Please read these instructions carefully!

- Answer the test questions in the separate answer sheet.
- You may use the back of all the paper sheets as drafting area (*rascunho*).
- How to:

	A	B	C	D	E
Select the answer (A):	(●	○	○	○	○)
Replace the answer (A) by (C):	(✗	○	●	○	○)
Cancel (C) and reactivate (A):	(●✗	○	✗	○	○)

- This test has 36 QUESTIONS, each question has a score of 200/36 points.
- **POINTS LOST** for each wrong answer (in percentage of the question's points):

$\sum wrong$	$1 = 0\%$	$2 = 11.11\%$	$3 = 22.22\%$	$\geq 4 = 33.33\%$.

Name: _____ Number: _____

Consider the pipeline of a modern graphics card, used by a 3D WebGL program.

1. Which of the following names identifies a variable that needs to be assigned a value in all vertex shaders?
   A. `gl_PointSize` B. `gl_FragDepth` C. `gl_FragColor` D. `gl_Position`

2. Choose the option that best describes the output of a vertex shader.
   A. the vertex position in model or object coordinates.
   B. the vertex position in world coordinates (WC).
   C. the vertex position in a normalized space [-1,1]×[-1,1]×[-1,1].
   D. the vertex position in camera or eye coordinates.

3. Choose the correct option regarding the `discard` GLSL instruction.
   A. It can be used in both the vertex and fragment shaders and it prevents the primitive or the fragment from being processed.
   B. It can only be used in the fragment shader to discard a fragment, not passing it along the pipeline.
   C. None of the other options is correct.
   D. It can only be used in the vertex shader to discard a vertex, not passing it along the pipeline.

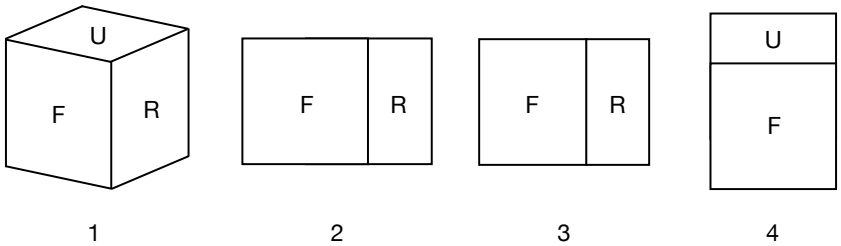
4. An application, that uses a projection matrix to **project objects** on the screen, will use it for that purpose:
   A. in the vertex shader.
   B. it can be used either in the fragment or the vertex shader.
   C. in the fragment shader.
   D. in the javascript side of the application.

5. Consider the GLSL (Graphics Library Shading Language) piece of code presented on the right. What is the value that gets assigned to 'c'?
   A. -89. B. 89. C. -15. D. 15.

```
N = vec3(0.0, 1.0, 0.0);
L = vec3(3.0, 8.0, 4.0);
R = reflect(L, N)

c = dot(R, R);
```

An axis aligned cube, centred at the origin, is shown in the figure using different projections. The faces have been labeled in the following way: F - Front, R - Right, U - Up, L - Left, D - Down, B - Bottom. The hidden faces were removed with an appropriate HLHSR algorithm.



6. Choose the type of projection that was used in case 1.
   A. Perspective, C=(0,0,d). B. Axonometric. C. Oblique. D. Perspective, C=(0,0,0).

7. Choose a set of valid parameter conditions for case 1.
   A. $\alpha > 0, l < 0$. B. $\theta < 0, \gamma > 0$. C. $\alpha < 0, l > 0$. D. $\theta > 0, \gamma < 0$.

8. Choose the corresponding parameter conditions for case 2.
   A. $\theta < 0, \gamma = 0$. B. $\alpha = 0, l > 0$. C. $\theta = 0, \gamma < 0$. D. $\alpha > 0, l = 0$.

9. Choose the type of projection that was used in case 3.

   A. Axonometric. B. Perspective, C=(0,0,d). C. Oblique. D. Perspective, C=(0,0,0).

10. Choose the corresponding parameter conditions for case 3.

    A. $\alpha = 0, l > 0$. B. $\theta = 0, \gamma < 0$. C. $\theta < 0, \gamma = 0$. D. $\alpha > 0, l = 0$.

11. Choose the type of projection that was used in case 4.

    A. Oblique. B. Perspective, C=(0,0,d). C. Perspective, C=(0,0,0). D. Axonometric.

12. Regarding the removal of the hidden faces, choose the most appropriate sentence. **Note:** Although the figure shows lines around the visible faces, give your answer assuming that what is drawn (painted) is just the interior area of each face of the cube.

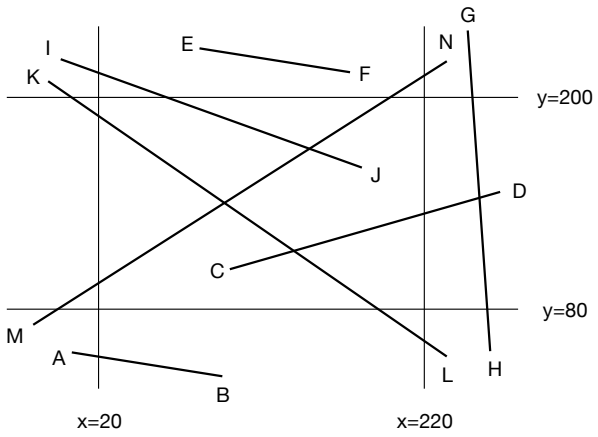
    A. Both the z-buffer and the back-face culling must be used.

    B. Either the z-buffer or the back-face culling can be used.

    C. Only the z-buffer algorithm can be used.

    D. Only the back-face culling technique can be used.

The image on the side shows several line segments that are going to be clipped with the Cothen-Sutherland line clipping algorithm. The window limits are also shown. The order of progression of the algorithm (and the order of the bits, from left to right) is: TOP, RIGHT, BOTTOM, LEFT.



13. What are the bit codes assigned to I and K endpoints?

    A. 1001 B. 1010 C. 0101 D. 0110

14. How many line segments are trivially rejected?

    A. 3. B. 0. C. 2. D. 1.

15. How many line segment are effectively clipped exactly 2 times?

    A. 2. B. none. C. 3. D. 1.

16. Which line segments are effectively clipped 4 times?

    A. $\overline{KL}$ and $\overline{MN}$. B. none. C. $\overline{MN}$. D. $\overline{KL}$.

17. Against which line is line segment $\overline{MN}$ clipped in the first place?

    A. $y = 80$. B. $x = 220$. C. $x = 20$. D. $y = 200$.

18. Against which line is line segment $\overline{MN}$ clipped in the second place?

    A. $y = 80$. B. $x = 220$. C. $y = 200$. D. $x = 20$.

Suppose that the clipping window is going to be maped into a viewport on a screen with 1920x1080 (16:9) resolution without clipping the window contents and without deformation. The viewport will be centred vertically and aligned with the right edge of the screen. The device coordinates (DC) have their origin on the top left corner.

19. What would you choose as the first transformation to be applied as part of the window to viewport transformation?

    A. T(-220,-200). B. T(1920,540). C. T(1920,0). D. T(-220,-140).

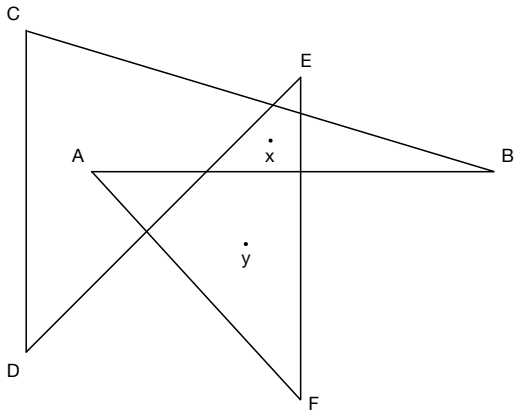
20. What would you choose as the last transformation to be applied as part of the window to viewport transformation?

    A. T(-220,-200). B. T(1920,0). C. T(1920,540). D. T(-220,-140).

21. Supose you also had some interface elements to put on the screen. Where would you place them relative to the screen?

    A. At the right. B. At the left. C. There is no space left. D. At the top or bottom.

Consider the polygon P = [A, B, C, D, E, F], which is going to be painted with the scanline algorithm (fillarea). Apart from the polygon's vertices, two aditional locations are indicated (labels x and y).



22. How many entries in the edges table (TA) will be non empty?

A. 5. B. 3. C. 6. D. 4.

23. Which edges are stored in entry Y_D of the edges table (TA[Y_D])?

A. $\overline{DC} \rightarrow \overline{DE} \rightarrow \overline{FA} \rightarrow \overline{FE}$

B. $\overline{DE}$

C. $\overline{DC} \rightarrow \overline{DE}$

D. $\overline{DC}$

24. Choose the last non empty entry in the edges table (TA).

A. TA[Y_C] B. TA[Y_F] C. TA[Y_D] D. TA[Y_A]

25. What is the maximum length of the active edges table (TAA) during the execution of the algorithm?

A. 5 B. 3 C. 4 D. 2

26. What is the contents of the active edges table (TAA) immediately before filling line Y_B?

A. $\overline{CD} \rightarrow \overline{DE} \rightarrow \overline{FE} \rightarrow \overline{BC}$

B. $\overline{CD} \rightarrow \overline{FA} \rightarrow \overline{DE} \rightarrow \overline{FE}$

C. $\overline{CD} \rightarrow \overline{FA} \rightarrow \overline{DE} \rightarrow \overline{FE} \rightarrow \overline{BA}$

D. $\overline{CD} \rightarrow \overline{DE} \rightarrow \overline{FE}$

27. Assuming that the polygon vertices lie at exact pixel locations, which vertices correspond to pixels that will be filled during execution of the algorithm?

A. A,D and F B. none. C. A D. A, C and B

28. Which of the x and y locations are going to be painted by the algorithm?

A. Only x. B. None. C. Only y. D. Both.

29. Imagine that the edges of polygon P will be painted with lines with unit width. Choose the **correct** sentence.

A. If the interior of the polygon is painted after the edges, some pixels will be painted over.

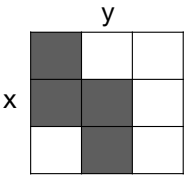
B. The perceived intensity of all the edges is the same.

C. The set of points that are painted for each of the edges is always to the same side of the ideal line that connectes the edges endpoints.

D. The staircase effect is visible in all the edges.

Consider that the antialiasing filter shown on the left is going to be applied to a grayscale image.

$$\frac{1}{32}\begin{bmatrix} 2 & 4 & 2 \\ 4 & 8 & 4 \\ 2 & 4 & 2 \end{bmatrix}$$



30. What is the final intensity value computed for the pixel at the centre of the image on the right. Note that black pixels have an intensity of 0, while white pixels have an intensity of 1.

A. 7/16. B. 4/9. C. 5/9. D. 9/16.

31. Which of the following filters could also have been used for antialiasing without changing the overal image intensity?

A. $\frac{1}{50}\begin{bmatrix} 8 & 4 & 8 \\ 4 & 2 & 4 \\ 8 & 4 & 8 \end{bmatrix}$ B. $\frac{1}{46}\begin{bmatrix} 2 & 6 & 2 \\ 6 & 12 & 6 \\ 2 & 6 & 2 \end{bmatrix}$ C. $\frac{1}{44}\begin{bmatrix} 3 & 6 & 3 \\ 6 & 10 & 6 \\ 3 & 6 & 3 \end{bmatrix}$ D. $\frac{1}{37}\begin{bmatrix} 2 & 5 & 2 \\ 5 & 9 & 5 \\ 2 & 5 & 2 \end{bmatrix}$

Consider the variant of the Phong illumination model computed by the expression below, for direct illumination (surfaces directly visible to the eye):

$$\mathbf{I} = \mathbf{I}_a\mathbf{K}_d + \mathbf{I}_p[\mathbf{K}_d \cos(\alpha) + \mathbf{K}_s \cos(\phi)^n].$$

32. For a specular reflection factor of RGB(1,1,1), what will be the color of the specular highlights?

A. $\mathbf{K}_s$ B. $\mathbf{I}_a$ C. $\mathbf{I}_p$ D. $\mathbf{K}_d$

33. The amount diffuse reflection is maximized when:

A. **R** and **V** are parallel. B. **N** and **H** are parallel. C. **L** and **V** are parallel. D. **N** and **L** are parallel.

34. The amount of reflected light given by the specular term is porportional to the n^{th} power of the cosine of the angle formed between:

A. **N** and **L** B. **R** and **L** C. **R** and **V** D. **V** and **L**

35. Assume that the specular term was set to 0 before lighting an object, which has unknown color, with two different light sources, both aligned in a way that maximize the diffuse reflection. The ambient light was set to RGB(1,1,1), and the light colors where RGB(0,1,1) and RGB(1,0,1), for which the observed colors of the object were RGB(0.3, 0, 0.4) and RGB(0.6, 0, 0.4), respectively. What is the color of the object?

A. (0.3, 0, 0.4).

B. (0.6, 0, 0.2).

C. (0.3, 0, 0.2).

D. (0.6, 0, 0.4).

36. Imagine that we add another source of light to our model. The new light comes from a powerful light projector placed above the scene at a distance far away enough that we may consider its light is arriving along parallel rays aligned with the y vertical axis. In front of the projector we have placed a positive of an image that behaves as a filter (just like in traditional projection of photography slides). How could we change our illumination/reflection model in a GLSL program? Note: Assume that the point being lit is give by `fPosition`

A. replace $\mathbf{K}_d$ with `texture2D(image, fPosition.xz)`.

B. add a second diffuse and specular term but with $\mathbf{I}_p$ replaced by `texture2D(image, fPosition.xz)`.

C. replace $\mathbf{I}_p$ with `texture2D(image, fPosition.xy)`.

D. add a second diffuse and specular term but with $\mathbf{K}_d$ replaced by `texture2D(image, fPosition.xy)`.

Boa Sorte!