VGP352 – Week 4 Agenda

- Microfacet theory in BRDFs
  - Overview
  - Normal distribution functions
  - Occlusion
- More framebuffer objects
  - This will be on the whiteboard
- Assignments:
  - Assignment #1 due at start of class
  - Assignment #2
    - We'll get a good start on this in class
  - Assign next week's reading for presentation

Microfacet Overview

- A surface is made up of numerous, small facets
  - Each facet only reflects light along the ideal reflection vector
  - Determining the number of visible facets for a given V and L is enough to determine the BRDF

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  - Each facet only reflects light along the ideal reflection vector
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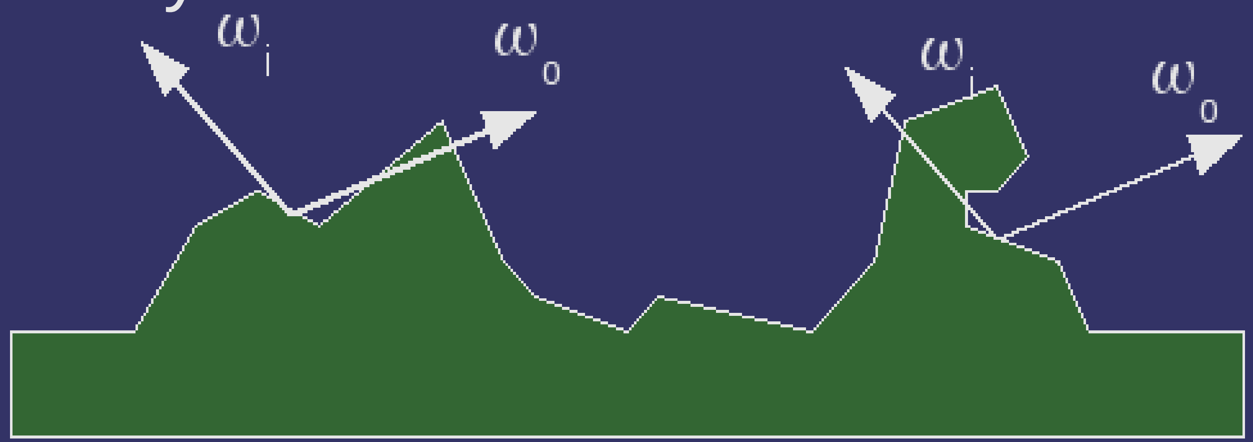
- Add two assumptions:
  - Facet normals have a probability distribution $p(H)$
  - A facet only contributes if it is visible to both V and L



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Microfacet Overview

- BRDF is determined entirely by:
  - Fresnel term
  - Fraction of microfacets with normal vector that is H
  - Fraction of microfacets visible to both L and V
    - Non-visibility to L is often called “shadowing”
    - Non-visibility to V is often called “masking”
    - Can also call both “occlusion”

Normal Distribution

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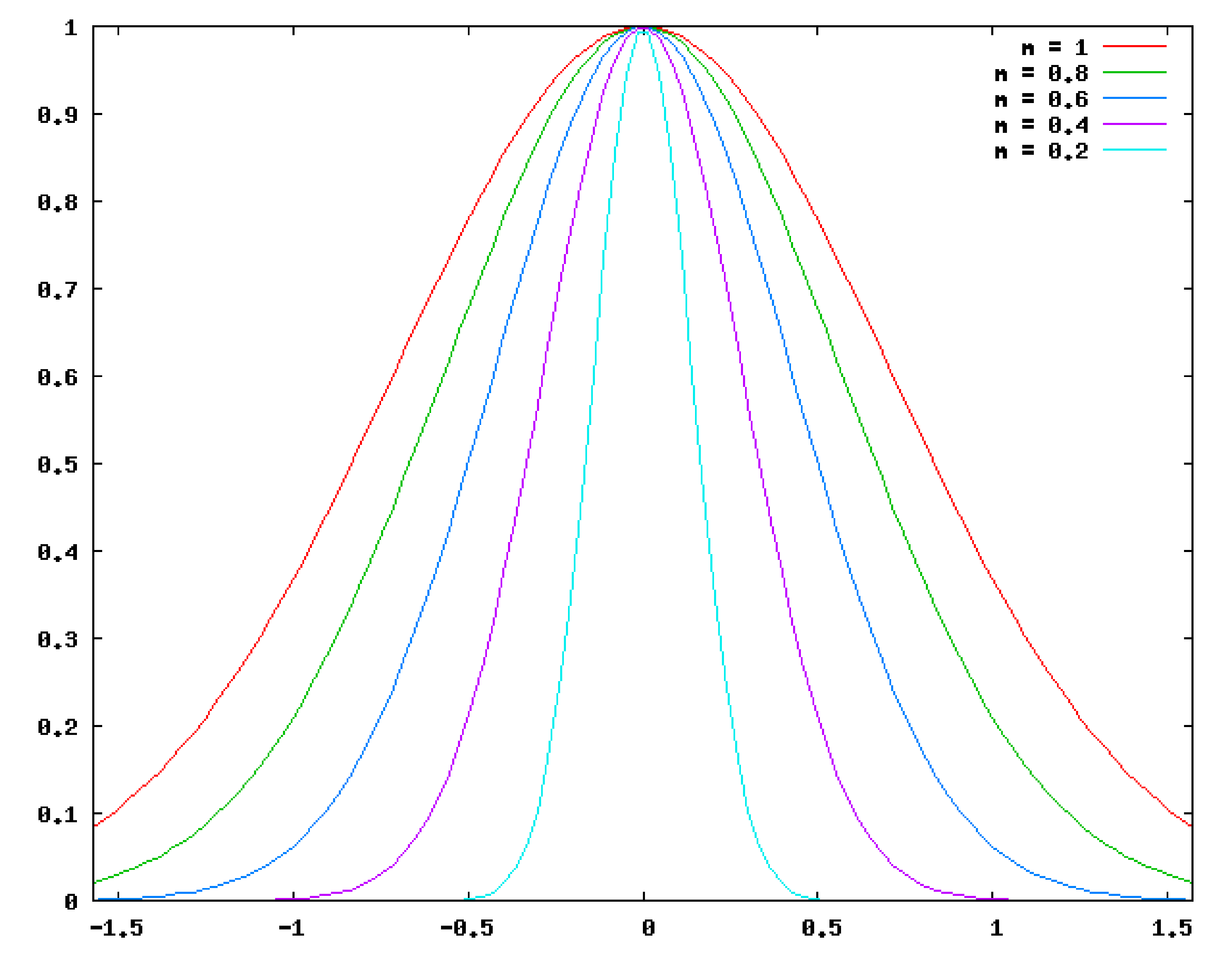
  - Can use a Gaussian-like probability function
    - Most facet normals match the surface normal
    - The more different the facet normal is, the lower the probability is
  - Can encode arbitrary probability functions in a texture
    - If the domain of the probability function is one (or more) dot-products, this is *very* convenient!

Gaussian Distribution

$$P(\theta) = c\, e^{-\left(\frac{\theta}{m}\right)^2}$$

c is an arbitrary, magic constant
m is the root-mean-squared of slope of the microfacets

Gaussian Distribution



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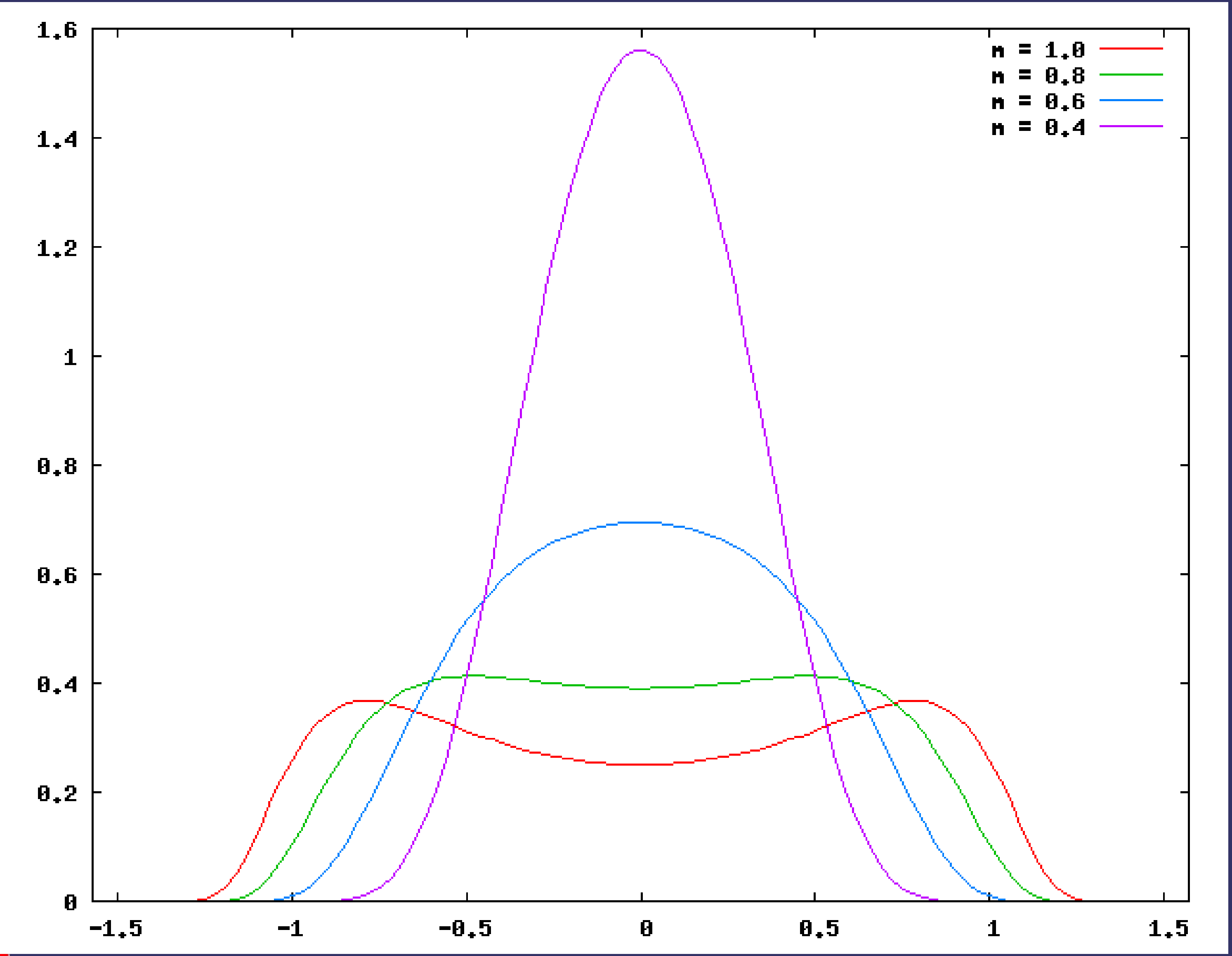
- Looking at the graphs, what's wrong with this distribution?
  - The total of all probabilities should be 1.0
    - This is the area under the curve
    - This implies that all the curves should have the same area...and it's obvious that they don't
- The distribution is based on θ
  - We can't get that easily...only cos θ

Beckmann Distribution

$$D(\theta) = \frac{1}{4m^2\cos^4\theta} e^{-\left(\frac{\tan^2\theta}{m^2}\right)}$$

- Physically based model of rough surfaces
  - Based on Beckmann's research in the early 60's
- θ is used in calculations
  - cos θ is just $N \cdot H$
  - $\tan^2\theta$ is $(1 - \cos^2\theta) / \cos^2\theta$
    - You always knew those trig identities would be useful!

Beckmann Distribution



Microfacet Occlusion

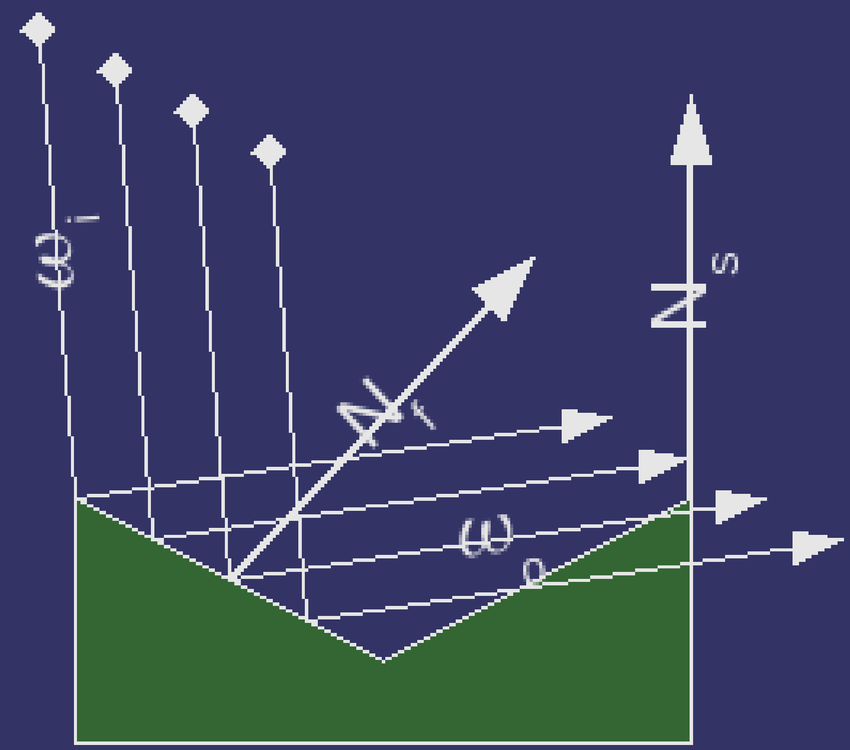
- For a given reflection direction, calculate the probability of a facet being visible
  - The same function, $p(\theta)$, is used to determine visibility from V or from L
- If $p(\theta_V)$ and $p(\theta_L)$ are known, how do we combine them?

Microfacet Occlusion

- For a given reflection direction, calculate the probability of a facet being visible
  - The same function, $p(\theta)$, is used to determine visibility from V or from L
- If $p(\theta_V)$ and $p(\theta_L)$ are known, how do we combine them?
  - Multiplying the two over estimates the occlusion
    - Some portion of V that is occluded is also occluded from L
  - Cook & Torrance suggest taking the smaller value
  - Other methods exist
    - The reading for next week contains one

Microfacet Occlusion

- How do we estimate $p(\theta)$?
  - Clearly ω_i, ω_o, N_f, and N_s are involved
    - N_f is the facet normal
    - N_s is the surface normal



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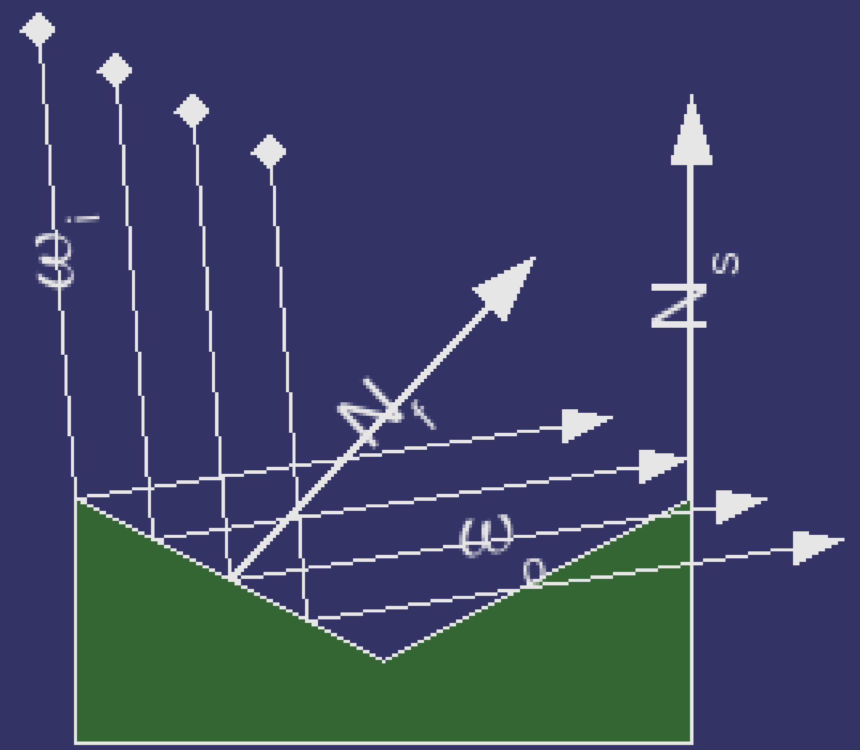
Microfacet Occlusion

- How do we estimate $p(\theta)$?
  - Clearly ω_i, ω_o, N_f, and N_s are involved
    - N_f is the facet normal
    - N_s is the surface normal
- Observations:
  - Occlusion increases as...
    - $(N_f \bullet N_s)$ approaches zero
    - $(\omega_i \bullet N_s)$ approaches zero
  - Occlusion decreases as...
    - $(\omega_i \bullet N_f)$ approaches zero

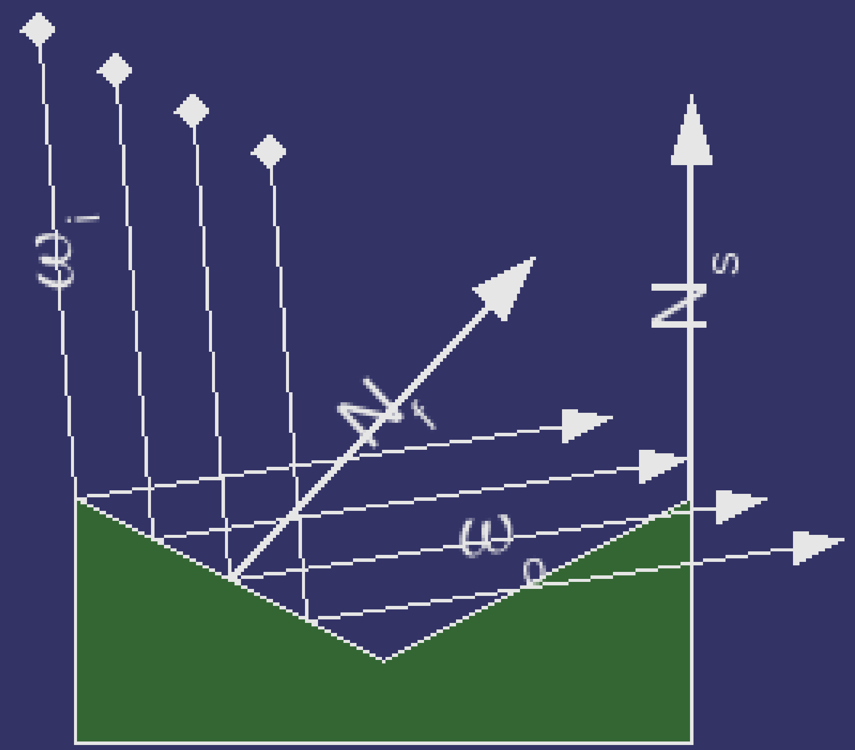


Microfacet Occlusion

- Cook & Torrance use:

$$p(\theta)=\frac{2(N_s\cdot N_f)(N_s\cdot\omega)}{\omega\cdot N_f}$$

- But what is N_f?



Microfacet Occlusion

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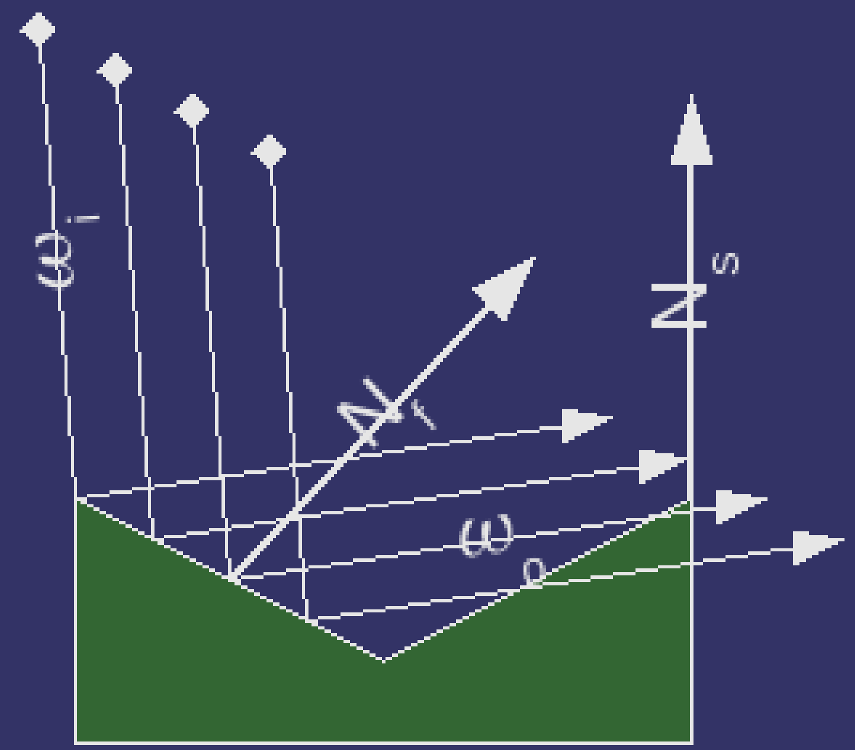
$$p(\theta)=\frac{2(N_s\cdot N_f)(N_s\cdot\omega)}{\omega\cdot N_f}$$

- But what is N_f?
  - H!

$$G_V=\frac{2(N\cdot H)(N\cdot V)}{V\cdot H}$$

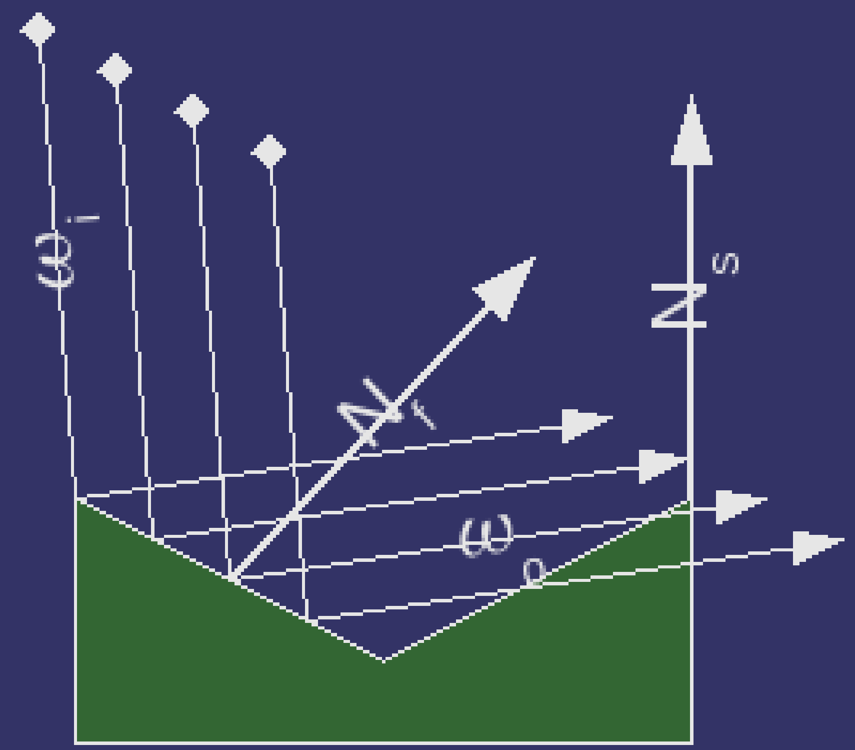
$$G_L=\frac{2(N\cdot H)(N\cdot L)}{L\cdot H}$$

$$L\cdot H=V\cdot H$$



Microfacet Occlusion

- This turns out to be a poor model
  - Real surfaces aren't made of long, V-shaped channels
  - The reading for next week discusses this at length



Next week...

- Anisotropic BRDFs
  - What is anisotropy and anisotropic reflection?
  - Ward
  - Ashikhmin
- Implementation of BRDFs in shaders
- Assignment #2 due
- Assignment #3 given
- Quiz #2

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