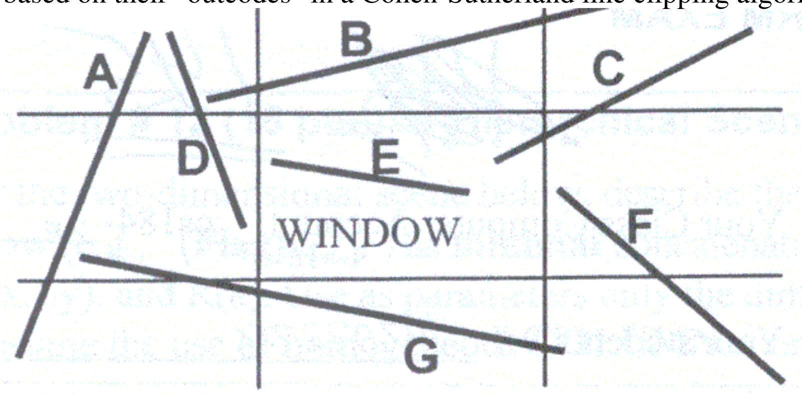
Problem #1 (8 pts.) - Clipping

For the figure below list all the line segments that can be trivially culled away in the first step based on their "outcodes" in a Cohen-Sutherland line clipping algorithm.



These line segments can be trivially rejected: _____________

Problem #2 (10 pts.) - Circle the correct answer.

Rotations are described by orthonormal matrices.

True False
A perspective projection from 3D to 2D is a linear transformation.

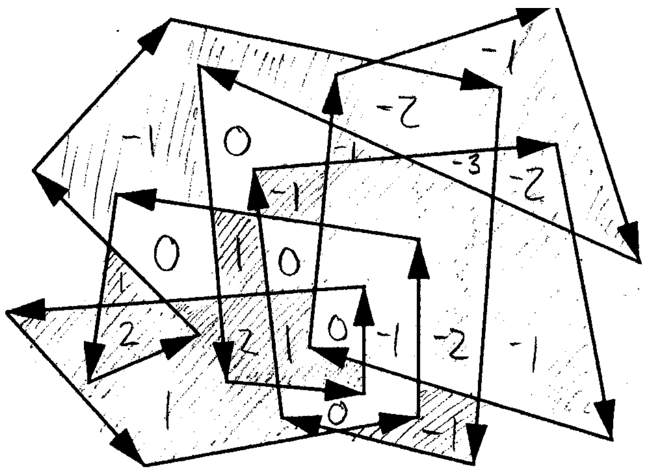
True False
In a perspective projection, the smaller the distance between the object and the center of projection, the larger teh image of the object will be.

True False
A sphere with a surface that acts as a Lambertian diffuse reflector will look to an observer like a uniformly lit flat circular disk when illuminated only with an ambient light source and viewed with perspective projection.

True False

Problem #3 (12 pts.)

For the self-intersecting polygon below, paint the "inside" according to the definitions of "inside": using the WINDING NUMBER MODEL.



Problem #4 (28 pts.) - Short Questions.

(6) Circle all the 3D transformations that commute with non-uniform scaling in x :

nonuniform scaling in y; translation in z; mirroring in y; rotation around x; rotation around y.

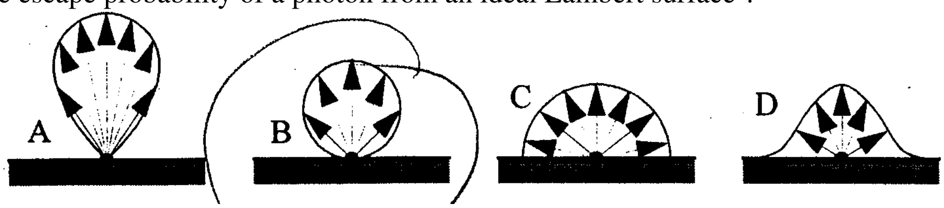
(4) How many degrees of freedom are associated with all possible planar **ellipses** in **R3**? ______

(4) How many degrees of freedom are associated with all possible **infinitely long cylinders** of some (variable) diameter D in **R3**? __________

(6) What are the minimum and maximum number of vanishing points that can be obtained from a perspective projection of a **regular five-sided prism** ?

MIN:_____________________ MAX:______________

(4) Which of the four directional vector diagrams below describes most appropriately the escape probability of a photon from an ideal Lambert surface ?



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

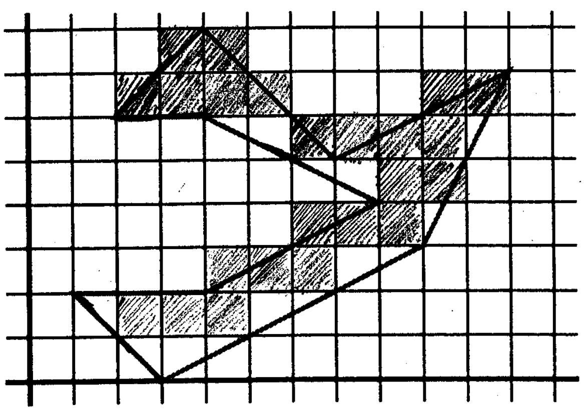
Problem # 5 (8pts.) - Perspective Warp
What is the equation of the resulting plane in 3-space after the perspective transform of the **plane x=z** in the canonical perspective viewing volume ? (for your convenience, below is the homogeneous

perspective transformation matrix).

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \frac{1}{1+z_{min}} & \frac{-z_{min}}{1+z_{min}} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

Problem # 6 (12 pts.) - Rasterization

Using the paradigm discussed in class and used on Assignment #8 (lower left pixel-corner sampling), rasterize the polygon below, i.e. paint in all the pixels that would get turned on in a scanline based fill algorithm. (Apparent coincidences are meant to be exact coincidences).



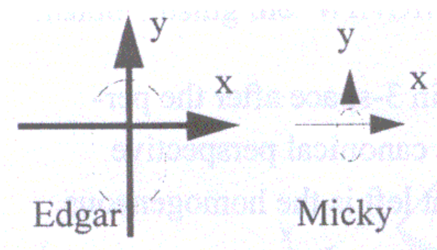
Problem # 7 (16 pts.) - Compound Transformations

An elephant, "Edgar", stands at the origin of a 2D right-handed coordinate system, facing 'forward' in the +y direction. Nine meters to the right of him { at (900cm, 0cm) in WORLD } stands a mouse, "Micky", also facing in the +y direction. The two local coordinate systems of Edgar and Micky are parallel to that of WORLD. The circus director gives the commands:

· Forward (4) ! - TurnLeft (110°) ! - Forward (9) !

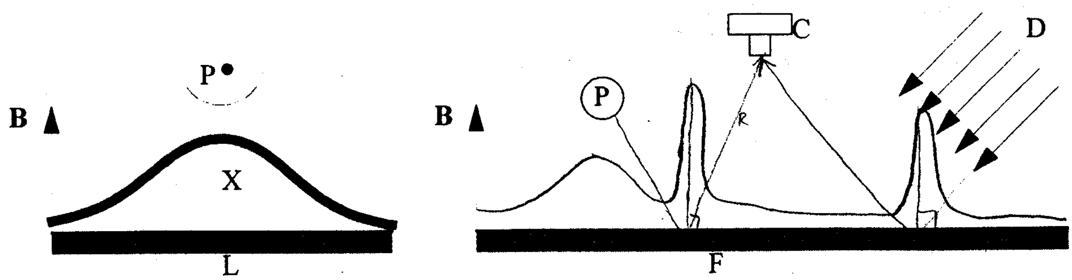
Both animals obey; however, Edgar interpretes Forward(distance) commands in 'meters' (1m = 100cm), while Mickey thinks it means 'centi-meters'; thus their individual paths are different.

What is the relative position of Micky with respect to Edgar after executing the above commands? Give a simple string string of transformation matrices **for column coordinate vectors** in short form notation, {T(x,y), R(alpha) }, with numerical arguments in centi-meters {cm} and/or in degrees {°}.



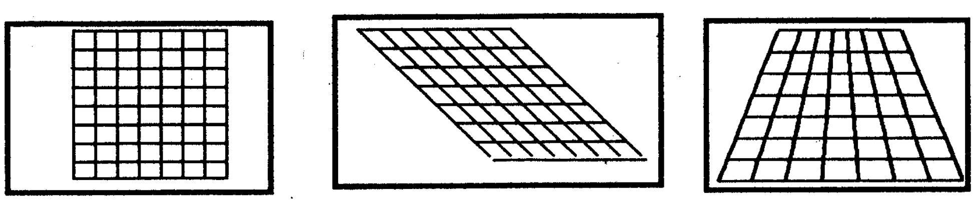
Problem # 8 (12 pts.) - Illumination

(A) 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 # 9 (9 pts.) - Projections

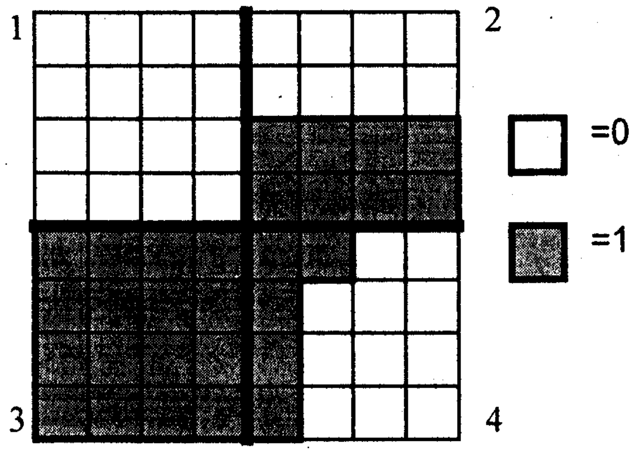
The following images are all snapshots of an orthogonal planar grid, but taken with different cameras from different locations in 3-space.
Determine the type of projection used in each case; circle the proper answer below each image.



Parallel - Perspective - Can't Tell! | Parallel - Perspective - Can't Tell! | Parallel - Perspective - Can't Tell!

Problem # 10 (12 pts.) - Quadtree

Show a QUAD-TREE representing the geometry in the Figure below. Draw the tree with the children of each node appearing in order {1,2,3,4} from left to right, and show the leaf-node values.

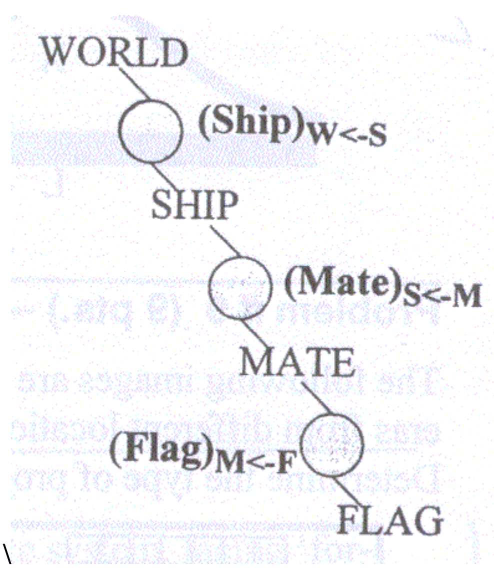


Problem # 11 (7 pts.) - Parametric Representation

Give a parametric representation of a ray that starts at point A, passes through point B, and then goes off to infinity.

Problem # 12 (16 pts.) - Hierarchical Scene

For the two-dimensional scene below, describe the various instance transform matrices listed below (e.g., **(Flag)** $_{M<-F}$) as **minimal** concatenations of simple matrices of the type T(dx, dy), S(sx,sy), and R(a). Use as parameters only the dimensions and angles shown int eh figure below. (Assume teh use of homogeneous **COLUMN** coordinate triples.)

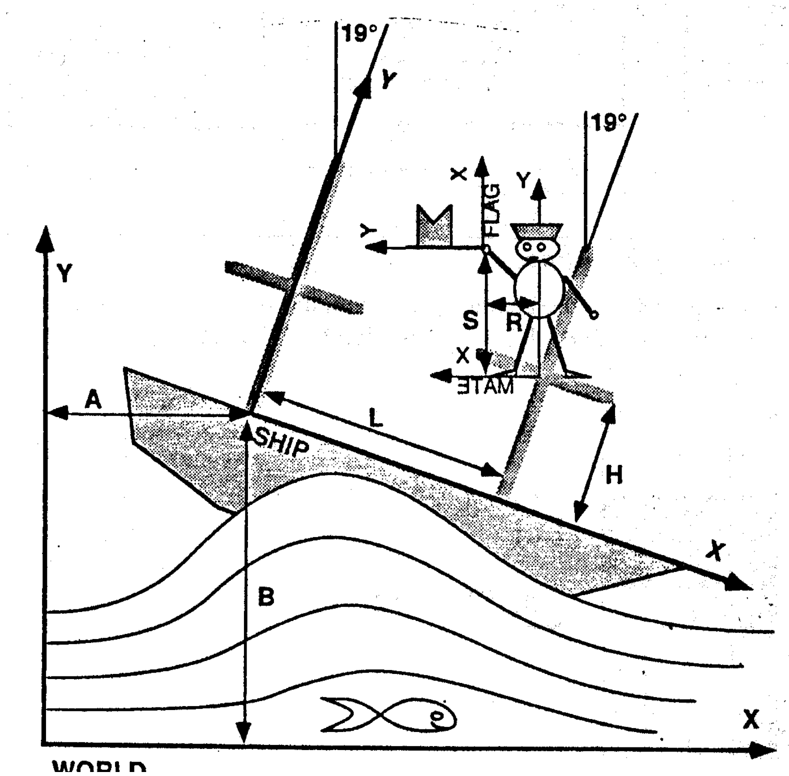


\

(Ship) $_{W<-S}$ =

(Mate) $_{S<-M}$=

(Flag) $_{M<-F}$=


19°
Y
19°
X
Y
Y
FLAG
Y
S
R
X
MATE
A
L
SHIP
H
X
B
X
WORLD