University of California, San Diego

CSE 167 – Midterm
Computer Graphics

Instructor: Prof. Ravi Ramamoorthi

Feb 23, 2023

Name: _____

Student ID: _____

Instructions:

- This exam contains **14** pages (including this cover page and two additional worksheet pages) and **4** questions.
- The last two pages are worksheets if you need extra space for any question.
- Total number of points is **60**.
- This exam is closed-book. You may not use any notes or printed/electronic materials.
- No calculators.
- In class, **1 hour and 15 minutes**.

Distribution of Points

Question	Points	Score
Shading	6	
Short Answer	14	
Transformations	20	
Curves	20	
Total:	**60**	

Question 1: Shading (6 points)

Consider the following snippet of shading from the GLSL fragment shader in homework 0 or homework 2. **direction** is the direction to the light, and **halfvec** is the half-vector between light and eye (normalized and properly in eye coordinates). The variables **mydiffuse**, **myspecular** and **myshininess** stand as usual for the diffuse, specular and shininess coefficients (the first two are RGB colors), and **lightcolor** is the (RGBA) color of the light. Note that we only deal with the diffuse and specular terms here, with no ambient or emission.

```
vec4 ComputeLight (     const in vec3 direction ,
                        const in vec4 lightcolor ,
                        const in vec3 normal ,
                        const in vec3 halfvec ,
                        const in vec4 mydiffuse ,
                        const in vec4 myspecular ,
                        const in float myshininess ) {
    1. float nDotL = dot(normal , direction );
    2. vec4 lambert = mydiffuse * lightcolor ;
    3. float nDotH = dot(normal , halfvec );
    4. vec4 phong = myspecular * lightcolor * _____ ;
    5.  vec4 retval = lambert + phong ;
    return retval ;
}
```

i. There is a subtle (mathematical) error in line 2. Please identify the error and correct the code. Also provide the mathematical formula for Lambertian reflectance. (3 points)

- Error explanation:

- Corrected Code of Line 2:

- Mathematical Formula:

ii. Please complete line 4. Also, provide the mathematical formula for Blinn-Phong reflectance. *nb: getting the exact GLSL syntax right is not important, but you should be able to convey the formula.* (3 points)

- Completed Line 4:

- Mathematical Formula:

Question 2: Short Answer (14 points)

(i) Assume you are trying to display a color (on a linear scale, not pre-corrected) (0.25, 1.0, 0.64) on a monitor with a gamma of 2.0. What color value should you actually send to the monitor with gamma correction so the correct colors are displayed? (3 points)

Answer: R: G: B:

(ii) In OpenGL, consider the following stages:

- Rasterization
- Fragment Shader
- Vertex Shader

In what order are these stages executed in the graphics pipeline? Which of these stages are programmable versus fixed? (3 points)
(Please put a check after Programmable or Fixed for each stage below.)

Stage 1:		Programmable	Fixed
Stage 2:		Programmable	Fixed
Stage 3:		Programmable	Fixed

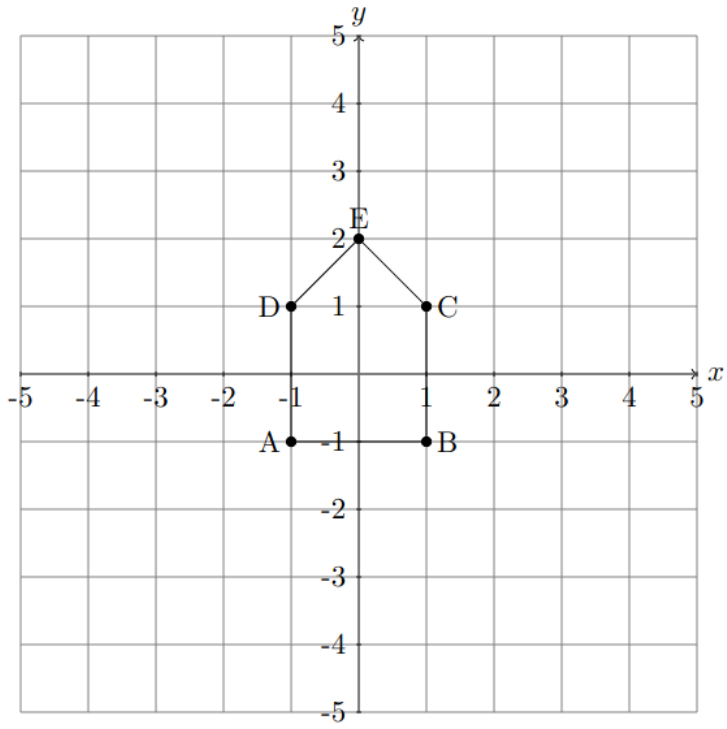
(iii) Briefly describe the difference between raster and vector graphics. (3 points)

(iv) For the eye position (0, 1, 0), looking at the origin (0, 0, 0), and with an up vector (1, 1, 0), what is the resulting orthonormal ***uvw*** basis (used for coordinate transforms and gluLookAt)? (5 points) (Please put your answer in the table below and use the room below to work)

u	(, ,)
v	(, ,)
w	(, ,)

Question 3: Transformations (20 points)

Consider a house in the xy-plane (z = 0) with vertices on the square ABCD,
where A = (−1, −1); B = (1, −1); C = (1, 1); D = (−1, 1); with the apex E = (0, 2).
For each of the following transformations, draw out the transformed house (marking each vertex) and provide the 4 by 4 matrix for the transform.
All of the transforms are independently applied to the rest configuration unless stated otherwise.

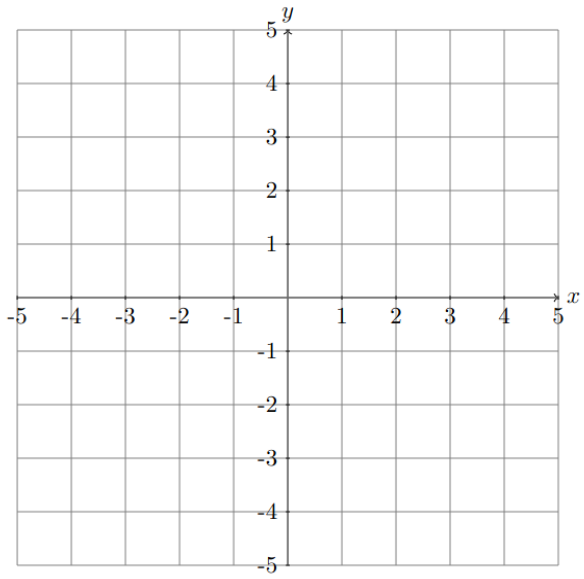


(i) A shear along the x-axis, so that the bottom (at y = −1) of the house is not affected, but the top of the square (at y = +1) is moved one unit to the right, i.e. (−1, 1) is moved to (0, 1) for example. Remember to provide the 4 by 4 transform.

Hint: first apply a translation in y to bring the lower part of the house to y = 0. (7 points)

Please make use of the coordinate grid and the answer box on the next page. Use the extra space on the next page to show your work.

Draw the transformed figure:

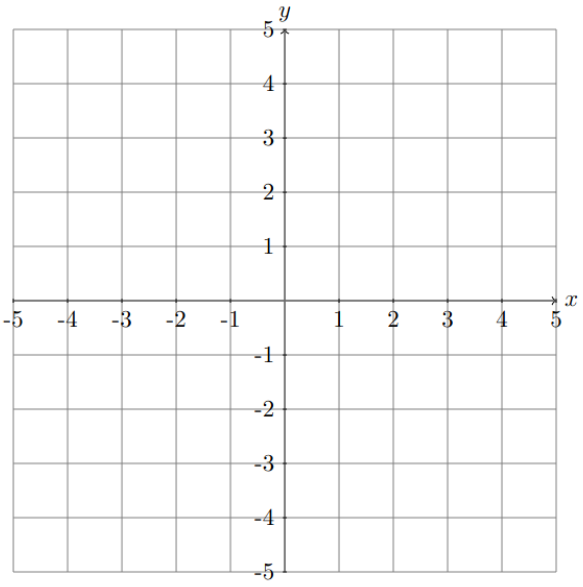


Transformation matrix:

$$\begin{bmatrix} \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \end{bmatrix}$$

(ii) [Independent question, not carried over from (i)]. Now, consider a rotation by 45 degrees counterclockwise (in the plane), followed by a translation of +2 units on the x-axis. Draw the resulting picture for the house, and write down the 4 by 4 transformation matrix. (7 points)

Draw the transformed figure:



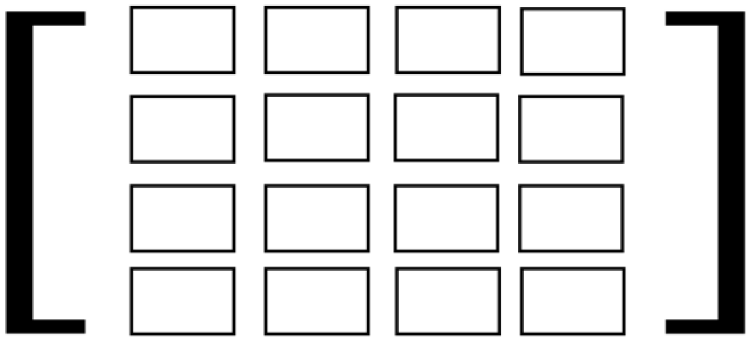
Transformation matrix:

$$\begin{bmatrix} \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \\ \square & \square & \square & \square \end{bmatrix}$$

（Space for working）

(iii) Provide the inverse 4 by 4 transformation matrix for (ii). (6 points)

Inverse transformation matrix:



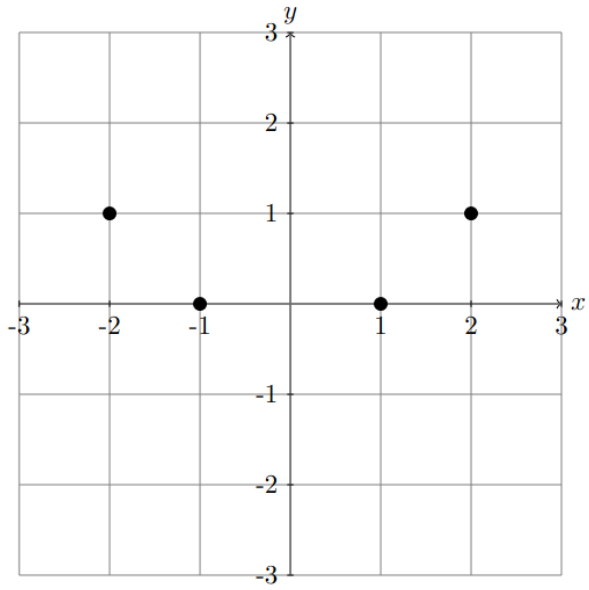
(Space for working.)

Question 4: Curves (20 points)

(i) Consider a cubic Bezier curve in the plane with control points (−2, 1), (−1, 0), (1, 0), (2, 1). What are the end-points and mid-point of this Bezier curve? (8 points)

The grid is provided as an optional working sheet and does not form part of the answer.

	x	y
Left end-point		
Mid-point		
Right end-point		

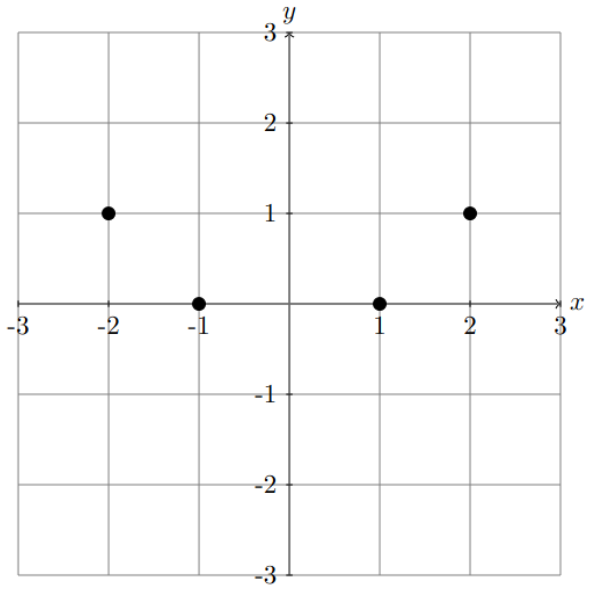


(Space for working)

(ii) Consider a uniform cubic B-spline curve with the same control points.
What are the end-points and mid-point of the B-spline curve? (8 points)

The grid is provided as an optional working sheet and does not form part of the answer.

	x	y
Left end-point		
Mid-point		
Right end-point		

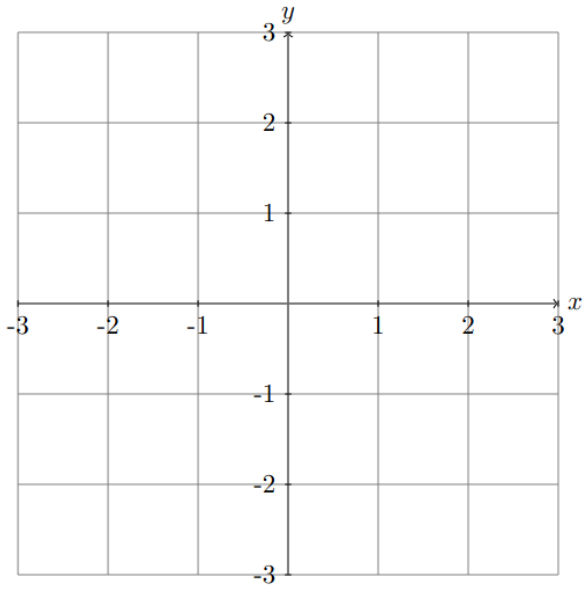


(Space for working)

(iii) What would be the control points of a cubic Bezier curve that reproduces (is identical to) the B-spline curve in (ii)? Provide the control points from left to right. (4 points)

The grid is provided as an optional working sheet and does not form part of the answer.

	x	y
Control point 1		
Control point 2		
Control point 3		
Control point 4		



(Space for working)

END OF EXAMINATION

Scratch Page

Scratch Page