DELFT UNIVERSITY OF TECHNOLOGY
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Computer Graphics (in2770)
21 June 2005, 14.00 - 16.00 h.

N.B.: This examination contains 30 questions
Total number of pages: 12

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, if you are 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

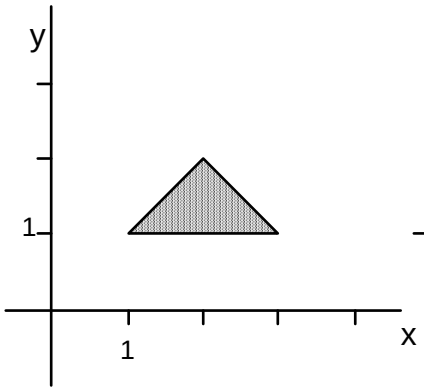


Figure 1

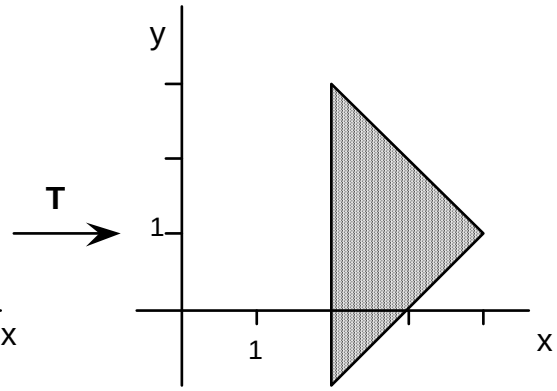


Figure 2

Which matrix represents the transformation **T** that maps the triangle in figure 1 on the triangle in figure 2?

a. $\begin{matrix} 0 & -2 & 4 \\ 2 & 0 & -3 \\ 0 & 0 & 1 \end{matrix}$ b. $\begin{matrix} 0 & -2 & 4 \\ -2 & 0 & -3 \\ 0 & 0 & 1 \end{matrix}$ c. $\begin{matrix} 0 & -2 & 4 \\ -2 & 0 & 5 \\ 0 & 0 & 1 \end{matrix}$ d. $\begin{matrix} 0 & 2 & 0 \\ -2 & 0 & 5 \\ 0 & 0 & 1 \end{matrix}$

Question 2

In a perspective projection of a 3D object lines that are parallel in the 3D object intersect in one point. However, this is not true for all parallel lines in the 3D object. Which statement is correct?

a. Only the parallel lines that are contained in the image plane are also parallel in the perspective projection.
b. Only the parallel lines that are perpendicular to the image plane are also parallel in the perspective projection.
c. Only the parallel lines that are parallel to the image plane are also parallel in the perspective projection.
d. Only the parallel lines that are not parallel to one of the axes of the coordinate system in which the object is defined, are also parallel in the perspective projection.

Question 3

A texture can be mapped on a polygon in many ways, for instance by

(I) linear interpolation of texture coordinates along polygon edges followed by linear interpolation along scan lines.
(II) bi-linear mapping.
(III) perspective mapping.

For how many of the three mapping methods above, in case of a square texture on an arbitrary quadrilateral polygon, a *horizontal straight line in texture space* will always be mapped on a *straight line in screen space*?

a. 0
b. 1
c. 2
d. 3

Question 4

A mip-map consists of several levels (D = 0, 1, 2, …). Each level contains a version of the texture on a certain resolution. What decides the level in the mip-map that is used to calculate the color of the pixel on which (part of) a texture is mapped?

a. The size of color changes in texture point (u, v) on which pixel (x, y) is mapped by the inverse mapping.
b. The amount of change of texture coordinates in case of linear interpolation.
c. The amount of curvature of the 3D surface on which the texture must be mapped in pixel (x, y).
d. The size of the pre-image of a (screen) pixel after mapping it back to texture space.

Question 5

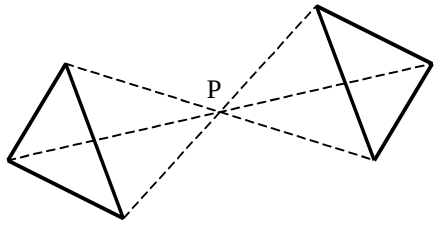
Somebody wants to write a program for drawing images of collections of convex and concave 3D objects, bounded by plane surfaces, with hidden surface removal. He wants to use a z-buffer algorithm in the program. Further, he considers applying back-face removal.

Which of the following statements is correct?

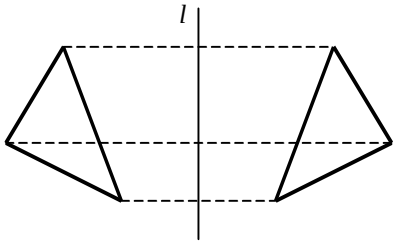
a. Back-face removal must be applied before applying the z-buffer algorithm, because otherwise back-faces can become visible.
b. Back-face removal can be applied before applying the z-buffer algorithm, and it will benefit the visualization speed, because back-faces cannot become visible.
c. Back-face removal cannot be applied, because as a result of back-face removal visible faces of concave objects can be removed by the z-buffer algorithm.
d. Back-face removal cannot be applied, because the z-buffer algorithm uses back-faces to find out that one object is behind another.

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:

$$\begin{matrix}1&0&0\\0&-1&0\\0&0&1\end{matrix},\quad \begin{matrix}-1&0&0\\0&1&0\\0&0&1\end{matrix},\quad \begin{matrix}-1&0&0\\0&-1&0\\0&0&1\end{matrix},\quad \begin{matrix}0&1&0\\1&0&0\\0&0&1\end{matrix}.$$

How many of these transformation matrices represent a *line mirroring (reflection)* operation?

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

Question 7

With Gouraud shading

a. the light reflection model is only applied at polygon vertices, and next the colors are interpolated over the polygon.
b. the light reflection model is only applied at intersections of scan lines and polygon edges, and next the colors are interpolated over the scan lines.
c. the light reflection model is only applied at one point on every polygon, and the colors are interpolated between the polygons.
d. the light reflection model is applied at every pixel inside the polygon.

Question 8

In a VRML file a Viewpoint node and a Shape node are children of the same Transform node. The object, defined by the Shape node, moves in the virtual world as a result of a route, which frequently alters the Transform node's translation field value. An observer is located in this virtual world. The observer does not navigate through the world. What happens with the observer if in a VRML browser the Viewpoint, which was mentioned above, is selected?

a. The observer moves with the object, as soon as the object is close enough to the observer.
b. The observer moves with the object, as soon as the viewpoint is selected.
c. The observer jumps to a new location in the virtual world, as soon as the viewpoint is selected, but does not move with the object.
d. The observer moves relative to the object, as soon as the viewpoint is selected. The movement is defined in the Viewpoint node's position field.

Question 9

Consider the following code fragment with OpenGL function calls:

```
glBegin (GL_TRIANGLE_STRIP);
   for (i=0; i<9; i++)
      glVertex2iv (points[i]);    /* nine points */
glEnd ();
```

How many triangles are in this "triangle strip"?

a. 3
b. 6
c. 7
d. 9

Question 10

Given are two polygon scan conversion algorithms (in pseudo-code):

(I) determine minimum and maximum y-coordinate (ymin, ymax) over all polygon vertices
for scan line ymin to ymax
determine all (say n) intersections of the scan line with polygon edges
sort the intersections on x-coordinate -> S(1), S(2), …, S(n)
for i = 1 to n/2
DrawSpan(S(2i-1), S(2i))

(II) determine the polygon's bounding box
for every pixel inside the bounding box
if the pixel is inside the polygon then DrawPoint(pixel)

Which algorithm is most calculation efficient and why?

a. Algorithm (I) is most calculation efficient, because algorithm (I) uses coherence properties on a scan line and algorithm (II) does not.
b. Algorithm (I) is most calculation efficient, because algorithm (I) uses coherence properties between consecutive scan lines and algorithm (II) does not.
c. Algorithm (II) is most calculation efficient, because it avoids sorting.
d. Algorithm (II) is most calculation efficient, because by using a bounding box it processes less pixels than algorithm (I).

Question 11

Consider the following two statements about the z-buffer (depth buffer) algorithm:

(I) The z-buffer algorithm solves the visible surface problem by registering the depth of the closest (to the observer) polygon per pixel during scan conversion.
(II) The z-buffer algorithm cannot display polygons with cyclic overlap (see figure) correctly.

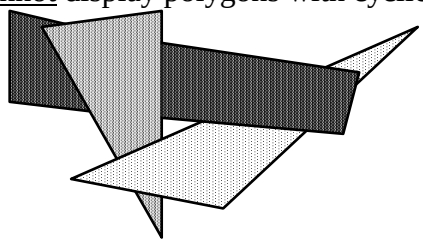


Figure: polygons with cyclic overlap

Are these statements correct?

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

Question 12

What is the refresh frequency of a display screen?

a. the maximal number of times per second that the phosphor can glow (and fade again)
b. the number of times per second that the image is drawn on the screen
c. the number of times per second that the contents of the frame buffer is altered
d. the number of times per second it is checked whether the image on the display screen still corresponds with the contents of the frame buffer

Question 13

Which component of an elementary light reflection model is dependent on the direction **V** to the observer?

a. the diffuse reflection component and the specular reflection component
b. only the diffuse reflection component
c. only the specular reflection component
d. not the diffuse reflection component and also not the specular reflection component

Question 14

The Cohen and Sutherland line clipping algorithm uses 4-bits codes to define the position of a line endpoint relative to the clipping window. Let codeA = $a_1a_2a_3a_4$ and codeB = $b_1b_2b_3b_4$ be the two 4-bits codes for a line segment AB. Which condition must hold for the two 4-bits codes, in order that the line segment can be *rejected* (so the line segment is not displayed)?

a. codeA AND codeB = 0
b. codeA AND codeB $\neq$ 0
c. codeA OR codeB = 0
d. codeA OR codeB $\neq$ 0

Question 15

Consider the statements below about the cross product **a** x **b** of two vectors **a** and **b**.

I. The vectors **a**, **b** and **a** x **b** establish a right handed coordinate system.
II. The length of **a** x **b** is equal to the length of vector **a** times the length of the projection of vector **b** on vector **a**.
III. The vector **a** x **b** is a normal vector to the plane spanned by the vectors **a** and **b**.

How many of these statements are correct?

a. 0
b. 1
c. 2
d. 3

Question 16

Which plane is parallel to the plane containing A(4, 0, 0), B(4, 2, 2) and C (3, 1, 1) ?

a. $x - y + z = 0$
b. $- x + y + z = 0$
c. $y + z = 0$
d. $- y + z = 0$

Question 17

Given is a polygon edge AB in screen coordinates. A = (750, 850) en B = (550, 250). The polygon is displayed with a texture on it. The texture coordinates for point A and B are (uA, vA) = (0.2, 1.0) and (uB, vB) = (1.0, 0.4). The texture is mapped with linear interpolation of texture coordinates on the edges of the polygon followed by linear interpolation along the scan line.

What are the texture coordinates on scan line 400 for edge AB?

a. (0.4, 0.55)
b. (0.4, 0.85)
c. (0.8, 0.55)
d. (0.8, 0.85)

Question 18

Given the following VRML code fragment:

```
Transform {
  translation 4 0 0
  rotation 0 1 0 1.57
  children [
    USE DefaultSphere
  ]
}
```

DefaultSphere is defined as a sphere with radius 1, center at the coordinate system origin and color grey.

What are the coordinates of the center of the sphere that is positioned in the virtual world with the Transform node in the code fragment?

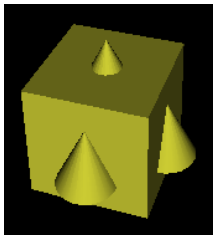
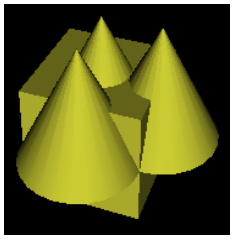
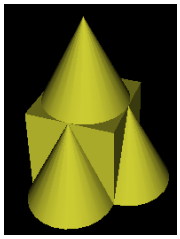
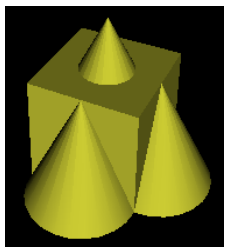
a. (0, 0, 0)
b. (4, 0 , 0)
c. (0, 0, 4)
d. (0, 0, -4)

Question 19

Given the following VRML virtual world:

```
#VRML V2.0 utf8
Shape {
  appearance DEF Yellow Appearance {
    material Material {
      diffuseColor .8 .8 .2
    }
  }
  geometry Box {}
}
Transform {
  translation 1 0 0
  children [
    DEF YellowCone Shape {
      appearance USE Yellow
      geometry Cone {}
    }
  ]
}
Transform {
  translation 0 1 0
  children [
    USE YellowCone
  ]
}
Transform {
  translation 0 0 1
  children [
    USE YellowCone
  ]
}
```

Which of the images below shows this world?

a.  b.  c.  d. 

Question 20

In OpenGL the function glPushMatrix can be used to implement a scene graph traversal. At which moment(s) glPushMatrix is called?

a. Before the start of the scene graph traversal.
b. During descending the scene graph (in the direction of the leaves).
c. During ascending the scene graph (in the direction of the root).
d. Both during descending the scene graph and ascending the scene graph.

Question 21

What is the effect of the statement

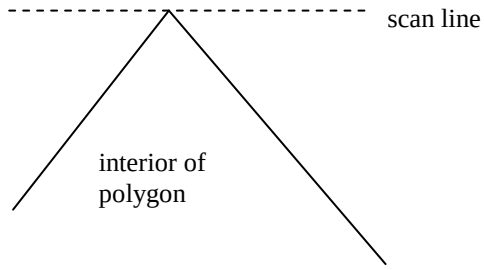
```
glutMouseFunc (mouse);
```

in a computer program that uses OpenGL?

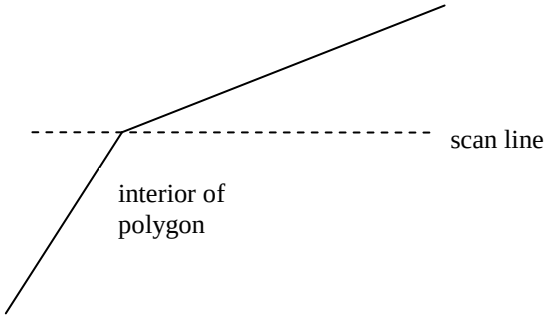
a. The mouse cursor coordinates are delivered to the program.
b. A name for the mouse callback function is defined.
c. It is checked whether there are any mouse events in the event queue and the first event is handled. If there are no mouse events, nothing happens.
d. The program waits until the user pushes a mouse button and returns the mouse cursor coordinates and an indication which button was pushed.

Question 22

A polygon scan conversion algorithm determines per scan line a list of polygon edge – scan line intersections. Polygon vertices on the scan line give a (small) complication in the algorithm. Situations I and II show two of these problem cases.



Situation I



Situation II

How many times the vertex must be added to the intersection point list in situations I and II ?

	Situation I	Situation II
a.	1 time	1 time
b.	1 time	2 times
c.	2 times	1 time
d.	2 times	2 times

Question 23

Which algorithm is not a clipping algorithm?

a. Bresenham algorithm
b. Liang-Barsky algorithm
c. Sutherland-Hodgeman algorithm
d. Cohen-Sutherland algorithm

Question 24

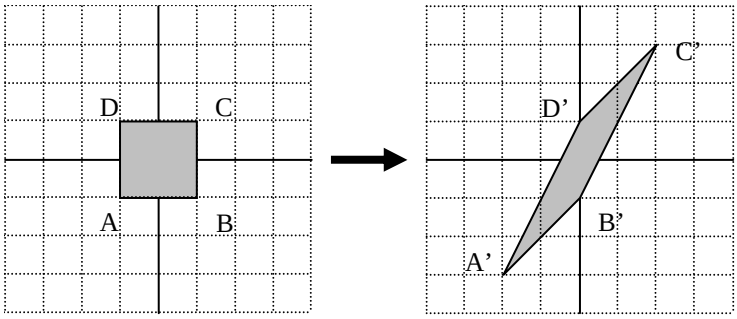
Which statement about the step sizes xStep and yStep in the x- and y-directions in the DDA line scan conversion algorithm is correct?

If the slope of the line is smaller than -1, then

a. xStep = -1 and $0 \leq$ yStep ≤ 1 or xStep = 1 and $-1 \leq$ yStep ≤ 0
b. xStep = -1 and $-1 \leq$ yStep ≤ 0 or xStep = 1 and $0 \leq$ yStep ≤ 1
c. $0 \leq$ xStep ≤ 1 and yStep = 1 or $-1 \leq$ xStep ≤ 0 and yStep = -1
d. $-1 \leq$ xStep ≤ 0 and yStep = 1 or $0 \leq$ xStep ≤ 1 and yStep = -1

Question 25

$\begin{pmatrix} p & q & 0 \\ r & s & 0 \\ 0 & 0 & 1 \end{pmatrix}$ is the transformation matrix for a combination of an x-direction shear followed by a y-direction shear. Square ABCD in the figure below is transformed to A'B'C'D' by this transformation.



What is the value of *s* ?

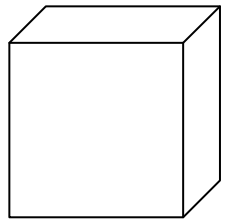
a. 1
b. 2
c. 3
d. 4

Question 26

In key frame animation

a. every frame of the animation is calculated according to a mathematical model and a start position and orientation.
b. every frame of the animation is calculated by interpolation between positions and orientations that are defined by the animator.
c. every frame of the animation is specified by the animator.
d. every frame of the animation is checked for collision by using the key frames.

Question 27



The image shows a parallel projection of a cube. The angle between the projection direction and the projection plane is α. The edges of the cube that are perpendicular to the image plane in the 3D model are shown at $\frac{1}{3}$ of their real length.

Which equation holds for the angle α ?

a. $\cos\alpha = \frac{1}{3}$
b. $\cos\alpha = 3$
c. $\tan\alpha = \frac{1}{3}$
d. $\tan\alpha = 3$

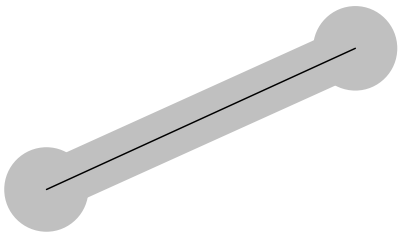
Question 28

Given the matrix $M = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ Which rotation represents M ?

a. a rotation about the x-as with -90 degrees
b. a rotation about the y-as with 45 degrees
c. a rotation about the z-as with 90 degrees
d. a rotation about the vector (1, 1, 1) with -120 degrees

Question 29

In a drawing program the following technique is implemented in order to benefit accurate drawing:



If the user selects a point inside the bar-bell shaped area surrounding the line segment, then the selected point is moved to the nearest point on the line segment.

This technique is called

a. grid constraint
b. gravity field constraint
c. rubber band technique
d. rubber line technique

Question 30

A polygon has plane equation $3x + 2y – 5z – 20 = 0$ in 3D screen coordinates.
The pixels (x_0, y_0) and (x_0+1, y_0) are inside the projected polygon.
An image including the polygon is displayed with the z-buffer algorithm. The polygon depth for pixel (x_0, y_0) has already been calculated and is equal to 28.0.
What is the polygon depth for pixel (x_0+1, y_0) ?

a. 27.4
b. 27.6
c. 28.4
d. 28.6

end of examination