This is a 60 minute, CLOSED notes, books, etc. exam. You are allowed one 8.5x11 “cheat sheet”.

Strategy: Scan the entire exam first. Work on the easier ones before the harder ones. Don’t waste too much time on any one problem. Difficulty of problem is not necessarily proportional to the points.

BE NEAT. We cannot give you points for something that we can’t read. Write down your assumptions. Don’t just write your answers, **show how you got them.** Show all your work on the space provided and **clearly mark your answers**.

Write your name on each page. Check to make sure you have 5 pages.

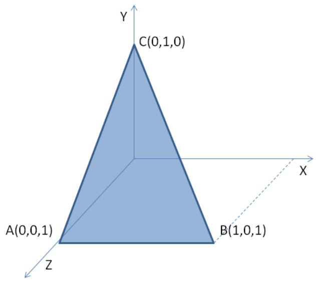
1	25 points	Linear Algebra	
2	25 points	Lighting	
3	25 points	Shading	
4	25 points	Transformation	
	100 points	GRAND TOTAL	

For your exam to be graded, you need to read and sign the statement below:

I certify that I worked independently, did not cheat, receive, or give any help in this exam. I understand that any infraction will result in my failing this class. In addition, a record of any infraction will be reported to the School of Engineering, to my College provost, and that I may also be suspended or expelled from the University.

Signature: ____________________________

1. **Linear Algebra (25 points)**



(a) **(10 points)**: Find the normal of triangle ABC in the figure above. You do not need to normalize your answer.

(b) **(15 points)**: Given a light vector L = [1,1,1], find the reflection vector R. You do not need to normalize your answer.

2. **Lighting (25 points)**

   The material properties for a polygon is as follows: Ka = (0, 0, 0.2), Kd = (1, 0, 0), Ks = (0, 1, 0), and glossiness factor is 1. In addition, you are given the following information: the polygon normal is [0 1 1], the view direction is [0 0 1], the light direction is [1 1 1], and the light color is (1,1,1).

   (a) **(5 points)**: What is the ambient lighting observed on the polygon?

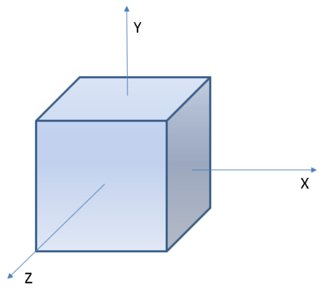
   (b) **(10 points)**: What is the diffuse lighting observed on the polygon? You can leave square-roots in your answer.

   (c) **(5 points)**: What is the halfway vector (normalized) between the light vector and the view vector? You can leave square-roots in your answer.

   (d) **(5 points)**: What is the specular lighting observed on the polygon? You can leave square-roots in your answer.

3. **Shading (25 points)**

   You are given a unit cube centered at the origin.

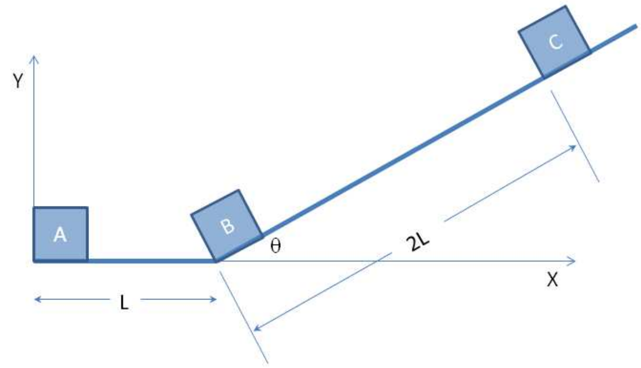


   (a) (**15 points**): What are the polygon normals for the front, top, and right faces?

   (b) (**5 points**): What is the vertex normal where the three meet?

   (c) (**5 points**): If the colors at the 4 vertices of the front face are Ca:(ra,ga,ba) Cb:(rb,gb,bb), Cc:(rc,gc,bc), and Cd:(rd,gd,bd), what is the color at the center of the front face if it were smoothly shaded using Gouraud shading?

4. **Transformation (25 points)**



In the problems below, use the convention from lecture i.e. matrices are evaluated left to right. Specify how each matrix will look like but don't multiply out the matrices.

(a) (**10 points**): A unit square is to be moved from its current position on the left (A) to a new position on the incline (B). What is the composite transformation matrix that will achieve this move?

(b) (**10 points**): The unit square is to be moved from position (B) further up the incline to position (C). What is the composite transformation matrix that will achieve this move?

(c) (**5 points**): What is the composite matrix that will move the unit square from (A) to (C)?