Texture Mapping: Solid Texturing

Texture Mapping

Visual complexity on demand

Vary display properties over object

Visible pixel maps to location on object

Location on object
used to lookup display attributes
Or
as function parameters to generate attributes

Solid Texture Mapping

Object is 'carved' out of textured volume

Use x,y,z location of pixel

Use location in simple procedure to generate, e.g.

- Material color to be used in shading calculation
- Ambient, diffuse, or specular reflection coefficient
- Opacity
- Final color

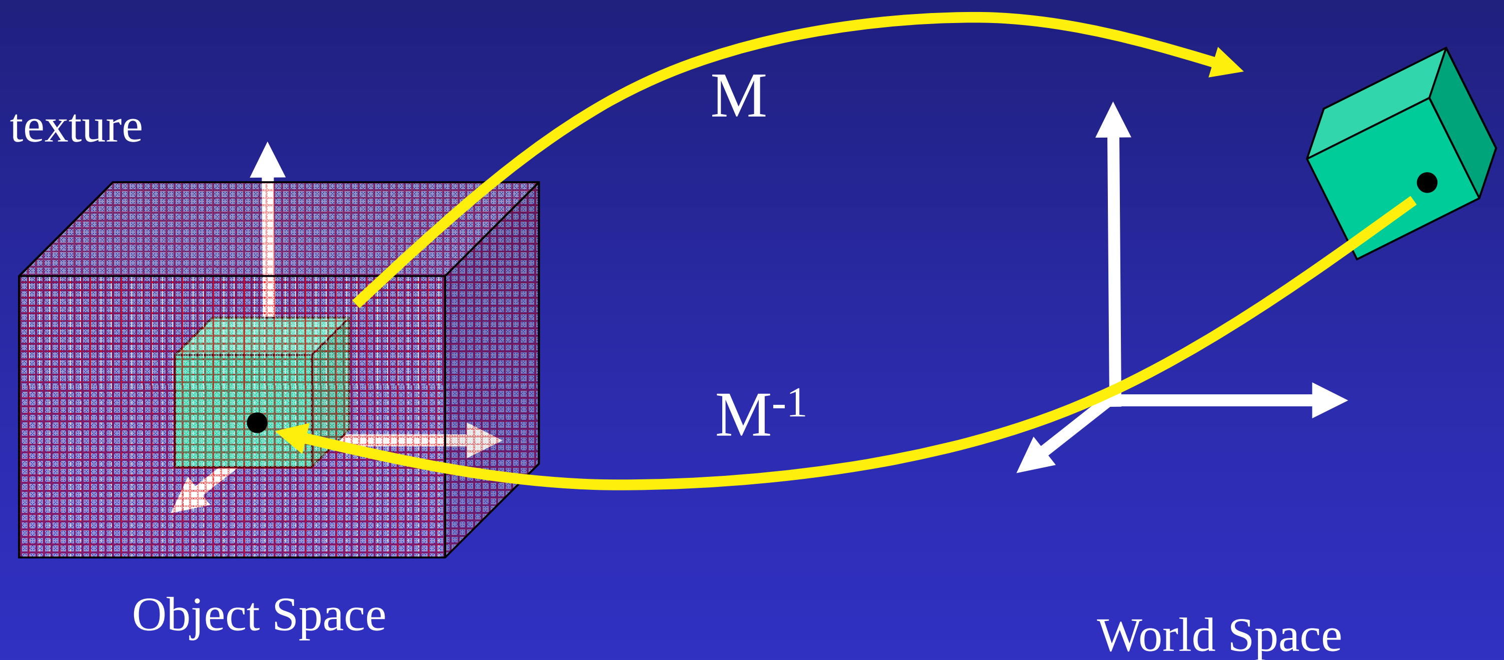
World space coordinates v. object space coordinates?

Solid Texture Map Coordinates

If world space
- Ok in static scenes
- Object moves through texture if object animated

If object space
- Texture is ‘fixed’ to object
- need to inverse transform intersection
  - or need to trace inverse ray in object space

Solid Texture Map Coordinates



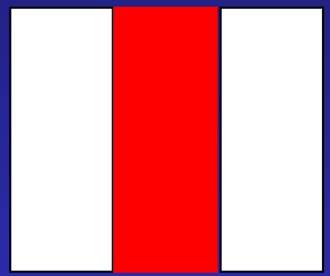
Space Filling Stripes

Uses: modulo divisor %

jump(x,y,z) = ((int)(x))%2
if (jump == 0) color = yellow
else if (jump == 1) color = red

jump(x,y,z) = ((int)(A + x/s.x)%2
if (jump == 0) color = yellow
else if (jump == 1) color = red

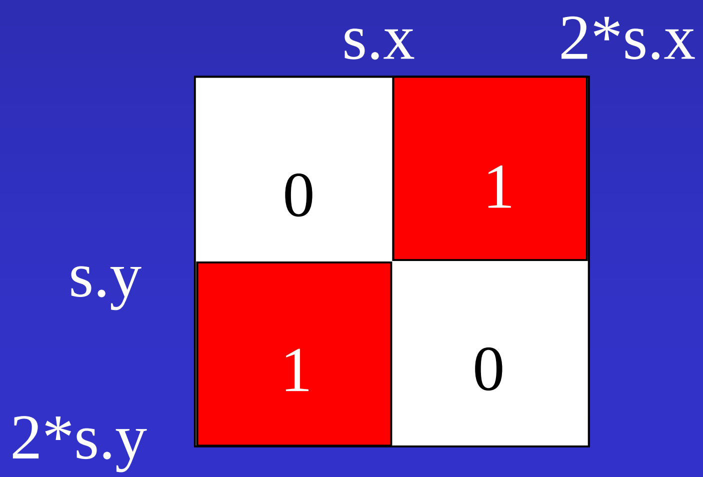
0…….1…..0

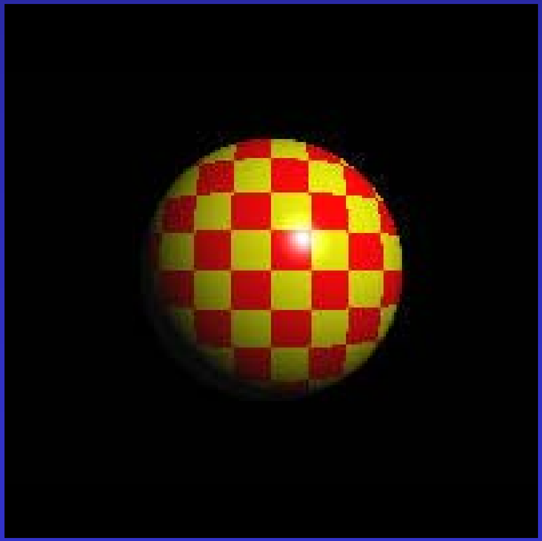


0...s.x...2*s.x..3*s.x

Space Filling 2D Checkerboard

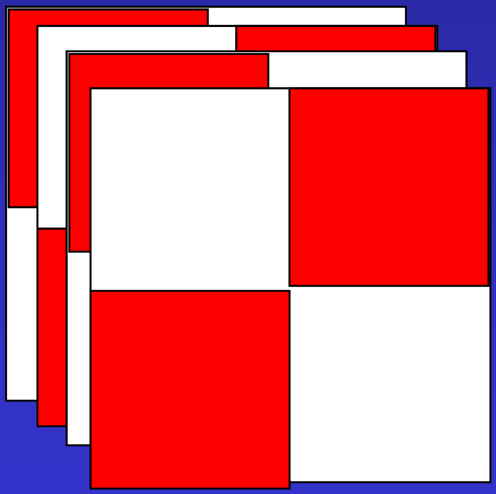
jump(x,y,z) = ((int)(A+x/s.x)+(int)(A+y/s.y))%2
if (jump == 0)
 color = yellow
Else if (jump == 1)
 color = red





Space Filling 3D Checkerboard

jump(x,y,z) = ((int)(A+x/s.x)+(int)(A+y/s.y)+(int)(A+z/s.z))%2
if (jump == 0)
 color = yellow
Else if (jump == 1)
 color = red



Cube of Smoothly Varying Colors

Uses fract(x) = x - (floor)(x)

Texture(x,y,z) = (1 - |2*fract(x)-1|, 1-|2*fract(y) - 1|, 1-|2*fract(z)-1|)

0….1…..0

Rings

rings(r) = (int (r)) % 2

$r = sqrt(x^2+y^2);$

rings(x,y,z) = D + A * rings(r/M)

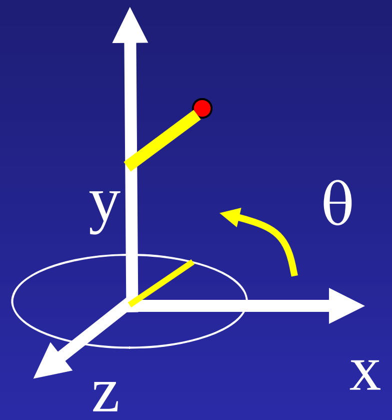
M - thickness

D & A
scale and translate into arbitrary values

Or, as before, map 0 & 1 into yellow and red

Wood Grain

Add twist to rings:



Rotate texture around y-axis by θ

Implement by rotating point by –θ around y-axis

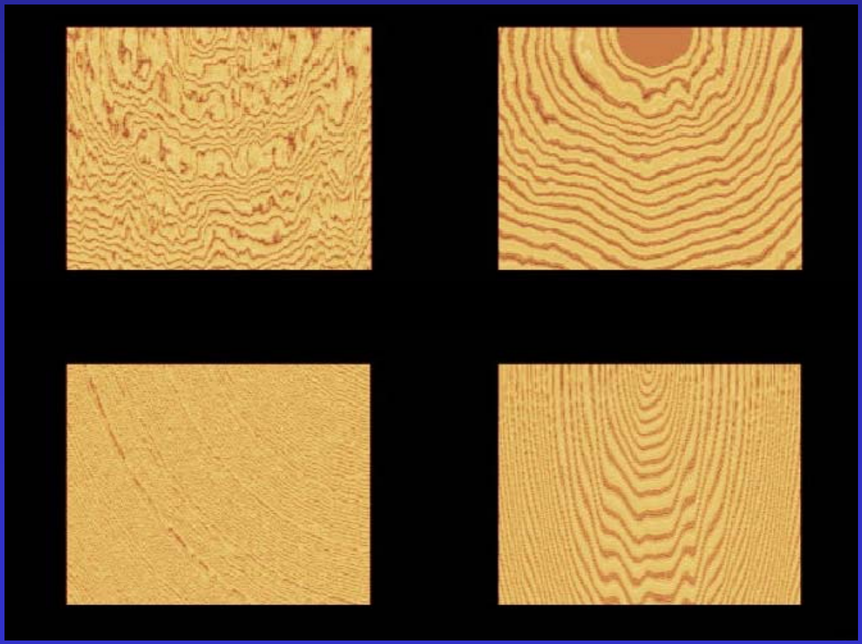
Similarly, rotate (x,y,z) point around z-axis

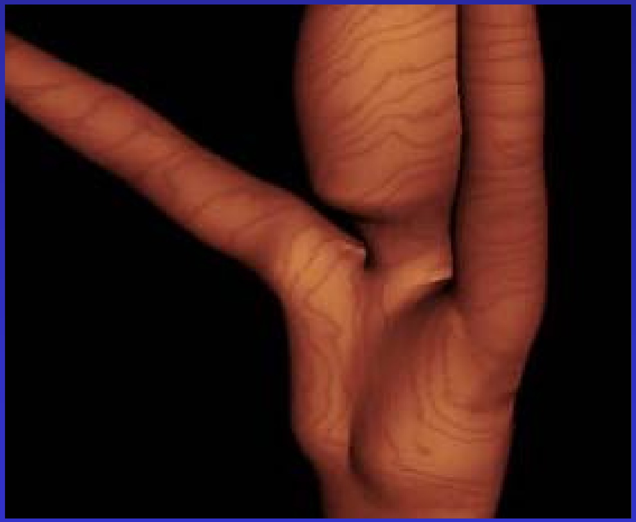
Use some randomness to break up regularity

Wood Grain

Make one color much thinner

Make jitter pseudo-random

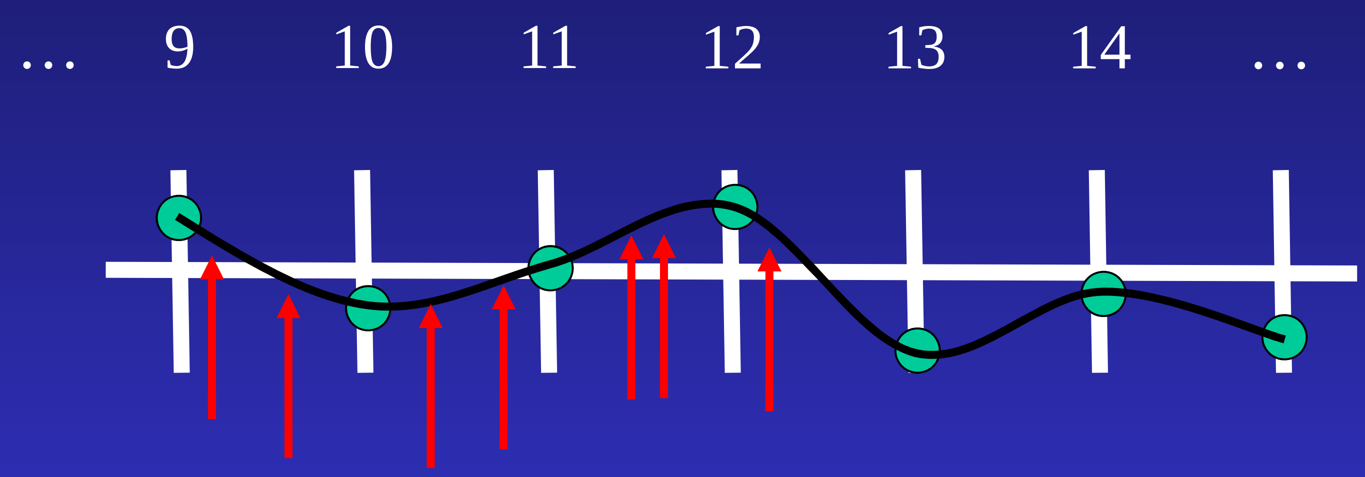




Noise, Turbulence, Marble

- Define function of random values which is
  - A function of 3D point
  - continuous
  - repeatable
- Use 3D point to retrieve random value
- 3D volume has frequency determined by spacing of random values
- Scale point first to change frequency of noise function

1D Noise Example

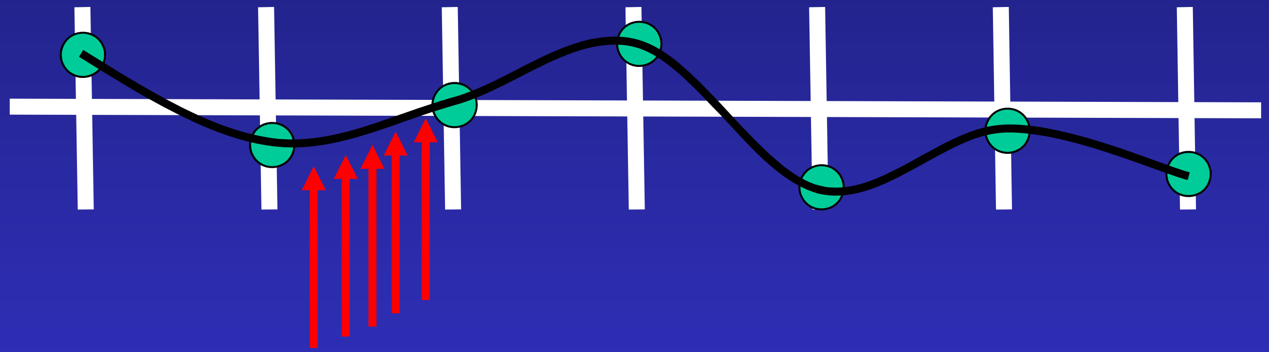


Deposit random values at integer locations

Interpolate through values to get continuous function

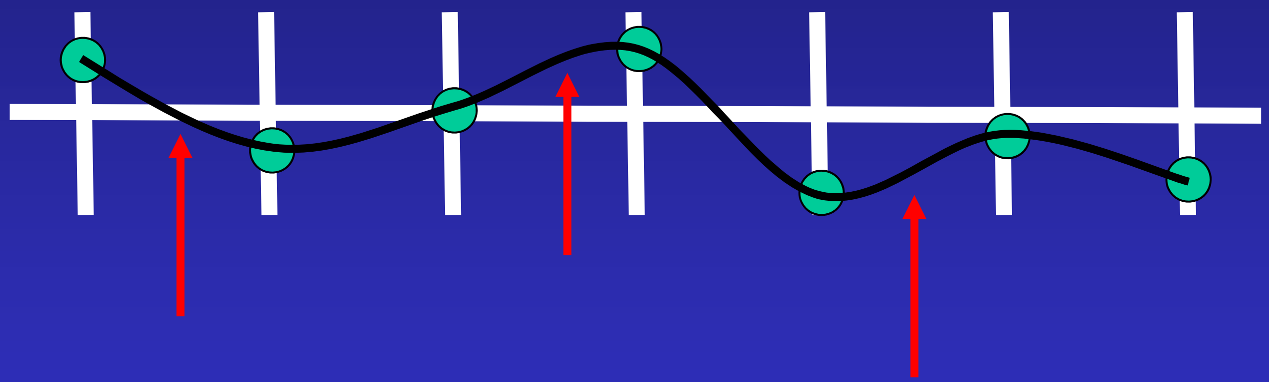
Sample function at intersection points of object with ray

1D Noise Example



Sample too frequently - no randomness

1D Noise Example



Sample too sparsely - no continuity

(Nyquist limit)

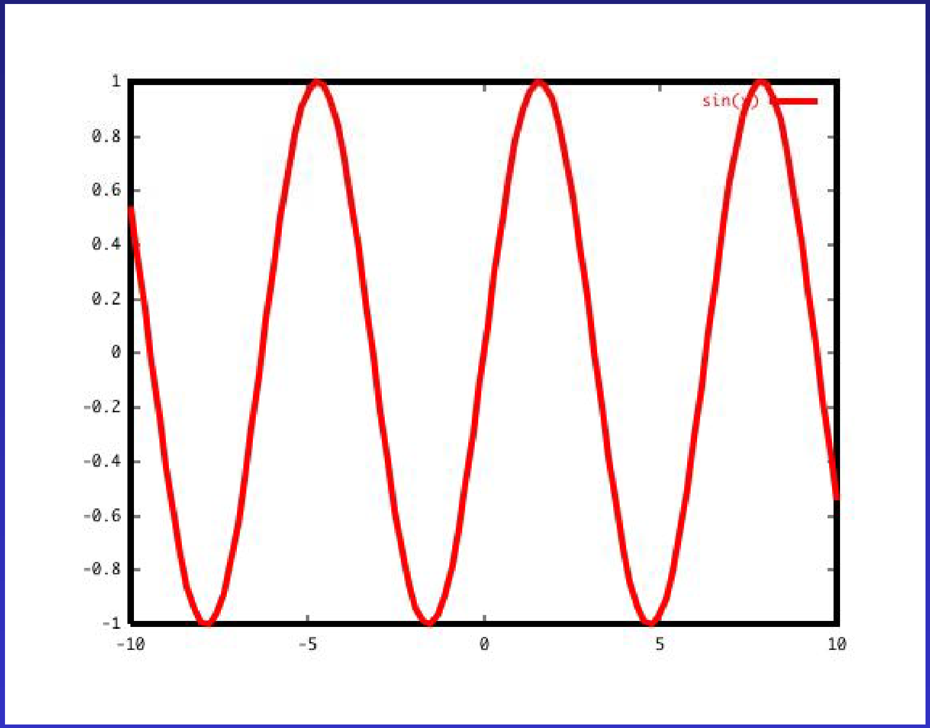
Turbulence

Add multiple frequencies together

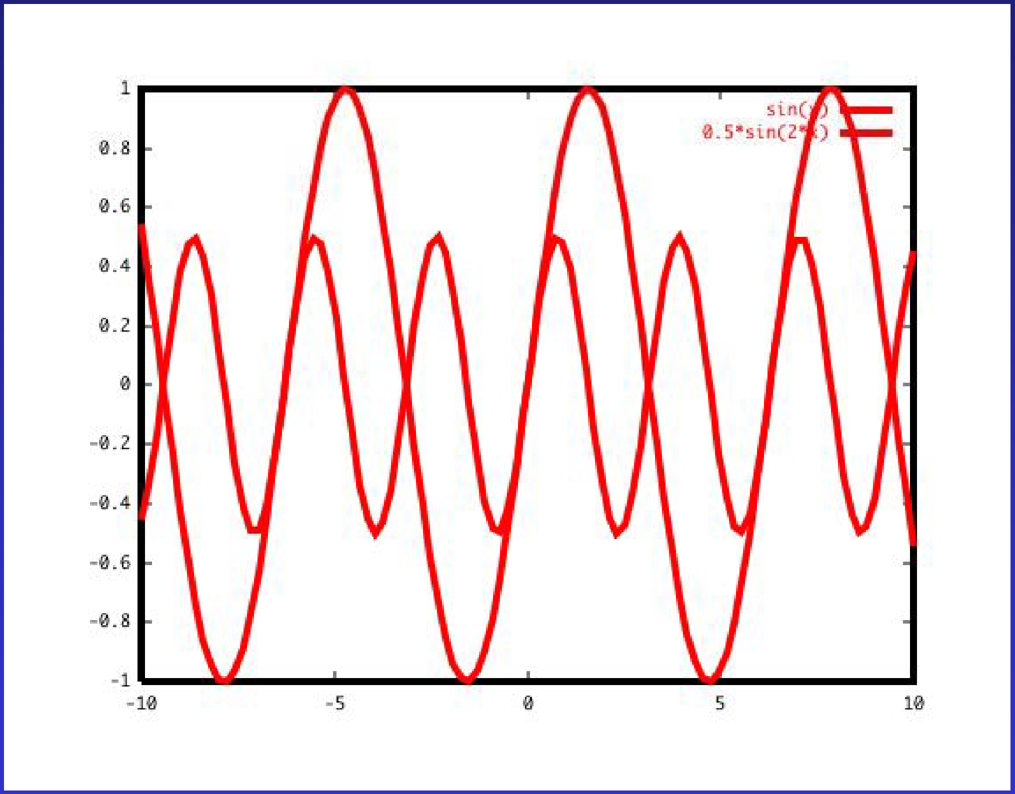
As frequency goes up, amplitude goes down

Each component similar under scale
- Fractal
- e.g. coastline

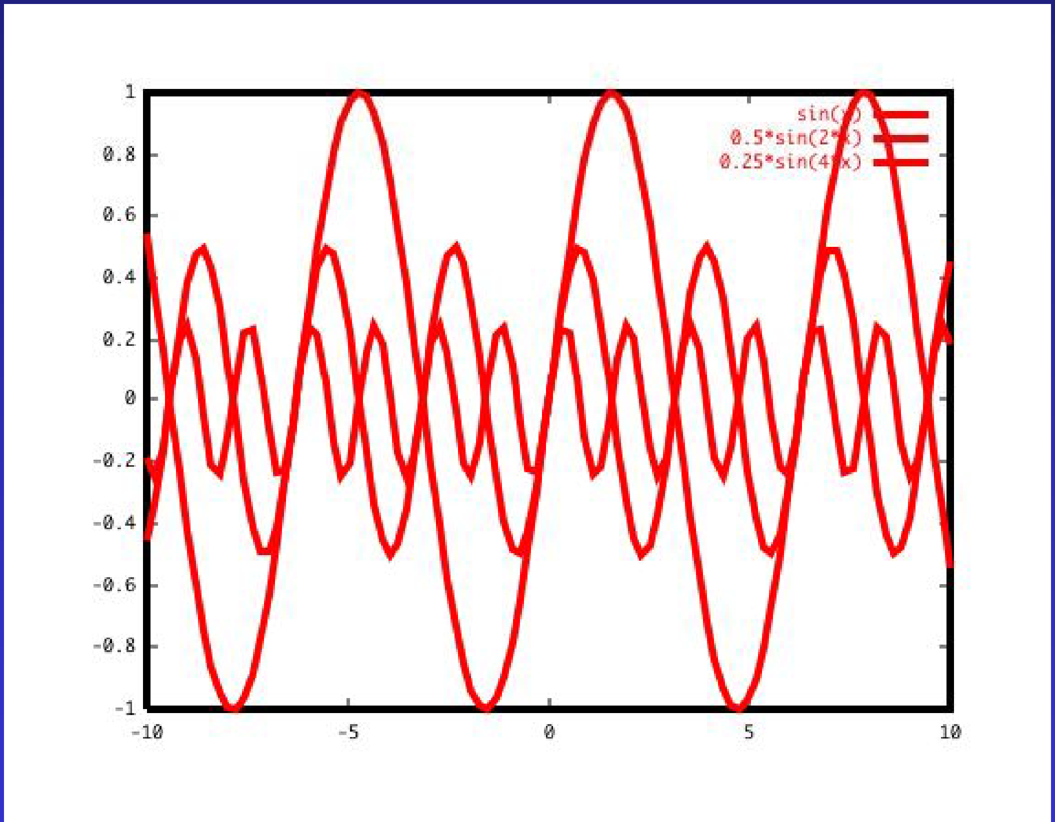
1D Turbulence Example



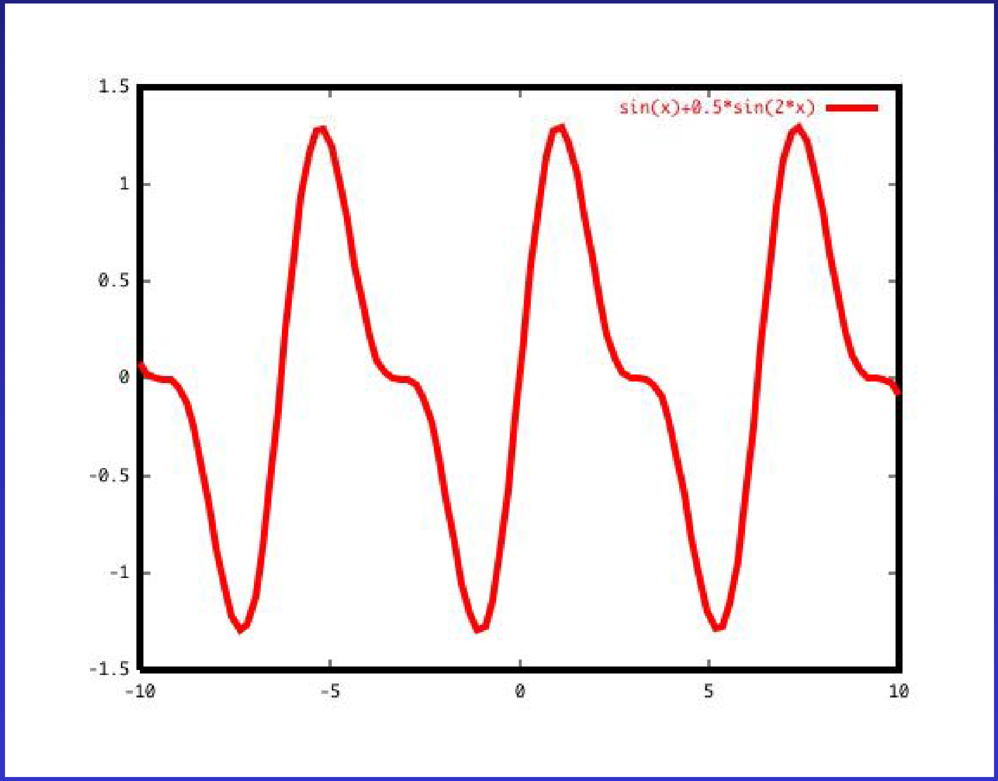
1D Turbulence Example



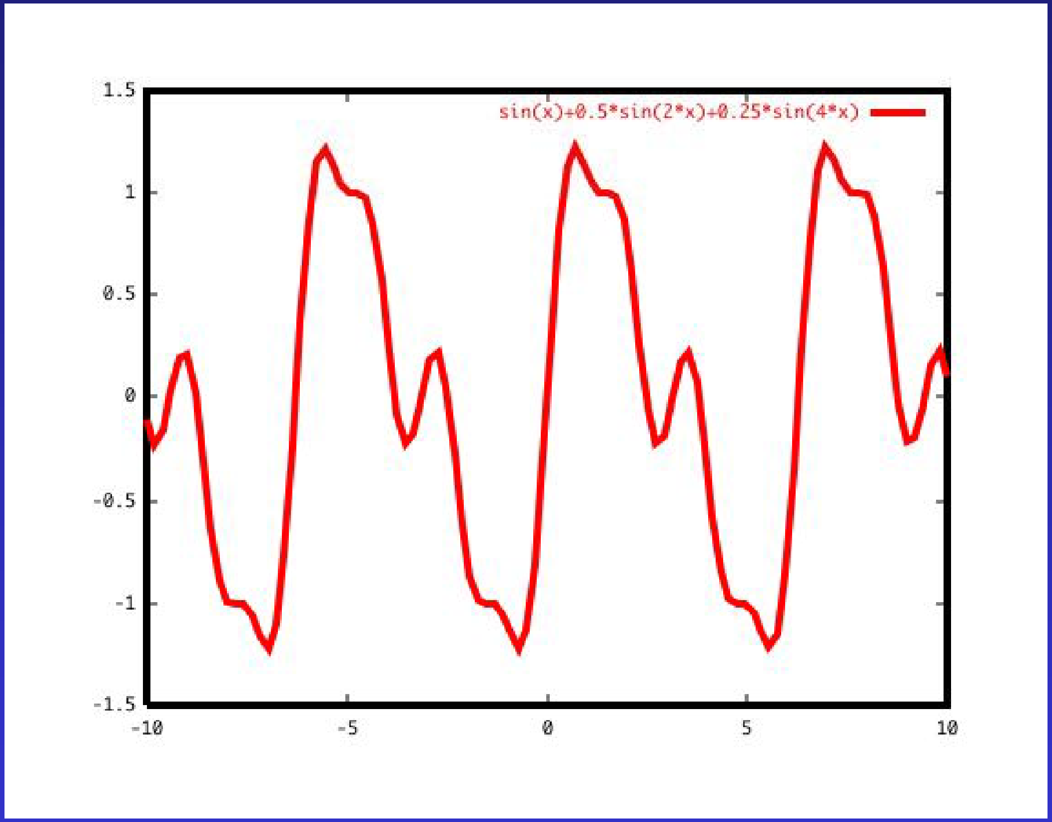
1D Turbulence Example



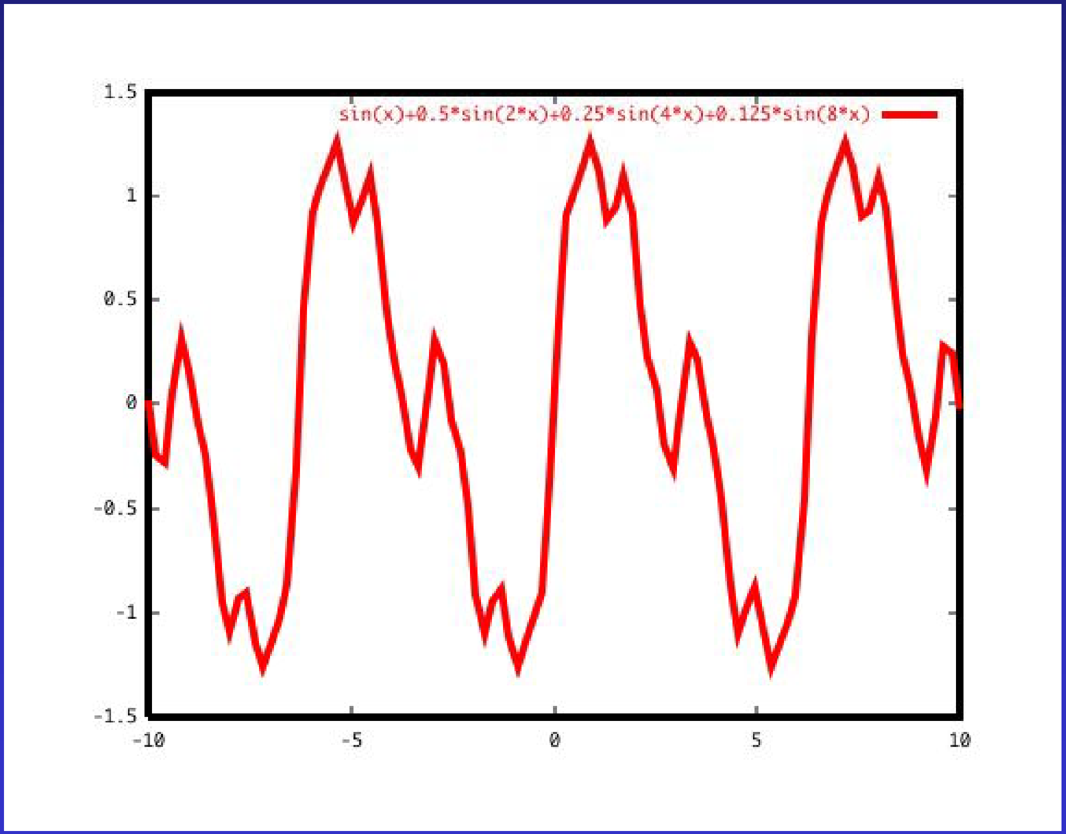
1D Turbulence Example



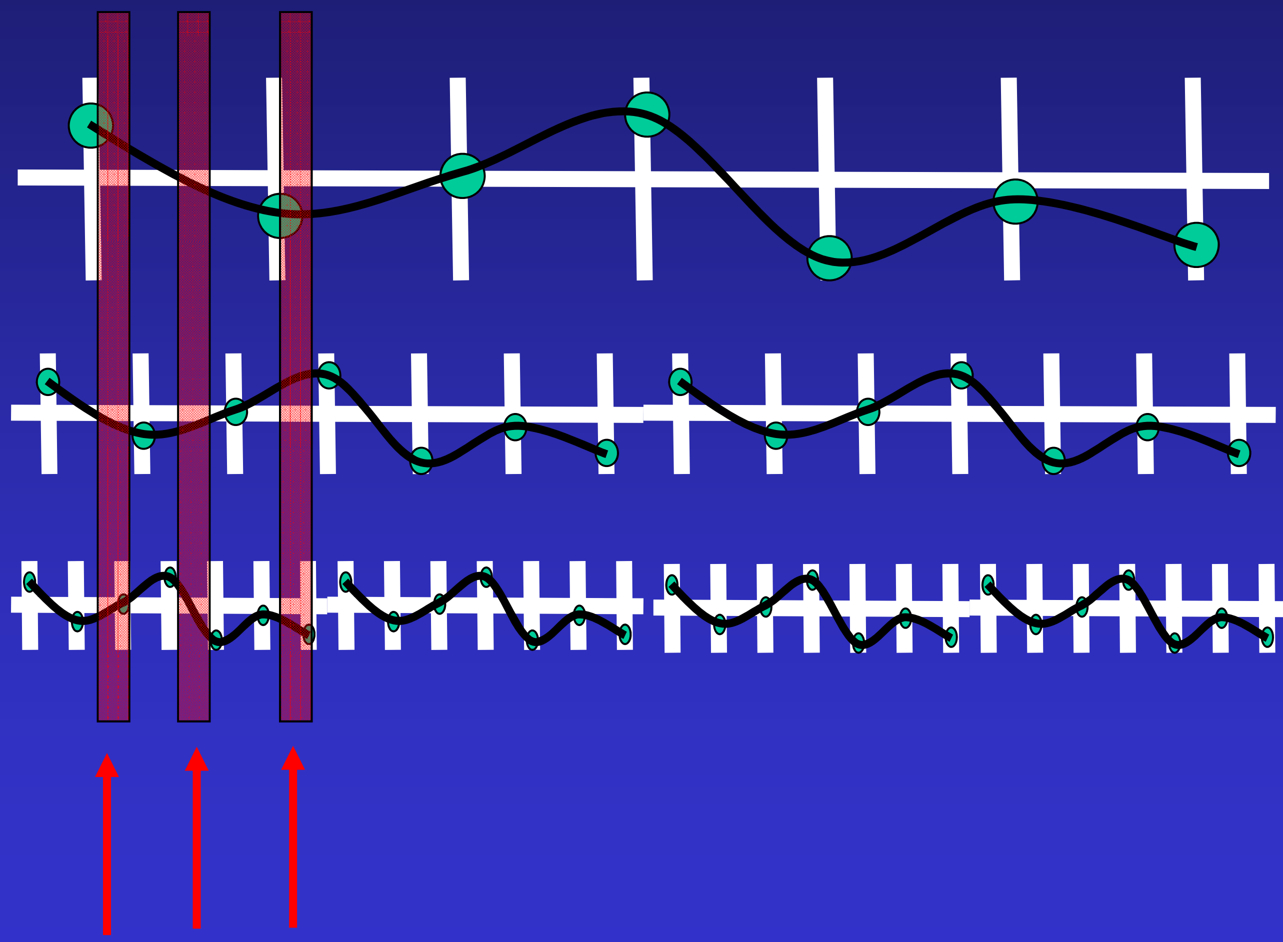
1D Turbulence Example



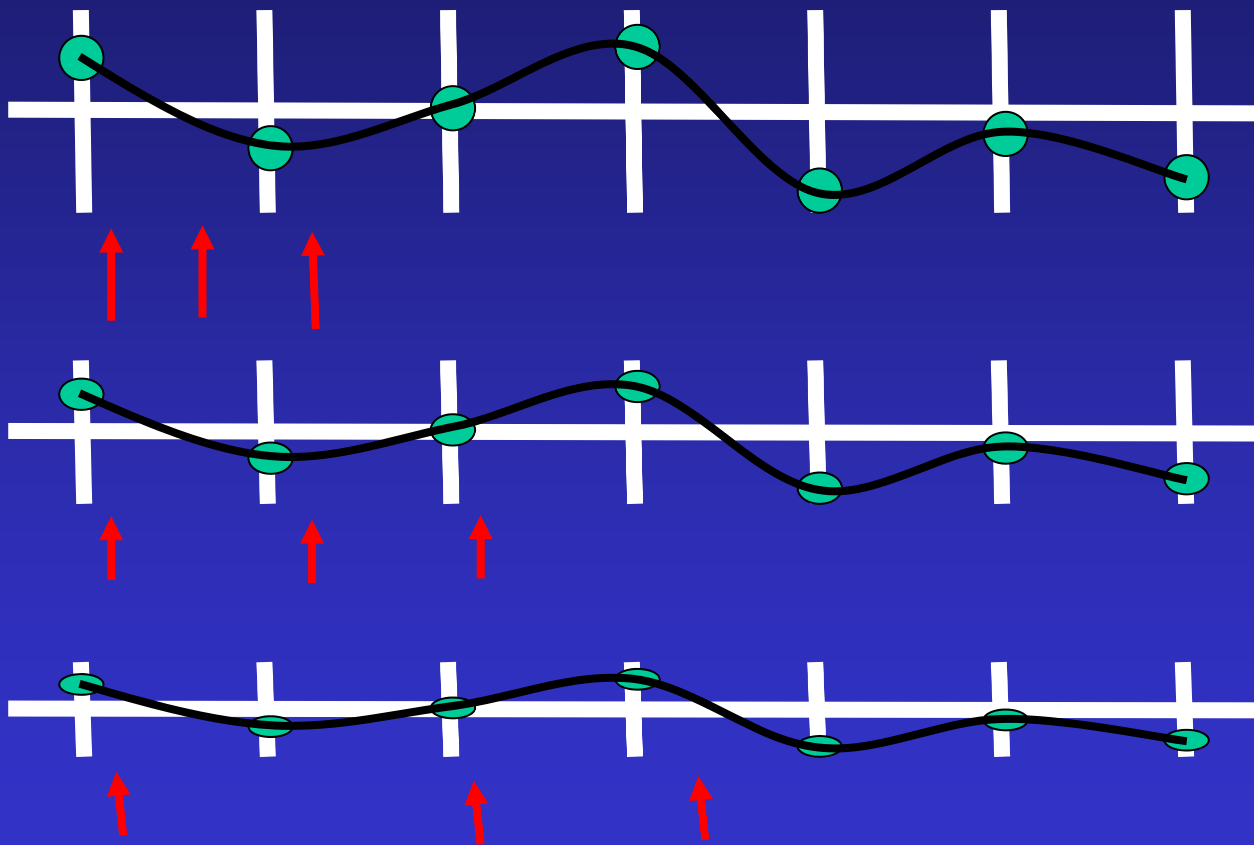
1D Turbulence Example



1D Turbulence Example



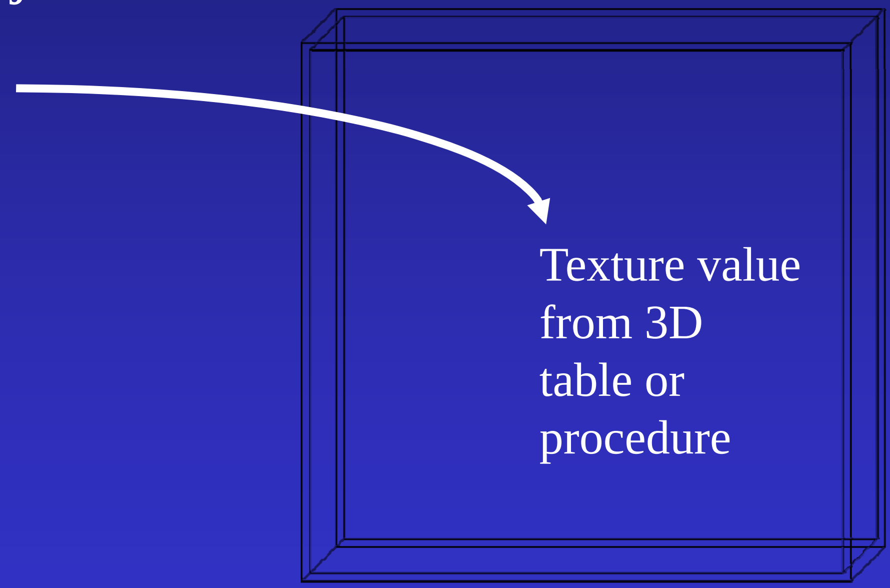
1D Turbulence Example



3D Noise

Visible point from
surface of object

(x,y,z)

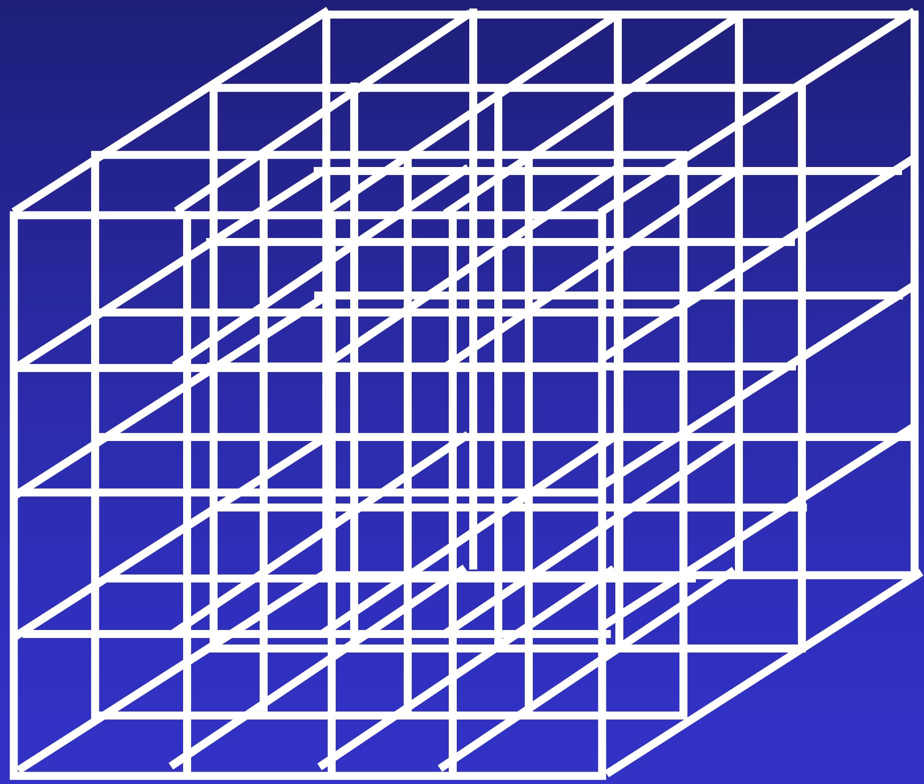


Need controlled randomness => varying but continuous function

Integer Lattice

Use 256x256x256 volume

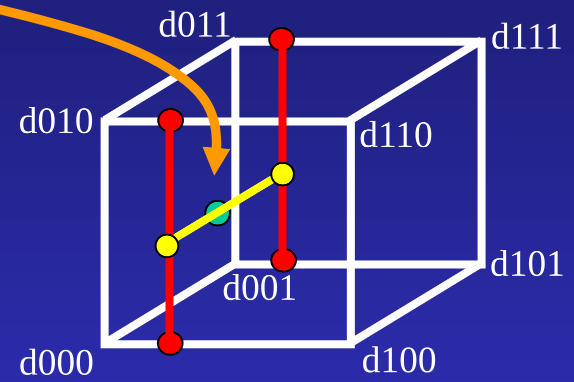
Deposit random values at integer grid points



Interpolate values within cube

(x,y,z)

fx = FRACT(x)
fy = FRACT(y)
fz = FRACT(z)



Use tri-linear interpolation

d00 = d000+fx(d100-d000)
d10 = d010+fx(d110-d010)
d01 = d001+fx(d101-d001)
d11 = d011+fx(d111-d011)

d0 = d00+fy(d10-d00)
d1 = d01+fy(d11-d01)

d = d0+fz(d1-d0)

Implementation notes

NoiseTable[256]: random values [0, 1]

Index[256]: random permutation of values 0:255

```
#define    PERM(x)             index[x & 255]
#define    INDEX(ix,iy,iz)     PERM( ix + PERM(iy + PREM(iz)))
```

```
Float latticeNoise(i,j,k)
    Return NoiseTable[INDEX(i,j,k)]
```

Turbulence implementation

Noise(s,x,y,z)

- Scale point by s, add 1000 to each coordinate
- Get integer (ix,iy,iz) and fractional parts (fx,fy,fz)
- Get cell lattice noise values
  - d000,d001,d010,d011, d100,d101,d110,d111
- Do the trilinear interpolation by fx,fy,fz

$$Turb(s,x,y,z,n1,n2) = \sum_{k=n1}^{n2} \left(\frac{1}{2}\right)^k noise(2^k s,x,y,z)$$

Where n1,n2 control how many, and which, frequencies

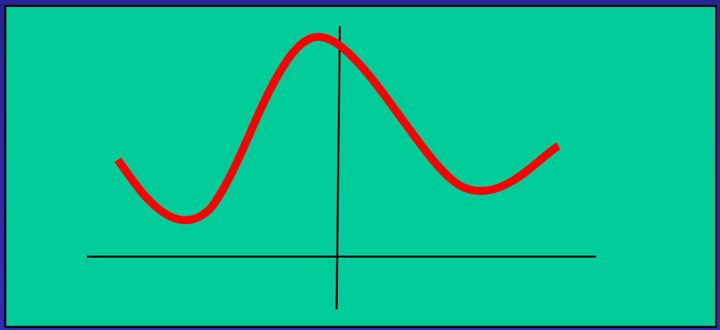
NoiseTexture

See examples

www.cse.ohio-state.edu/~parent/classes/681/Noise/noise.html

Marble Texture

Undulate(x) - basic ripple in x



Marble(x,y,z) = undulate(sin(2πxyz + A*turb(s,x,y,z,k)))

Paramters: amplitude, scale, number of frequencies

Marble Texture

See examples

www.cse.ohio-state.edu/~parent/classes/681/SolidTexture/solidTexture.html