Impulse: Discussion Guide and Examples

Preparation

Before introducing your students to the game, please be sure to play *Impulse* yourself up to level 45 (or as far as you can), using the *Teacher Play Guide* to orient yourself to the game and how you will discuss it with your students.

The first 45 levels of *Impulse* deal with gravitational forces between objects. At higher levels, the electric force is introduced so there are both attractive and repulsive forces at play. The material that your students will be assessed upon for this research study is their understanding of Newton's first and second laws of motion:

- **Newton's first law of motion**: An object at rest (or in constant motion) will stay at rest (or at the same speed and direction of motion) unless acted upon by a net force.

- **Newton's second law of motion**: The acceleration (change in speed and/or direction of motion) is dependent on the strength of the net force imparted upon it, and its mass—such that force = mass x acceleration.

Particle Guide

Although this information is not explicit in the game, it might be useful to you as a teacher to know the relative masses and sizes of the particles to help you lead class discussions about the particles' behaviors and the physics behind those behaviors.

color	mass	size	charge
green (player particle)	80	25	0
red	80	25	0
blue	40	23	0
white	160	35	0
gray	180	20	0
cyan	80	25	+1
orange	80	25	-1

Bridging Gameplay & Classroom Lessons

To create a bridge between the game that kids will be playing in their free time, and the lessons on forces and motion you are using in class, we would like you to integrate discussions about the students' experiences with the game along with live gameplay demonstrations (led by either yourself or student volunteers) or video clips of the game into your lessons, particularly those relating to Newton's first and second laws of motion.

Video Clips

If you would prefer to use video clips rather than (or in addition to) live gameplay demonstrations in class, you can either make your own or use the clips we have created.

Here are a variety of clips of play from roughly levels 35-45 of *Impulse*. Videos can be viewed on our **Impulse Video Clips Vimeo channel** (https://vimeo.com/channels/impulsevideos).

How to Use Video Clips

We recommend that you watch all the video clips before showing them in class so you can identify specific clips or portions of clips that are most relevant to the day's discussion. Here's an example of how you might approach breaking down a video clip to prepare for a lesson.

Clip 1*: This is a 1-minute clip showing basic gameplay with the gray (dense) particles. At about 20 seconds into the clip, the player particle had been moving at a constant speed, but is then accelerated by the gravity from the clump of gray particles ahead. At 40 seconds, there is a nice example of the particles clumping from mutual gravitation and then scattering away due to collisions. At 1:06, there is a situation in which the force of gravity of the clump of gray particles is so great that the impulse cannot overcome it.*

The rest of the clips have many similar examples. Pick and choose what fits best with your own curriculum. Use any or all of the clips, along with the discussion questions below to bridge students' learning of Newton's laws of motion and their experiences while playing *Impulse*.

Discussion Questions for *Impulse*

Below, we've provided suggested discussion questions to accompany any of the video clips. We've also provided some background information (*in italics*) that you might want to know about the physics in the game. It is *not* required that you teach everything covered below to your students. Do what you feel is best to help them understand Newton's first and second laws of motion, using examples from the game. Please be sure to document everything you do, including which video clips you used and what questions you asked, in your daily logs.

1. **Select a video and let it run through at least once, asking students to observe the ambient particles (not worrying about the green player particle for now).**

Ask students what patterns they notice in the motions of the ambient particles (e.g., clumping and/or collisions).

All of the particles in the game (up through level 45) are mutually attracted by gravitational forces. The mutual attraction often causes particles to clump together (making way for the player to go around them) but also often ends in collisions that scatter the particle again. This is typical of gravitational systems.

2. Stop the video at a still frame during the gameplay and pick one ambient particle to focus on. Have students identify all the forces acting on that particle.

Up through level 45 the forces include the gravitational pull of any nearby particles as well as the force imparted by any player "click" (an impulse). After level 45, the dominant force is electrostatic (the particles have charge and their mass is ignored).

The net force is the result of balancing the x and y components of all the forces and finding what is leftover. This is the force that will cause the particles to accelerate.

Focus on one isolated particle at a time to see that when there are no other nearby forces being exerted on the particle, its motion is straight and constant speed. Then focus on a different particle as it gets close to another particle (especially a massive gray or white) particle, looking to see if its speed and direction are altered. Any changes in speed and direction are the effect of the force of gravity exerted on the particle by the nearby massive particle.

Students may confuse motion, or inertia, with forces. A common misconception is that a force is required to sustain constant motion, or that constant motion is an indicator of a force. This misconception may be caused by our real world experience where friction typically plays a role, but in Impulse there is no friction and an object will continue its straight line constant motion without an external force.

Show how a player's click (the force of the impulse) will also alter the speed and direction of a nearby particle.

3. Stop the video just before the player clicks on the screen to impart an impulse. Identify all the forces acting on the green player particle and explain how the force imparted by the impulse is useful (or not) for the player.

Players use the impulse, typically, to speed-up, redirect, or oppose (stop) the green player particle. These are all forms of the acceleration caused by the net force on the object.

The particle would go in a straight line, at a constant speed, unless a) it is close to a massive

particle (or charge in levels higher than 45) or b) the player imparts an impulse nearby.

4. Ask students which particles seem heavier and why they seem that way (for up to level 45).

The white particles and gray particles have high mass, and thus exert stronger gravitational forces on other particles than do the relatively low mass red and blue particles. The white and gray particles are harder to accelerate (change speed and/or direction). They have more inertia because they are more massive.

The gray particles are more dense because they are more massive yet have a smaller volume.