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The Science of Pixar

At the Oregon Museum of Science and Industry (OMSI)

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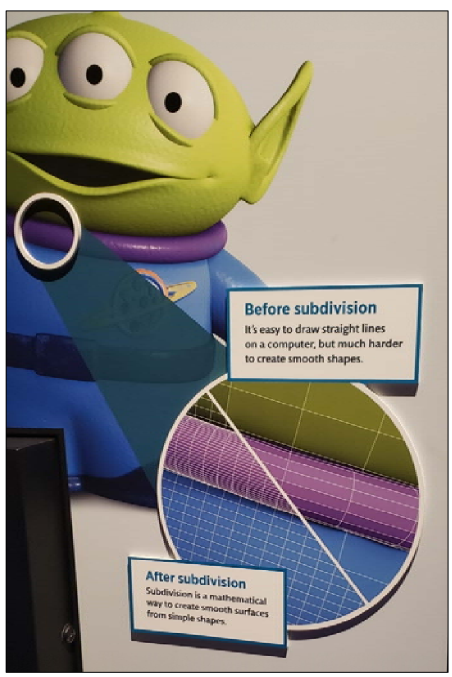

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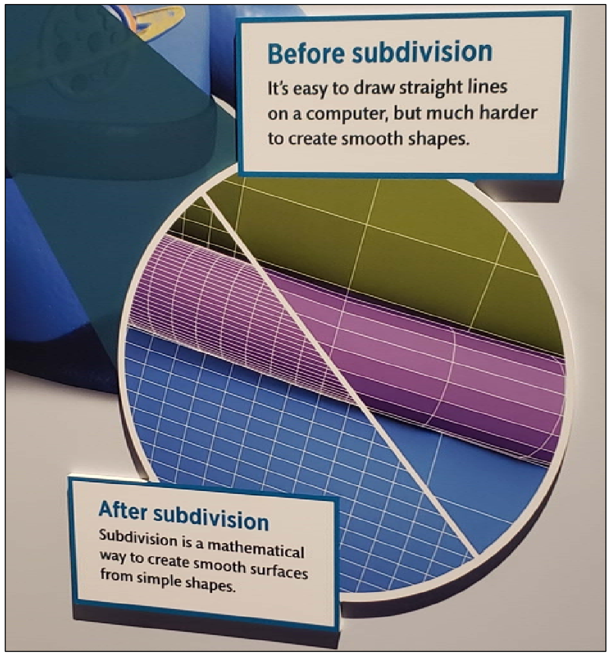

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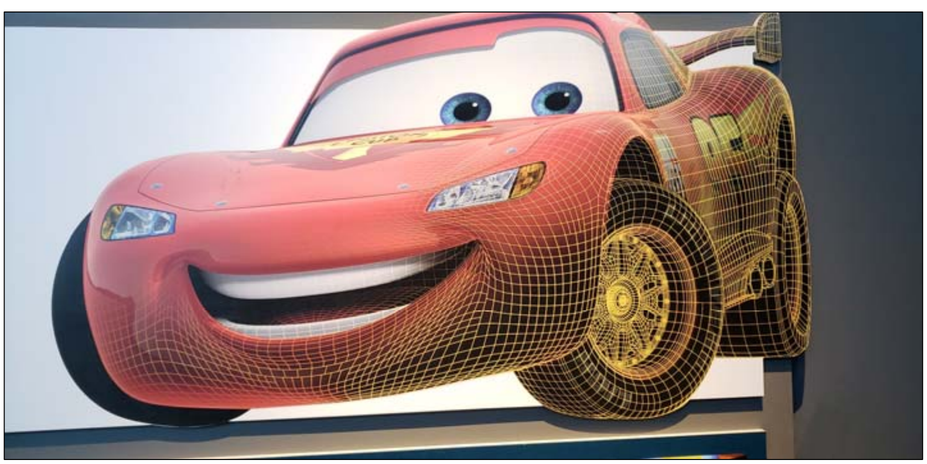

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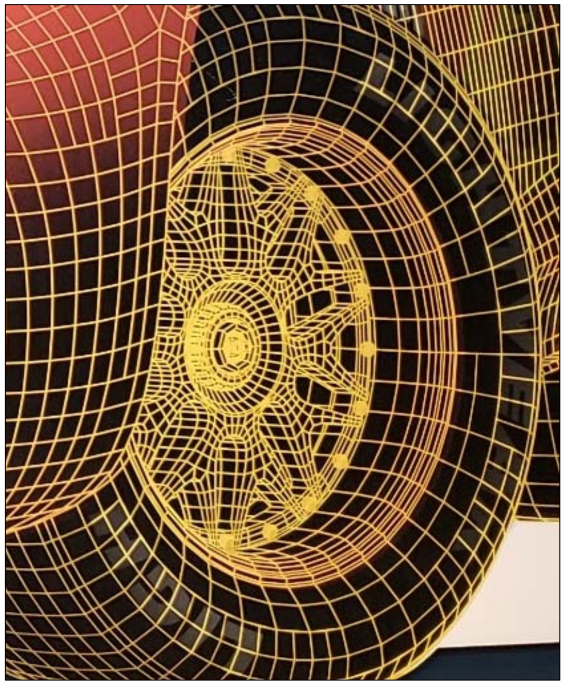

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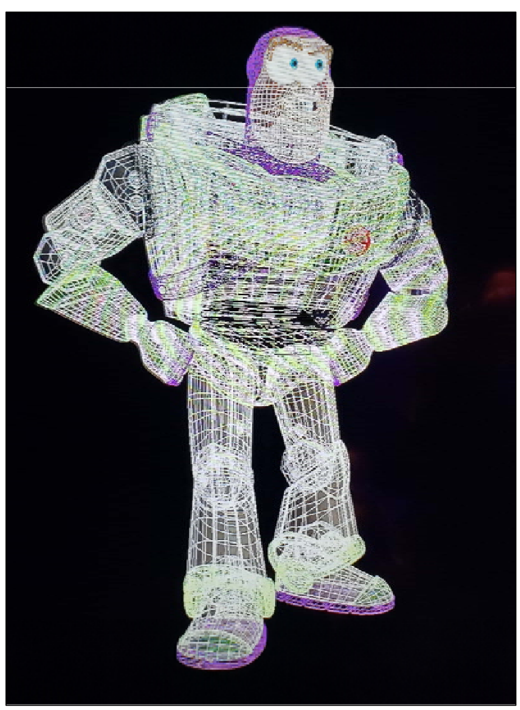

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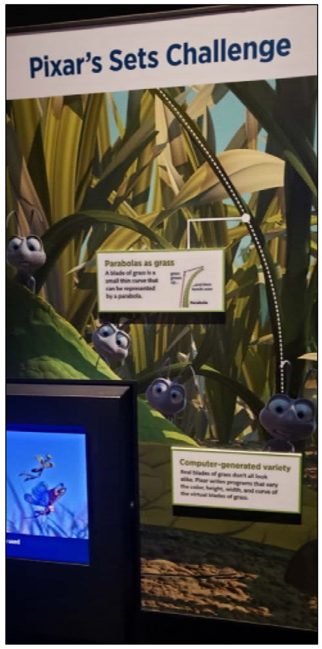

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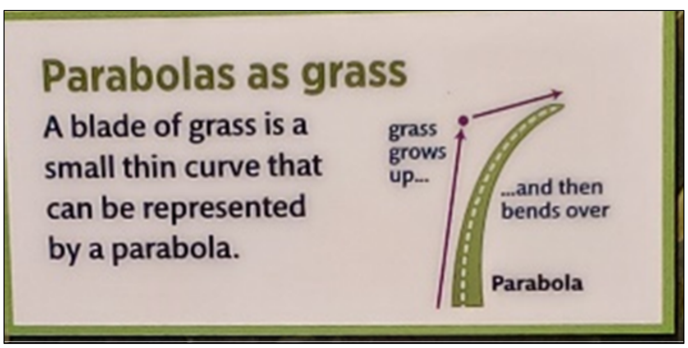

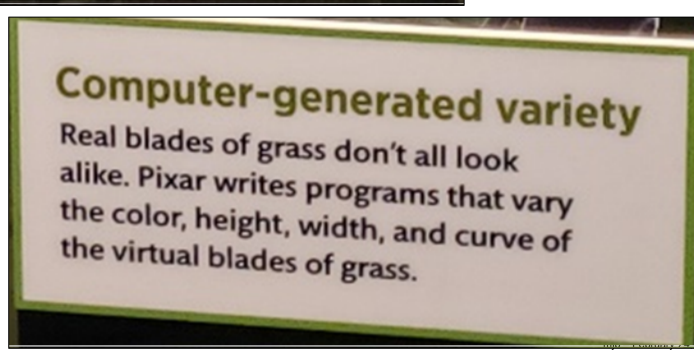

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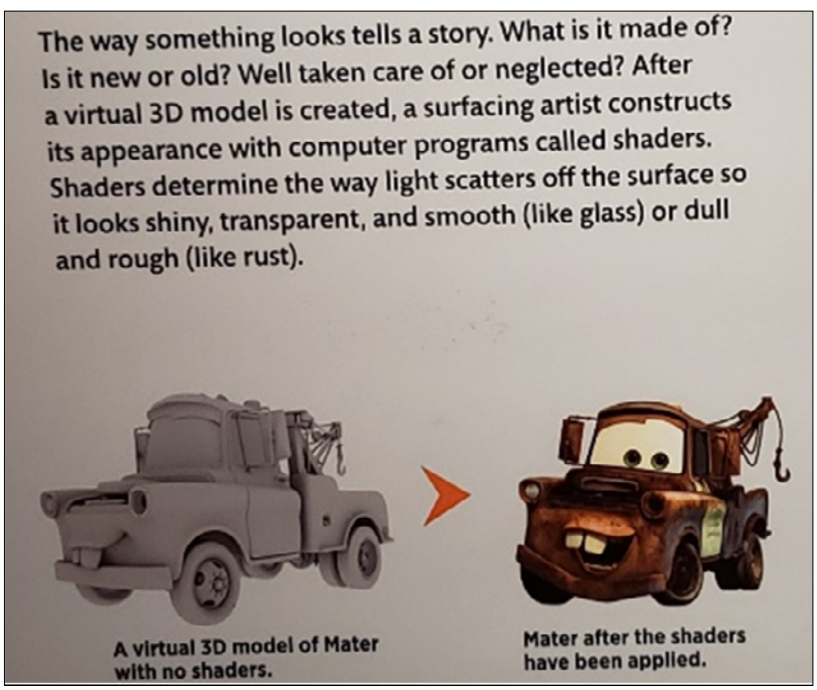

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Shaders
Shaders are programs that tell a computer how to display all aspects of an object's surface appearance.
Red onions
A surface pattern shader gives these onions a mottled appearance.
A worn pot handle
A shader created a bump map that instructs light to bounce unevenly off the handle's surface.

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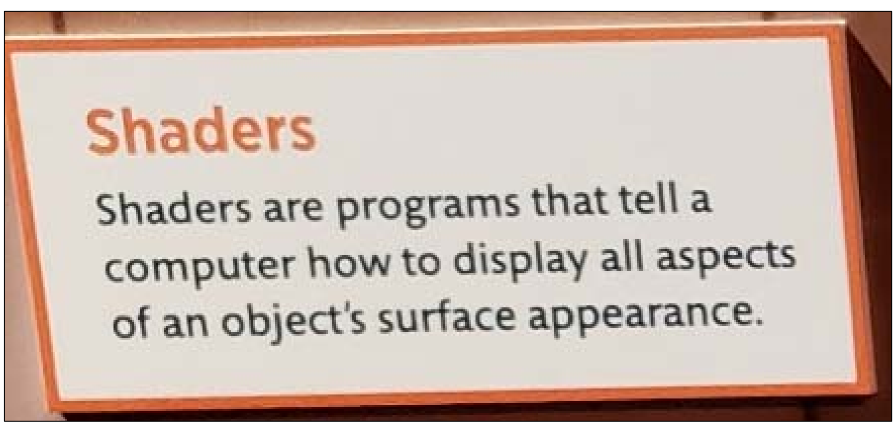

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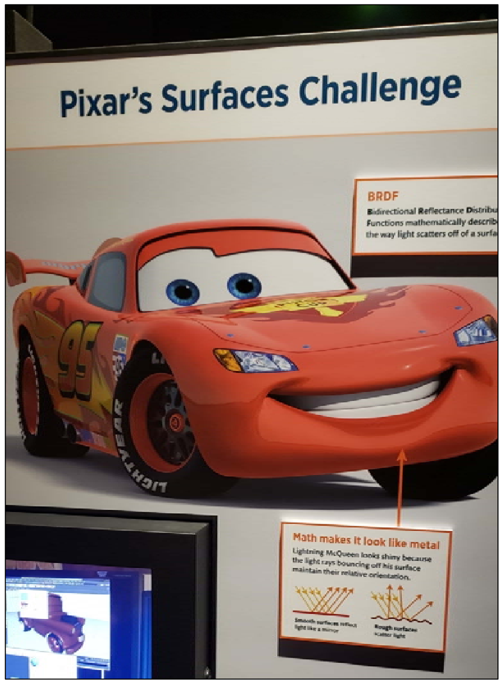

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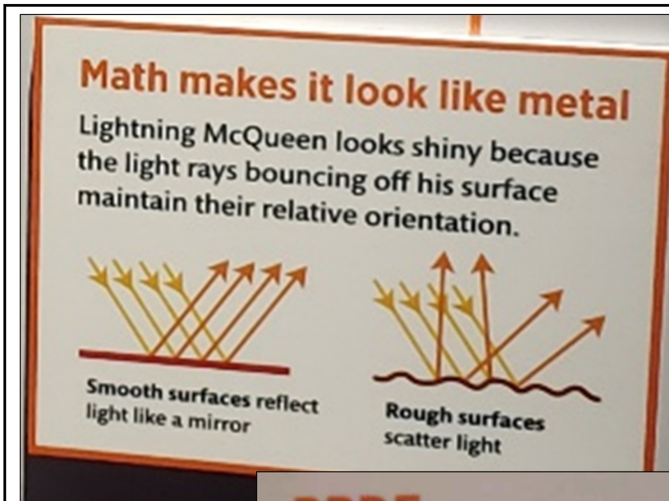

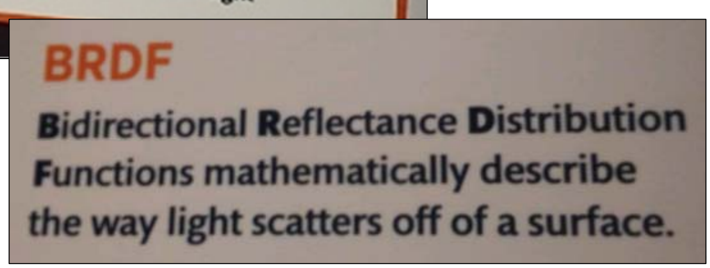

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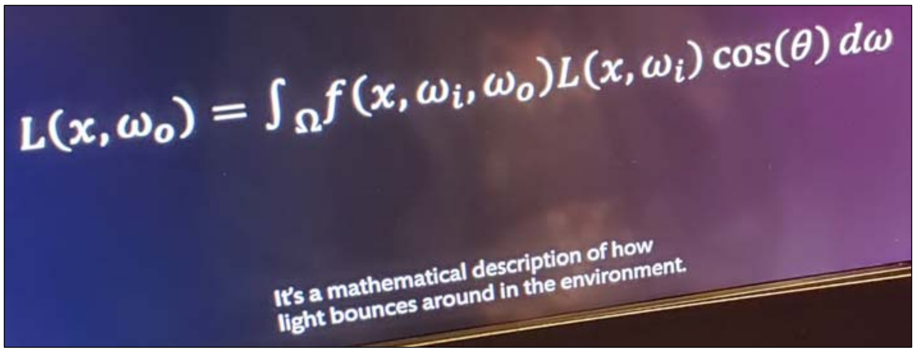

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The Rendering Equation

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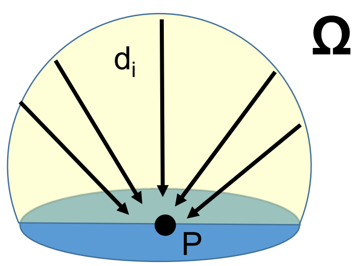
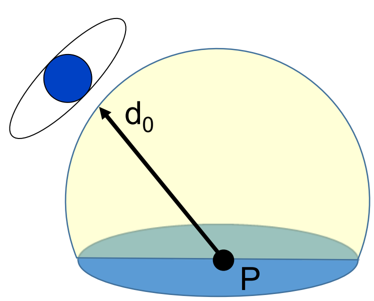
Light Arriving



$$L(P, d_0, \lambda) = E(P, d_0, \lambda) + \int_\Omega L(P, d_i, \lambda) f(\lambda, d_i, d_0)(d_i \cdot \hat{n})\, d\Omega$$

Light Departing



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The Rendering Equation

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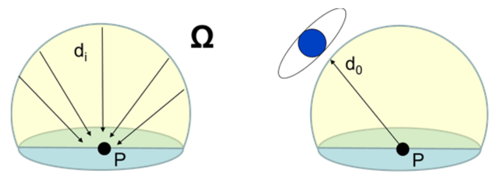

$$B(x, d_0, \lambda) = E(P, d_0, \lambda) + \int_{\Omega} B(x, d_i, \lambda) f(x, \lambda, d_i, d_0)(d_i \cdot \hat{n}) d\Omega$$

In plain language, this is a simultaneous-equation energy balance:

"The light shining from the point P is the reflection of the incoming light directed to the point P from all of the other points in the scene."

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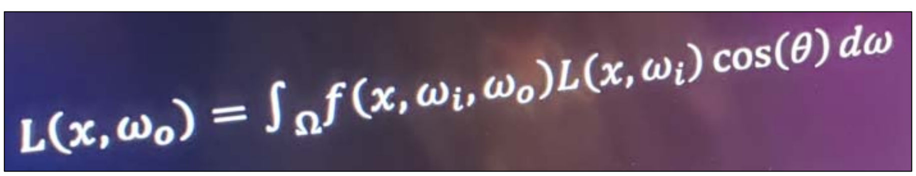

$$L(x, d_0, \lambda) = E(P, d_0, \lambda) + \int_{\Omega} L(x, d_i, \lambda) f(x, \lambda, d_i, d_0)(d_i \cdot \hat{n}) d\Omega$$

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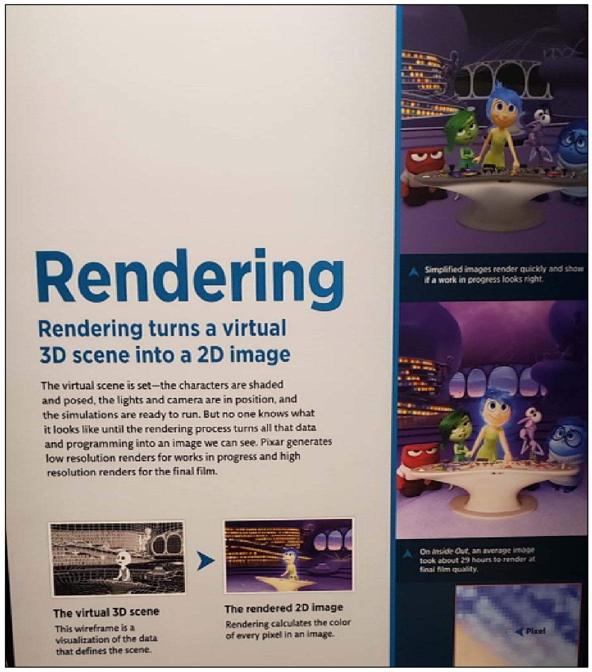

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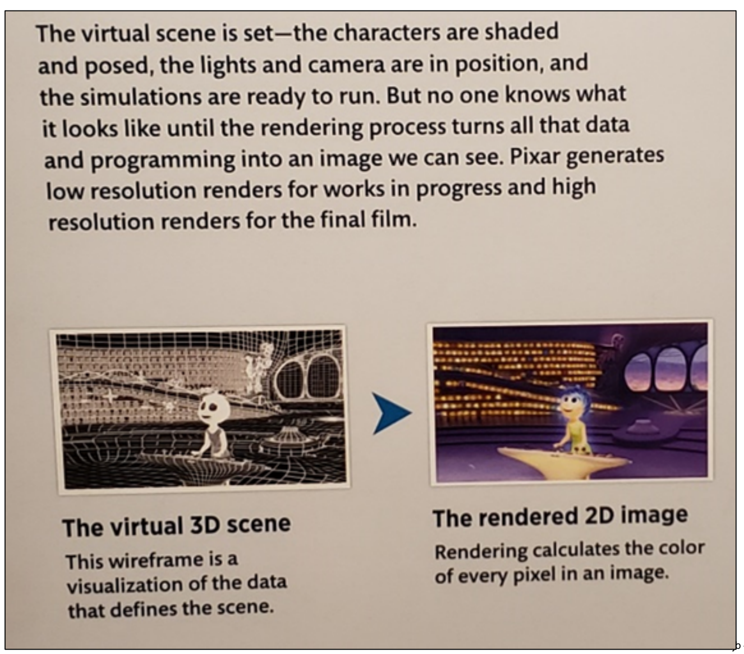

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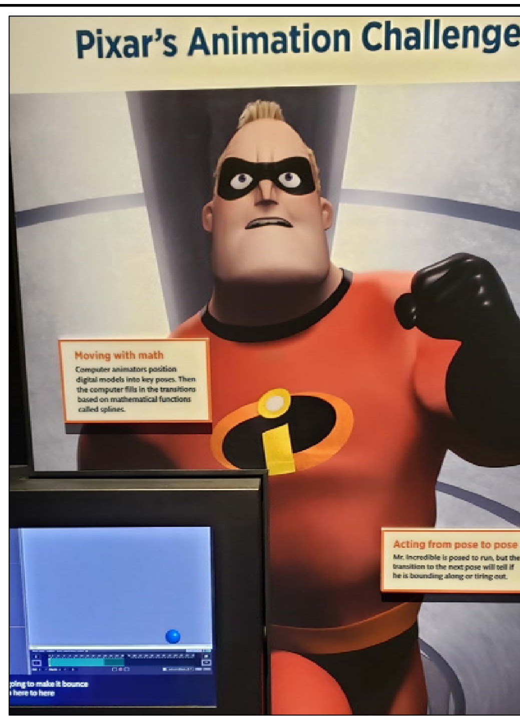

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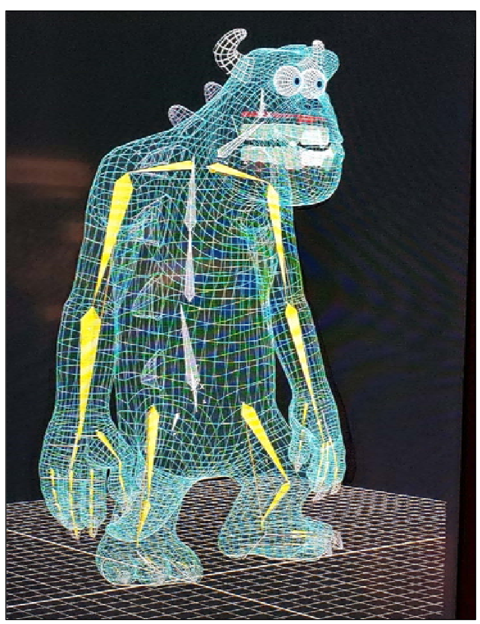
Moving with math

Computer animators position digital models into key poses. Then the computer fills in the transitions based on mathematical functions called splines.

Acting from pose to pose

Mr. Incredible is posed to run, but the transition to the next pose will tell if he is bounding along or tiring out.



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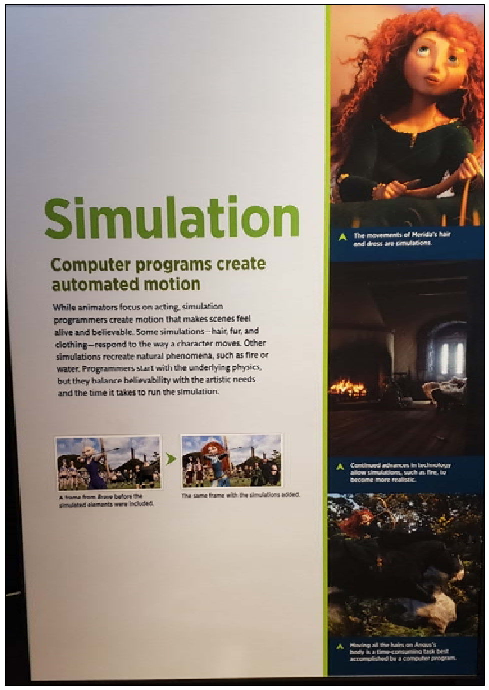

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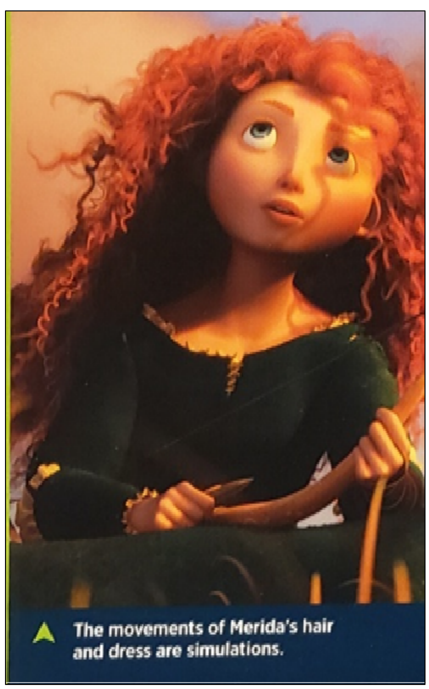

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While animators focus on acting, simulation programmers create motion that makes scenes feel alive and believable. Some simulations—hair, fur, and clothing—respond to the way a character moves. Other simulations recreate natural phenomena, such as fire or water. Programmers start with the underlying physics, but they balance believability with the artistic needs and the time it takes to run the simulation.

A frame from *Brave* before the simulated elements were included.

The same frame with the simulations added.

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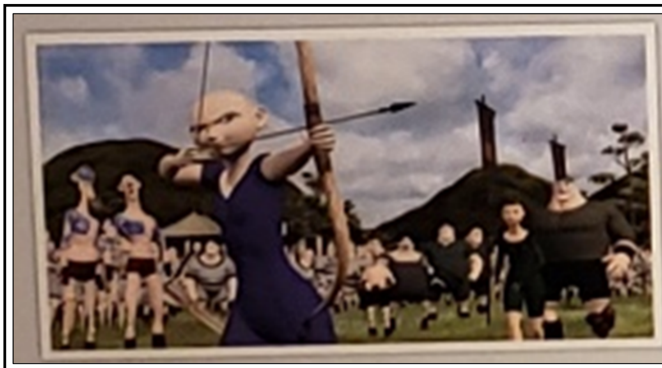

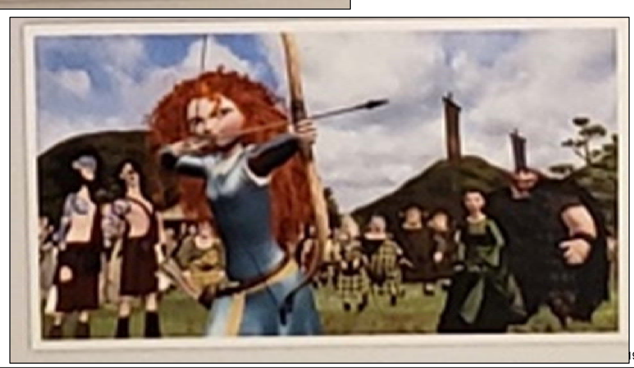

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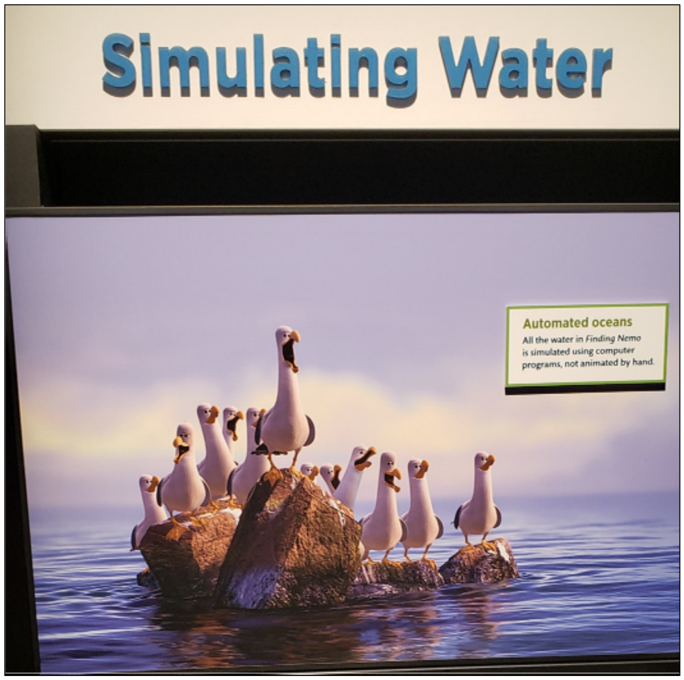

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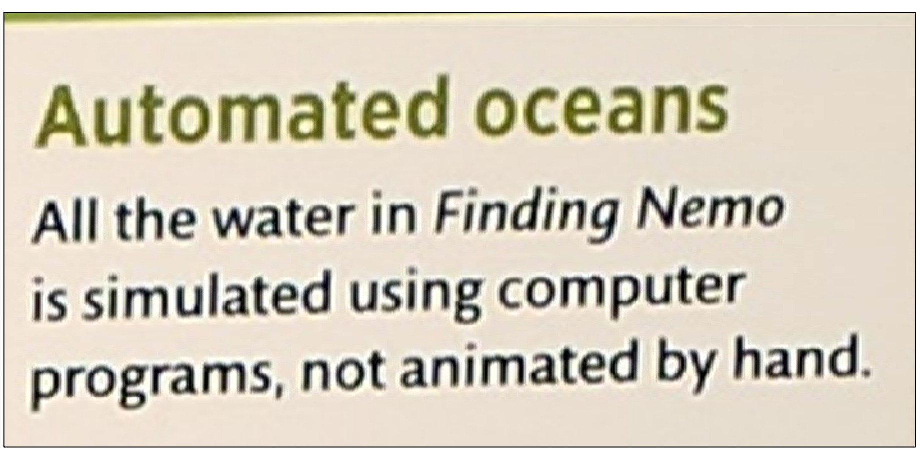

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