

Multiple Choice (100 points, 10 points each, -2 points for each wrong answer)

1. Definition of an affine function
2. Which transformations do not preserve angles?
3. What is the order of the stages of OpenGL pipeline?
4. Is perspective transformation (including homogenizing) linear?
5. Is a parallel line on view plane still parallel?
6. Find the  $(x', y', z')$  on the view plane ( $z = -N$ ) given  $(x, y, z)$
7. Why are triangles taken as the most common primitive?
8. When a line  $(1-g)A + gB$  in view coordinate system transforms into projection coordinate system as  $(1-f)A' + fB'$ , are  $g$  and  $f$  the same?
9. What are the advantages of using implicit (instead of explicit or parametric) equation to represent a line?
10. How to reflect a point  $(x, y)$  about a line  $y = ax$ ?

Drawing (25 points)

```
mvstack.push(model_view);  
model_view *= Translate(0, 1, 0);  
model_view *= Scale(2, 1, 1);  
drawCube();  
model_view = mvstack.pop();  
mvstack.push(model_view);  
model_view *= Scale(2, 1, 1);  
model_view *= Translate(1, 0, 0);  
drawCube();  
model_view *= Translate(0, 1, 0);  
model_view *= RotateZ(90);  
drawCube(); // Tricky!  
model_view = mvstack.pop();
```

1. [10 points] What is an affine combination of points?

- a.  $\sum_{i=1}^n \alpha_i P_i$
- b.  $\sum_{i=1}^n \alpha_i P_i$  where  $\sum_{i=1}^n \alpha_i = 0$
- c.  $\sum_{i=1}^n \alpha_i P_i$  where  $\sum_{i=1}^n \alpha_i > 0$
- d.  $\sum_{i=1}^n \alpha_i P_i$  where  $\sum_{i=1}^n \alpha_i = 1$
- e. None of the above

2. [10 points] Which elementary transformation(s) is(are) not guaranteed to preserve angles?  
*i. Uniform Scale    ii. Non-Uniform Scale    iii. Shear    iv. Rotation*

- a. *i, ii, iii, & iv*
- b. *ii, iii, & iv*
- c. *iii & iv*
- d. *ii & iii*
- e. *iii*

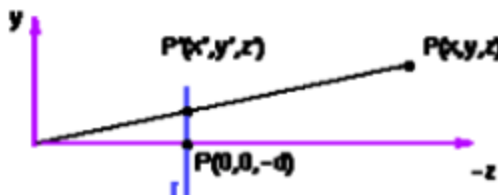
3. [10 points] Which series of transformations produces the reflection of a two dimensional point about an arbitrary line  $y = ax + b$ ?

- a.  $\text{translate}(0, -b) * \text{rotate}(-\tan^{-1} a) * \text{scale}(1, -1) * \text{rotate}(\tan^{-1} a) * \text{translate}(0, b)$
- b.  $\text{translate}(0, b) * \text{rotate}(\tan^{-1} a) * \text{scale}(1, -1) * \text{rotate}(-\tan^{-1} a) * \text{translate}(0, -b)$
- c.  $\text{translate}(0, b) * \text{rotate}(\tan^{-1} a) * \text{scale}(-1, 1) * \text{rotate}(\tan^{-1} a) * \text{translate}(0, b)$
- d.  $\text{translate}(0, -b) * \text{rotate}(-\tan^{-1} a) * \text{scale}(-1, 1) * \text{rotate}(\tan^{-1} a) * \text{translate}(0, b)$
- e. None of the above

4. [10 points] What is the advantage(s) of the implicit formulation of a 2D line over the explicit and the parametric one?

- a. We can calculate intersections more efficiently
- b. We can determine whether a point is above or below the line
- c. We can perform geometric transformations more efficiently
- d. All of the above
- e. None of the above

5. [10 points] Compute the perspective projection  $P' = (x', y', z')$  of point  $P = (x, y, z)$  onto the plane  $I$  ( $z = -d$ ) through the origin  $(0, 0, 0)$ .



- |    |                |                |           |
|----|----------------|----------------|-----------|
| a. | $x' = dx / z$  | $y' = dy / z$  | $z' = -d$ |
| b. | $x' = dx / -z$ | $y' = dy / -z$ | $z' = -d$ |
| c. | $x' = x / z$   | $y' = y / z$   | $z' = -d$ |
| d. | $x' = x / -zd$ | $y' = y / -zd$ | $z' = -d$ |
| e. | $x' = x / d$   | $y' = y / d$   | $z' = -d$ |
6. [10 points] Is the perspective projection including the perspective division a linear transformation?
- Yes
  - No
7. [10 points] Consider the transformation stages in the OpenGL pipeline. If  $M_M$  is the model matrix,  $M_V$  is the viewing matrix, and  $M_P$  the projection matrix, the combined transformations matrix is:
- $M_M M_V M_P$
  - $M_P M_V M_M$
  - $M_P M_M M_V$
  - $M_M M_P M_V$
8. [10 points] Perspective projections (including the perspective division) always maintain ratios. That is, if  $P = (1-g)A + gB$ , then  $P' = (1-g)A' + gB'$ .
- True
  - False
9. [10 points] Do parallel lines remain parallel after a perspective projection (including the perspective division)?
- Yes
  - No
  - Depends on their direction

**10. [10 points]** Why are triangles a popular graphics primitive?

- a. They are always planar
- b. They are always simple
- c. They are always convex
- d. a & b
- e. a, b, & c

11. [25 points] Draw the projection of the image created on the  $z = 0$  plane. Assume that the projection is orthographic and doesn't scale points.

```
modelMatrix.setAsIdentity();
matrixStack.push(modelMatrix);
matrixStack.push(modelMatrix);
modelMatrix *= translate(-1,0,0);
modelMatrix *= scale(2,1,1);
drawCube(); // cube 1
modelMatrix = matrixStack.pop();

modelMatrix *= scale(2,1,1);
modelMatrix *= translate(1,0,0);
drawCube(); // cube 2

modelMatrix *= translate(0,2,0);
modelMatrix *= rotateZ(90); // angle is in degrees
drawCube(); // cube 3 (Tricky!)
modelMatrix = matrixStack.pop();
```

