

How do you calculate the Angle of Incidence?

Asked 15 years, 10 months ago Modified 15 years, 7 months ago

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4



I'm working on a raytracer for a large side project, with the goal being to produce realistic renders without worrying about CPU time. Basically pre-rendering, so I'm going for accuracy over speed.

I'm having some trouble wrapping my head around some of the more advanced math going on in the lighting aspects of things. Basically, I have a point for my light. Assuming no distance falloff, I should be able to use the point on the polygon I've found, and compare the normal at that point to the angle of incidence on the light to figure out my illumination value. So given a point on a plane, the normal for that plane, and the point light, how would I go about figuring out that angle?

The reason I ask is that I can't seem to find any reference on finding the angle of incidence. I can find lots of references detailing what to do once you've got it, but nothing telling me how to get it in the first place. I imagine it's something simple, but I just can't logic it out.

Thanks

math

raytracing

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edited Feb 27, 2009 at 6:26



Devin Jeanpierre

95.3k ● 4 ● 58 ● 79

asked Feb 20, 2009 at 18:31



Blank

7,188 ● 13 ● 51 ● 71

3 Answers

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8

The [dot product](#) of the surface normal vector and the incident light vector will give you the cosine of the angle of incidence, if you've normalised your vectors.



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answered Feb 20, 2009 at 18:35



Ian Hopkinson

3,432 ● 4 ● 26 ● 28



Just had a look back at my old raytracer code from university, and indeed the only time it mentions angle of incidence is related to the cosine of it, which is calculated exactly this way. – [Chad Birch](#) Feb 20, 2009 at 18:40



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It sounds to me like you are trying to calculate diffuse illumination. Assuming you have [Surface Point](#)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bp_o%7D)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bp_o%7D) the point on the surface, [Light Position](#)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bp_L%7D)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bp_L%7D), and the

[Normal Vector http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bn%7D)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Cinline%20%5Coverrightarrow%7Bn%7D) normal

vector. You can calculate diffuse illumination like this:

[Diffuse Illumination](#)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Coverrightarrow%7BL%7D%3D%5Coverrightarrow%7Bp_L%7D-%5Coverrightarrow%7Bp_o%7D%5C%5C%0A%5Cfrac%7B%5Coverrightarrow%7BL%7D%5Cdot%5Coverrightarrow%7Bn%7D%7D%7B%5C%7C%5Coverrightarrow%7BL%7D%5C%7C%2a%5C%7C%5Coverrightarrow%7Bn%7D%5C%7C%7D)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Coverrightarrow%7BL%7D%3D%5Coverrightarrow%7Bp_L%7D-%5Coverrightarrow%7Bp_o%7D%5C%5C%0A%5Cfrac%7B%5Coverrightarrow%7BL%7D%5Cdot%5Coverrightarrow%7Bn%7D%7D%7B%5C%7C%5Coverrightarrow%7BL%7D%5C%7C%2a%5C%7C%5Coverrightarrow%7Bn%7D%5C%7C%7D)

[http://www.yourequations.com/eq.latex?](http://www.yourequations.com/eq.latex?%5Coverrightarrow%7BL%7D%3D%5Coverrightarrow%7Bp_L%7D-%5Coverrightarrow%7Bp_o%7D%5C%5C%0A%5Cfrac%7B%5Coverrightarrow%7BL%7D%5Cdot%5Coverrightarrow%7Bn%7D%7D%7B%5C%7C%5Coverrightarrow%7BL%7D%5C%7C%2a%5C%7C%5Coverrightarrow%7Bn%7D%5C%7C%7D)

You technically don't need to calculate the actual angle of incident because you only need the cosine of that which the [dot product](#) conveniently gives you.

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edited Feb 20, 2009 at 19:16

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answered Feb 20, 2009 at 19:01



Kevin Loney

Nice typesetting for the equations, Kevin. What did you use to do it? – [duffyymo](#) Feb 20, 2009 at 19:17

- 1 [yourequations.com](#) I've been waiting for a question I could use it on. – [Kevin Loney](#) Feb 20, 2009 at 19:19

with youreequations.com being offline, the answer should be removed or updated. – [Sebastian Hojas](#) May 1, 2015 at 12:47



0



NOTE: From where I'm sitting right now, I can't upload a picture for you. I'll try to lay it out for you in words, though.

Here's how you can imagine this process:

Define [alt text http://www.yourequations.com/eq.latex?%5Chat%7Bn%7D](http://www.yourequations.com/eq.latex?%5Chat%7Bn%7D) as your normalized normal (the vertical vector that comes out of your planar polygon and is of unit length, making the math easier).

Define [alt text http://www.yourequations.com/eq.latex?p_0](http://www.yourequations.com/eq.latex?p_0) as your eyeball point.

Define [alt text http://www.yourequations.com/eq.latex?p_1](http://www.yourequations.com/eq.latex?p_1) as the impact point of your "eyeball ray" on the polygon.

Define [alt text http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D](http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D) as the normalized vector pointing from [alt text http://www.yourequations.com/eq.latex?p_1](http://www.yourequations.com/eq.latex?p_1) back

to [alt text http://www.yourequations.com/eq.latex?p_0](http://www.yourequations.com/eq.latex?p_0).

You can write this like so:

[alt text http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D%20=%20%5Cfrac%7B%5Coverrightrrow%7B\(p_0%20-%20p_1\)%7D%7D%7B||p_0%20-%20p_1||%7D](http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D%20=%20%5Cfrac%7B%5Coverrightrrow%7B(p_0%20-%20p_1)%7D%7D%7B||p_0%20-%20p_1||%7D)

So, you have created a vector that points from [alt text http://www.yourequations.com/eq.latex?p_1](http://www.yourequations.com/eq.latex?p_1) to [alt text http://www.yourequations.com/eq.latex?p_0](http://www.yourequations.com/eq.latex?p_0) and then divided that vector by its own length, giving you a vector of length 1 that points from [alt text http://www.yourequations.com/eq.latex?p_1](http://www.yourequations.com/eq.latex?p_1) to [alt text http://www.yourequations.com/eq.latex?p_0](http://www.yourequations.com/eq.latex?p_0)

The reason that we went to all this trouble is that we would really like the angle [alt text http://www.yourequations.com/eq.latex?%5Ctheta](http://www.yourequations.com/eq.latex?%5Ctheta) which is the angle between the normal [alt text http://www.yourequations.com/eq.latex?%5Chat%7Bn%7D](http://www.yourequations.com/eq.latex?%5Chat%7Bn%7D) and that vector [alt text http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D](http://www.yourequations.com/eq.latex?%5Chat%7Bv%7D) that you just created. Another word for theta is the *angle of incidence*.

An easy way to calculate this angle of incidence is to use the [dot product](#). Using the terms defined above, you take the x, y and z components of each of those unit length vectors, multiply them together and add the sums to get the dot product.

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%5Cchat%7Bn%7D%20%5Ccdot%20%5Cchat%7Bv%7D
%20=%20%5Ccos%7B%5Ctheta%7D%20=%20n_x%20
%20v_x%20+%20n_y%20%20v_y%20+%20n_z%20%20
v_z](http://www.yourequations.com/eq.latex?%5Cchat%7Bn%7D%20%5Ccdot%20%5Cchat%7Bv%7D%20=%20%5Ccos%7B%5Ctheta%7D%20=%20n_x%20%20v_x%20+%20n_y%20%20v_y%20+%20n_z%20%20v_z)

To calculate alt text

<http://www.yourequations.com/eq.latex?%5Ctheta>,
therefore, you simply use the inverse cosine on the dot product:

[alt text http://www.yourequations.com/eq.latex?
%5Ctheta%20=%20%5Carccos%28%5Chat%7Bn%7D%
20%5Ccdot%20%5Chat%7Bv%7D%29](http://www.yourequations.com/eq.latex?%5Ctheta%20=%20%5Carccos%28%5Chat%7Bn%7D%20%5Ccdot%20%5Chat%7Bv%7D%29)

Edit: modified the above to add yourequations.com formatting.

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edited May 15, 2009 at 14:00

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answered Feb 20, 2009 at 19:02



Bob Cross

22.3k ● 12 ● 62 ● 95