



# CS 354

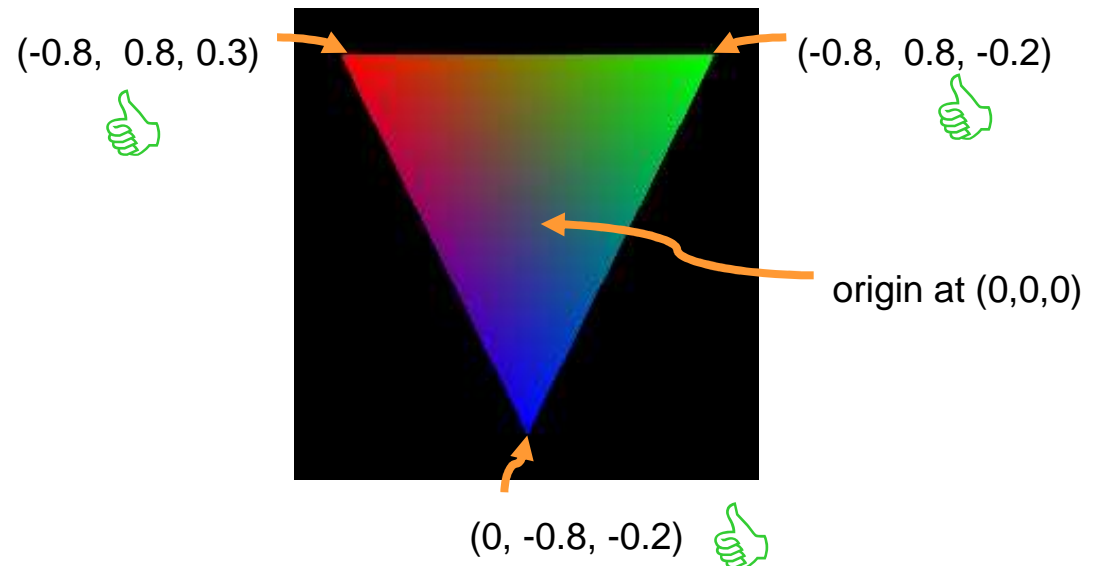
## Viewing Stuff

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# What about clipping?

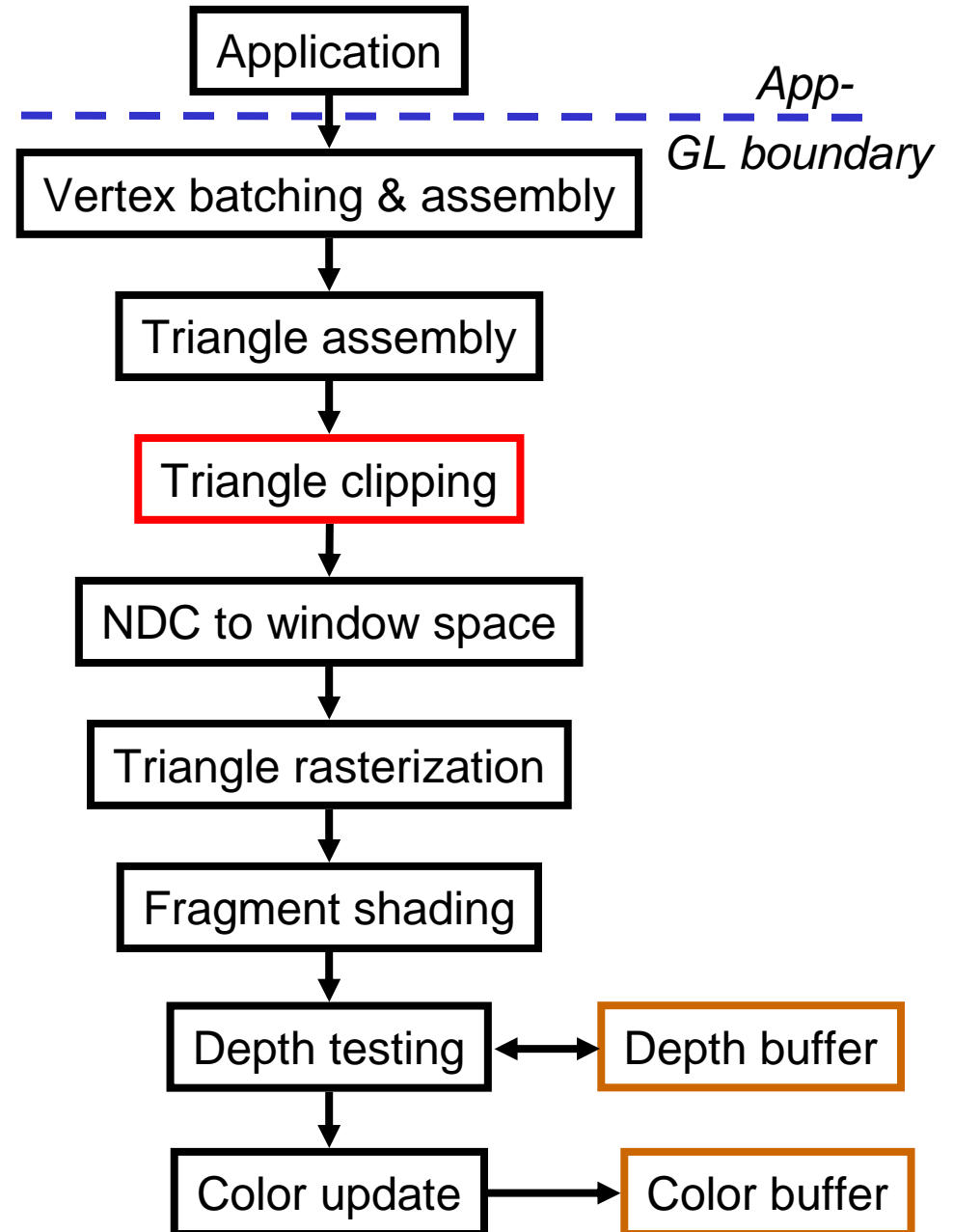
- What if any portion of our triangle extended beyond the NDC range of the  $[-1,+1]^3$  cube?
  - Only regions of the triangle  $[-1,+1]^3$  cube should be rasterized!
- No clipping for our simple triangle 😊
  - This situation is known as “trivial accept”
  - Because all 3 vertices in the  $[-1,+1]^3$  cube

*Vertexes of a triangle are extrema points defining an exact convex hull so entire triangle must also be in the cube if the vertexes are*



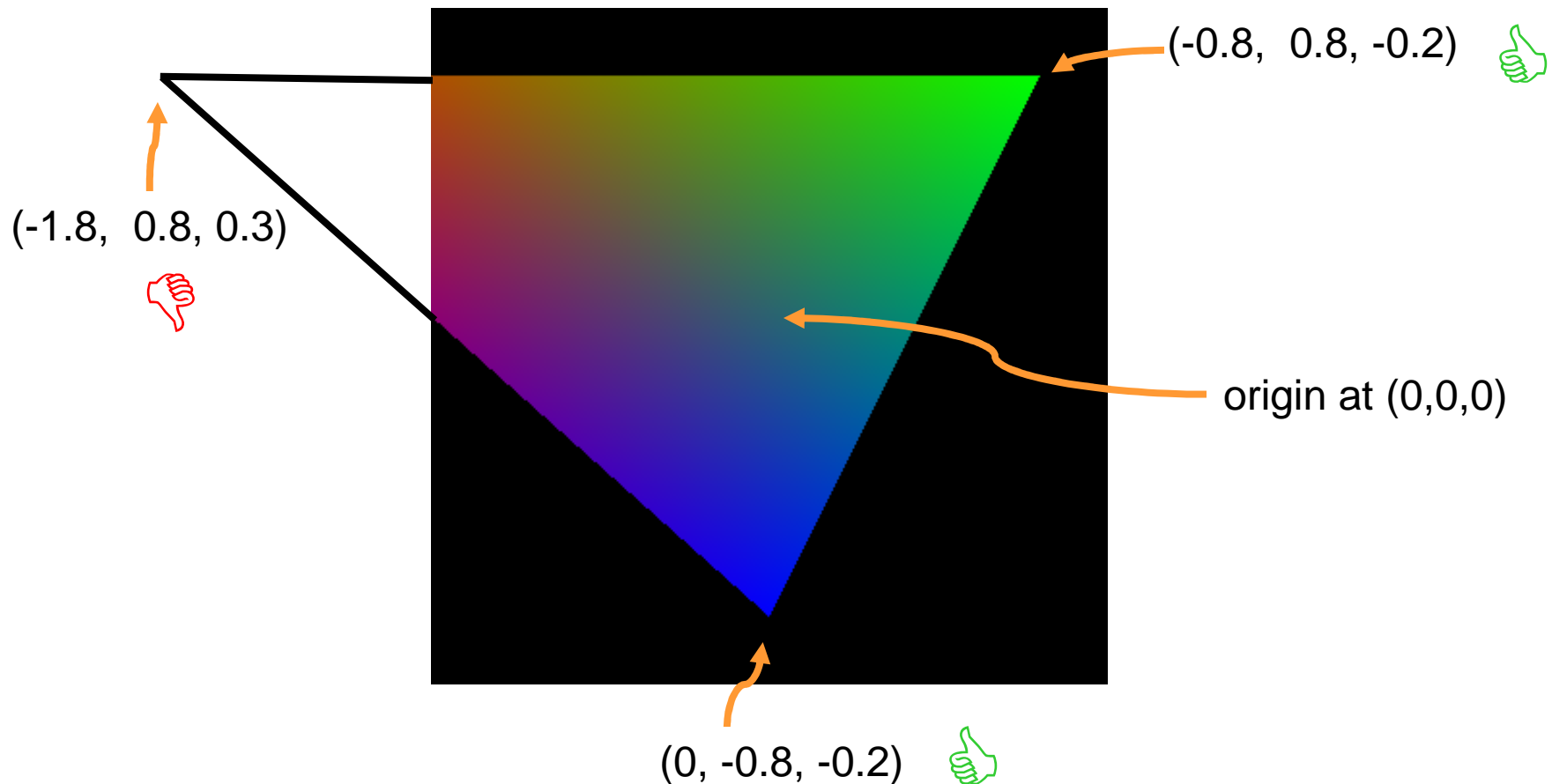
# Triangle Clipping

- Triangles can straddle the NDC cube
  - Could happens with lines too
- In this case, we must “clip” the triangle to the NDC cube
  - This is an involved process but one that must be done

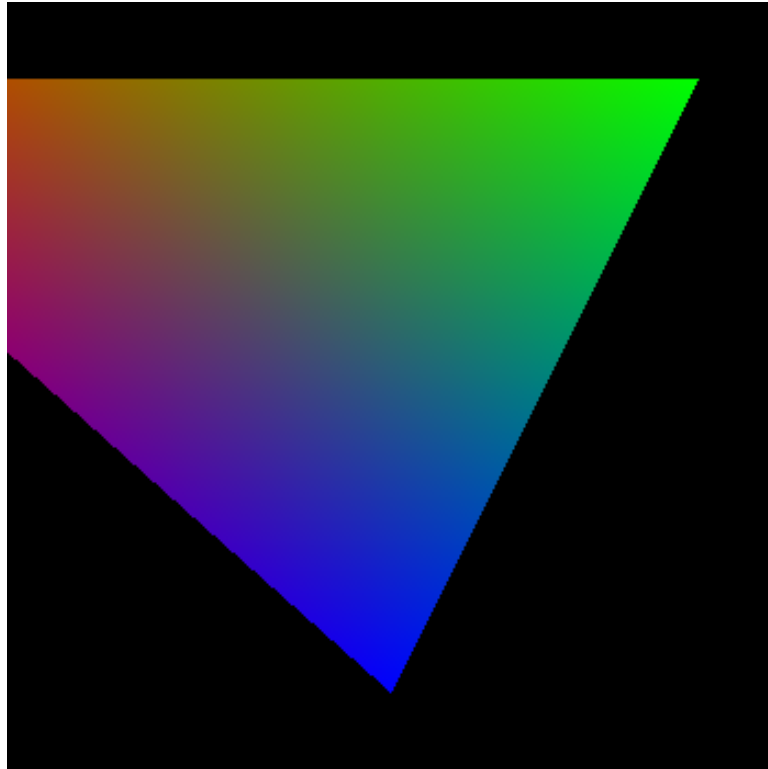


# Consider a Different Triangle

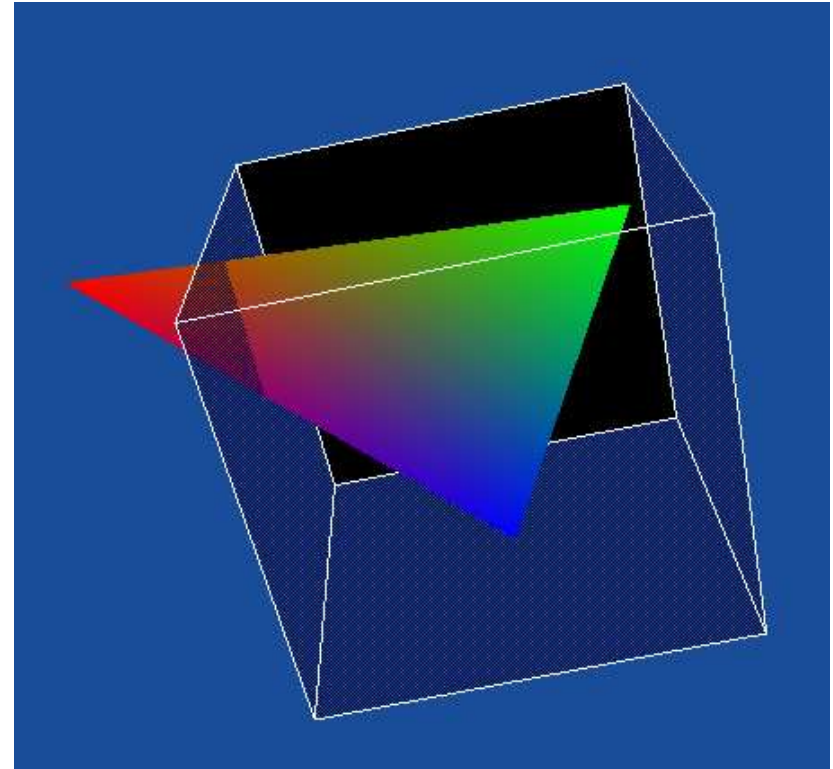
- Move left vertex so it's  $X = -1.8$ 
  - Result is a clipped triangle



# Clipped Triangle Visualized



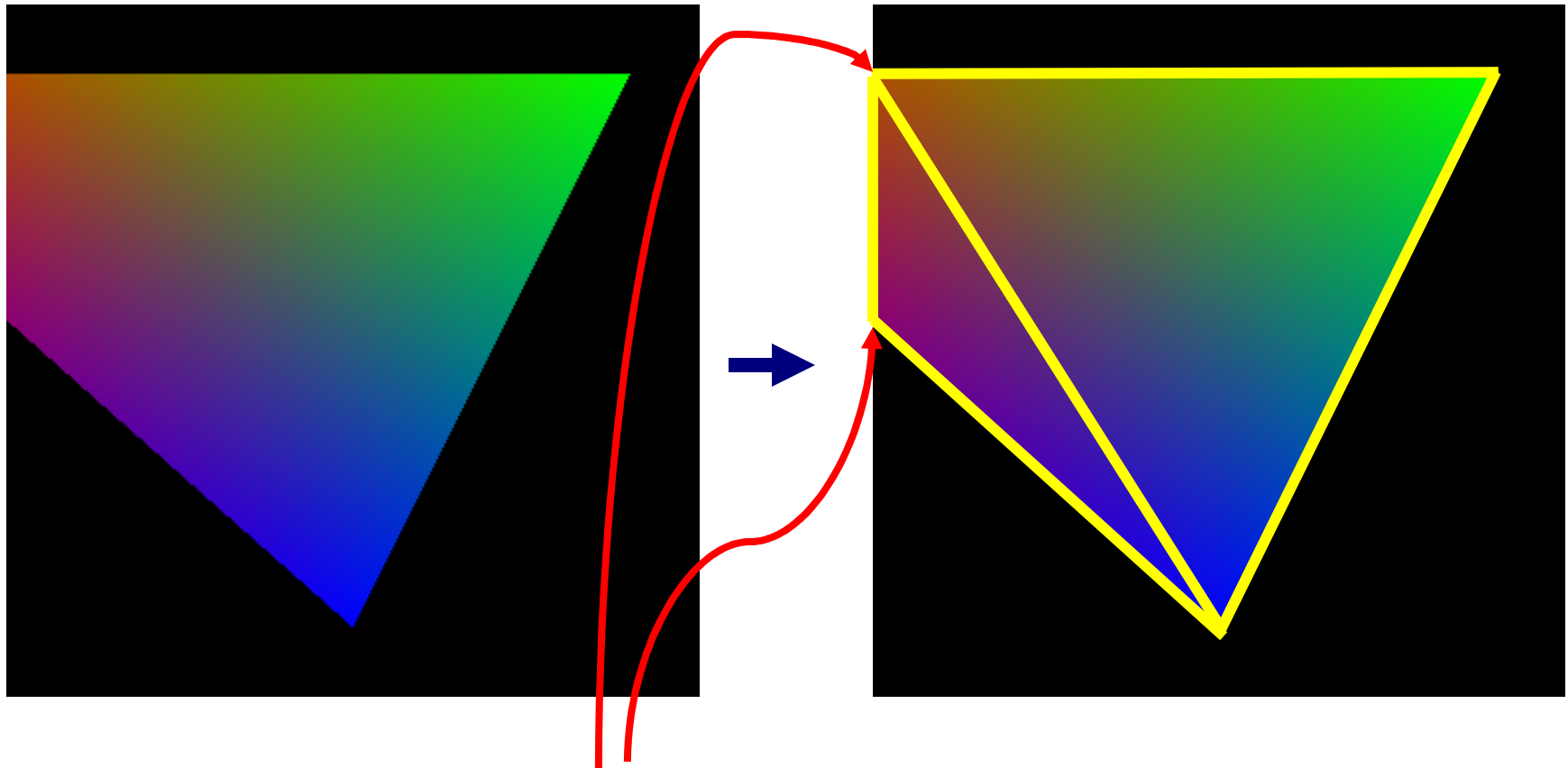
Clipped and Rasterized Normally



Visualization of NDC space

*Notice triangle is “poking out” of the cube;  
this is the reason that should be clipped*

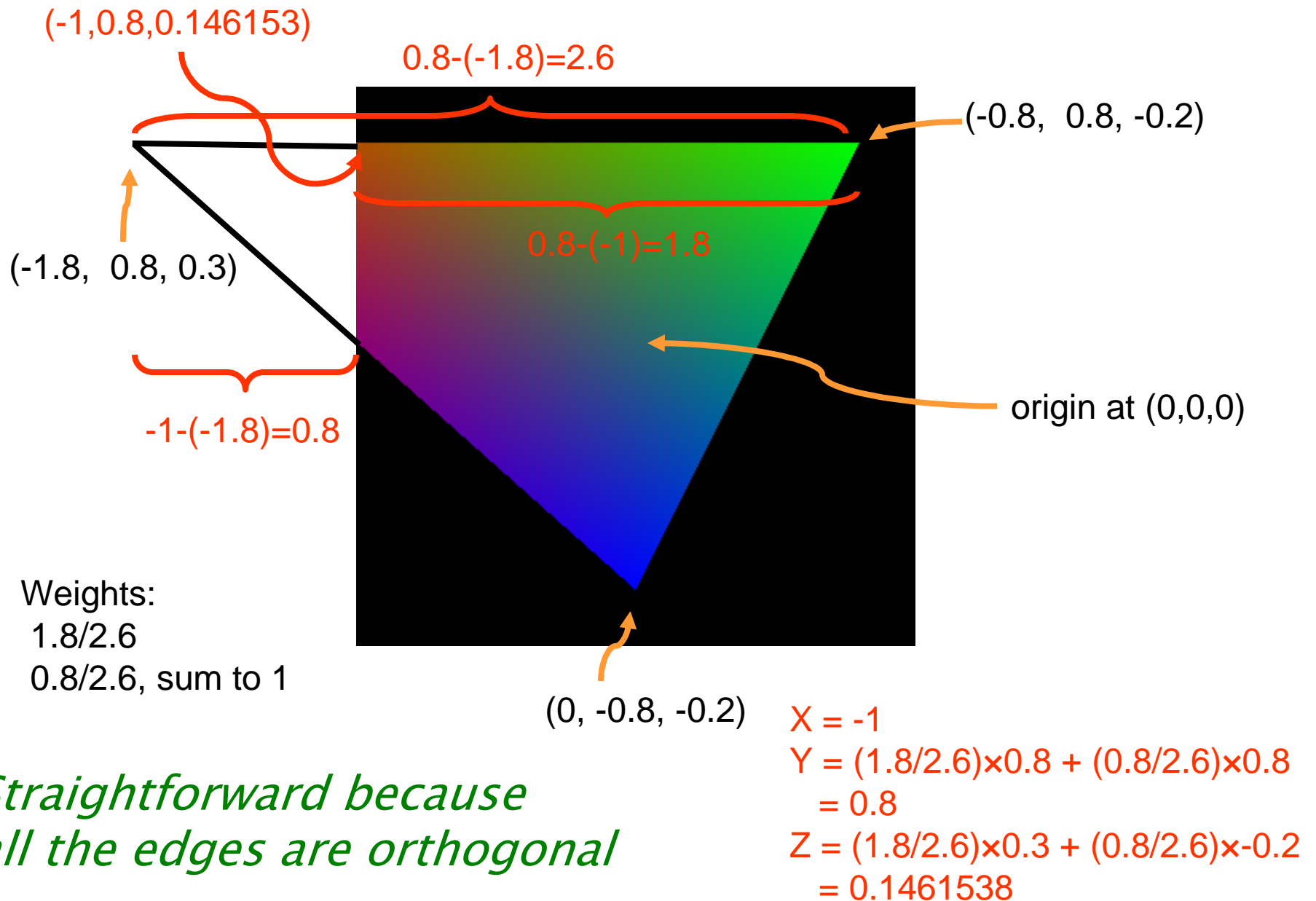
# Break Clipped Triangle into Two Triangles



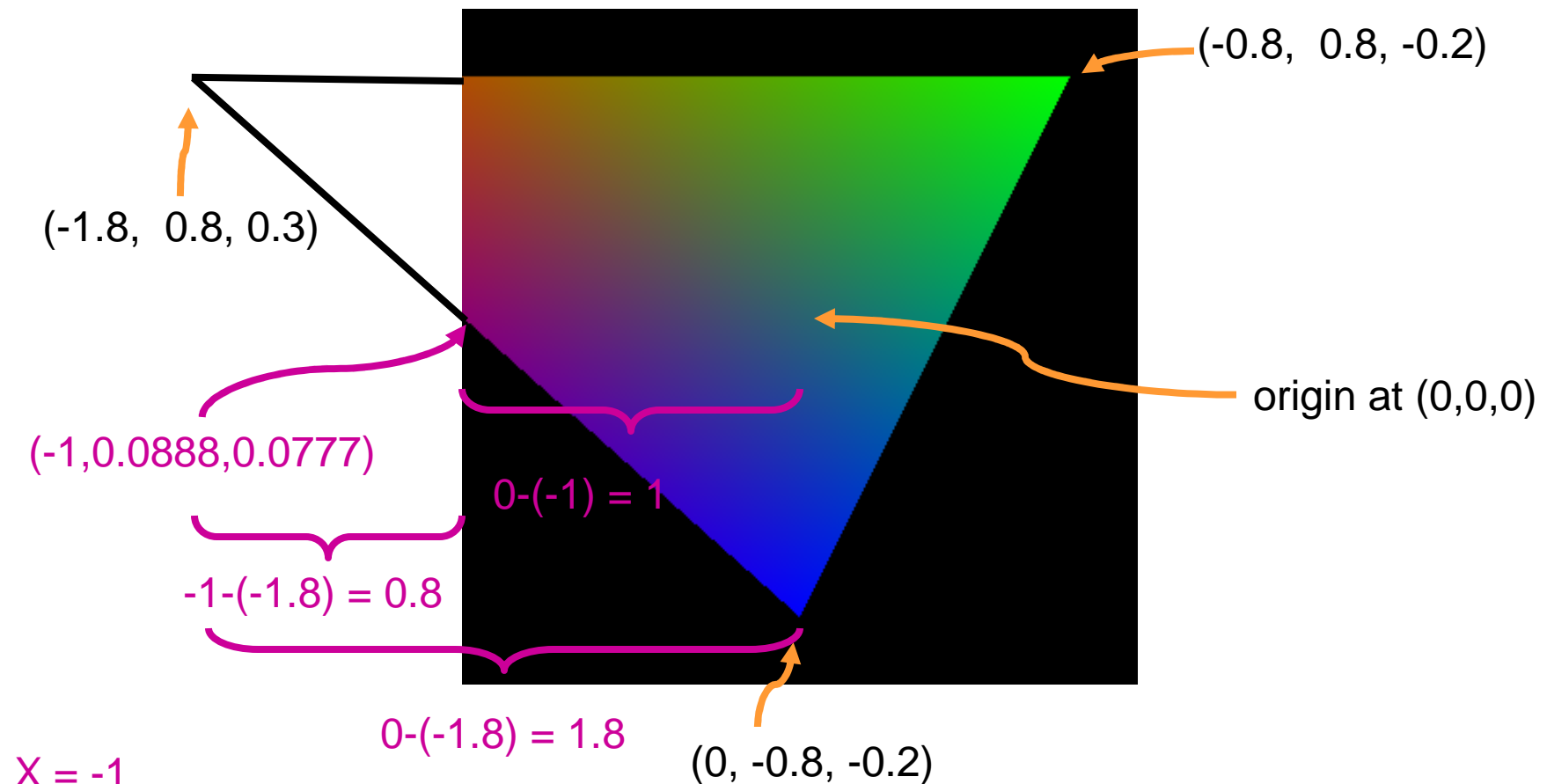
*But how do we find these “new” vertices?*

*The edge clipping the triangle is the line at  $X = -1$   
so we know  $X = -1$  at these points—but what about  $Y$ ?*

# Use Ratios to Interpolate Clipped Positions



# Use Ratios to Interpolate Clipped Positions



$$\begin{aligned}
 X &= -1 \\
 Y &= (1/1.8) \times 0.8 + (0.8/1.8) \times -0.8 \\
 &= 0.08888... \\
 Z &= (1/1.8) \times 0.3 + (0.8/1.8) \times -0.2 \\
 &= 0.07777...
 \end{aligned}$$

Weights:  
 $1/1.8$   
 $0.8/1.8$ , sum to 1

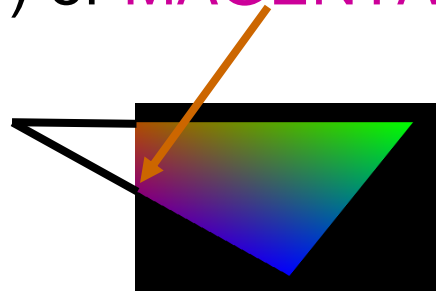


# Clipping Complications

- Given primitive may be clipped by multiple cube faces
  - Potentially clipping by all 6 faces!
- Approach
  - Four possibilities
    - Face doesn't actually result in any clipping of a triangle
      - Triangle is unaffected by this plane then
    - Clipping eliminates a triangle completely
      - All 3 vertices on “wrong” side of the face's plane
    - Triangle “tip” clipped away
      - Leaving two triangles
    - Triangle “base” is clipped away
      - Leaving a single triangle
  - **Strategy:** implement recursive clipping process
    - “Two triangle” case means resulting two triangles must be clipped by all remaining planes

# Attribute Interpolation too for Clipping

- When splitting triangles for clipping, must also interpolate new attributes
  - For example, color
  - Also texture coordinates
- Back to our example
  - $\text{BLUE} \times 0.8/1.8 + \text{RED} \times 1/1.8$ 
    - $(0,0,1,1) \times 0.8/1.8 + (1,0,0,1) \times 1/1.8$
    - $(0.444, 0, .555, 1)$  or **MAGENTA**



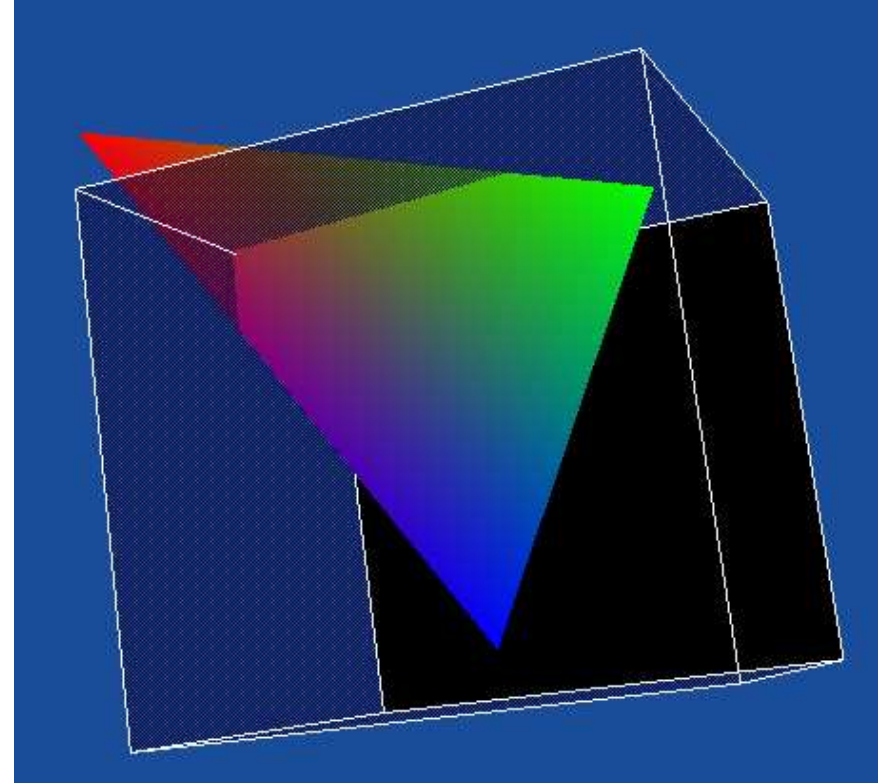
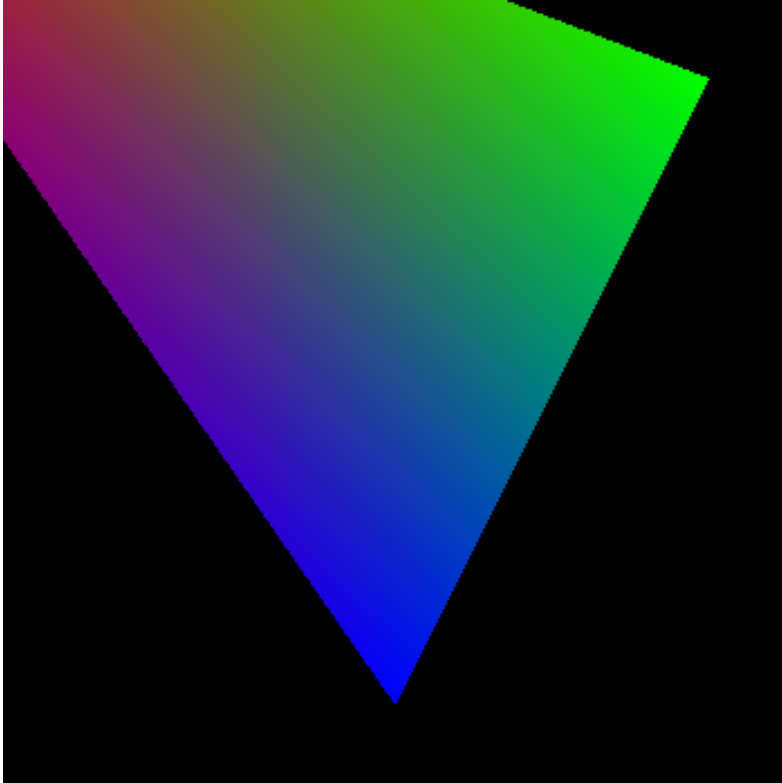
Weights:  
1/1.8  
0.8/1.8, sum to 1

# What to do about this?

## ■ Several possibilities

- Require applications to never send primitives that require clipping
  - Wishful thinking
  - And a cop-out—makes clipping their problem
- Rasterize into larger space than normal and discard pixels outside the NDC cube
  - Increases useless rasterizer work
    - Requires additional math precision in the rasterizer
  - Worse, creates problems when rendering into a projective clip space (needed for perspective)
    - Something for a future lecture
- Break clipped triangles into smaller triangles that tessellate the clipped region...

# Triangle clipped by Two Planes Visualization



*Recursive process can make 4 triangles  
And it gets worse with more non-trivial clipping*