boundaries with the line segment.

Question 13

A parallel projection where the three axes of the objects coordinate system (so the three main directions in the model) make the same angle with the projection plane is called

a. oblique projection
b. isometric projection
c. cabinet projection
d. cavalier projection

Question 14

The z-buffer algorithm is a hidden surface removal algorithm. With this algorithm many times for a pixel (x, y) the z-coordinate of a point in a polygon with plane equation ax+by+cz+d=0 must be calculated. For neighboring pixels (x, y) and (x+1, y) this can be done with an incremental calculation: z(x+1, y) = z(x, y) + inc. Here, the meaning of z(x, y) is the depth (so the z-coordinate) of the polygon for pixel (x, y).
What is the correct increment inc that must be used to calculate the depth z(x+1, y) for pixel (x+1, y) from the depth z(x, y) for pixel (x, y)?

a. inc = -a / c
b. inc = -a / b
c. inc = -b / c
d. inc = b / c

Question 15

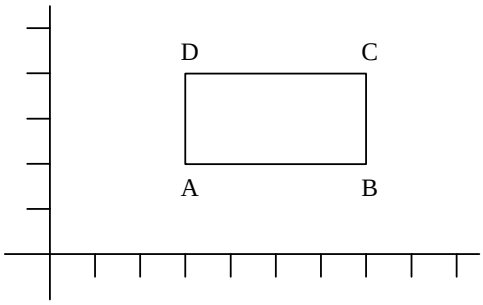
A line segment AB is clipped with the Cohen and Sutherland line clipping algorithm. The 4-bits codes of the two line segment end points are codeA = 0110 and codeB = 1001. The 4 bits (from the right to the left) indicate a position to the left, to the right, below and above the window. Which statement is correct?

a. Line segment AB is accepted on the ground of codes codeA and codeB.
b. Line segment AB is rejected on the ground of codes codeA and codeB.
c. Line segment AB is not accepted and not rejected on the ground of codes codeA and codeB, but it is a fact that, after clipping one or more parts of the line segment, a final line segment will be accepted.
d. Line segment AB is not accepted and not rejected on the ground of codes codeA and codeB, and it is not yet a fact whether, after clipping one or more parts of the line segment, a final line segment will be accepted or rejected.

Question 16

The following notations are used for 2D transformations:
$T_{(a,b)}$ is a translation by the vector (a, b).
$R_{O,\alpha}$ is a rotation about the origin by α degrees.
$S_{(sx,sy)}$ is a scaling relative to the origin with scale factors sx and xy.

Rectangle ABCD in the figure below can be mapped on itself in different ways (by a combination of reflection, rotation, translation and scaling).



Which compound transformation maps ABCD on BCDA, so A is mapped on B, B on C, C on D and D on A ?

a. $T_{(5,3)} \cdot R_{O,90} \cdot S_{(0.5,2.0)} \cdot T_{(-5,-3)}$
b. $T_{(5,3)} \cdot R_{O,90} \cdot T_{(-5,-3)}$
c. $T_{(5,3)} \cdot S_{(0.5,2.0)} \cdot T_{(-5,-3)}$
d. $T_{(5,3)} \cdot R_{O,180} \cdot T_{(-5,-3)}$

Question 17

Line segment AB with A = (200, 200) and B = (100, 30) is displayed with the DDA line scan conversion algorithm. Which pixels both get the color of the line?

a. the pixels (131, 83) and (131, 84)
b. the pixels (131, 83) and (132, 84)
c. the pixels (131, 84) and (132, 84)
d. the pixels (132, 83) and (132, 84)

Question 18

In a VRML virtual world an object with a Sphere geometry must gradually change color if the observer comes close to the object. Between which types of nodes a route must be defined to realize this effect?

a. ProximitySensor => TimeSensor => ColorInterpolator => Material
b. ProximitySensor => TimeSensor => ColorInterpolator => Sphere
c. TimeSensor => ProximitySensor => ColorInterpolator => Material
d. TimeSensor => ProximitySensor => ColorInterpolator => Sphere

Question 19

Which component of the Phong light reflection model causes highlights on surfaces of objects?

a. the spotlight component
b. the area light source component
c. the diffuse reflection component
d. the specular reflection component

Question 20

How many implicit events are defined for a *field*, and how many for an *exposed field* in VRML?

	field	exposed field
a.	0	0
b.	0	2
c.	2	0
d.	2	2

Question 21

Consider the following code (with OpenGL function calls):

```
glMatrixMode (GL_MODELVIEW);
glLoadIdentity ();
glRotatef (theta, vx, vy, vz);
glScalef (sx, sy, sz);
glTranslatef (tx, ty, tz);
```

Objects defined hereafter undergo the transformations from the code above. In which order are the transformations performed?

a. The order is always, irrespective of the order of the calls in the code, first translate, then rotate and finally scale.
b. The order is always, irrespective of the order of the calls in the code, first scale, then rotate and finally translate.
c. The order is dependent of the order of the calls in the code. In this case it means that there will we rotated first, then scaled and finally translated.
d. The order is dependent of the order of the calls in the code. In this case it means that there will be translated first, then scaled and finally rotated.

Question 22

A polygon scan conversion algorithm uses an active edge list (AEL). Which edges are in this AEL?

a. All polygon edges which are not horizontal.
b. All polygon edges which intersect the current scan line.
c. All polygon edges which do not intersect any other polygon edges.
d. All polygon edges which are not hidden behind any other polygon.

Question 23

In scan conversion

a. raster data is transformed in the frame buffer.
b. raster data is converted to another resolution.
c. vector data is transformed to another coordinate system.
d. vector data is converted to raster data.

Question 24

In a computer program, that uses OpenGL, the following program fragment is contained.

```
// arguments xmin, ymin, width, height in this order
glViewport (200.0, 500.0, 400.0, 200.0);
glMatrixMode (GL_PROJECTION);
glLoadIdentity ();
// arguments xmin, xmax, ymin, ymax in this order
glOrtho (100.0, 700.0, 200.0, 600.0, -1.0, 1.0);
```

On which point inside the display window, the point with world coordinates (460.0, 300.0) is mapped?

a. on point (380.0, 650.0)
b. on point (380.0, 550.0)
c. on point (440.0, 650.0)
d. on point (440.0, 550.0)

Question 25

Which step does not show up in the viewing process if we display a scene with the ray tracing method?

a. Determine the intersection of the ray and an object surface which is closest to the observer.
b. Apply the light reflection model.
c. Perform the window to viewport transformation.
d. Perform the viewing transformation.

Question 26

Given are the points A = (100, 550) and B = (300, 150). AB is a polygon edge. The polygon is displayed with a texture on it. Vertex A corresponds with point (0.0, 0.5) in the texture and vertex B with point (1.0, 1.0). Texture coordinates are linearly interpolated along polygon edges.
Which texture coordinates are used for point P = (260, 230) on edge AB?

a. (0.8, 0.9)
b. (0.75, 0.875)
c. (0.5, 0.75)
d. (0.2, 0.6)

Question 27

Which conclusion is correct, if the bounding volumes of two moving objects overlap each other in a frame of an animation?

a. The objects are in collision.
b. The objects may be in collision. A more accurate test is needed to find out whether the objects are really in collision.
c. The objects are not yet in collision, but they will collide soon.
d. The objects are not yet in collision, but there is a chance that they will collide soon.

Question 28

A texture must be mapped on a polygon. Antialiasing is done with a mip-map. How big a part of the mip-map is used to store the version of the texture on half the maximal resolution?

a. $\frac{1}{16}$
b. $\frac{3}{16}$
c. $\frac{1}{4}$
d. $\frac{3}{8}$

Question 29

The matrix $\begin{pmatrix} \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2}\sqrt{2} & 0 \\ -\frac{1}{2} & \frac{1}{2} & \frac{1}{2}\sqrt{2} & 0 \\ -\frac{1}{2}\sqrt{2} & -\frac{1}{2}\sqrt{2} & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ is the transformation matrix of a rotation about line *l* by 90 degrees. What is the correct parameter representation of line *l*?

a. $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \lambda \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$ b. $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \lambda \begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$ c. $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \lambda \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}$ d. $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \lambda \begin{pmatrix} 0 \\ -1 \\ 1 \end{pmatrix}$

Question 30

What is the advantage to use a Directed Acyclic Graph (DAG) instead of a tree to store a 3D scene?

a. With a DAG the final image on the screen looks better.
b. Collision detection and scene graph traversal are more easy with a DAG.
c. Caching of display lists is more easy with a DAG.
d. With a DAG more than one copy of an object can be placed in a scene, without putting several physical copies of the object in the scene graph.

end of examination