UNIVERSITY OF TORONTO

Faculty of Arts and Science

Dec. 2015 EXAMINATIONS

CSC 418H1F/ CSC 2504HF

No Examination Aids Allowed

Duration - 3 hours

There are 8 pages, including this one. The examination is out of 60 marks and the value of each question is provided; please use this information to manage your time effectively.

Q.1:	/10
Q.2:	/5
Q.3:	/3
Q.4:	/6
Q.5:	/14
Q.6:	/8
Q.7:	/14
Total:	/60

1) [10 marks] Polygons (Assume the polygons in all these questions are non self-intersecting).

a) [2.5 marks] What is the normal vector **N** of a triangle in 3D, in terms of its vertices $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$?

b) [2.5 marks] What is the implicit equation $\mathbf{f(P)=0}$ for a point **P** on the plane of a 3D triangle with normal vector **N** and vertices $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$?

c) [2.5 marks] Given a 3D quadrilateral with vertices $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$, $\mathbf{P_4}$, how can we test if it is planar?

d) [2.5 marks] Describe how to compute a bounding sphere for a 3D quadrilateral with vertices $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$, $\mathbf{P_4}$? What is the center point and radius of this sphere?

2) [5 marks] Animation

a) [2 marks] A 2D circular ball falling vertically hits the ground and is squashed vertically into an elliptical shape of half its original diameter. By what factor should the ball be stretched horizontally to conserve its overall area?

b) [3 marks] Name and describe three principles of animation as proposed in Disney's Illusion of life.

3) [3 marks] Graphics Pipeline Enumerate the different stages in a graphics pipeline that a point on an object typically goes through to result in a pixel on the screen.

4) [6 marks] Projection, visibility (True or False with reason, 2 marks each, **NO marks** without the correct reason).

a) Every family of parallel lines converges to a single 2D vanishing point on the view-plane under perspective projection.

b) Given three polygons, we can always find a depth ordering such that their visibility can be resolved using the Painter's algorithm without splitting the polygons. (accompany your answer with an illustration).

c) A 3D circular arc can project in 2D to a straight line under orthographic projection. (accompany your answer with an illustration).

5) [14 marks] Illumination (True or False with reason, 2 marks each, **NO marks** without the correct reason).

a) The difference between Gourard and Phong shading is likely to be more visibly evident on diffuse objects than on specular objects.

b) The local illumination of an ideally diffuse object is invariant to view-point changes.

c) Distributed ray tracing allows us to render soft-shadows.

d) Sunlight is well approximated using a directional light source.

e) If a ray does not intersect the plane representing a BSP tree node, none of the objects on the other side of the plane from origin of the ray will intersect the ray.

f) Given a point light source that co-incides with a view-point, we are guaranteed a specular highlight on a completely visible specular sphere, no matter where it is placed in the 3D scene.

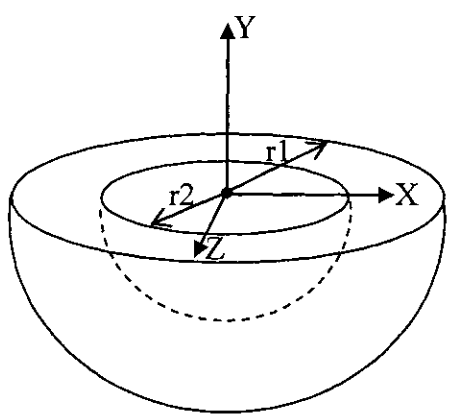
g) Backwards-ray-tracing captures global light interactions between multiple diffuse objects.

6) [8 marks] Ray-object intersections

Describe a procedure **cupIntersect** which returns the number of intersections between a ray (starting from point **S** with direction **D**) and a hollow hemispherical cup centered at the origin with its hemisphere below the **XZ** plane (i.e. with **Y** negative), and outer and inner radii **r1** and **r2** (assume **r1**>**r2**>0). Parameter values along the ray (**t>0**), for any intersection points are returned in an array **t** (in increasing order of **t**).

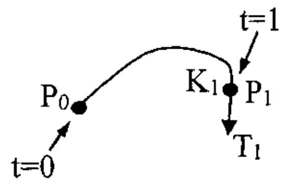
What is the maximum # of intersections between the cup and a ray?

int **cupIntersect**(point **S**, vector **D**, float **r1**, float **r2**, float &**t**[]) ;



7) [14 marks] Curves

a) [4 marks] Consider a cubic curve $\mathbf{C(t)}$ with $\mathbf{0 \le t \le 1}$,defined by 4 geometric constraints, such that:



a. $\mathbf{C(0) = P_0}$

b. $\mathbf{C(1) = P_1}$

c. $\mathbf{C'(1) = T_1}$

d. $\mathbf{C''(1) = K_1}$

Write an expression for the basis matrix of the cubic curve when the constraints are written as

$\mathbf{[\, P_0\ P_1\ T_1\ K_1\,]^T}$

b) [3 marks] A curve $\mathbf{C(t)}$ is defined using two pieces:

$\mathbf{C(t) = (t^2, t^3)}$ for $\mathbf{t<1}$ and $\mathbf{C(t) = (t^3+t^2-t,\ t^5+t-1)}$ for $\mathbf{t>=1}$.

What is the level of geometric $\mathbf{G}$, and parametric $\mathbf{C}$, continuity of the overall curve?

c) [3 marks] Give three reasons why cubic curves are popular in computer graphics.

d) [4 marks] A curve **C(t)** over **0<=t<=1** is defined using a set of **n** basis functions **B_i(t)** corresponding to points **P_i**, such that **C(t)**= $\sum_i$ (**B_i(t)*P_i**). What is the Affine Invariance property for such a curve **C(t)** and under what conditions will **C(t)** be Affine Invariant.

End of Examination.