

EFFECTS: FIRST LESSON ([link to lesson](#))



Standards alignment:

NGSS:

[HS-PS2-2](#)

[HS-PS2-3](#)

Common Core:

[HSN.Q.A.2](#)

Summary/Overview:

Pixar effects artists create explosions, fire, and water by breaking them down into millions of tiny particles and controlling them using computer programming. In this lesson, you'll use basic physics to create mini-special effects like flowing water and exploding fireworks.

Lesson Structure: This lesson contains 7 videos and 5 exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:

Approximately 90-120 minutes to complete the videos and exercises.

Age: Grade 5 - infinity and beyond!

Objectives:

In this lesson, students will:

- Explore how water, fire and smoke effects are created using millions of tiny particles.

Materials Needed:

- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator's projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 0: Effects Overview (length: 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Effects Overview.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Effects** - The creation and animation for anything that moves, but isn't a character

Discussion questions (3-5 mins):

- **Q:** Is water in the real world also made up of particles?
- **A:** Yes, because molecules are just super tiny particles
- **Q:** What are some forces that can be applied to particles in order to create water in the computer?
- **A:** Wind, gravity, or more particles
- **Q:** How does a particle affect other particles around it?
- **A:** Particles can push and pull each other

VIDEO 1: Introduction to Particle Systems (length: 3 mins)

Instructions: Let's get started! First we'll explore the origins of particle systems with the man who invented them, Bill Reeves. Have everyone sit where they can see the screen. From the lesson page, play the video "Introduction to Particle Systems" When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Particle system** - Using a large number of very small particles to simulate certain kinds of effects, which are otherwise very hard to reproduce with conventional animation.

Discussion questions (5 mins):

- **Q:** The more particles you use, the closer you get to _____
- **A:** Real physics!

VIDEO 2: Simulating water (length: 3 mins)

Instructions: How can we model water using particles? Have everyone sit where they can see the screen. From the lesson page, play the video “Simulating Water.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Elasticity** - How bouncy a particle is. That is, how much energy is lost when it collides with something
- **Perfect elastic collision** - A value of one means the particle loses no energy. It'll bounce forever. It doesn't happen in real life.

Discussion Questions (3-4 minutes):

- **Q:** In Elasticity, if the value of one means the particle loses no energy, what does the value of 0 mean?
- **A:** The particle loses all of its energy
- **Q:** Which has more elasticity, a marble or a rubber ball?
- **A:** A rubber ball

EXERCISE 1: Water Simulation (length: 5 mins)

Instructions: See what kind of looks you can create using this particle simulator. Can you make the particles look like water? After students are nearly finished, here are some questions to help check for understanding before moving on to the next video:

Exercise Questions (5 mins):

- **Q:** How can you make the ball appear heavier?
- **A:** Increase the gravity
- **Q:** What are some ways you can contain all of the particles so they don't flow off the screen?
- **A:** Decrease size of particle, increase gravity, decrease elasticity.
- **Q:** Try filling the bucket with tiny particles, then enlarge the size of the particles. What happens?
- **A:** It's cool, you should try it!
- **Q:** Can anyone simulate water? Mud? Sand?
- **A:** See if students would like to share their screens with the group.

VIDEO 3: Smooth Collisions (length: 3 mins)

Instructions: To make realistic water we'll need to soften the particle collisions. Have everyone sit where they can see the screen. From the lesson page, play the video "Smooth Collisions." When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Hydrodynamics** - The motion of fluids
- **Smoothed Particle Hydrodynamics (SPH)** - The smooth collisions are an approximation of the pressure forces that water normally experiences.
- **Viscosity** - A measure of how easily things flow. Fluids with low viscosity like water, flow pretty freely. Fluids with high viscosity like honey, flow more slowly.

Discussion Questions (2-3 mins):

- **Q:** What happens to the speed of the computing process when you increase the number of particles? Why?
- **A:** It requires more computation, and the program responds more slowly.

EXERCISE 2: Smoothed Particle Hydrodynamics (length: 5-10 mins)

Instructions: Explore what happens when you change viscosity and collision softness.

Exercise Prompts:

- Can you make it look like water & honey?
- Share your results with the person sitting next to you.
- Why do you think the blue changes color?

VIDEO 4: Create water surface using particles (length: 2 mins)

Instructions: How do we draw a surface of water using only particles? In this video we'll introduce a powerful analogy using heat to help us out. Have everyone sit where they can see the screen. From the lesson page, play the video "Create water surface using particles." When the video ends, start a discussion with your group using questions below.

Discussion Questions (2-3 mins):

- **Q:** What are some other things we could simulate this way?
- **A:** Other liquids, clouds, fire, sand...

EXERCISE 3: Calculating contour lines (length: 5-10 mins)

Instructions: We can create a surface based on the position of particles by treating each particle as a heat source and then drawing a line through each point that has a particular temperature.

Exercise Questions:

- **Q:** What happens to the temperature as you move closer to the particle?
- **A:** It gets hotter or higher
- **Q:** Why are we using this method instead of just using particles?
- **A:** It's a faster way to calculate a surface using relatively few particles
- **Q:** How can you get the surface to be closer to the particle?
- **A:** Increase the temperature

VIDEO 5: What else can you make with particle systems **(length: 2 mins)**

Instructions: In this video we'll show you how to create fireworks using the exact same methods we used to make water. Have everyone sit where they can see the screen. From the lesson page, play the video "What else can you make with particle systems?" When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Child particles:** Created by exploding particles, they have their own lifetime.

Discussion Questions:

- **Q:** What other types of effects can be created using particle systems?
- **A:** Call on different students for ideas
- **Q:** What are some settings Matt changes to make his fireworks look more believable?
- **A:** He uses a variety of settings to create randomness. Some of those include:
 - Adding random variation to the speed of the child particles
 - Adding variation to the angle of the launch

EXERCISE 4: Fireworks simulator (length: 10-20 mins)

Instructions: See what kind of interesting looks you can come up with. Have fun!

Exercise Prompts:

- **Q:** What does a large gravity value do to particles? How about a small gravity value?
- **A:** A large value keeps the particles from rising very high, and a small value causes particles to fly off the screen.
- **Q:** Can you create a fireworks show that represents an emotion? Try these, for starters:
 - Joy
 - Sadness
 - Anger
 - Fear
 - Disgust
- **A:** Have students share their shows

EXERCISE 5: Genesis Effect (length 10-15 mins)

Instructions: See what kind of looks you can achieve with this Genesis effect inspired simulator. To get started, click on the box at the top of the simulator to become familiar with the sliders and their functions. Have fun!

Exercise Questions:

- Ask students to take turns sharing their work and explaining how they made their effect.

VIDEO 6: Getting to know Matt Wong (length: 2 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Getting to know Matt Wong.” When the video ends, start a discussion with your group using questions below.

Discussion Questions:

- **Q:** What does Matt see as the *value* in collaborating with other effects artists?
- **A:** They can split up the work into various shots, are always looking at each other's work, comparing each other's techniques, solutions to problems. They give and take from each other, and kind of try to match the look amongst the entire team.
- **Q:** Can you think of anything you've done that requires “getting it wrong” the first, second or third time? What's the most times you've tried something before you got it right?