DELFT UNIVERSITY OF TECHNOLOGY
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Department of Mediamatics

Computer Graphics (in2770)
27 June 2006, 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, 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

In the ray tracing algorithm several secondary rays are traced from an intersection point with an object. Of which secondary ray(s) the direction is not determined from the direction of the ray coming from the eye?

a. refracted ray
b. reflected ray and refracted ray
c. refracted ray and shadow ray
d. shadow ray

Question 2

The 3D Cohen and Sutherland line clipping algorithm uses 6-bits codes of line endpoints and as clipping order: left, right, below, above, before, behind. Points inside the window have code 000000.
Which of the following 6-bits codes is <u>not</u> a correct code for an endpoint of a line to be clipped?

a. 010101
b. 011000
c. 001100
d. 100110

Question 3

What are PositionInterpolator nodes in VRML used for?

a. to enable hierarchical modeling of scenes
b. to enable positioning of area light sources
c. to enable navigation through a virtual world
d. to enable key frame animation

Question 4

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 5

The value of a VRML node's rotation field specifies a rotation. A rotation in VRML is given as

a. 1 angle and an axis specification (X-axis, Y-axis or Z-axis)
b. 2 angles
c. 3 angles
d. a 3D vector and an angle

Question 6

The 3D viewing pipeline is

a. the volume that contains the part of the model that is displayed on the screen.
b. the sequence of operations that transforms the three dimensional model description into an image on the screen.
c. the interactions with the user in order to establish the viewing parameters.
d. the tracing of rays and the calculation of colors during the ray tracing.

Question 7

Under which condition, the hidden surface removal problem, i.e. the determination of visible (parts of) surfaces, is totally solved by back face removal?

a. when there are only convex objects in the scene
b. when all polygons in the scene are triangles
c. when all triangles in the scene are convex
d. when the scene consists of only one object and the object is convex

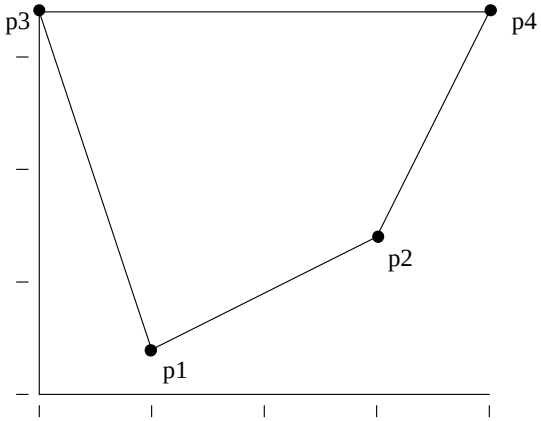
Question 8

We consider the light, coming directly from a light source, and falling on an object surface. Part of this light is reflected specularly to the eye of the observer.
Which of the following factors does <u>not</u> influence the amount of specularly reflected light?

a. the surface smoothness
b. the ambient factor
c. thee surface orientation
d. the vector in the direction of the light source

Question 9

A texture is mapped on the polygon below with a *perspective mapping*. Point (0, 0) in the texture is mapped on p1 = (50, 20), point (1, 0) on p2 = (150, 70), point (0, 1) on p3 = (0, 170) and point (1, 1) on p4 = (200, 170).



What is the correct matrix for this perspective mapping?

a. $\begin{pmatrix} 100 & -50 & 50 \\ 50 & 43.75 & 20 \\ 0.5 & -0.625 & 1 \end{pmatrix}$

b. $\begin{pmatrix} 175 & -50 & 50 \\ 85 & 43.75 & 20 \\ 0.5 & -0.625 & 1 \end{pmatrix}$

c. $\begin{pmatrix} 100 & -50 & 50 \\ 50 & 150 & 20 \\ 0.5 & -0.625 & 1 \end{pmatrix}$

d. $\begin{pmatrix} 175 & -50 & 50 \\ 85 & 150 & 20 \\ 0.5 & -0.625 & 1 \end{pmatrix}$

Question 10

We want to establish, relative to a 3D coordinate system, the 4 x 4 homogeneous coordinate matrix of a rotation with angle θ about the line through the origin with direction vector (3, 1, -1). We can build this rotation from the following combination of elementary transformations (rotations about the coordinate system axes):

$$Rx(-\alpha) \,.\, Ry(-\beta) \,.\, Rz(\theta) \,.\, Ry(\beta) \,.\, Rx(\alpha)$$

What is the correct rotation angle α about the x-axis?

a. 45°
b. 60°
c. 90°
d. 135°

Question 11

A window with window boundaries (xwmin, xwmax, ywmin, ywmax) = (2, 6, -1, 2) in world coordinates is mapped on a viewport with viewport boundaries (xvmin, xvmax, yvmin, yvmax) = (0, 800, 100, 1000) in screen coordinates. Line segment AB with A = (4, 0) and B = (6, 1) is mapped on line segment A'B' in the viewport.

What is the length (in screen coordinate system units) of line segment A'B' ?

a. $100\sqrt{13} \approx 361$
b. 500
c. $200\sqrt{10} \approx 632$
d. $200\sqrt{13} \approx 721$

Question 12

A line segment AB with A = (100, 700) and B = (400, 100) is displayed with the DDA scan conversion algorithm. Drawing starts in point A. What is the increment in x-direction used in the algorithm?

a. -1
b. -0.5
c. 0.5
d. 1

Question 13

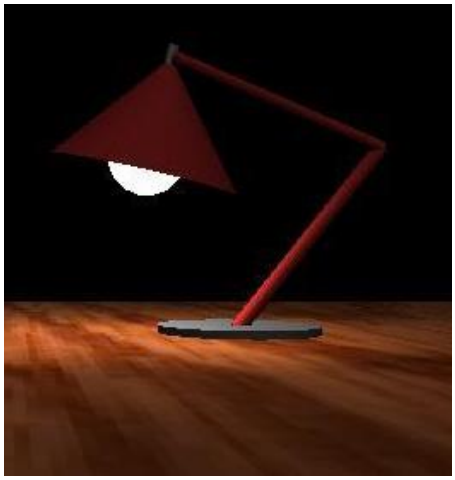
Given is the following program code with OpenGL function calls

```
glBegin (polygonMode);
  ...        /* 24 points */
glEnd ();
```

With which polygonMode the largest amount of polygons is defined?

a. GL_POLYGON
b. GL_TRIANGLES
c. GL_TRIANGLE_STRIP
d. GL_QUAD_STRIP

Question 14



In a VRML virtual world (left figure) the follow interaction has occurred. The mouse cursor is placed on the (flat cylinder shaped) lamp base, the left mouse button is pushed and the mouse is moved. Because of this action the lamp was moved (right figure).
Which type of VRML sensor(s) is/are used in order to achieve this interaction?

a. only a plane sensor
b. only a touch sensor
c. only a cylinder sensor
d. a touch sensor and a cylinder sensor

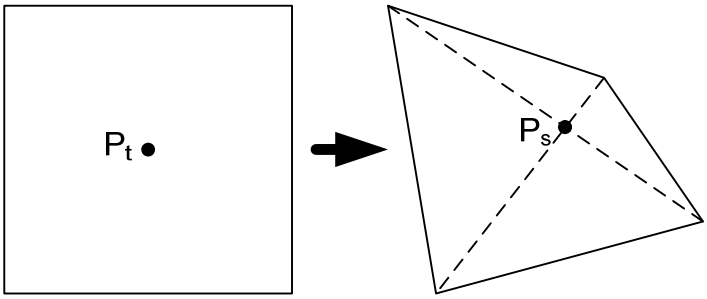
Question 15

Which method / which algorithm must be applied to achieve that a correct image of a 3D scene, consisting of polygons, can be generated with the painters algorithm?

a. back face removal
b. z-buffering
c. scan conversion of the polygons
d. depth sorting of the polygons

Question 16

A square texture (with coordinates between 0 and 1 in u- and v-direction in texture space) is mapped on a quadrilateral in screen space (see figure).



For which type of mapping the centre P_t = (0.5, 0.5) of the texture is mapped on the intersection P_s of the diagonals of the quadrilateral in screen space?

	perspective mapping	bi-linear mapping
a.	P_t mapped on P_s	P_t mapped on P_s
b.	P_t mapped on P_s	P_t <u>not</u> mapped on P_s
c.	P_t <u>not</u> mapped on P_s	P_t mapped on P_s
d.	P_t <u>not</u> mapped on P_s	P_t <u>not</u> mapped on P_s

Question 17

2D transformations can be performed by a matrix-vector multiplication $\begin{pmatrix} x' \\ y' \end{pmatrix} = M \begin{pmatrix} x \\ y \end{pmatrix}$.

Which 2D transformation can not be represented by a 2 x 2 matrix M ?

a. a translation
b. a rotation
c. a scaling
d. a shearing

Question 18

The matrix $\begin{pmatrix} (1-m^2)/w & 2m/w & 0 \\ 2m/w & (m^2-1)/w & 0 \\ 0 & 0 & 1 \end{pmatrix}$ represents a 2D reflection in the line $y = mx$.

What is the value of w?

a. 1
b. 2
c. $m + 1$
d. $m^2 + 1$

Question 19

The matrix M represents a viewing transformation, i.e. a transformation that maps points from an orthonormal world coordinate system on points in an orthonormal viewing coordinate system.

$$M = \begin{pmatrix} a & b & c & 0 \\ d & e & f & 0 \\ g & h & i & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Consider the statements:

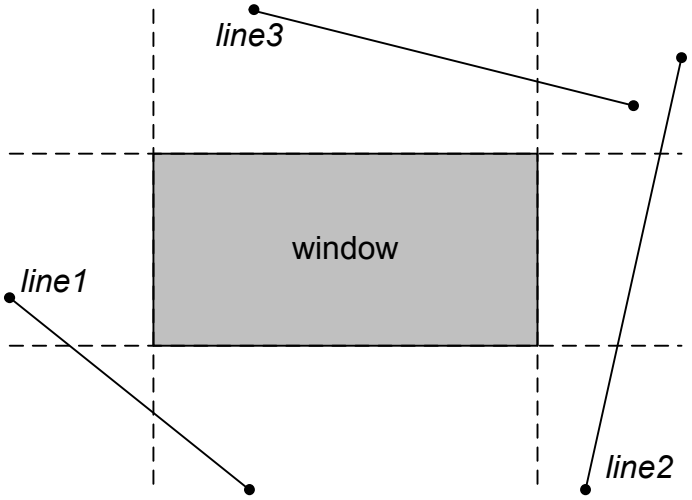
(I) $\begin{pmatrix} a \\ b \\ c \end{pmatrix} \times \begin{pmatrix} d \\ e \\ f \end{pmatrix} = \begin{pmatrix} g \\ h \\ i \end{pmatrix}$ is always true and (II) $\begin{pmatrix} a \\ b \\ c \end{pmatrix} \bullet \begin{pmatrix} d \\ e \\ f \end{pmatrix} = 0$ is always true

In these statements is • the dot product and × the cross product. Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	not correct
c.	not correct	correct
d.	not correct	not correct

Question 20

The lines in the figure below are clipped with the Cohen and Sutherland line clipping algorithm against the grey window.

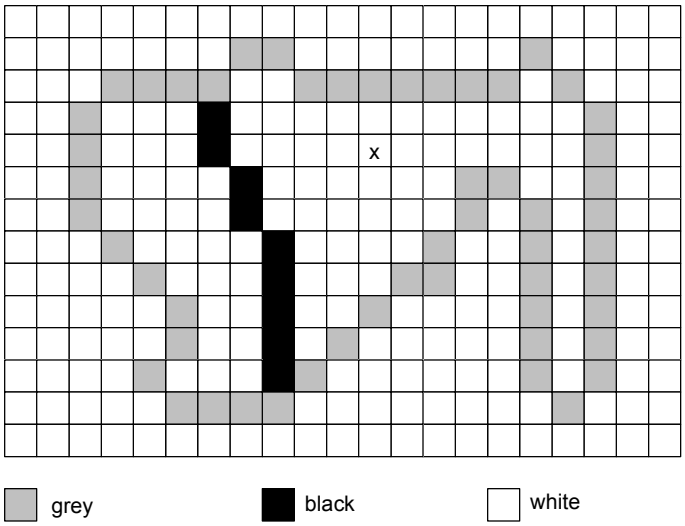


For how many of these lines no intersection points with horizontal or vertical window boundaries need to be calculated during the clipping process?

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

Question 21

A frame buffer contains the colours as shown in the figure below.



The area bounded by the grey pixels must totally be filled with the colour grey. The pixel with x is selected as starting point. Which fill algorithm can fill the whole area by using it only one time?

a. 4-connected boundary fill algorithm
b. 4-connected flood fill algorithm
c. 8-connected boundary fill algorithm
d. 8-connected flood fill algorithm

Question 22

Which pseudo code fragment best describes the structure of the z-buffer hidden surface removal algorithm?

a. for every pixel on the screen
    for every sample along the ray through that pixel
        use contribution of sample to alter buffers

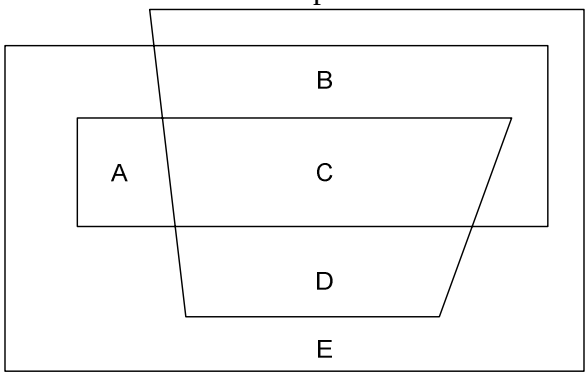
b. for every pixel on the screen
    for every polygon where the pixel is inside the projected polygon
        use polygon colour and polygon depth to alter buffers

c. for every polygon
    for every pixel inside the projected polygon
        use polygon colour and polygon depth to alter buffers

d. for every depth (from far away to close)
    for every polygon with this depth in its depth interval
        use polygon colour to alter buffer

Question 23

To determine whether a point is inside or outside a polygon the *odd even* rule can be applied.



How many of the areas A, B, C, D and E in the figure above, showing a polygon with intersecting edges, are inside the polygon when using the *odd even* rule?

a. 2
b. 3
c. 4
d. 5

Question 24

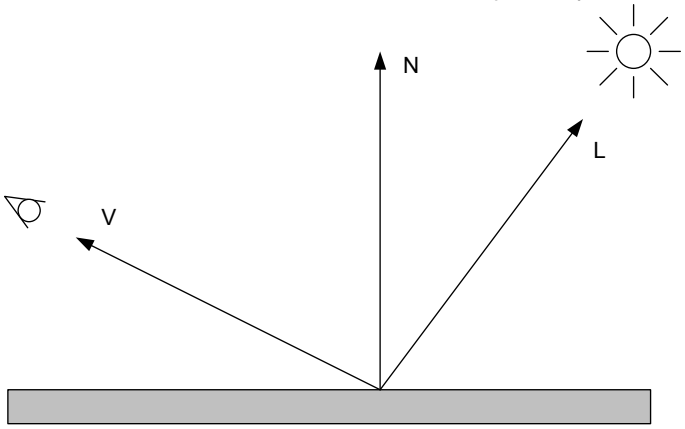
A simple light reflection model uses the vectors L (to the light source), V (to the observer) and N (normal vector on the surface). For calculating the specular reflection component in this light reflection model one of two vectors must be used:

- the vector R in the direction of perfect specular reflection of light from the light source

or

- the vector H, that divides the angle between L and V in two equal angles.

Let φ be the angle between V and R. Let ψ be the angle between N and H.
Is there a fixed relation for the angles φ and ψ? And if so, what is that relation?



a. $\varphi = \psi$
b. $\varphi = 2\psi$
c. $\varphi = \frac{1}{2}\psi$
d. there is no fixed relation for φ and ψ

Question 25

In OpenGL the current drawing colour is defined by a `glColor` function call. One version of this function is `glColor4f`. What is the meaning of the fourth argument in a `glColor4f` function call?

a. This argument defines the **Black** component of the colour, i.e. the amount of black that is added to the colour in order to make it darker.
b. This argument defines the **Transparency** for colour blending with overlapping objects.
c. This argument defines the **Intensity** of the colour.
d. This argument defines the **Saturation** of the colour.

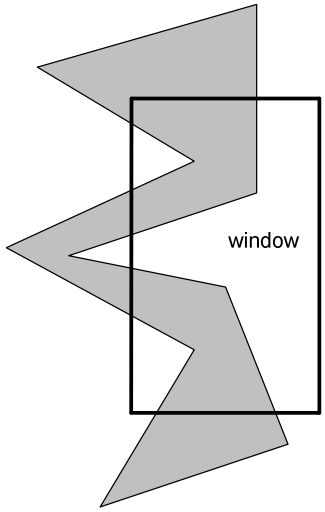
Question 26

Which plane is perpendicular to the plane containing the points A(1, 1, 2), B(2, 5, 3) and C(-1, 4, 5)?

a. $x + y + 4z + 3 = 0$
b. $x + 4y + z + 3 = 0$
c. $4x + y + z = 0$
d. $4x + y + 4z = 0$

Question 27

Consider the figure below. The grey polygon is clipped with the Sutherland Hodgman polygon clipping algorithm against the rectangular window. The clipping order is left, right, bottom, top.



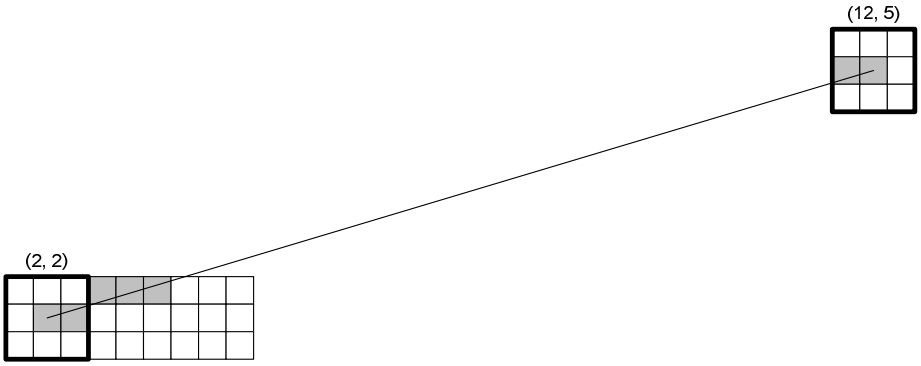
What is the number of vertices of the polygon after clipping against the left window boundary? (So, before clipping against right, bottom and top boundary)

a. 11
b. 12
c. 13
d. 14

Question 28

A line segment from pixel (2, 2) to pixel (12, 5) is displayed on a screen. Anti-aliasing is done with supersampling. The line is scan converted with the DDA algorithm on a resolution of 3 times the screen resolution (both in horizontal and in vertical direction). Pixel colours are calculated from the sub-pixel colours. A pixel can get the following colours:

colour 0 (background colour; none of the sub-pixels of the pixel is on the line)
for i = 1, 2, 3: colour i (i sub-pixels of the pixel are on the line)
Pixel (2, 2) and pixel (12, 5) get colour 2; pixel (3, 2) gets colour 3, as is shown in the figure.



What is the colour of pixel (6, 3)?

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

Question 29

Consider the following statements about projections:

(I) A line, that is perpendicular to the projection plane in the 3D model, is always mapped on one point when applying an *orthographic projection*.
(II) A line, that is perpendicular to the projection plane in the 3D model, is always mapped on one point when applying an *oblique parallel projection*.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	not correct
c.	not correct	correct
d.	not correct	not correct

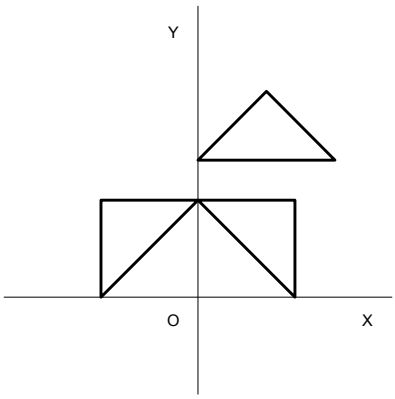
Question 30

Given is the following program fragment with OpenGL function calls:

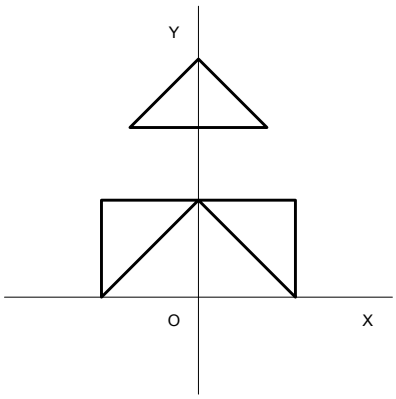
```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();

glBegin(GL_TRIANGLES);
glVertex2f(0.0, 1.0);   glVertex2f(1.0, 1.0);   glVertex2f(1.0, 0.0);
glEnd(GL_TRIANGLES);

glRotatef(45.0, 0.0, 0.0, 1.0);
glPushMatrix();
glTranslate2f(1.0, 0.0);

glBegin(GL_TRIANGLES);
glVertex2f(0.0, 1.0);   glVertex2f(1.0, 1.0);   glVertex2f(1.0, 0.0);
glEnd(GL_TRIANGLES);

glPopMatrix();
glRotatef(45.0, 0.0, 0.0, 1.0);

glBegin(GL_TRIANGLES);
glVertex2f(0.0, 1.0);   glVertex2f(1.0, 1.0);   glVertex2f(1.0, 0.0);
glEnd(GL_TRIANGLES);
```

Which figure shows the correct graphical output?

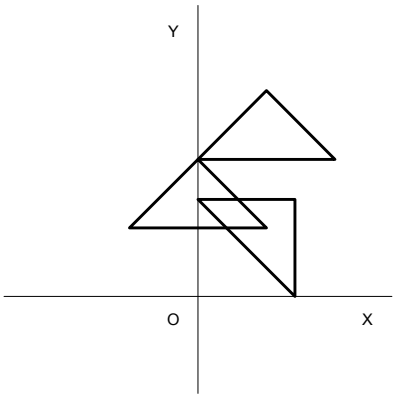
a.



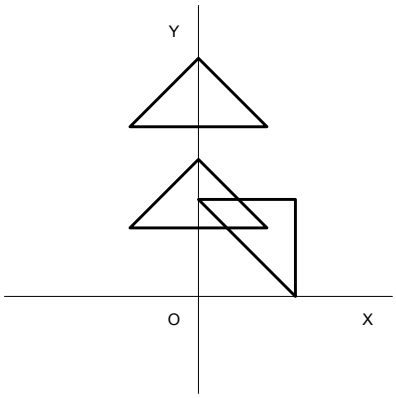
b.



c.



d.



end of examination