

Name: \_\_\_\_\_

**Homework1**  
**15-462 Computer Graphics, Spring 2014**  
**due Tuesday, Feb 25<sup>th</sup> just before class**

70 points

Please show your work.

Write down your assumptions and steps so that I can give you partial credit.

Please list all sources that you use other than the course slides and notes.

1. **(10 points) Homogeneous coordinates.**
  - a. How do we represent a point in 3D space using homogeneous coordinates?
  - b. How do we represent a vector (a direction) in 3D space using homogeneous coordinates?
  - c. Why do we use this representation?
  
2. **(10 points) Implicit form of a line.** An implicit equation for a line through the 2D points  $(x_0, y_0)$  and  $(x_1, y_1)$  is given below. Prove that this equation is correct. To do this, you must show that it interpolates the two points and is indeed an equation for a line.

$$f(x, y) = (y_1 - y_0)x + (x_0 - x_1)y + x_1y_0 - x_0y_1$$

3. **(5 points) Parametric form of a line.** Write the parametric form for the line through the 2D points  $(x_0, y_0)$  and  $(x_1, y_1)$ .
  
4. **(15 points) Direct illumination.** The Phong Illumination equation is given below. (It has also been referred to as Blinn-Phong in class.)

$$I = k_a L_a + k_d (l \cdot n) L_d + k_s (r \cdot v)^\alpha L_s$$

- a. Sketch the  $l$ ,  $n$ ,  $r$ , and  $v$  vectors and briefly define each one.
  - b. What terms in this equation are properties of the surface material of objects in the scene?
  - c. What terms in this equation are properties of the light source(s)?
  - d. What is the role of parameter  $\alpha$ ?
  - e. Why do we include an ambient light term?
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5. **(10 points) Transforms.** Derive the transformation matrix that brings points in the world frame into the camera frame. The camera is located at eye point  $e$ , with look direction  $l$  and up vector  $p$ . Please start by sketching the scene to indicate your understanding of the problem.

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6. **(10 points) Barycentric coordinates.** Draw a triangle and label vertices a, b, and c. Sketch in points at the following barycentric coordinate locations. If a point should not be plotted because it does not have valid barycentric coordinates, please indicate this is the case.

- a. [0.2, 1.0, -0.2]
- b. [0.2, 0.3, 0.5]
- c. [.1, .1, .1]
- d. [-1, 1, 1]
- e. [.5, .4, .3]

7. **(10 points) . Curves and splines.** Derive from scratch the equations for the Bezier spline using the following 4 facts:

- the spline is a cubic spline in parameter  $u$ ,
- the spline interpolates control points  $P_0$  and  $P_3$ ,
- the first derivative of the curve at  $P_0$  is  $3(P_1 - P_0)$ , and
- the first derivative of the curve at  $P_3$  is  $3(P_3 - P_2)$