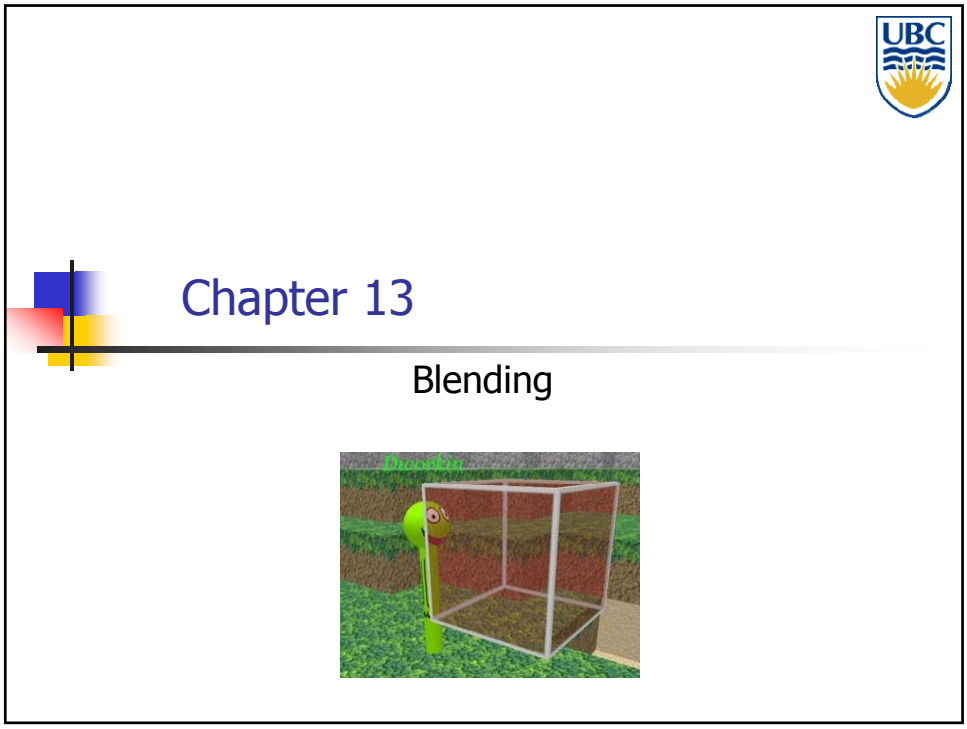
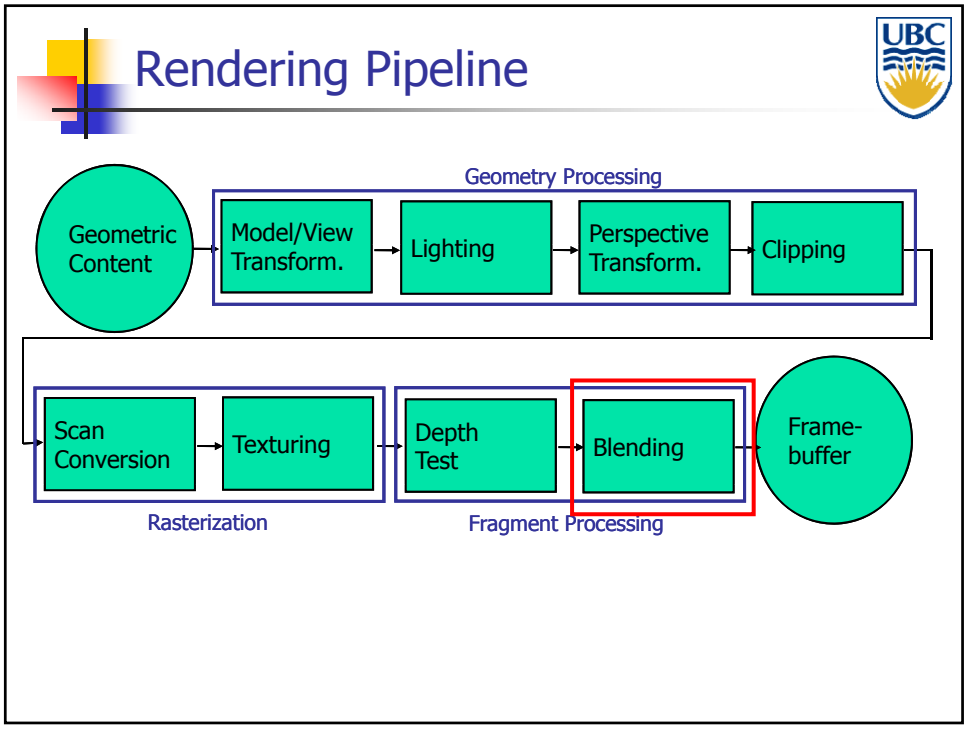
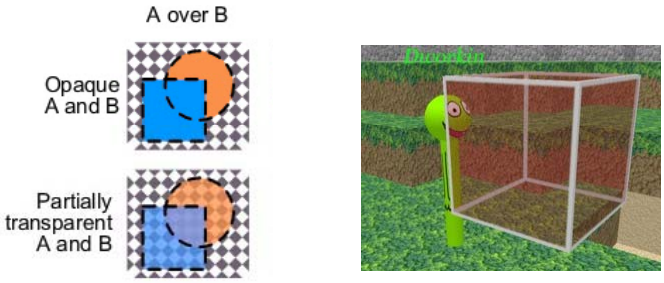




Blending

- How might you combine multiple elements?
  - New color **A**, old color **B**

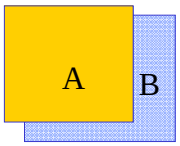


Alpha Blending (OpenGL)

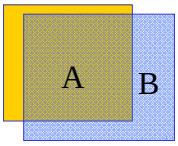
- Parameters:
  - s = source color
  - d = destination color
  - b = source blend factor
  - c = dest blend factor
  - d' = bs + cd (?)
- Where
  - "Source" means "color/alpha of currently rendered primitive"
  - "Destination" means framebuffer value

Over operator

- $d' = \alpha_s\, s + (1-\alpha_s)d$
- Examples: $a_A=1$ $a_B=0.4$



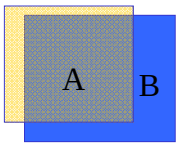
A over B:
$d'=1*C_A+(1-1)*C_B$



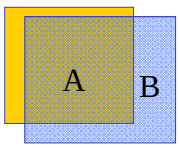
B over A:
$d'=0.4*C_B+(0.6)*C_A$

Over operator

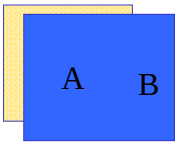
- $d' = \alpha_s\, s + (1-\alpha_s)d$
- Examples: $\alpha_A=0.4$ $\alpha_B=1.0$



A over B:
$d'=0.4*C_A+(0.6)*C_B$



Comparison:
$d' = bs + cd$



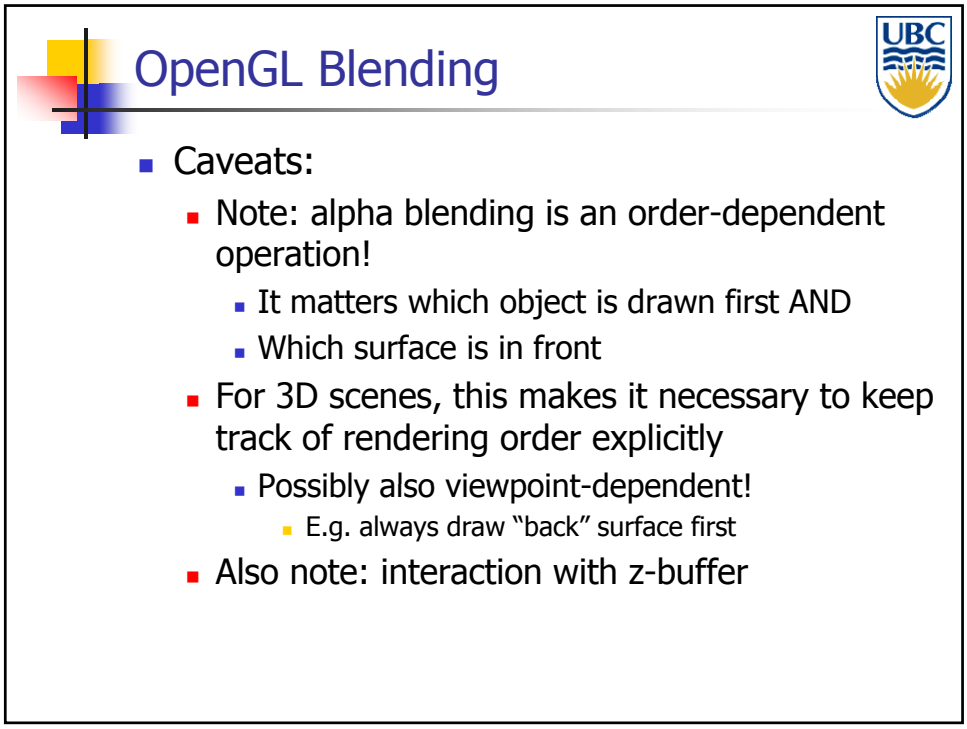
B over A:
$d'=1*C_B+(0)*C_A$

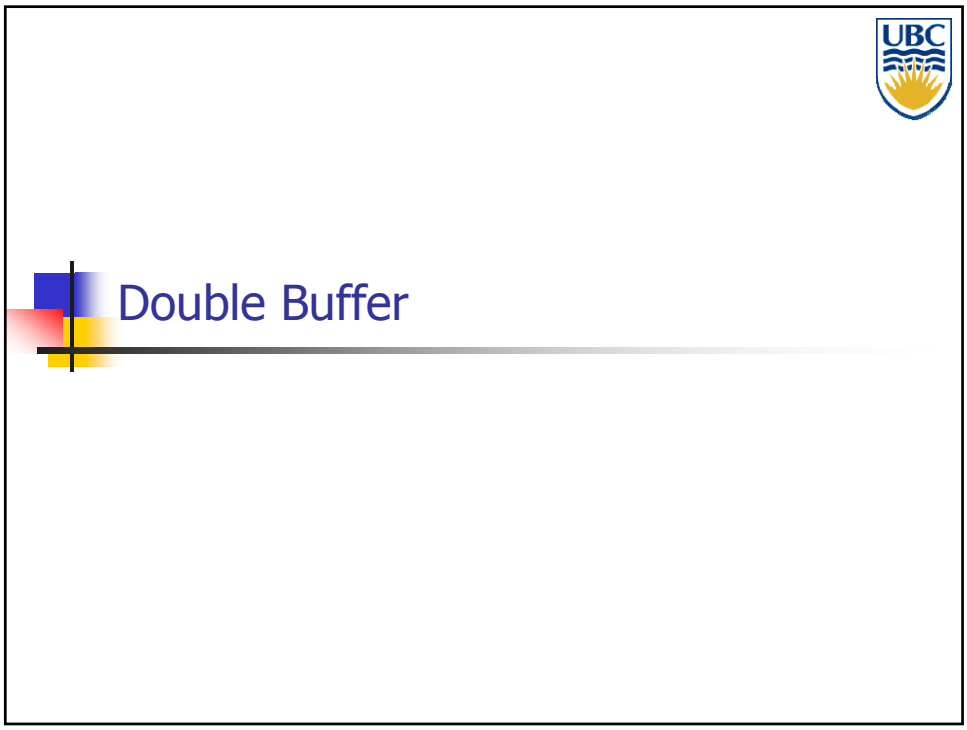
Over operator

- $d' = \alpha_s\, s + (1-\alpha_s)d$
- $\alpha' = \alpha_s\, \alpha_s + (1-\alpha_s)\, \alpha_d$

OpenGL Blending

- In OpenGL:
  - Enable blending
    - glEnable(GL_BLEND)
  - Specify alpha channel for colors
    - glColor4f(r, g, b, alpha)
  - Specify blending function
    - E.g: glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPH)
      - C= alpha_new*Cnew + (1-alpha_new)*Cold
    - Other options available





Double Buffering

- Framebuffer:
  - Piece of memory where the final image is written
  - Problem:
    - The display needs to read the contents, cyclically, while the GPU is already working on the next frame
    - Could result in display of partially rendered images on screen
  - Solution:
    - Have TWO buffers
      - Currently displayed (front buffer)
      - Render target for the next frame (back buffer)

Double Buffering

- Front/back buffer:
  - Each buffer has both color channels and a depth channel
    - Important for advanced rendering algorithms
    - Doubles memory requirements!
- Switching buffers:
  - At end of rendering one frame, simply exchange the pointers to the front and back buffer
  - GLUT toolkit: glutSwapBuffers() function
    - Different functions under windows/X11 if not using GLUT