CPSC 314
Computer Graphics

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Rendering 1

Textbook Chapter 14

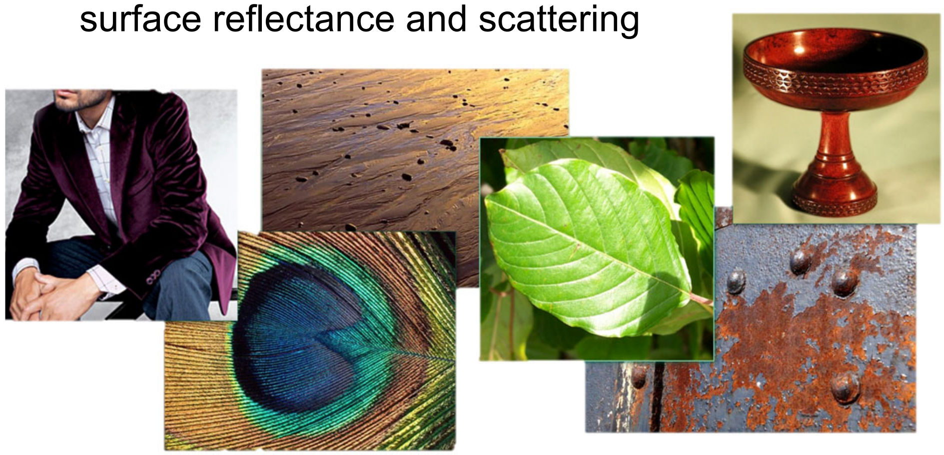
Some slides courtesy of M. Kim (KAIST)

Preliminaries

- Reminders and Announcements
  - Midterm on Friday Feb 18, during class time, answer on Canvas using your laptop
  - Wednesday Feb 16 will be review, but to make the most of it, study lecture notes and textbook before that.
- Today
  - Rendering 1 (need for Assignment 3)
  - Midterm format

Today: Modeling Material Appearance

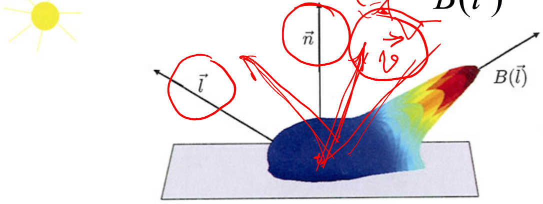
- Rich variety of materials: characterized by surface reflectance and scattering



Light blob from PVC plastic

- PVC blob
  - Note that this figure just describes the result of light that comes in from the specific shown direction $\vec{l}$.
    For other incoming directions we would need a different blob to visualize the resulting scattering.
- The plastic will appear brightest when observed in the directions clustered about the 'bounce' direction of the light:

$B(\vec{l}\,)$



Bidirectional
Reflectance
Distribution
Function

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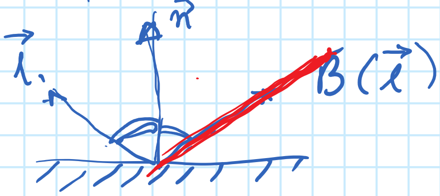
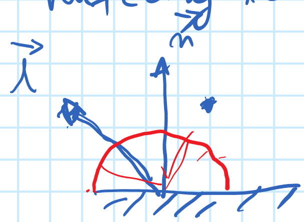
Perfect Mirror



Perfectly Rough Surface



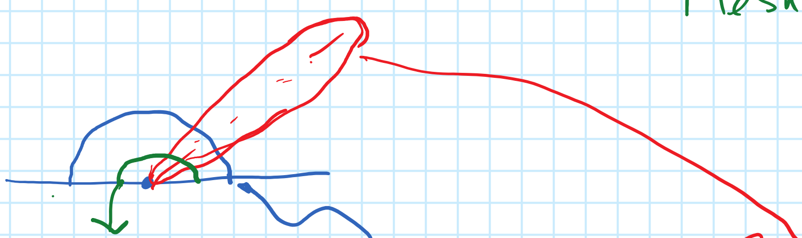
Diffuse Reflection

$I = k_d \vec{l} \cdot \vec{n}$

Lambert's Law

Phong Reflection Model

In Three.js
MeshPhongMaterial



Ambient + Diffuse + Specular

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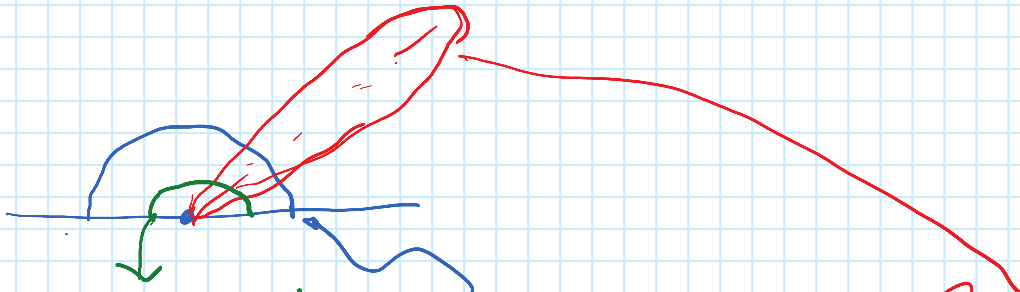
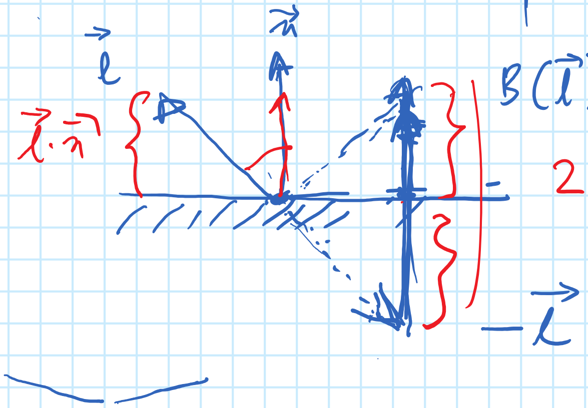


Ambient + Diffuse + Specular

constant
crude approx.
of Global
Illumination

Lambert's
Law

Bounce Vector Computation



assume
$\|\vec{l}\| = \|\vec{n}\| = \|\vec{v}\| = 1$

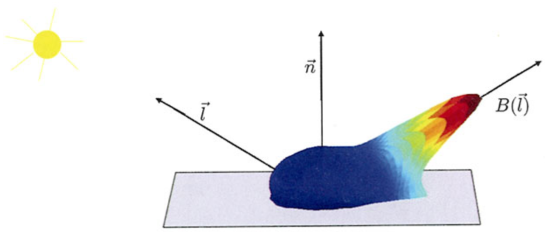
$$B(\vec{l}) = -\vec{l} + 2(\vec{l}\cdot\vec{n})\,\vec{n}$$

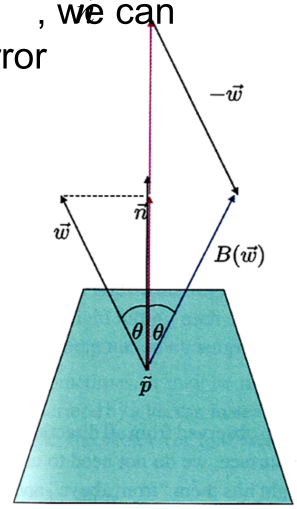
$2\ \vec{l}\cdot\vec{n}\ \vec{n}$

Light blob from PVC plastic

- Given any vector $\vec{w}$ (not necessarily of unit norm) and a unit normal vector $\vec{n}$, we can compute the bounce vector (mirror reflection) of $\vec{w}$ as

$$B(\vec{w}) = 2(\vec{w} \cdot \vec{n})\vec{n} - \vec{w}$$





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About "in class" quizzes and midterm

Similar to Quiz 1, but in-person only

- Duration 50 minutes, closed book, closed Internet, no communication with any human about exam.
- During the class hour

Midterm structure

- Exam is for 50 minutes, in class
- Budget 45 minutes for doing the quiz (One minute per mark)
- 4 Types of Question (Parts A,B,C,D)
  - Parts A-C: as in Quiz 1. 35 Marks
    - T/F questions. 1 mark each
    - “Recognition” Fill in the blanks (with multiple choice). 1 mark each (note: less than Quiz 1)
    - “Computing” Solve a small problem, and select the correct answer.
- Part D (10 marks). Solve a problem from a verbal description.
  - Either enter free-form answer or upload a file with answer for marking.

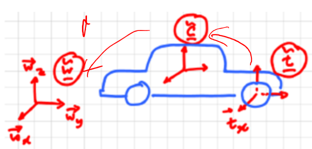
Midterm Preparation

- CAREFULLY review ALL lectures before exam (including review lecture).
- Greater emphasis on topics covered after Quiz 1
  - Frames.
  - Chains of transformations
  - Types of transformations (TRS). Ch 2.4,2.5,2.6, and 3.4
  - Scene Graphs and Hierarchies. Ch 5.4.
    - Mainly focus on lecture notes (Three.js version)
  - Projection. Ch 10. Mainly focus on lecture notes
  - Depth. Ch 11.2 and 11.3 only. Skip 11.2.1
  - Rendering 1 (Ch 14)
  - Texturing 1 (Ch 15.1)

Midterm Preparation

- Review material from Quiz 1 too!
- Review Assignments 1 and 2

Example of Part D



You are given the task of animating a car driving on a road. The geometry of all the parts of the car, including the tires, is given in the "car frame," $\underline{\tilde{c}} = \underline{\tilde{w}}\,\underline{C}$. $\underline{\tilde{w}}$ is fixed to the world. Suppose $\tilde{\mathbf{p}}$ is a point on the tire, with coordinates $\overline{\mathbf{p}}_c$ in frame $\underline{\tilde{c}}$.

(a) The car is moving to the right (in the $\vec{\mathbf{w}}_y$ direction) with speed v m/s. What are the coordinates of $\tilde{\mathbf{p}}$ in the world frame after s seconds?

Answer: To move all points p_c on the car to the right we pre-multiply by a translation matrix $M(s)$

$p_w = M(s)\ C\ p_c$

where

$$M(s) = \begin{pmatrix} 1 & . & . & . \\ . & 1 & . & vs \\ . & . & 1 & . \\ . & . & . & 1 \end{pmatrix}$$

(b) In addition to the above, your boss wants you to make the tires rotate at r radians/s. Frame $\underline{\tilde{t}} = \underline{\tilde{c}}\,\underline{T}$ is located on the tire with its X-axis along the axis of rotation. Note that $\underline{\tilde{t}}$ is defined with respect to the car frame. What are the coordinates of $\tilde{\mathbf{p}}$ in the world frame after s seconds?

Answer: This is an example of "transforming about an auxiliary frame" that we looked at in Lecture 9. Now we need to rotate about the tire's x axis (in addition to the rightward motion).

$p_w = M(s)\ C\ T\ R(\theta)\ T^{-1}\ p_c$

where the angle of rotation is $\theta = rs$ and

$$R(\theta) = \begin{pmatrix} 1 & . & . & . \\ . & \cos\theta & -\sin\theta & . \\ . & \sin\theta & \cos\theta & . \\ . & . & . & 1 \end{pmatrix}$$

Uploading answers to Part D

- Answer the questions by entering the answers (including math) in the text box
  - Matrices should be formatted, with LaTeX

Entering math in Canvas text boxes

Choose Math > Switch to Advanced

- 4X4 matrix template

```
\begin{pmatrix}
. & . & . & . \\
. & . & . & . \\
. & . & . & . \\
. & . & . & 1
\end{pmatrix}
```

- 3X3 matrix template

```
\begin{pmatrix}
. & . & . \\
. & . & . \\
. & . & 1
\end{pmatrix}
```

Next Class

- Basic Texture mapping