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# Procedural Texturing and Shading



# Procedural Texturing/Shading

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**Paradigm for programmability in the graphics pipeline**

**Allows for a wide variety of surface materials and embellishments**

**May be facilitated by a custom shading language**

- **e.g. Pixar's RenderMan, NVIDIA's CG**



# Potential Advantages of Procedural Textures

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**Compact representation**

**No fixed resolution**

**No fixed area**

**Parameterized - generates class of related textures**



# Disadvantages of Procedural Textures

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**Difficult to build and debug**

**Surprising results**

**Slow evaluation**

**Antialiasing handled manually**



# Procedural Texture Conventions

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## Avoid conditionals

- Convert to mathematical functions when possible
- Makes anti-aliasing easier

## Parameterize rather than building in constants

- Assign reasonable defaults which may be overridden



# Simple Building Blocks

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**Mix (lerp)**

**Step, smoothstep, pulse**

**Min, max, clamp, abs**

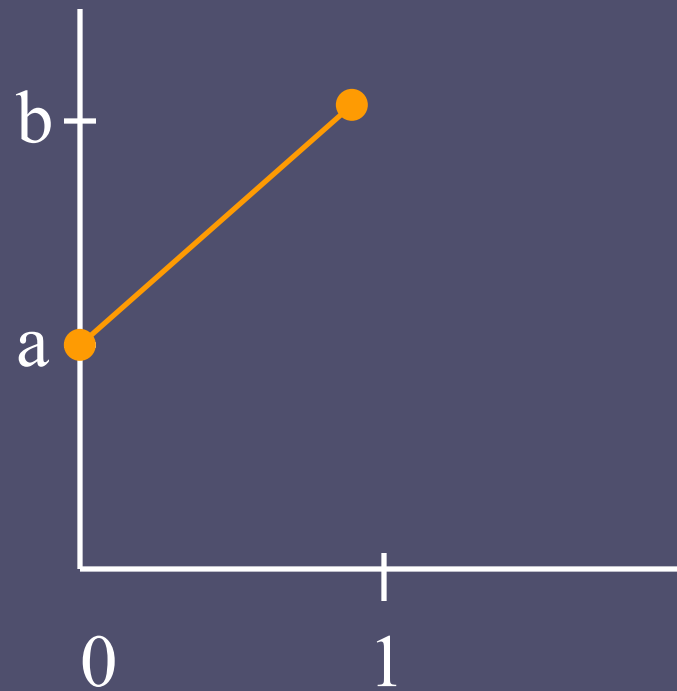
**Sin, cos**

**Mod, floor, ceil**



# Mix

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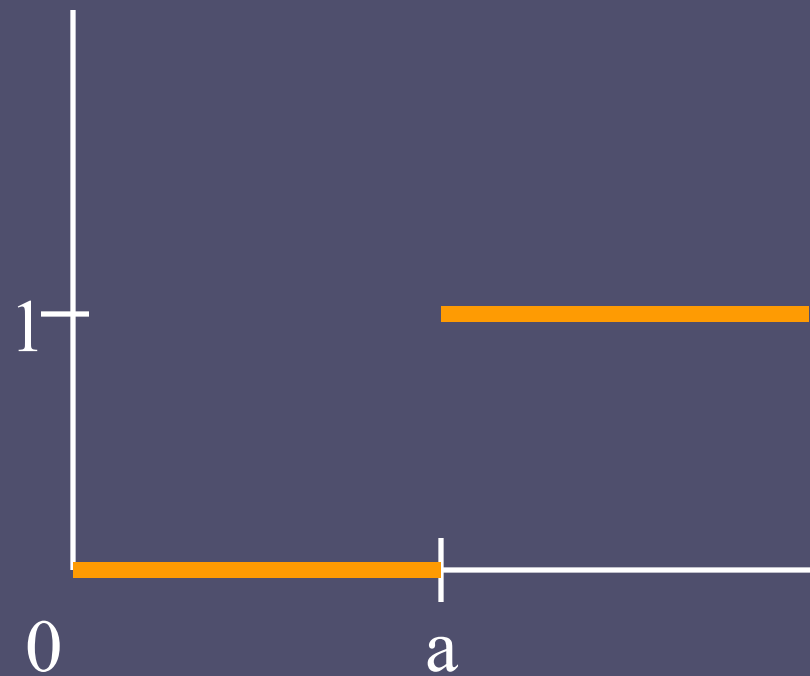


$\text{mix}(a,b,x)$



# Step

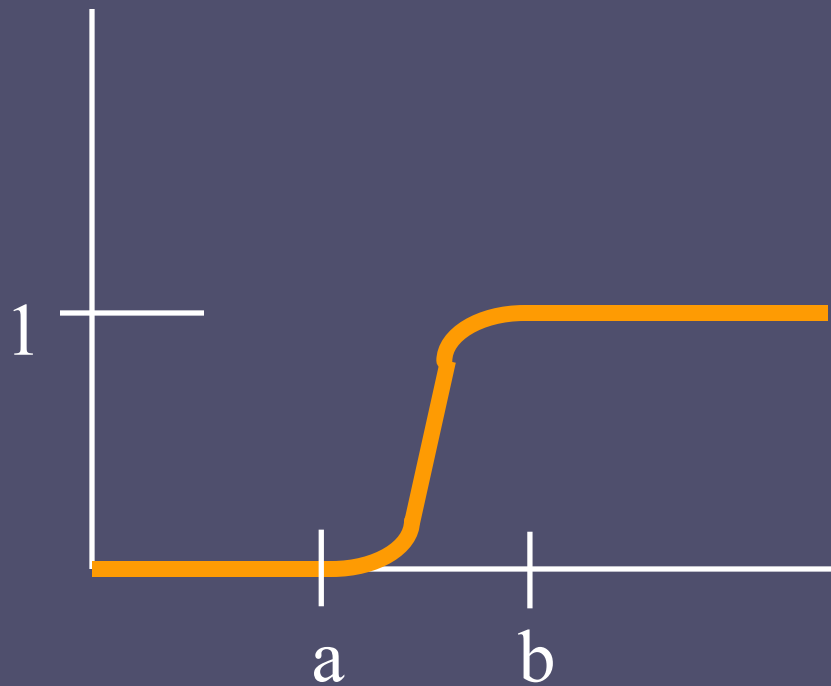
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$\text{step}(a, x)$



# Smoothstep

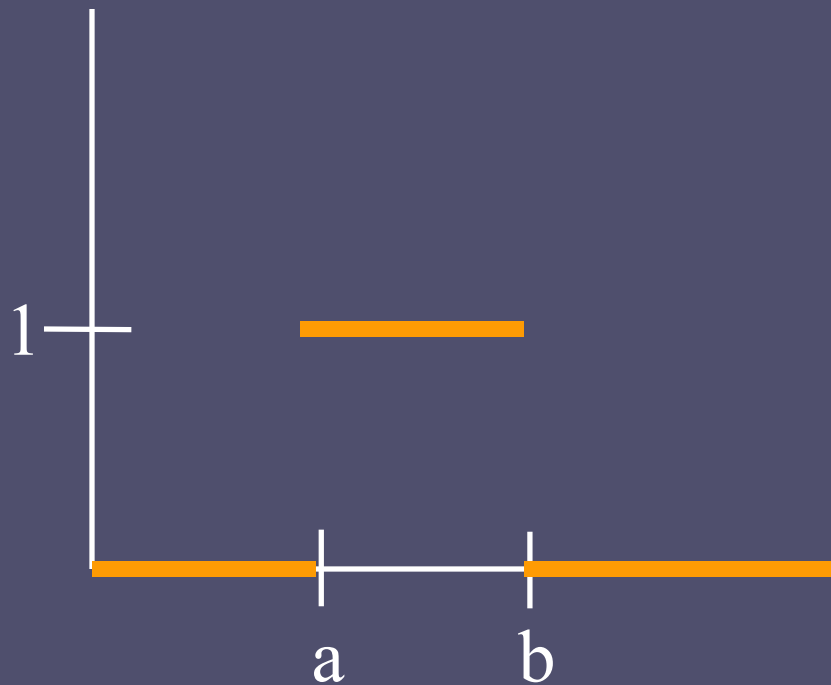


$\text{smoothstep}(a,b,x)$



# Pulse

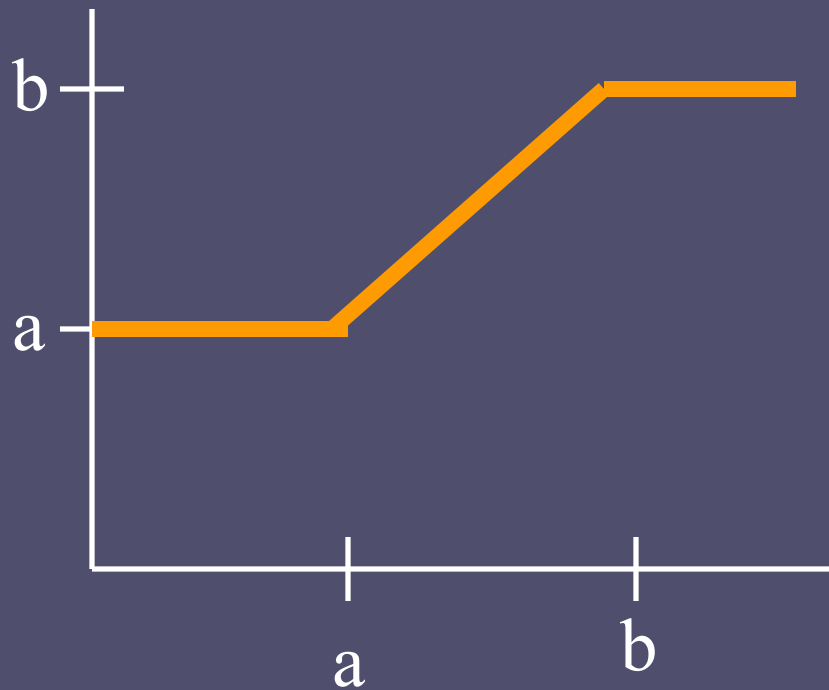
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$$\text{pulse}(a,b,x) = \text{step}(a,x) - \text{step}(b,x)$$



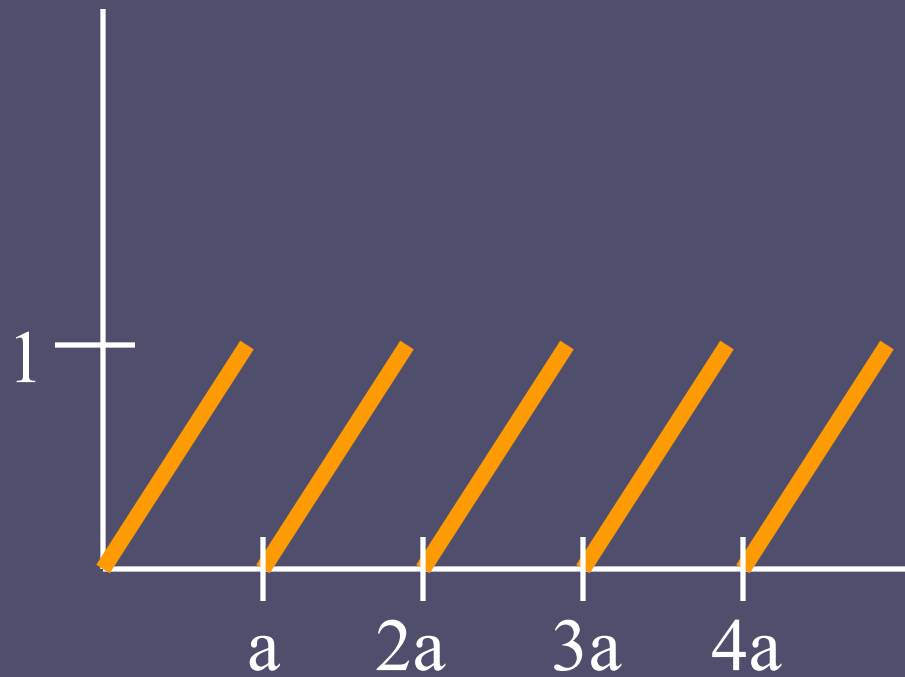
# Clamp



$$\text{clamp}(x,a,b) = \min(\max(x,a), b)$$



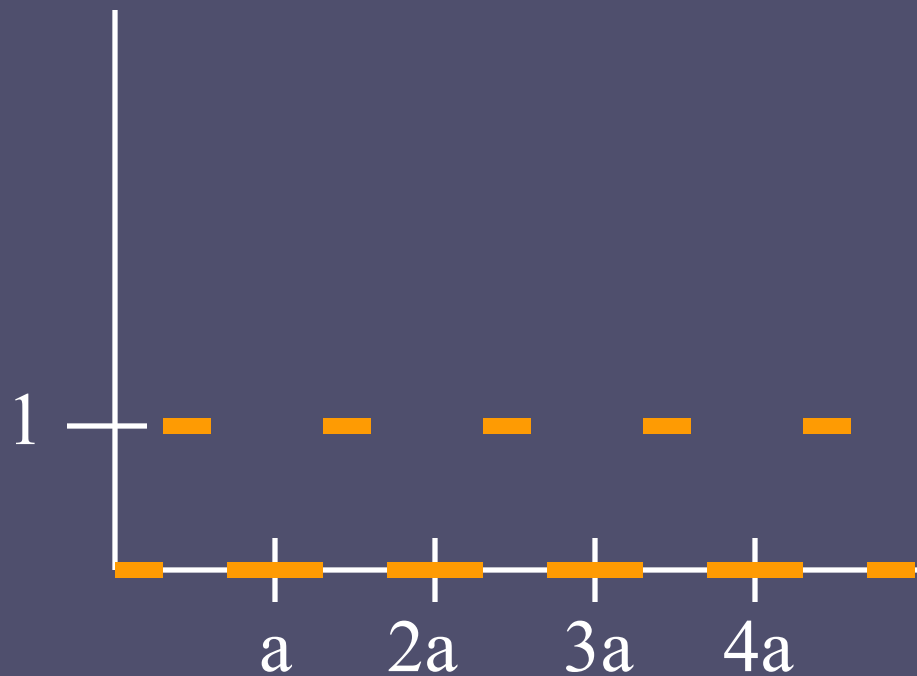
# Mod



$\text{mod}(x,a) / a$



# Periodic Pulse



$$\text{pulse}(0.4, 0.6, \text{mod}(x,a)/a)$$



# Example 1 - brick (see handout)

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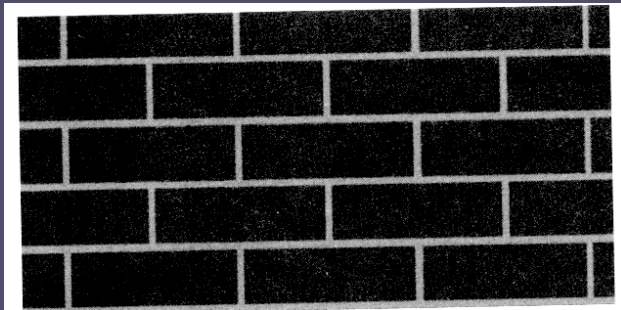
**Brick is primarily a 2D pulse**

**Input parameters may include:**

- **color of brick and mortar**
- **size of brick**
- **thickness of mortar**
- **mortar bump size**
- **frequency of brick color variation**
- **etc.**



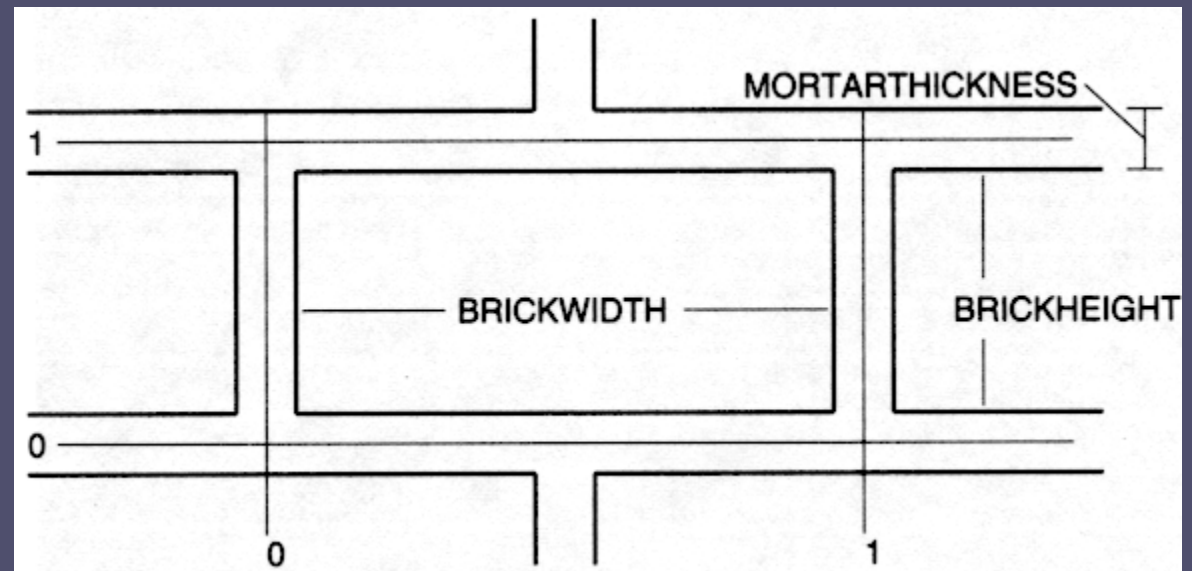
# Brick



(pulse)



(pulse)



from Ebert, ed., *Texturing and Modeling: a Procedural Approach*, 1994, pages 37-38.



## Example 2 - star (see handout)

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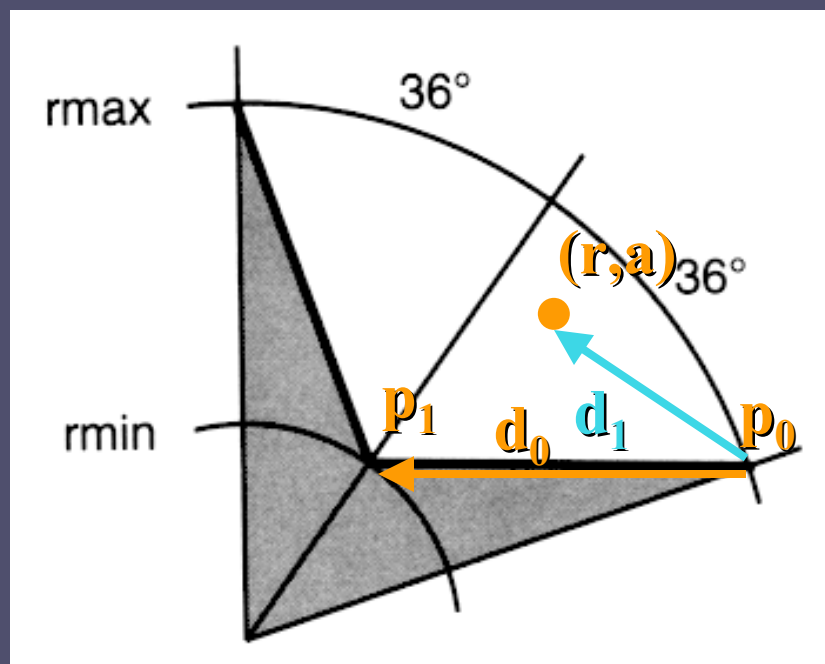
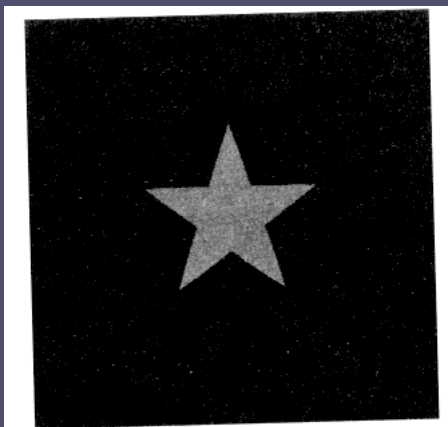
**Exploit symmetry of star geometry**

**Input parameters may include:**

- **Inner and outer star radii**
- **Number of points**
- **Star and background colors**
- **Star bump parameters**
- **Parameters for star distribution**



# Star



from Ebert, ed., *Texturing and Modeling: a Procedural Approach*, 1994, pages 44-46.