The Science Behind
PIXAR

Activity Cards

Activity Cards

The Science Behind Pixar exhibition is designed to be engaging and hands-on! These activities are intended to support an extended learning sequence that starts in the classroom, continues in the exhibition, and continues upon returning to school. The activities were developed by teachers from Boston and Cambridge, MA. Links to related standards and additional resources can be found at **sciencebehindpixar.org/educators**.

1. Choose a subject and focus area in which students will concentrate on within the exhibit.
   - **Art 1: Create your own virtual or physical set or character**
   - **Art 2: Create a digital animation, stop-motion animation, or flip book**
   - **Math: Explore the world of numbers to create physical or virtual characters/sets**
   - **Science 1: Create a scientifically accurate character in an appropriate model habitat**
   - **Science 2: Create a stop-motion animation**

2. Print out the corresponding activity cards on the following pages. You may want to print one set of cards for each group of students or print enough cards so that each group gets one card to complete during their visit. There is a small letter/number code on the back of each card that corresponds with the card set. Some cards suggest having students take pictures, videos, or sketch their results.

3. You can extend your student's learning by facilitating culminating projects based on what student's experienced in the exhibit. Below are project ideas that can help start your planning process.
   - **Art 1 Project: Create your own virtual or physical set or character**
     Have students work independently, or as a group, to create their own character and/or set. This can be a physical or virtual model, and can incorporate a variety of visual art practices.
   - **Art 2 Project: Create a digital animation, stop-motion animation, or flip book**
     Have your students work in groups to create an animation, either digitally, stop-motion, or flip book. Each student would become an "expert" on one (or more) particular stage of the pipeline by collecting information during the focused activity portion of the field trip. This project can incorporate a variety of visual art practices. It would also work well in combination with the science-focused project 2.

   - **Math Project: Explore the world of numbers to create physical or virtual characters/sets**
     There is a vast array of math concepts and practices imbedded in *The Science Behind Pixar* exhibition. You can use students' experiences to review content specific ideas/concepts (coordinate grids, geometry, etc), or to explore them in a new context. Have students use the math concepts explained in the exhibition to create their own physical or virtual characters or sets. This project links to specific math units and standards, and would work well with any other art or science focused project. Khan Academy's *Pixar in a Box* also has resources for math connections at **pixarinabox.org**.

   - **Science 1 Project: Create a scientifically accurate character in an appropriate model habitat**
     Have your students gather information about the process involved in Pixar character and set creation, and then create their own scientifically accurate character in an appropriate model habitat. This project would link well with studies of human body systems and/or habitats. It would also work well in combination with the art-focused project 1.

   - **Science 2 Project: Create a stop-motion animation**
     Have your students collect information about the ways in which animation creates the illusion of motion. This project would link well with physics-based studies, such as forces and motion. It would also work well in combination with the art-focused project 2.
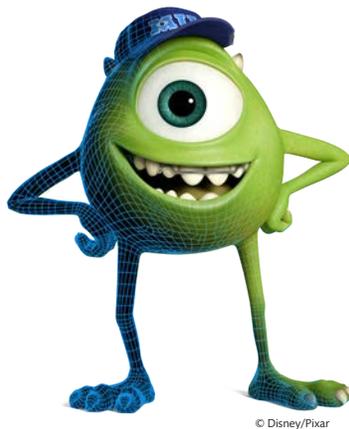
Card Set 1:

Art 1

**Create your own virtual or
physical set or character**

Modeling

© Disney/Pixar

At Pixar, modeling is the digital version of sculpting. A Pixar model can be built as a virtual 3D model directly on the computer, or start as a physical sculpture that is then scanned.

Rigging

© Disney/Pixar

A rig is the virtual bones, joints, and muscles that allow a model to move. People who work on rigging study how animals, people, and objects move to create believable rigs.

Do
Use **Modeling Workstation** to create a 3D model of your own character. Make a detailed sketch or take a picture of your character.

Think
How do Pixar models go from 2D illustrations to a 3D model? What real world objects or organisms would you need to study to create a character model?
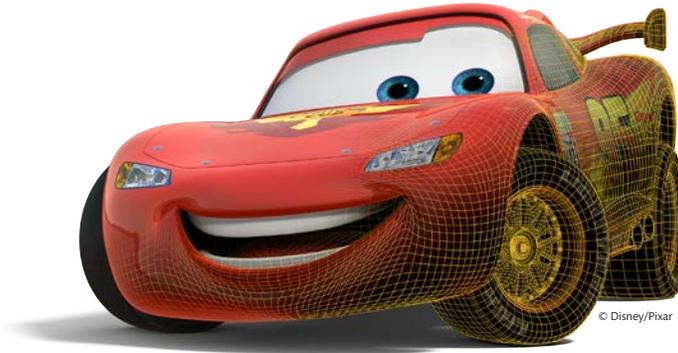
A1

Do
Use **Arm Rigging Workstation** to change the range of motion for a character's arm. Take a video or sketch your most memorable rig.

Think
Think about a character you might want to create. What would you need to research in order determine how it moves? Why is a real-world understanding important, even for creating imaginary creatures?

A1

Surfaces

© Disney/Pixar

The appearance of an object is controlled separately from its shape.
The surface appearance can be described by the way light scatters
off of it.
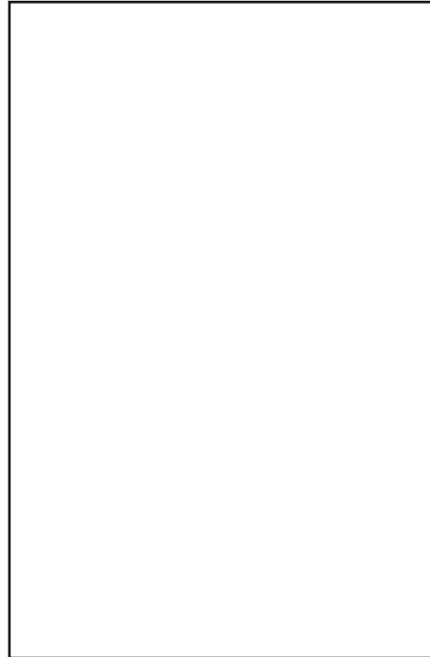
Sets & Cameras

© Disney/Pixar

Sets are the rooms and landscapes in which a story takes place.
The tasks of building virtual sets and positioning virtual cameras are
similar to their live action counterparts.

Do

Use **Surface Appearance Workstation** to change the way the virtual sphere looks. Can you match one of the three challenges or make your own challenge?

Think

How does changing the surface of an object change what it seems to be? Look at your own clothing, how do the different surfaces look and feel? How does light affect them?
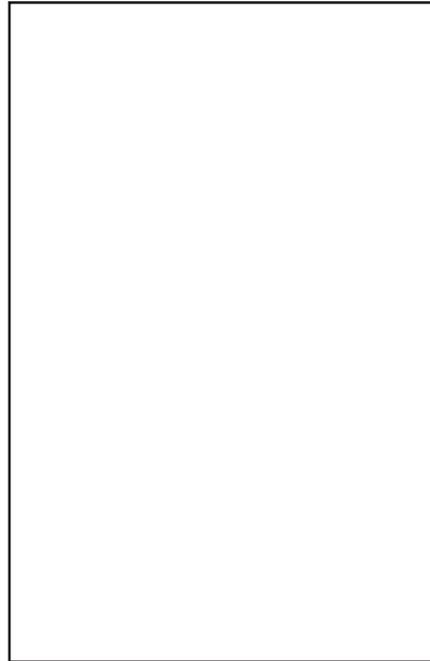
A1

Do

Observe the physical model of the set for *Up* in **Lighting Design Basics**. Document at least two different views through drawings or photos.

Think

How do the different views provide different information about the set? How did the developers get the information they needed to create a realistic set?

A1

Animation

© Disney/Pixar

Animation is a series of 2D images that create the illusion of motion when shown quickly one after the other. Animators act out the story by creating one individual frame at a time.

Simulation

© Disney/Pixar

Some objects are programmed to move automatically. Simulations are mathematical algorithms (rules) that recreate complex behavior like schools of fish, explosions, and even hair and clothing!

Do
Explore the *Incredibles* frame by frame in the **Animation Immersive**. Take a video of a partner making a movement. Watch the video in slow motion. What would you need to study in order to make an animation just like real life? What would the "key frames" be?

Think
If you were going to create a realistic animation of a human, what would you study to help in your preparation? Is the goal of Pixar animators to create real life models of movement? Why or why not?
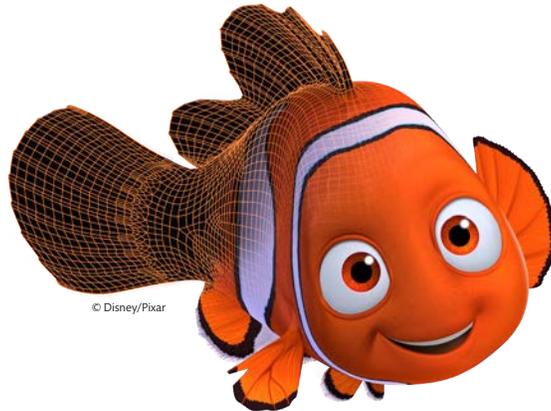
A1

Do
Turn the simulations on and off in the **Simulation Immersive** to explore how simulations improve the quality of Pixar films. Document the difference with and without simulation using pictures, sketches, or videos.

Think
Think about a scene you might create. Which motions would you make as simulations? Which would you animate by hand?

A1

Lighting

© Disney/Pixar

Virtual lights enhance mood and believability. Each aspect of light needs to to programmed individually.

Rendering

© Disney/Pixar

Rendering turns a virtual 3D scene into a series of 2D images by taking all the information about the scene and determining the color of every pixel in an image.

Do
Have a partner stand next to Dory
(the large blue fish) in the **Lighting
Immersive**. Take pictures that show
how three different lighting choices
affect her appearance.

Think
How does lighting effect the "feel"
of the set and character? How
might lighting make a model seem
unrealistic? How does lighting
contribute to the story you are trying
to tell?

A1

Do
Use **Rendering Workstation**
to compare the time it takes to
render different images. If you were
rendering images of a realistic
character model, what are some
features that you would be sure were
of high quality? Why?

Think
Why does it takes so long to render
an image? Images are composed
of pixels. How do pixels create an
image?

A1

Card Set 2:

Art 2

Create a digital animation, stop-motion animation, or flip book

Modeling

© Disney/Pixar

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Rigging

© Disney/Pixar

A rig is the virtual bones, joints, and muscles that allow a model to move. People who work on rigging study how animals, people, and objects move to create believable rigs.

Do
Use **Virtual Modeling Workstation** or **Build a Robot** to create a simple character model out of 3D shapes. Make a detailed sketch or take a picture of your character.

Think
How do Pixar models go from 2D illustrations to a 3D model? What real world objects or organisms would you need to study to create a character model?
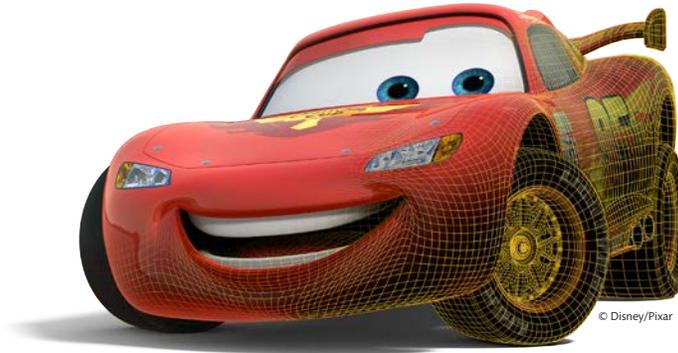
A2

Do
Use **Arm Rigging Workstation** to change the range of motion for a character's arm. Take a video of your most memorable rig.

Think
Why is rigging important to a virtual model? Think of a character you might create. Which human body or animal systems would you study to develop your character's rig?

A2

Surfaces

© Disney/Pixar

The appearance of an object is controlled separately from its shape. The surface appearance can be described by the way light scatters off of it.

Sets & Cameras

© Disney/Pixar

Sets are the rooms and landscapes in which a story takes place. The tasks of building virtual sets and positioning virtual cameras are similar to their live action counterparts.

Do
Use the **Surfaces Immersive** to change the surface of the hood of a car. Change the decal and finish. Does it look the way you thought it would?

Think
What would you want to pay attention to about surfaces if you wanted to create your own animation? Why might you create individual aspects separately?

A2

Do
Design a virtual set at **Set Layout Workstation**. Document at least two views of your set through sketches or photos.

Think
How can a set help to demonstrate the mood or personality of a character?

A2

Animation

© Disney/Pixar

Animation is a series of 2D images that create the illusion of motion when shown quickly one after the other. Animators act out the story by creating one individual frame at a time.

Simulation

© Disney/Pixar

Some objects are programmed to move automatically. Simulations are mathematical algorithms (rules) that recreate complex behavior like schools of fish, explosions, and even hair and clothing!

Do

At **Stop-motion Animation**, create one animation where the lamp completes its jump in 16 frames, and another that takes only 8 frames. In which animation does the lamp appear to move faster? Why?

Think

Why do we say that animation creates the "illusion" of motion? Why does Pixar say that animating is acting?
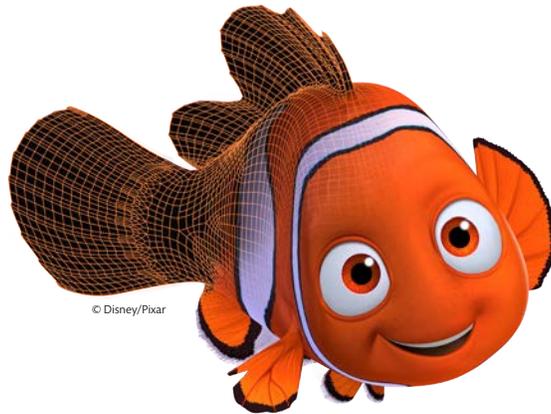
A2

Do

Turn the simulations on and off in the **Simulation Immersive** to explore how simulations improve the quality of Pixar films. Document the difference with and without simulation using pictures, sketches, or videos.

Think

When would a virtual scene require simulations?

A2

Lighting

© Disney/Pixar

Virtual lights enhance mood and believability. Each aspect of light needs to to programmed individually.

Rendering

© Disney/Pixar

Rendering turns a virtual 3D scene into a series of 2D images by taking all the information about the scene and determining the color of every pixel in an image.

Do

Have a partner stand next to Dory (the large blue fish) in the **Lighting Immersive**. Take pictures that show how three different lighting choices affect her appearance.

Think

How does lighting effect the feel of the set and character? How might lighting make a model seem unrealistic? How does lighting contribute to the story you are trying to tell?

A2

Do

Use **Rendering Workstation** to compare the time it takes to render different images. If you were rendering images of a realistic human character, what are some features that you would be sure were of high quality? Why?

Think

Why does it takes so long to render an image? Images are composed of pixels. How do pixels create an image?
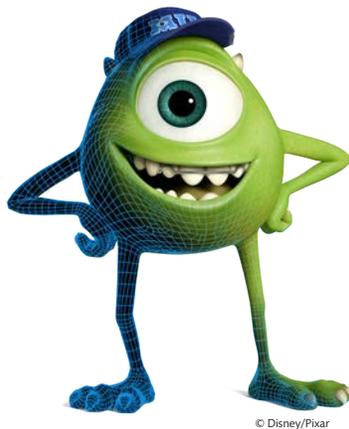
A2

Card Set 3:

Math

Explore the world of numbers to create physical or virtual characters/sets

Modeling

© Disney/Pixar

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Rigging

© Disney/Pixar

A rig is the virtual bones, joints, and muscles that allow a model to move. People who work on rigging study how animals, people, and objects move to create believable rigs.

Do
Use **Sculpt by Numbers** to create a virtual rectangular box by plotting 3D coordinates.

Think
Pixar creates physical sculptures of their characters. Then they scan them using a 3D scanner. The results are crafted into how many coordinates per point?

M

Do
Use **Face Rigging Workstation** to make Jessie look surprised. What part of here face did you manipulate the most? Sketch or take a picture of your outcome.

Think
How many variables are you able to use to create facial expressions? How many other controls would you like to have? How many does Pixar create?

M

Surfaces

© Disney/Pixar

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off of it.

Sets & Cameras

© Disney/Pixar

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similar to their live action counterparts.

Do
Pick one challenge at **Surface Appearance Workstation**. What variables did you change to meet the challenge?

Think
Look at your clothing. If you were a digital character, how many variables do you think would affect the appearance of your outfit?

M

Do
Use **Programming Natural Variety** to create a background of grass either blowing in a strong wind or during a drought. Sketch or take a picture of your results.

Think
When creating sets, Pixar needed to quickly create backgrounds with a lot of variety such as grass, trees, and buildings. How can math help create variety and randomness? (Hint: press the "More info" button on screen.)

M

Animation

© Disney/Pixar

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Simulation

© Disney/Pixar

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Do

At **Animation Workstation** make Mike Wazowski wave for different lengths of time by setting the number of frames to 8, 16, 24, and 32. Which setting creates the slowest wave? Why?

Think

Pixar uses the standard rate of 24 frames per second. If a movie is 90 minutes long, how many frames is that? Can you write the equation? Solve it?
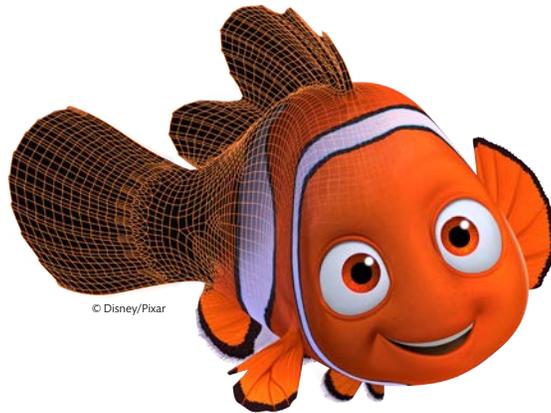
M

Do

How many settings do each of the three variables in **Crowd Simulation Workstation** have? How many different schools of fish can you design with these controls?

Think

What other controls might you add to this activity (e.g., color or size)? How many settings would each control have? How would that increase the number of schools you can make?

M

Lighting

© Disney/Pixar

Virtual lights enhance mood and believability. Each aspect of light needs to to programmed individually.

Rendering

© Disney/Pixar

Rendering turns a virtual 3D scene into a series of 2D images by taking all the information about the scene and determining the color of every pixel in an image.

Do

Compare the virtual and physical scenes at **Lighting Effects Basics**. How many combinations of lighting can you create? How would you write an equation for it?

Think

Using 3D modeling, the world can be translated into math, which can be turned into a computer program. How might you represent the variations of lighting effects with numbers?

M

Do

Pick one image at **Rending Workstation** and make adjustments to the time it takes to render the image. What differences do you notice in the images?

Think

Press the button to render a frame from *Inside Out*. If this frame took 33 hours to render, how long do you think it took to render the whole movie? Why do you think Pixar would invest that much time in rendering the movie?
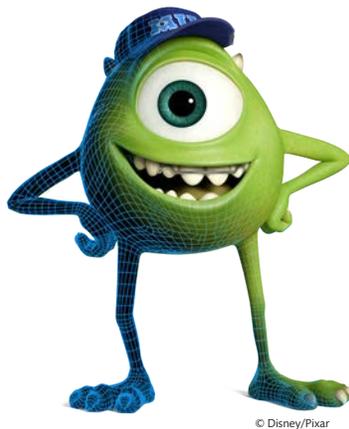
M

Card Set 4:

Science 1

Create a scientifically accurate character in an appropriate model habitat

Modeling

© Disney/Pixar

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Rigging

© Disney/Pixar

A rig is the virtual bones, joints, and muscles that allow a model to move. People who work on rigging study how animals, people, and objects move to create believable rigs.

<u>Do</u>
Create a robot model at **Build a Robot**. Make a detailed sketch of your robot or take a picture of it.

<u>Think</u>
Which human body systems or other organisms would a modeler need to study to create a believable virtual model of your robot?

S1

<u>Do</u>
Use **Arm Rigging Workstation** to change the range of motion for an arm rig. What do you notice about the movement when you change the number of segments?

<u>Think</u>
Which human body systems are involved in creating the motion of the arm? How would a study of the human body inform the creation of a virtual "monster"?

S1

Surfaces

© Disney/Pixar

The appearance of an object is controlled separately from its shape. The surface appearance can be described by the way light scatters off of it.

Sets & Cameras

© Disney/Pixar

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<u>Do</u>
Change the variables at **Surface Appearance Workstation** to match one of the challenges. Make up your own challenge and document the result.

<u>Think</u>
What are the advantages of having separate controls for different aspects of appearance? What are the challenges? What other aspects would you like to add?

S1

<u>Do</u>
Observe the 3D model set in **Lighting Design Basics**. How do the different views provide different information about the set? How did the developers get the information they needed to create a realistic set? Document at least two different views through drawings or photos.

<u>Think</u>
How is scale important to modeling, both physical and virtual? If you were making a 3D model set, how might you research the habitat?

S1

Animation

© Disney/Pixar

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Simulation

© Disney/Pixar

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<u>Do</u>
At **Computer Animation Workstation** experiment with different variables to make realistic movement. Can you make the character move like a robot?

<u>Think</u>
If you were going to create a believable animation of a human, what would you study in preparation? Is the goal of Pixar animators to create realistic movement? Why or why not?
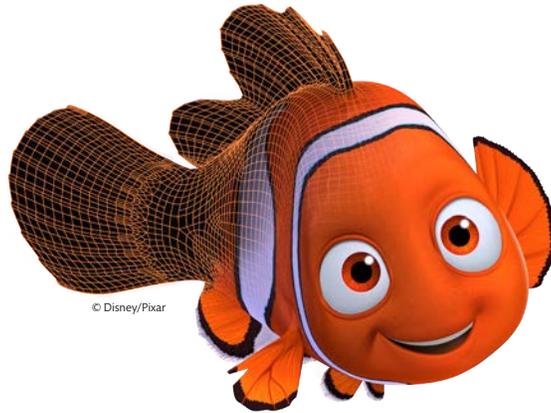
S1

<u>Do</u>
Use the **Simulation Immersive** to explore how simulations improve the quality of Pixar films. Document the difference with and without simulation using pictures, sketches, or videos.

<u>Think</u>
If your job was to create a simulation of a running crowd running, which human body systems would you study? Why would these systems be important in creating a realistic crowd simulation?

S1

Lighting

© Disney/Pixar

Virtual lights enhance mood and believability. Each aspect of light needs to to programmed individually.

Rendering

© Disney/Pixar

Rendering turns a virtual 3D scene into a series of 2D images by taking all the information about the scene and determining the color of every pixel in an image.

<u>Do</u>
Have a partner stand next to Dory
(the large blue fish) in the **Lighting
Immersive**. Take pictures that show
how three different lighting choices
affect her appearance.

<u>Think</u>
How does lighting effect the feel
of the set and character? How
might lighting make a model seem
unrealistic? How can light highlight
certain aspects of an environment
or character?

<u>Do</u>
Use **Rendering Workstation**
to compare the time it takes to
render different images. If you were
rendering images of a realistic
character model, what are some
features that you would be sure were
of high quality? Why?

<u>Think</u>
Why does it takes so long to render
an image? Images are composed of
pixels. How do pixels create an image?

Card Set 5:

Science 2

Create a stop-motion animation

Modeling

© Disney/Pixar

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Rigging

© Disney/Pixar

A rig is the virtual bones, joints, and muscles that allow a model to move. People who work on rigging study how animals, people, and objects move to create believable rigs.

Do

Use **Sculpt by Numbers** to create a 3D shape. Document your work by sketching or taking a picture of your shape from at least three different views.

Think

How does this activity use the coordinate grid? How is this different than how you have used a grid in science class? How is it similar?
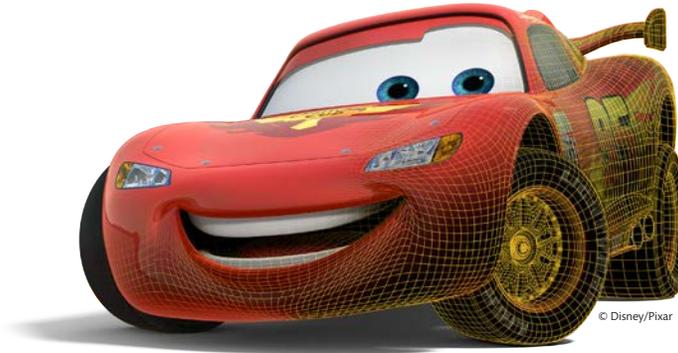
S2

Do

Use **Arm Rigging Workstation** to create a model of a character waving. Take a video or draw the motion when using different numbers of segments.

Think

How does the appearance of motion change as the number of segments in the rig increases?

S2

Surfaces

© Disney/Pixar

The appearance of an object is controlled separately from its shape. The surface appearance can be described by the way light scatters off of it.

Sets & Cameras

© Disney/Pixar

Sets are the rooms and landscapes in which a story takes place. The tasks of building virtual sets and positioning virtual cameras are similar to their live action counterparts.

Do

Complete a challenge at **Surface Appearance Workstation**. What makes a shape look realistic?

Think

If you were animating an object, how would the surface appearance change to make it look like it was moving?

S2

Do

Use **Set Layout Workstation** to create a virtual dorm room. Make a sketch or take a picture of your final set.

Think

How can you use the coordinate grid to describe the size and placement of the set pieces? Can you use the grid to describe the position of a piece of virtual furniture to a partner?

S2

Animation

© Disney/Pixar

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Simulation

© Disney/Pixar

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Do

At **Stop-motion Animation**, create one animation where the lamp completes its jump in 16 frames, and another that takes only 8 frames. In which animation does the lamp appear to move faster? Why?

Think

Why do we say that animation creates the "illusion" of motion? Why does Pixar say that animating is acting?
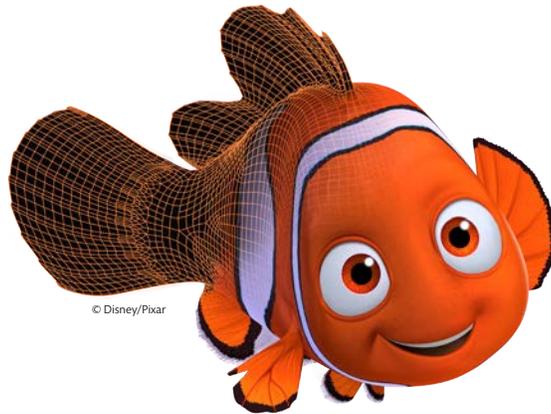

Do

Use **Simulating Water** to model the motion of a fluid. How are the different simulations of water similar? How are they different? Document your work through sketches or pictures.

Think

How are forces and motion important to simulation of Merida's hair? What challenges did the designers face in creating a believable simulation? What did they study in order to model believable forces and motion?

Lighting

Virtual lights enhance mood and believability. Each aspect of light needs to to programmed individually.

Rendering

Rendering turns a virtual 3D scene into a series of 2D images by taking all the information about the scene and determining the color of every pixel in an image.

<u>Do</u>
At **Virtual Lighting Workstation**
pick a time of day and create a
scene. Have a partner guess
what time it is in your scene.

<u>Think</u>
What would change in your scene
if it turned from day to night? How
does the light affect the mood of
the scene?

S2

<u>Do</u>
Use **Rendering Workstation**
to compare the time it takes to
render different images. If you were
rendering images of a realistic
human character, what are some
features that you would want to be
sure were of high quality? Why?

<u>Think</u>
Why does it takes so long to
render an image? Images are
composed of pixels. How do
pixels create an image?

S2