Graphics (INFOGR 2015-2016) – Mid-term Exam

Tuesday May 24th, 11.00 – 13.00 – EDUC-GAMMA

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- Fill in your name and student ID at the top of this page, and write it on every additional paper you want to turn in.
- Answer the questions in the designated areas on these exam sheets. For the math questions, only the final answer is needed. If you need more space for a problem, state this in the designated area for the problem and continue on the paper provided by us. On the additional paper, state your name and student ID, and clearly indicate the problem number.

Note: 0.8 for a wrong sign (e.g. (2,3,11));
0.5 for a wrong number (e.g. (2,3,10) or (2,3,-10)).

1. Write down the cross product $\vec{v} \times \vec{w}$ of the vectors $\vec{v} = \begin{pmatrix} 1 \\ 3 \\ 1 \end{pmatrix}$ and $\vec{w} = \begin{pmatrix} 4 \\ 1 \\ 1 \end{pmatrix}$ …… (2, 3, -11) …………

2. Write down a normal of the *plane* $y = 2x + 5$. *2x-1y+0z+5=0* ➔ $\vec{N} = \begin{pmatrix} 2 \\ -1 \\ 0 \end{pmatrix}$ *or* $\begin{pmatrix} 2/\sqrt{5} \\ -1/\sqrt{5} \\ 0 \end{pmatrix}$

3. If $\vec{v}$ and $\vec{w}$ are two unit vectors in $\mathbb{R}^3$, the result of $\vec{v} + (\vec{v} \times \vec{w}) + (\vec{w} \times \vec{v})$ is: *(circle one answer.)*

   a) 0 b) 1 c) (0,0,0) d) $\vec{v}$ e) undefined

4. Given: a line $P(t) = (2,0,0) + t(1,0,1)$ and a plane $3y + z = 5$. Calculate the intersection between the line and the plane. The intersection point I is at:

   $t = -\left(\begin{pmatrix} 2 \\ 0 \\ 0 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 3 \\ 1 \end{pmatrix} - 5\right) / \left(\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 3 \\ 1 \end{pmatrix}\right) = 5;\ P = \begin{pmatrix} 2 \\ 0 \\ 0 \end{pmatrix} + 5\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 7 \\ 0 \\ 5 \end{pmatrix}.$ (7,0,5)

   ……………………………………………………………

5. Given: a triangle defined by the points $v_0 = (5,1,1)$, $v_1 = (5,3,-1)$ and $v_2 = (1,5,-2)$. Calculate the normal $\vec{N}$ for this triangle. Select a correct normal from the options below.

   a) $\vec{N} = (0,1,0)$ b) $\vec{N} = (-4,2,-1)$ c) $\vec{N} = \left(\frac{1}{2}, 2, 2\right)$ *d)* $\vec{N} = (1,8,8)$ e) $\vec{N} = (1,2,-2)$

   $\begin{pmatrix} 0 \\ 2 \\ -2 \end{pmatrix} \times \begin{pmatrix} -4 \\ 2 \\ -1 \end{pmatrix} = \begin{pmatrix} 2 \\ 8 \\ 8 \end{pmatrix}$ ➔ $\begin{pmatrix} 1/2 \\ 2 \\ 2 \end{pmatrix}$

6. Given: sphere $(x-6)^2 + y^2 + (z-6)^2 = 36$ and ray $P(t) = \begin{pmatrix} 3 \\ 0 \\ 2 \end{pmatrix} + t\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$.

   Note: 0.2 for (3,0, …);
   0.2 for $\sqrt{27}$ anywhere;
   0.4 for both.

   Intersect $P(t) = \binom{-3}{-5} + t\binom{0}{1}$ with $x^2 + z^2 = 36$; we hit the circle at x=-3.

   Here, $9 + z^2 = 36$ so $z = +/-\sqrt{27}$. Transforming the ray back to (3,0,1) yields intersection points (3,0,6+$\sqrt{27}$) and (3,0,6-$\sqrt{27}$).

   $\sqrt{27} = \frac{1}{2}\sqrt{108} = 3\sqrt{3}$.

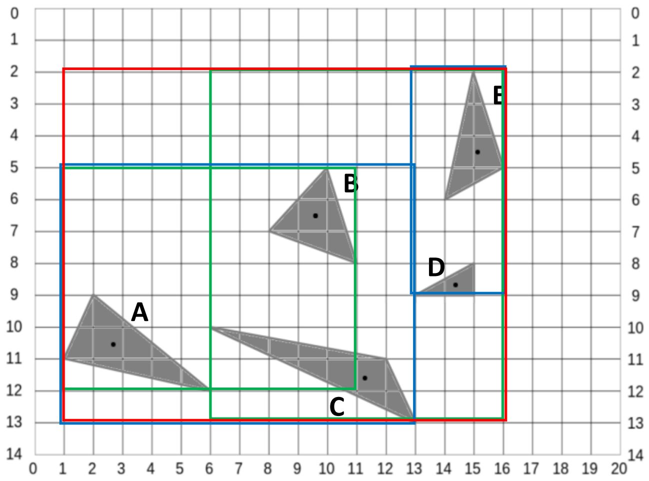
   a) Calculate the intersection point of the ray and the sphere. …………… $(3, 0, 6 + \sqrt{27})$………

   The normal direction is (6,0,6)-(3,0,6+$\sqrt{27}$)=3,0,- $\sqrt{27}$; no need to normalize.

   b) Calculate the sphere normal at this intersection point. ………………(3,0,- $\sqrt{27}$)…………
   (use intersection point (1,0,9) if you didn't answer 6a)

   Using (1,0,9):
   (6,0,6)-(1,0,9)=(5,0,-3).

7. Given: a scene with 5 triangles, as shown below. Determine the best split using the Surface Area Heuristic. Consider only vertical splits. Assume that all triangle vertices have integer coordinates. Assume that objects *on* a split plane are assigned to the left side. Write down the best split plane position (A,B,C,D or E), the cost before splitting and the cost after splitting.
Note: since this is a 2D scene, use circumference as you would normally use surface area.



Cost before splitting:

…(22+30)*5=260……………………

Best split plane position:

@B: cost=(20+14)*2+(20+22)*3=68+126=194;
@C: cost=(24+16)*3+(6+14)*2=120+40=160, so C.

Cost after splitting:

…………160…………………………

8. Fill in the blanks in the following sentence, so that the sentence as a whole makes sense.

Rasterization is a form of ……discretization or quantization……… , in the sense that a ……analog or continuous……… signal is converted into a digital signal. To improve the quality of rasterization, we can ……increase resolution…………… , or we can use ……anti-aliasing or animation………… .

Note: 0.2 per correct word;
1.0 for full correct sentence.

9. Fill in the blanks in the following sentence. Use a single word per blank.

The ray we trace from the eye to the first surface is called the ……primary…… ray. When a ray encounters a ……dielectric…… , we continue the path with two rays; one is reflected; the other is ……transmitted…………. . Their contributions are calculated using ……Fresnel……’s law.

Note: 0.2 per correct word;
1.0 for full correct sentence.

10. Explain why we do not cast shadows ray from pure specular surfaces.

Specular surfaces reflect light from a particular direction into a single direction. A ray that arrives at the specular can thus only continue in a single direction; sampling a different direction for light automatically yields 0.

Good luck!