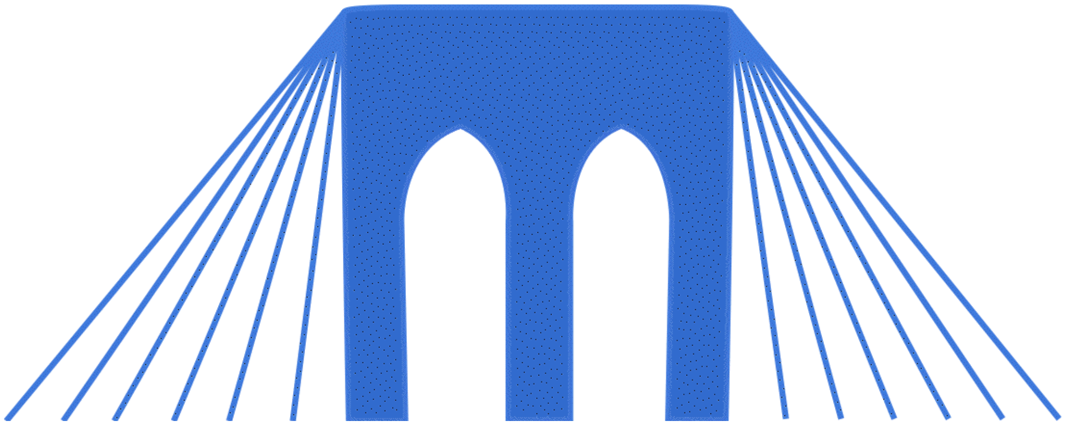
Bridges To Computing



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- For more information about the Bridges Program, please visit our website at: http://bridges.brooklyn.cuny.edu/

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Graphics Programming

Lecture 3

- Simple Animation

- Simple 3D Drawing

Resources

- Processing web site:
  - http://www.processing.org/
- Linear motion (moving stuff around):
  - http://www.processing.org/learning/topics/linear.html
- Bitmap animation (swapping pictures):
  - http://www.processing.org/learning/topics/sequential.html
- Reference:
  - http://www.processing.org/reference/index.html
- MORE MORE MORE TUTORIALS
  - http://www.processing.org/learning/

Content

Animation

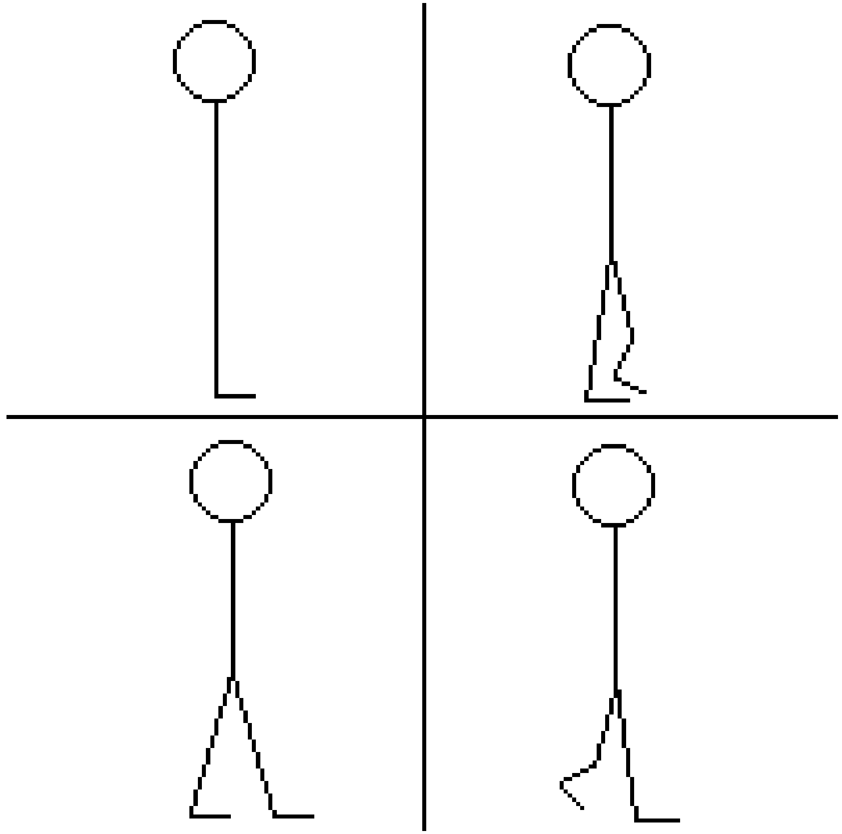
- Basic animation involves the following steps:
  1. Drawing initial frame - perhaps in setup().
  2. Waiting some amount of time (e.g., 1/60th of a second)
     - Processing does that automatically
  3. Erasing the screen.
     - Usually be reapplying the background (often the first thing we do in the draw( ) function).
  4. Drawing the next frame/image/picture.
  5. Repeating steps 2-4, until you are ready to stop animating.
- There are two basic ways to implement animation:
  - Drawing your own shapes, text, etc.
  - Displaying a GIF or other image file
- There are issues with the "frame rate" that we choose.

On Human Perception

- Human eyes and brains are unable to process properly images that are moving to fast.
- One famous example of this (which we can demonstrate) is the "flicker fusion" test.
  - A black box and a white box are alternately presented in the same exact place on the screen.
  - We change the frame rate so that those two boxes are alternated at faster and faster speeds.
  - Depending on the ambient light, at somewhere between 30 and 60 frames per second you will see a only a single grey box.
- You may need to slow down your own animations to 20-30 frames per second in order for some aspects of your animation to be visible.
- Most movies are and games are animated around the 24-30 frames per second rate.

Bitmap Animation (1)

- In Bitmap Animation we have a series of pictures, each of which is slightly different.
- We can achieve the illusion of animation, by presenting those different pictures rapidly in succession.
- In practical terms we will want to store our images in an array (a type of list).

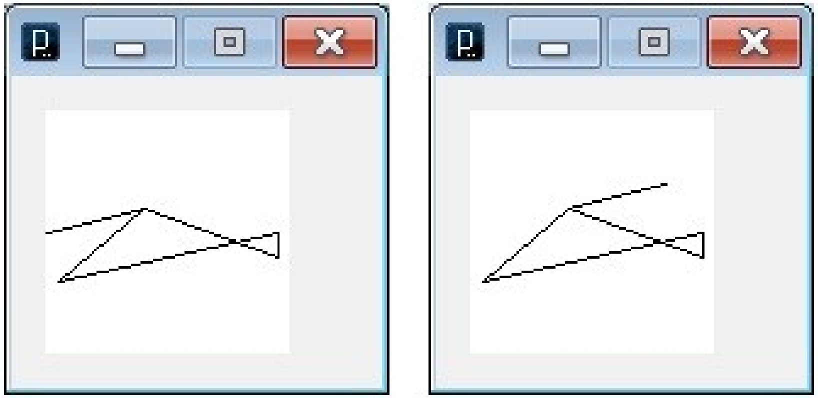


Bitmap Animation (2)

```
int numFrames = 4;      // The number of frames in the animation
int frame = 0;          // The picture to draw

PImage[ ] images = new PImage[numFrames];   // List of picture objects

void setup() {
   size( 200, 200 );
   frameRate( 30 );
   images[0] = loadImage("PT_anim0000.gif");
   images[1] = loadImage("PT_anim0001.gif");
   images[2] = loadImage("PT_anim0002.gif");
   images[3] = loadImage("PT_anim0003.gif");
}
void draw() {
   frame = ( frame + 1 ) % numFrames; // Cycle through frames
   image( images[frame], 50, 50 );
}
```

VECTOR ANIMATION (1)

- In Vector Animation we change the pictures that are drawn each frame by subtly modifying our mathematical code.
- In the example to the right, only one line of code is changed, in order to get the two different pictures.
- We can use a "gate" variable, to switch between drawing the different pictures each time.



Vector Animation (2)

```
int v_image=0;

void setup() {
   frameRate(20);
}

void draw() {
   background(#FFFFFF);    // clears the screen

    quad( 40,40, 95,60, 95,50, 5,70);    //body of the helicopter

   if(v_image == 0)  {
           line(40,40, 80,30);     // Line to the right
           v_image = 1;
    } else {
           line(40,40, 0,50);      // Line to the left
           v_image = 0;
    }
}
```

Animation and Movement

- Whether using a bitmap or a vector image, you will specify x and y coordinates for your image.
- If you add a variable to that coordinate you can change where an image is drawn.

```
int xPos = 0;     // x Position of our image.
void setup() {
   frameRate(20);
}
void draw() {
   background(#FFFFFF);
   rect( (0 + xPos) ,50 ,10 ,10 );
   xPos = xPos +1;
}
```

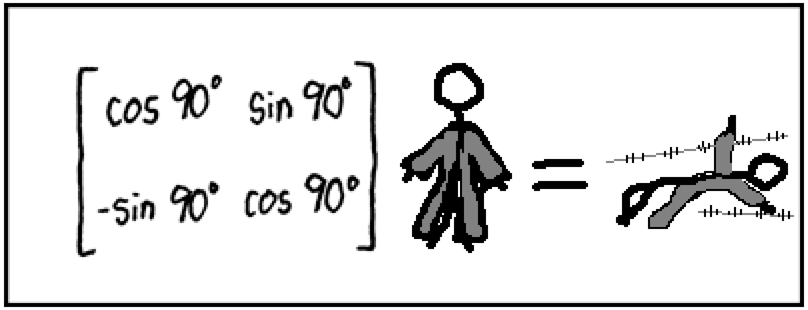
Animation and Movement (Vector)

```
int v_image=0;
int xPos = 0;     // x Position of our image.

void setup() {  frameRate(20);  }
void draw() {
    background(#FFFFFF);
    xPos = xPos -1;
    if(xPos < -95) {
            xPos = 95;
    }
    quad( 40+xPos,40,   95+xPos,60,   95+xPos,50,   5+xPos,70);
    if(v_image == 0) {
            line( 40+xPos,40,    80+xPos,30 );
            v_image = 1;
    } else {
            line( 40+xPos,40,    0+xPos,50 );
            v_image = 0;
    }
}
```

Animation and Movement (Bitmap)

```
int numFrames = 4;
int frame = 0;
int xPos = 0;
PImage[] images = new PImage[numFrames];

void setup() {
 ... // Same as before... load the four images
}

void draw() {
    background(#ffffff);
    frame = ( frame + 1 ) % numFrames;
    image( images[frame], 50+xPos, 50 );
    xPos = (xPos + 5);
    if( xPos > width) {
            xPos = -100;
    }
}
```

What is the Matrix?



- Unfortunately, no one can be told what the matrix is… you have to see if for yourself.
- Just kidding! A matrix (in graphics) is a kind of table (it has rows and columns).
- Think about a complex vector image; you should realize that it is made up of a LOT of points (X,Y,Z). Points that I might want to:
  - Translate (move in the X,Y or Z plane)
  - Rotate (again in the X,Y or Z plane)
  - Skew/Stretch/Resize (again in the X,Y or Z plane)
- That's a LOT of operations, over a LOT of points, and would be SLOW and TIME CONSUMING.

Matrices

- Graphic artists (and mathematicians) figured out that it was easier (and much FASTER) to load all the changes they wanted to perform on an image into a single matrix (again a kind of table).
- They could then and multiply that one matrix against all the points of the vector image they are working with.
- There is a special formula for multiplying matrices, which is beyond the scope of this class.

- Translation

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & d_x \\ 0 & 1 & d_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

- Scaling

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

- Rotation

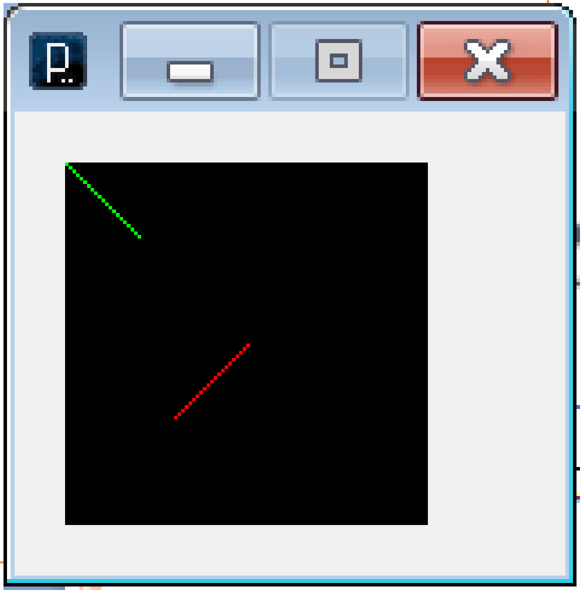
$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Matrices in Processing

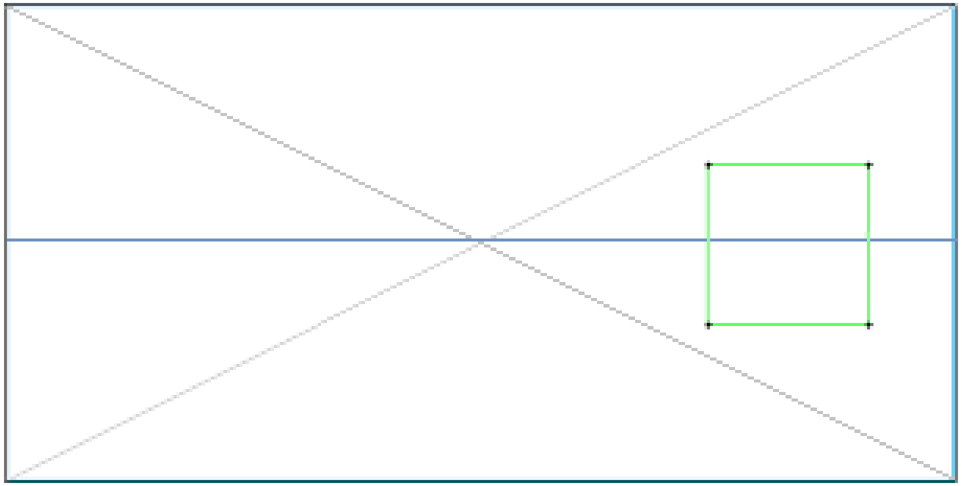
- You don't really need to worry about this... much.
- There are a bunch of neat operations (functions) that you can use to transform your images:
  - translate(x,y); // Will move your image
  - rotate(radians (a)); // Will rotate your image
- BUT YOU NEED TO BE CAREFUL!
  - When you perform the operations above you are changing the WORLD matrix. Which means that EVERYTHING you draw after a rotation() will be rotated.
  - To avoid this problem call pushmatrix() before you make any changes and popmatrix() after you have drawn what you wanted to change.

Processing Example

```
background(#000000);

pushMatrix();        // Save the state of the WORLD matrix

translate(50,50);       // Move the center of the WORLD to point 50,50
rotate( radians(90) );   // Rotate the WORLD by 90 degrees

stroke(#ff0000);        // Red line
line(0,0,20,20);

popMatrix();            // Reset the world

stroke(#00ff00);        // Green line
line(0,0,20,20);
```

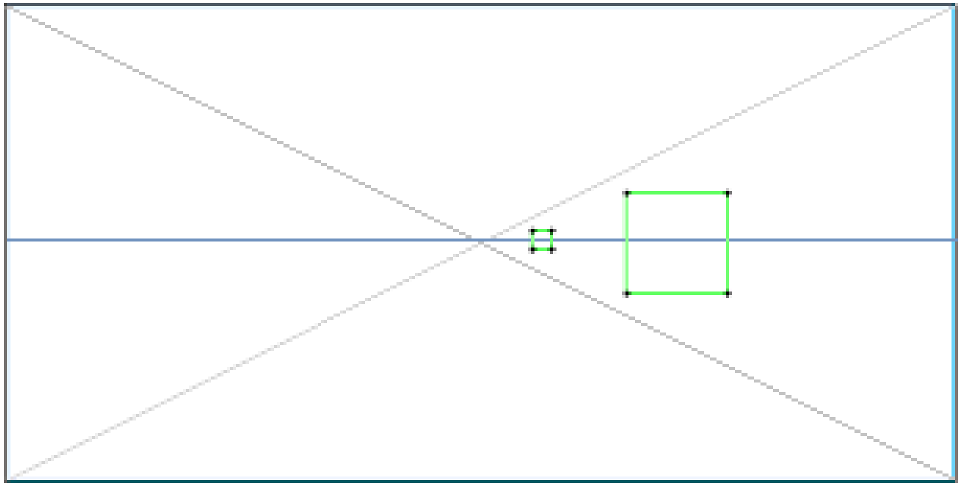


Simple 3D Animation (1)



- A vector image is made up of a series of connected points (x, y).
- In the real world a point has an x, y and **z** position.
- What happens to a point as it moves away from you?
- To put it another way, what will happen to the green box in the picture as it moves down the hall.

Simple 3D Animation (2)



- As the z value of all points increase (as the point move further into the distance) the x and y values will converge towards a single point (the focal point).
- The result of the convergence of the x and y points converging is that any images drawn using those points seem to get smaller.
- A 6' tall man remains six feet tall as he walks away, but takes up a smaller percentage of your field of view.

Simple 3D Animation (3)

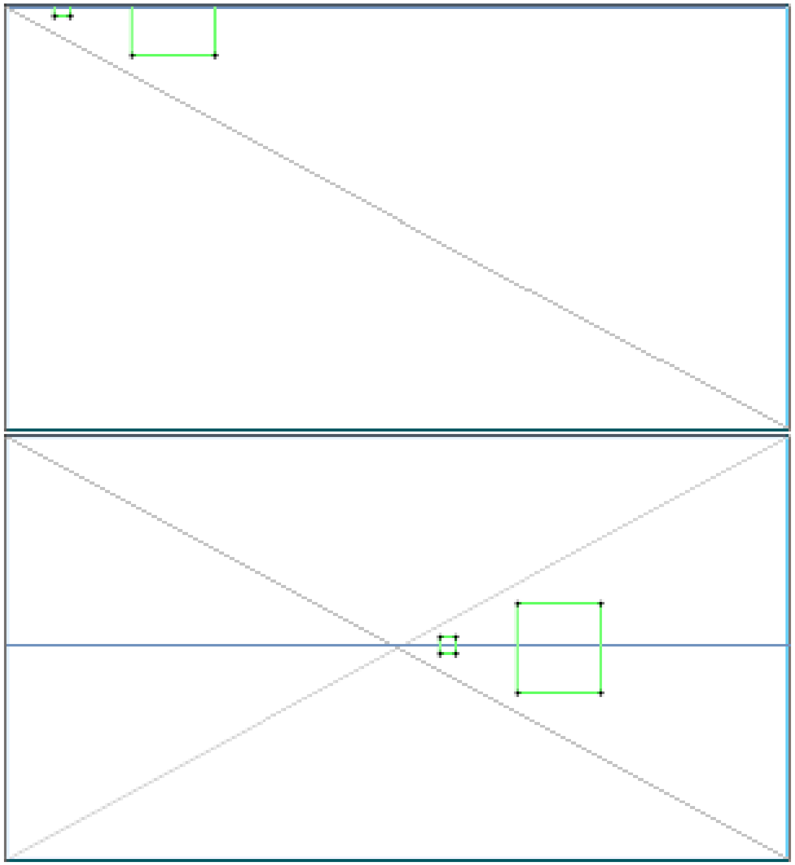
- To make an image appear to have 3 dimension or be able to move in 3 dimensions we must be able to construct it using a set of 3D points (x,y,z).
- We will also need:
  - Focal Point -> The place on the screen that all points will to converge too (usually specified as an offset).
  - Focal Length -> How far something can go in the z plane before it shrinks into nothing.
  - Px and Py -> To new variables that will represent the x and y positions of a point as they will actually appear on screen.
- We can then use the following formulas:

Px = (x * ((focalLength - z) / focalLength)) + offsetX;

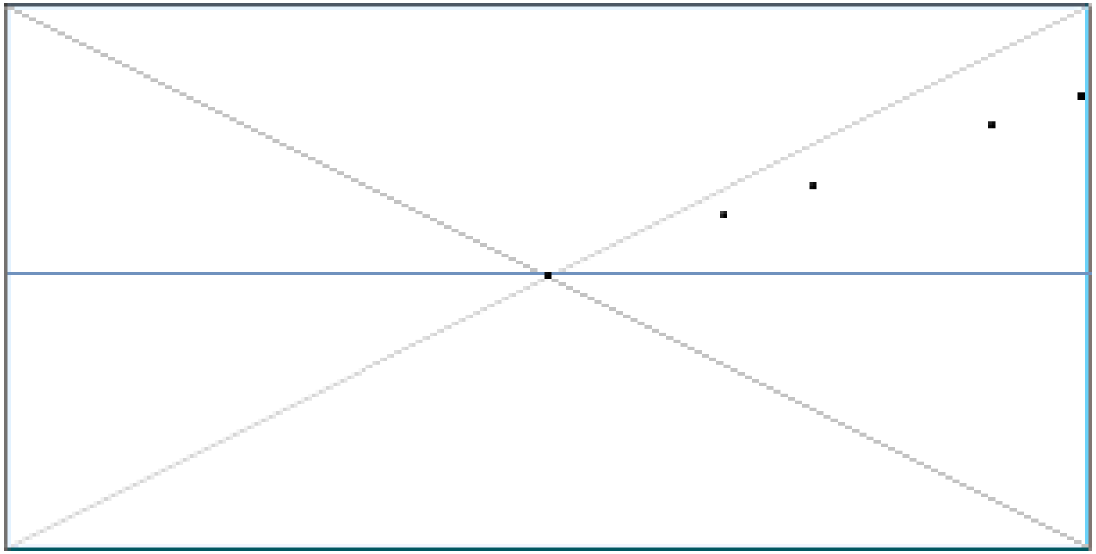
Py = (y * ((focalLength - z) / focalLength)) + offsetY;

Offset & Focal Point

- To keep the math simple we would like (0,0) to be our focal point.
- Unfortunately (0,0) is the top left of the screen.
- We can get around this problem by creating variable called offsetX and offsetY and adding them to all points.
- This has the effect of shifting the focal point.



Calculating Px and Py



Screen -> 300x150
offsetX -> 150
offsetY -> 75
focalLength ->300

x = 150
y = - 50
z = 0

Px = ?
Py = ?

- Formulas:

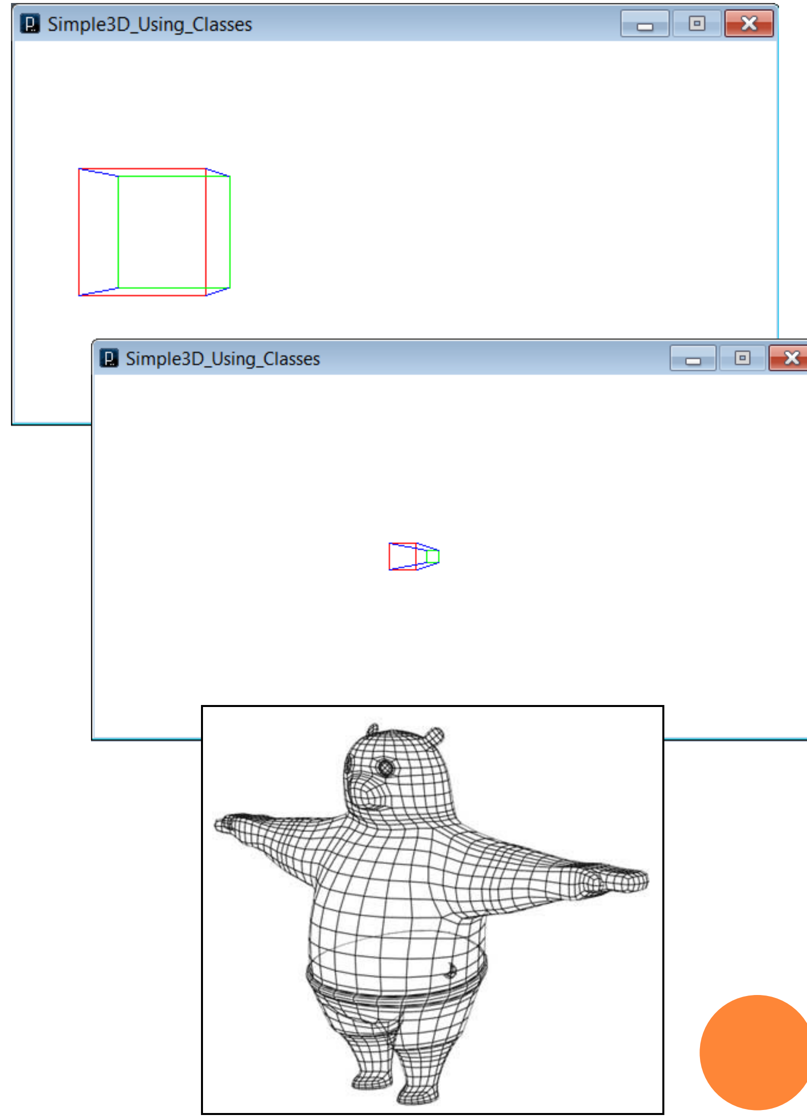
  Px = (x * ((focalLength - z) / focalLength)) + offsetX;

  Py = (y * ((focalLength - z) / focalLength)) + offsetY;

z	0	50	150	200	300
Px	300	375	225	200	150
Py	25	33	50	58	75

3D WireFrame Images

- A complex "wireframe" image is simple a vector image made up of lots of points, that are represented in the 3D
- Once you have the "wireframe" you can then color the areas between points and lines by applying "texels" which are usually bitmap images.
- Applying texels requires a little more math (but not much).



The End