COMP220: Graphics & Simulation

7: Materials and Lighting

Module Roadamp

Table 1: Indicative Assignment Timeline

	Week 2	~~Sh[illegible] to S[illegible] A).~~
Worksheet A	Week 4	~~S[illegible]ng Artefact Wo[illegible]ess to S[illegible]rvisor ([illegible] B).~~
Worksheet B	Week 6	~~S[illegible]ng Artefact W[illegible]ss to S[illegible]ervisor ([illegible] B).~~
Worksheet C	Week 8	Show Draft Poster to Supervisor (Part C).
	Week 8	Present Poster to Peers (Part D).
	Week 9	Peer Review Web Page (Part E).
Worksheet D	Week 10	Show Web Page to Supervisor (Part E).
	Week 10	Submit Poster and Web Page to LearningSpace (Part F).
	Week 13	Present Web Page at Viva (Part F).

Learning outcomes

- **Explain** the Blinn-Phong illumination model
- **Implement** Blinn-Phong illumination in your own programs
- **Describe** how effects such as normal mapping can be used to render realistic materials

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Vector products

Dot and cross product

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$$a \times b = (|a||b| \sin\theta) n$$

where n is a unit vector **perpendicular** to both a and b with direction given by the **right-hand rule**

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- vector $\cdot$ vector $=$ number; vector $\times$ vector $=$ vector

Surface normals

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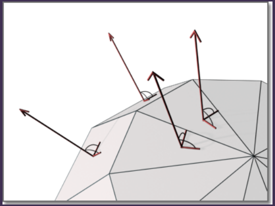

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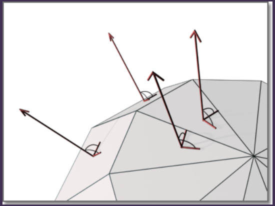

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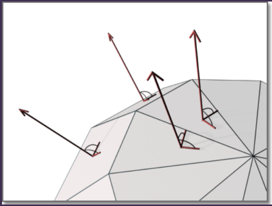

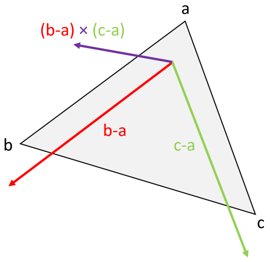

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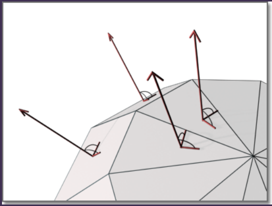

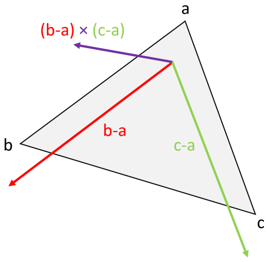

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- For a triangle with vertices a, b, c, two such vectors are $b - a$ and $c - a$
- So the normal is

$$\frac{n}{|n|} \quad \text{where} \quad n = (b - a) \times (c - a)$$

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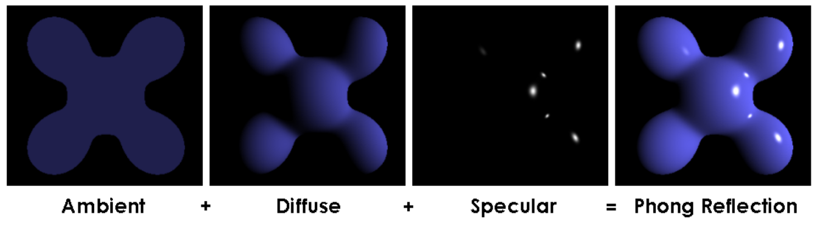

Diffuse lighting

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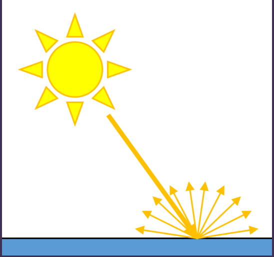

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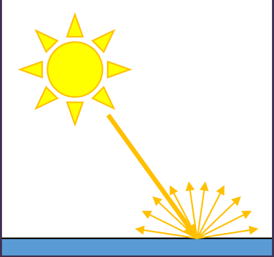
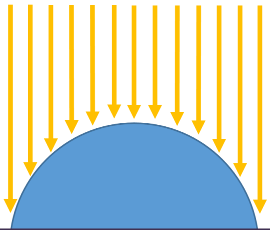
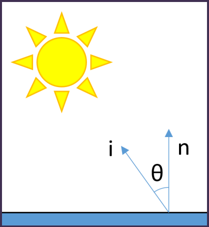


When light hits a “”rough surface, it is **scattered equally in all directions**

The amount of light hitting the surface depends on the **angle** between the surface and the light source



Diffuse lighting formula



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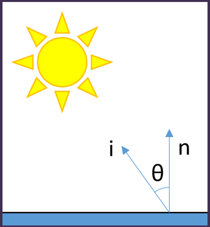

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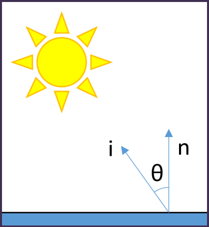

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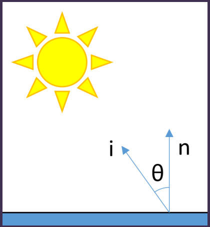

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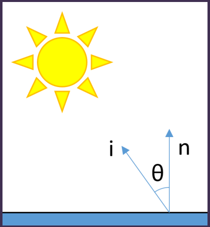

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- If the surface is **pointing away** from the light source, we get $\theta > \frac{\pi}{2}$ so $\cos\theta < 0$ — in this case we **clamp** the answer to 0

Light direction and intensity

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- For a **point** light source (e.g. a lightbulb):
  - Direction is calculated by subtracting the light position from the fragment position
  - Intensity obeys an **inverse square law**: if the distance between the fragment and the light source is d, then the light intensity is $\frac{1}{d^2}$

Specular lighting

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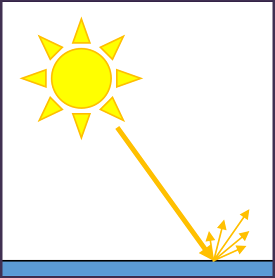
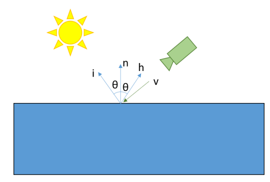


When light hits a “smooth” surface, it is **reflected** across a narrow range of angles

Specular lighting formula



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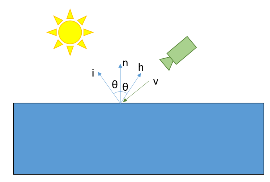

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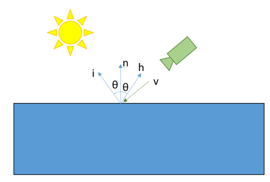

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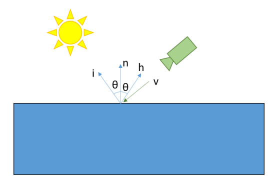

- Let h be the halfway vector, calculated by $i + v$
- h can be thought of as the surface normal which leads to the maximum reflection in v
- Specular light intensity is proportional to

$$\mathrm{clamp}(n \cdot h)^s$$

where s is a "shininess" parameter, and $\mathrm{clamp}(x)$ clamps its argument between 0 and 1

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- Another option would be to add more light sources...

Normal mapping

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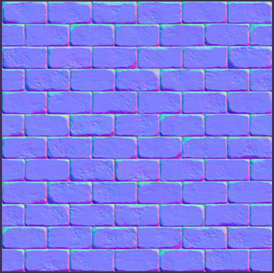

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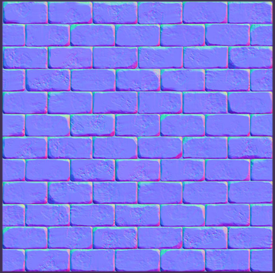
Normal mapping



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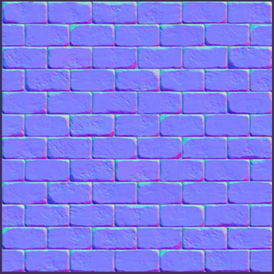

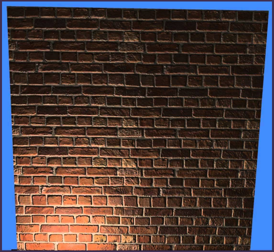

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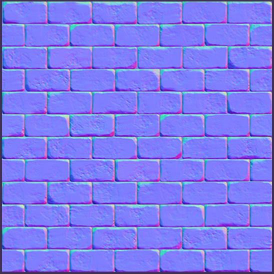

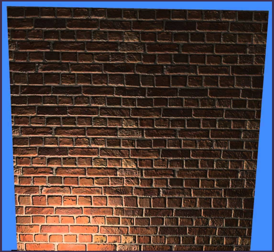

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- Can use textures to change other lighting parameters across a surface, e.g. **specular mapping**