The University of Victoria
Department of Computer Science
### CSC 305 Midterm Exam February 2019

*   *   *

Time allowed: 60 minutes, during the lecture time of February 14, 2019. Closed book; notes are not permitted. Non-graphical calculators are permitted. The grade of this midterm is marked out of 80 points in total, and this exam contributes to 10% of your final course grade.

Clearly show all your steps of derivation and calculation. Partial marks will be given based on the correctness of mathematical procedures when there are arithmetics mistakes.

Question 1. Vector Arithmetics. (10)
1. Let **v** = (4, 2, 5), what is the length of **v**? (**3**)
2. Let **u** = (-3, 0, 4), what is the angle between **u** and **v**? (**4**)
3. See figure to the right, if we calculate the cross product between vector **m** and **n**, which direction does the result point to? (**3**)
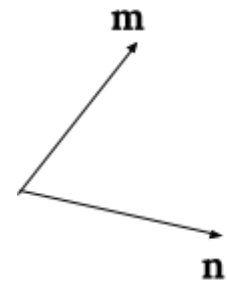
Question 2. Ray Tracing (8)
1. What is the ray equation that starts from the origin point (0, 0, -1) and goes through a pixel located at (0, 3, 3)? (**3**)
2. Given a sphere centred at (0, 0, 14) that has a radius of 10, does the ray intersect with the sphere? If it does, where is(are) the intersection point(s)? (**5**)

Question 3. Colour Theory (10)
Given two RGB colours: c_1 = (0.8146, 0.7539, 0.6812) and c_2 = (0.5769, 0.0488, 0.3134). From these numbers, decide:
1. Which colour is **brighter**? (**3**)
2. Which colour is **more saturated** (having a high purity of its hue)? (**3**)
3. Which colour is more **yellow-ish** and which one is more **purple-ish**? (**4**) <u>Provide reasons for your judgements.</u>

Question 4. Shading and Reflection Models (12)
A surface lies inside of the X-Z plane, with its normal pointing upwards to the positive Y direction. Given a point **P** (2, 0, 3) on this plane, and a point light source **L** placed at (4, 1, -2);
1. Calculate the lighting vector pointing from **P** to **L**.(**3**)

2. Assuming the colour of the light has an RGB of (0.8, 0.8, 0.8), and the surface having a red diffuse albedo, that is, Kd = (1, 0, 0), calculate the diffuse (Lambertian) shading component of point **P**. **(4)**
3. Given two unobstructed point of views, V_1 = (-0.5, 1.5, 7) and V_2 = (3, 2, -4), from which point of view can we observe a stronger specular (Phong-Blinn) reflection? <u>Provide reasons and calculations for your judgement.</u> **(5)**

Question 5. Interpolation (12)

A triangle has its three vertices located at V_A=(2, 0, 2), V_B=(5, 1, 5) and V_C=(3, 4, 3). A point **P** inside the triangle's plane has its first two barycentric coordinate w.r.t this triangle determined as α = 0.3 and β = 0.7.

1. Is **P** inside or outside of the triangle? <u>Provide reasons.</u> **(3)**
2. What is **P**'s spatial Cartesian coordinate? **(4)**
3. Given the UV coordinate of the three vertices to be (0.2, 0.4) for V_A, (0.3, 0.1) for V_B and (0.25, 0.6) for V_C, and a texture image for this triangle that has a pixel resolution of 1024 by 768 pixels, calculate the pixel coordinate of **P** to be used for texture sampling. **(5)**

Question 6. Transformation (10)

Provide a chain of 4x4 matrices that, when post-multiplied by the vertices of the simple house shape (figure to the right), will translate the entire shape from (0, 2, 0) to (4, 0, 0), rotate the shape 90 degrees clockwise, and scale the shape twice its size. **(10)**
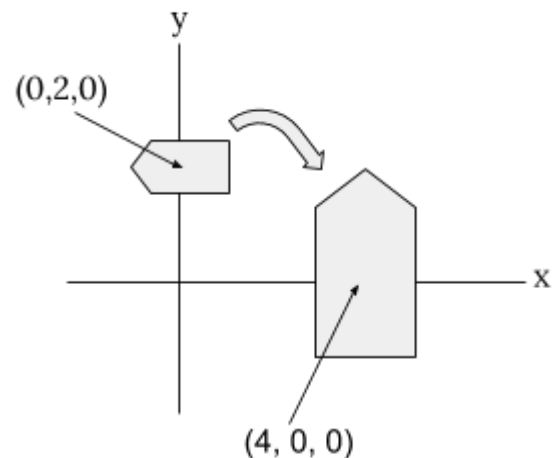
Question 7. General Knowledge. (18)

1. What does it means if two vectors are orthogonal? Given their Cartesian coordinates, how can you determine if two vectors are orthogonal? **(3)**
2. Given a function `Intersection(ray, object)` that will return a point of intersection (or no such a point) for a ray and an object in the scene, briefly describe the high-level structure of a ray-tracing rendering program using pseudocode. **(3)**
3. An apple appears red under white sunlight. <u>Briefly</u> reason about how the apple will look like when placed under an ultraviolet light that only has a small amount of visible light energy on the short-wavelength end of the visible spectrum. **(3)**

4. Based on your experiments with Assignment 1, what is the effect of increase/decrease the following to parameters of the Blinn–Phong specular reflection model? (a). the power α. (b). the specular albedo K_s. **(3)**
5. What are the Cartesian coordinates corresponding to the following homogeneous coordinates: (15, 9, 5, 3) and (8, 24, 10, 4). **(3)**
6. A rectangle has four values V_0, V_1, V_2 and V_3 assigned to its four vertices (figure to the right). Point **P** lies inside the rectangle with distance m to edge on the left, and distance n to the edge on the top. **P**'s value is to be bilinearly interpolated from the rectangle's four vertices using its spatial position. Write down **P**'s value in terms of V_0, V_1, V_2, V_3, m and n. **(3)**