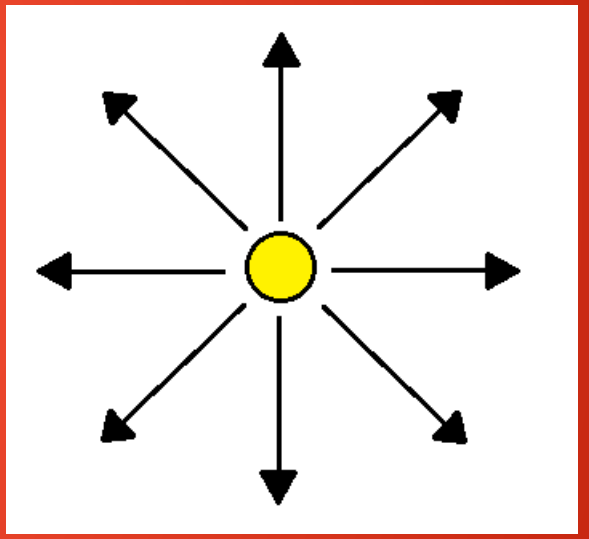
Point Lights and Spot Lights

Point Lights

- Lights with a position that emit light in ALL directions.
- Need to determine direction vector manually.
- Get difference between light position and fragment position.
- Apply directional lighting maths to the calculated direction vector.

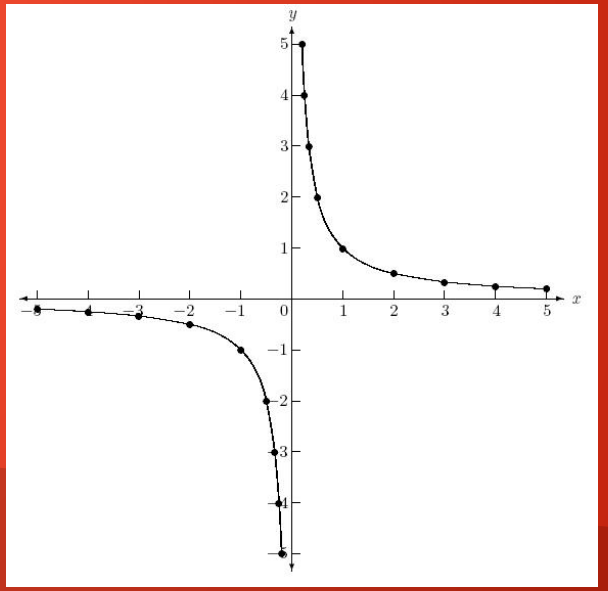


Point Lights – Attenuation

- Directional Lights simulate infinite distance, so distance doesn’t effect lighting power.
- Point Lights have positions, distance from point being lit changes power of lighting.
- One possible solution: Linear drop-off.
- Have the lighting power drop off in direct proportion with the distance of the light source.
- Simple, but not very realistic...

Point Lights – Attenuation

- In reality, light intensity initially drops quickly with distance…
- But the further you are, the slower it decreases!
- For positive values, the reciprocal of a quadratic function can create this effect!
- In other words: $1/(ax^2 + bx + c)$
- Where x is the distance between the light source and fragment.



Point Lights – Attenuation

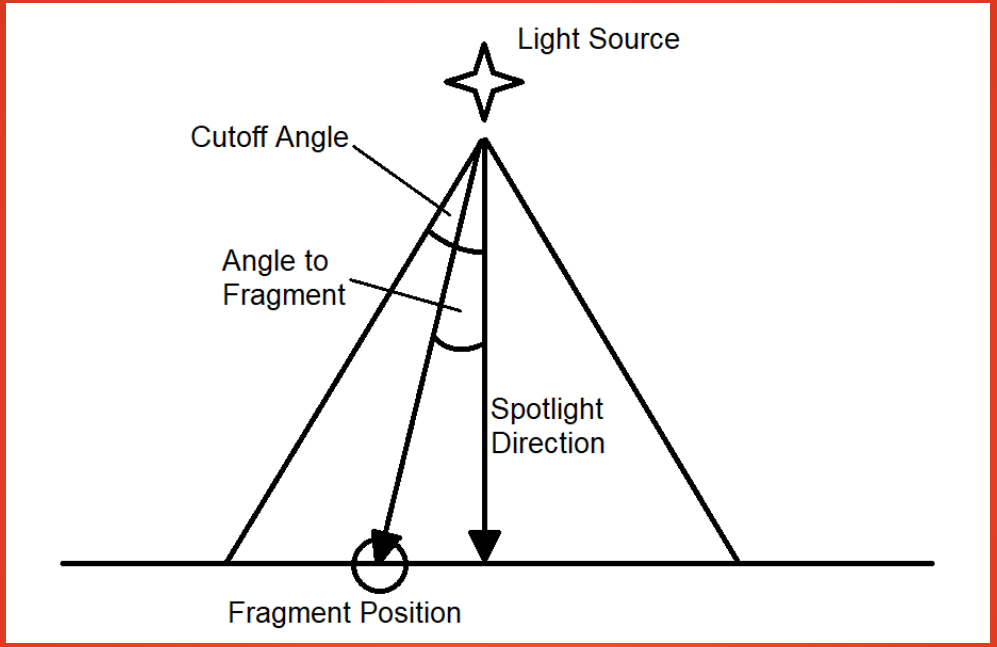
$$\text{Attenuation Factor} = \frac{1.0}{\text{quadratic} * \text{distance}^2 + \text{linear} * \text{distance} + \text{constant}}$$

- distance: Distance between light and fragment.
- quadratic: User-defined value, usually the lowest of the three.
- linear: User-defined value, lower than constant.
- constant: Usually 1.0 to ensure denominator is always greater than 1.
- E.g. if denominator is 0.8, then 1.0/0.5 = 2.0, so attenuation will DOUBLE power of light beyond its set value.
- For useful values see: http://wiki.ogre3d.org/tiki-index.php?page=-Point+Light+Attenuation
- Alternatively, toy around with values!
- Application: Apply attenuation to ambient, diffuse and specular.

Spot Lights

- Work the same as Point Lights in theory.
- Have position, use attenuation, etc…
- Also have a direction and a cut-off angle.
- Direction: Where the spot light is facing.
- Cut-off angle: The angle describing the “edges” of the light, from the direction vector.

Spot Lights



- Need a way to compare the “Angle to Fragment” to the “Cutoff Angle”.
- Use the Dot Product again!

Spot Lights

- angleToFragment = lightVector · lightDirection
- lightVector: The vector from the light to the fragment.
- lightDirection: The direction the Spot Light is facing.
- So angleToFragment will be a value between 0 and 1, representing the angle between the two.
- Can simply do cos(cutOffAngle) for the Cut Off Angle.
- Larger value: Smaller angle.
- Smaller value: Larger angle.

Spot Lights

- If angleToFragment value is larger than cos(cutOffAngle), then it is within the spot: Apply lighting.
- If angleToFragment value is smaller, then it has a greater angle than the Cut Off: Don’t apply lighting.

Spot Lights – Soft Edges

- Current approach has sharp cut-off at edges of spot.
- Creates unrealistic spot light (although might be good for retro video game effect).
- Need a way to soften when approaching edges of cut-off range.
- Use the dot product result from before as a factor!
- Issue: Due to select range, dot product won't scale very well.
- E.g. If cut-off is 10 degrees...
  - Minimum dot product is cos(10 degrees) = 0.98
  - Dot product range will be 0.98 – 1.00
  - Using dot product to fade edge will be almost unnoticeable!
- Solution: Scale dot product range to 0 – 1!

Spot Lights – Soft Edges

- Formula to scale value between ranges:

$$newValue = \frac{(newRangeMax - newRangeMin)(originalValue - originalRangeMin)}{originalRangeMax - originalRangeMin}$$

- newRangeMin is 0, newRangeMax is 1… so numerator is just originalValue – originalRangeMin.
- originalRangeMax is 1.
- So with some inverting of min and max values…

$$spotLightFade = 1 - \frac{1 - angleToFragment}{1 - cutOffAngle}$$

- Much simpler!

Spot Lights – Soft Edges

- After calculating Spot Light lighting…
- Multiply by spotLightFade effect.
- colour = spotLightColour * spotLightFade

Summary

- Point Lights emit light in all directions.
- Use Directional Light algorithm with light vector.
- Fade light with distance via attenuation values.
- Spot Lights are Point Lights with a direction and cut-off range.
- Compare light vector angle with cut off angle.
- Soften edges with scaled form of light vector angle.

See you next video!