U.C. Berkeley, EECS, Computer Science

CS 184 - Spring 2011 **COMPUTER GRAPHICS** **Prof. C. H. Séquin**

MIDTERM EXAM

Your Name:______________________________ Your Class Computer Account:___________

Room:_______ "Row":______ Seat:______ Your student ID #: ____________________

INSTRUCTIONS (Read carefully !)

DO NOT OPEN UNTIL TOLD TO DO SO !

TIME LIMIT: 75 minutes. Maximum number of points: 150.

CLEAN DESKS: No books; no calculators; only writing implements and ONE double-sided sheet of size 8.5 by 11 inches of your own personal notes to assist your memory.

NO QUESTIONS ! (They are typically unnecessary and disturb the other students.)
If any question on the exam appears unclear to you, write down what the difficulty is and what assumptions you made to try to solve the problem the way you understood it.

DO ALL WORK TO BE GRADED ON THESE SHEETS OR THEIR BACKFACES.

NO PEEKING; NO COLLABORATION OF ANY KIND!

I HAVE UNDERSTOOD THESE RULES:

Your Signature:__________________________________

Get a few points up front:

What was the most difficult-to-understand concept in the course so far ? (2 pts)

Problem #1 — Circle the correct answer (10 pts.; 2each, -3 each wrong)

| TRUE | FALSE | 2D translations can be represented by homogeneous orthonormal 3x3 matrices.

| TRUE | FALSE | In 3-space, any sequence of non-uniform scalings can be applied in arbitrary order without affecting the result.

| TRUE | FALSE | The Gouraud shading model will produce a uniform apparent brightness when applied to an isolated, irregular, planar Lambert polygon, illuminated with a single parallel light source, and viewed (perspectively) from a close-by eye-point.

| TRUE | FALSE | The Gouraud shading technique produces a planar {a*x + b*y + c} brightness distribution on triangular faces of a polyhedral object.

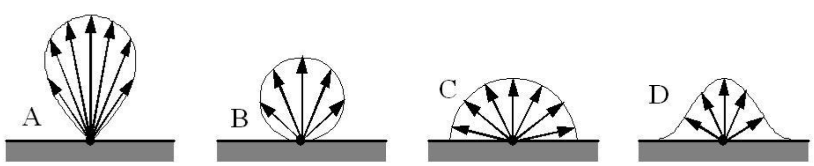
| TRUE | FALSE | The transpose of an orthonormal matrix is equal to its inverse.

Problem #2 — Circle the correct answers: (14 pts.)

(4) Circle all other operations with which a **rotation around the x-axis** does commute:

Mirroring in x; Translation in y; Uniform scaling; Non-uniform scaling; Rotation around z.

(4) Which of the four directional vector diagrams below describes most appropriately the perceived brightness observed on an ideal Lambert surface when viewing the surface from a direction opposite to each of the small arrow directions?



(6) A multi-segment cubic B-spline curve **with no cusps** is defined by six control points. Circle **all** the degrees of continuity that exist at its parametric midpoint (t=1.5):

G0 C0 G1 C1 G2 C2 G3 C3 G4 C4

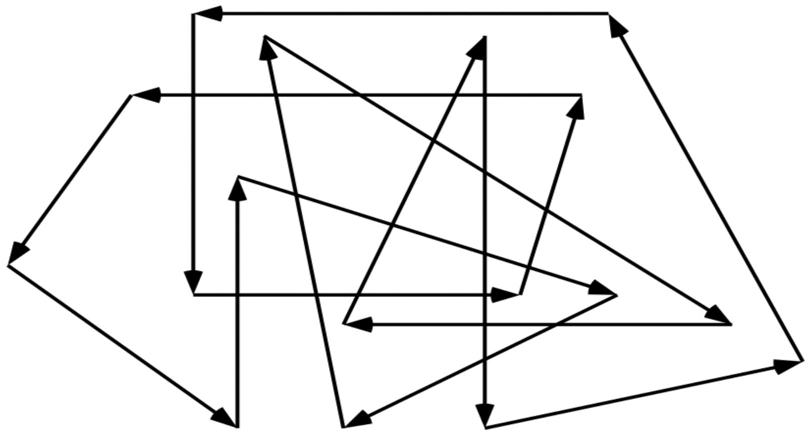
Problem # 3 — Parametric Representation (12 pts.)

(6) Give a parametric representation of a ray that starts at the eye E, passes through pixel center P, and then goes off to infinity:

(6) Give **two** reasons why a parametric curve representation: $\mathbf{x = F_x(t), \quad y = F_y(t), \quad z = F_z(t)}$ is preferable to the form: $\mathbf{y = f_y(x), \quad z = f_z(x).}$

Problem # 4 — Polygon-fill (8 pts.)

Paint the "inside" areas according to the NON-ZERO WINDING-NUMBER MODEL.



Problem # 5 — Short Questions (20 pts.)

(4) Given the choices (voxels | B-rep mesh | CSG | sweep | instantiation), which is the prefered way to model :

a) A perfect, rotationally symmetric ellipsoid ? ____________________

b) A piece of sponge (e.g., to wash your car) ? ____________________

(4) A cubic B-spline in the x,y plane has the following control points:
A(0,0), B(0,1), C(0,2), D(0,3), E(0,4), F(0,5), G(0,6);

How long is the drawn curve? __________________

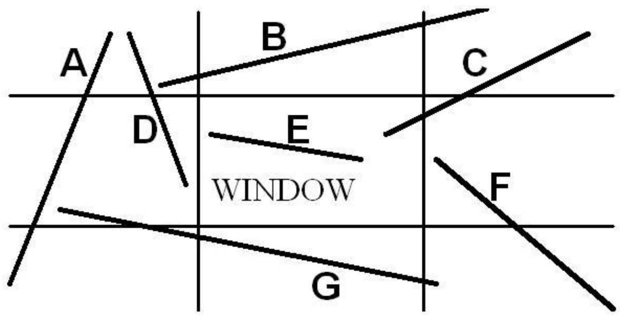
(4) A **square** cross section of area 1 cm^2 is swept along a piecewise linear space path. What is area of the cross-sectional "rib" at a properly mitered joint that makes a 90 degree turn? ________________

(4) A **rotation-minimizing** frame (RMF) is swept around a planar circular path. The RMF is initialized to the Frenet frame. How many degrees is it rotated relative to the Frenet frame after sweeping through a full revolution? ________________

(4) Describe in one sentence the essence of a contribution that Mr. **Phong** has made to the field of computer graphics:

Problem # 5 — Clipping (8 pts.)

For the figure below list all the line segments that, based on their "outcodes," can be trivially eliminated from being subjected to a more detailed line clipping algorithm.

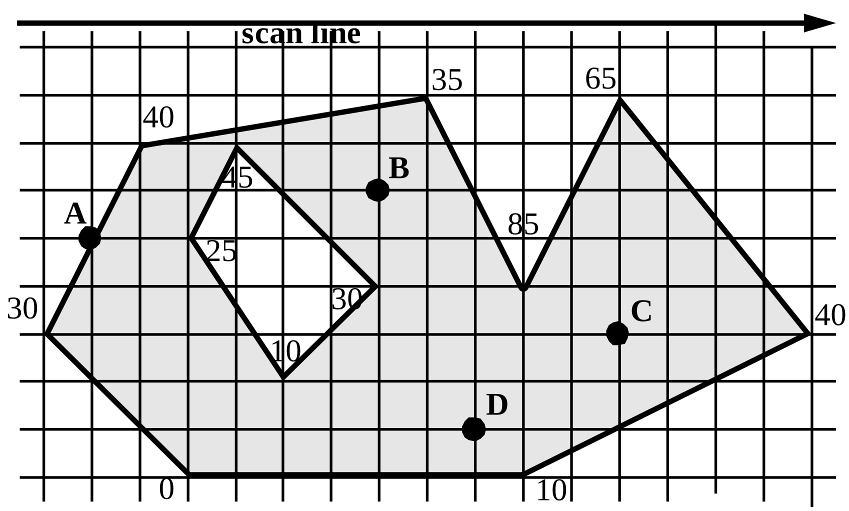


These lines can be trivially eliminated:

____

Problem # 7 — Gouraud Shading (12 pts.)

You are scan-line processing (in the usual way) the polygon below using **Gouraud** interpolation. The rendering intensities at the vertices are shown. Write out the intensities at the labeled points.



A = _____

B = _____

C = _____

D = _____

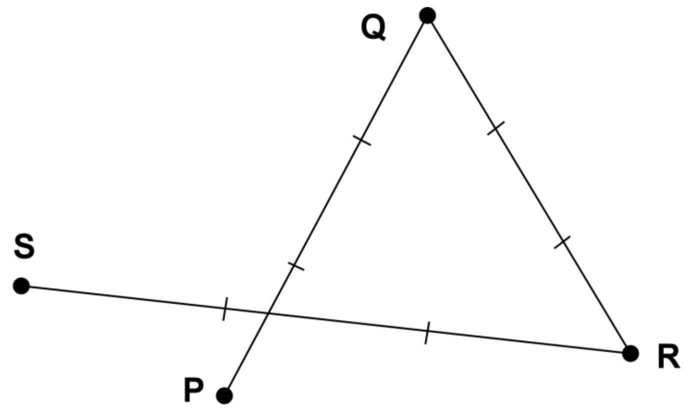
Problem # 8 — Polygon-fill (5 pts. each)

(A) Draw a curve with a turning number of -1 and a winding number of +2 around a point P.	(B) Draw a closed curve that has G1- and C1-contuinuity but not G2- or C2-continuity.

.**P**

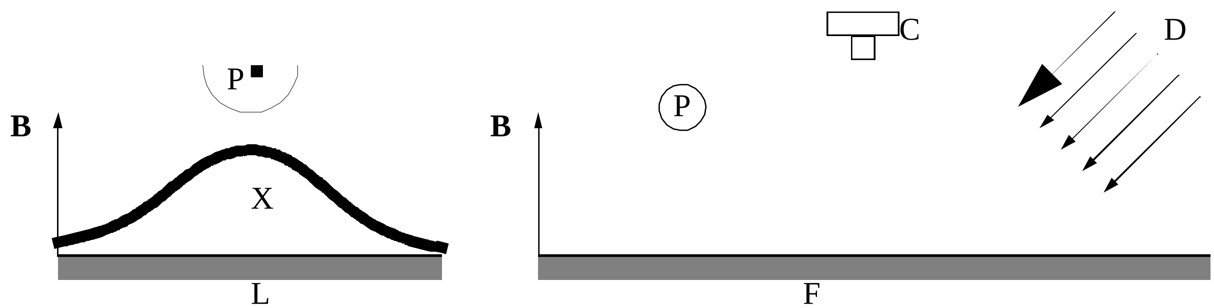
Problem # 9 — Bézier Curve (10 pts.)

For the given cubic Bezier segment (P,Q,R,S), find the points at **t = 1/3** and **t = 2/3** and their tangent direction using the deCasteljau method. Then sketch the resulting curve.



Problem # 10 — Illumination (10 pts.)

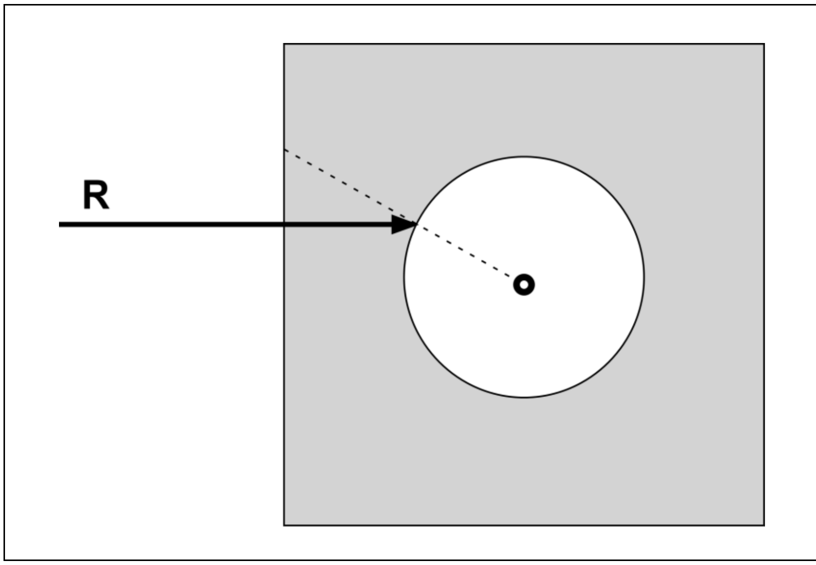
Sketch apparent brightness B, as seen from camera C, along real face F (Phong model, $K_{amb}=K_{diff}=K_{spec}=0.5$, $N_{phong}=50$), illuminated by point-light P and directional light D.
Follow example X, showing the brightness of an ideal Lambert surface L, illuminated by point-light P.



Problem # 11 — CSG (10 pts.)

Given the 2-dimensional bar-bell below and a 2-D computer graphics CSG system with only the primitives **unit-square** and **unit-circle**, draw a **simple CSG tree** that will model the bar-bell. Use a **minimal number** of elements and of Boolean operations (transformations do not count). Also show the **transformed, instantiated leaf objects overlaid** on the picture of the bar-bell.

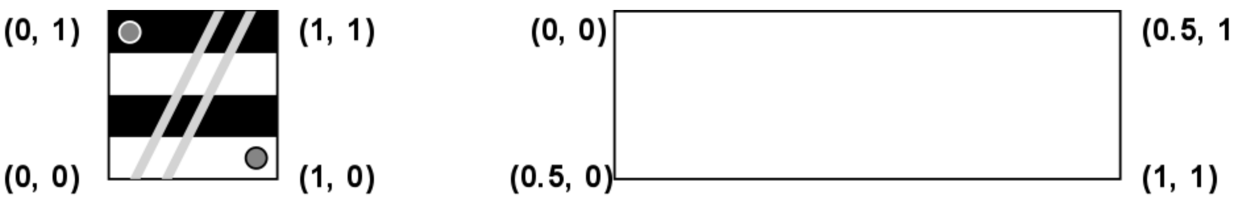
Problem # 12 — Refraction and Reflection (10 pts.)



Ray R has entered a glass cube (refractive index **n=1.5**) with a spherical evacuated hollow as shown. Ray-trace this ray through all interactions with **2** subsequent glass surfaces encountered, and show the directions of the emerging rays after that.

Problem # 13 — Texture Mapping (8 pts.)

Use the texture map below and apply it to the rectangular surface on the right, carefully observing the given texture coordinates (u,v).



Problem # 14 — Surface "Decoration" (6 pts.)

You should understanding the fundamental principles behind the following "decoration" techniques": Texture-mapping (T), Bump-mapping (B), Displacement-mapping (D), and Environment-mapping (E). Indicate with the proper labels (*) which of these four techniques do the following:

(a): **Affect** the surface normal used for the lighting calculation: _______________

(b): **Use** the surface normal as an entry into a look-up table: __________________