

Touchdown: Landing Systems – Teacher Notes

Time Requirement: At least 2, 50 minute class periods.

This activity can be used as an introduction to impulse and momentum or to reinforce Newton's Second Law of Motion. Students should have some familiarity with Newton's Laws before attempting this activity. You will need to find a location where you can drop a raw egg from a height of 30 feet (about 2 stories) for this activity. The activity includes a demonstration and then independent group work. The format of the independent work is left very open to maximize student creativity. The materials list provides suggestions for types of components that can be used in the creation of landing systems, but you could also leave it open for students to use any materials they can find.

Materials (Demonstration)	Materials (Needed)	Materials (Landing System)
One dozen raw eggs Old bed sheet	Scissors Drop cloth Glue Hot glue gun(s) tape Raw eggs (at least two per student group)	Tennis balls cut in _ Plastic garbage bags String Old pillow cases Straws Craft Sticks Cotton balls Plastic baggies Paper towel Foam Springs Cardboard Thread Paper

Procedure

This lesson is divided into two sections. In the first section, students analyze a demonstration to learn the science behind impacts. In the second section, students design a landing system to protect an egg during a 30 foot drop.

Section One:

In this stage of the activity, students will be introduced to the concept of impulse and momentum. Have four students hold the corners of the bed sheet so that it is perpendicular to the floor. The two students holding the bottom corners should kneel and hold the corners up so that the bottom 8-12 inches is parallel to the floor and can be used to catch an egg. Have student volunteers stand 5-10 ft from the sheet and throw the egg into the sheet. As long as the egg hits the sheet it will not break, regardless of how hard the egg is thrown!

Ask students to explain why the egg does not break. Encourage them to phrase their explanation in terms of force, acceleration and velocity. Do not let them use words like momentum unless they are able to provide an appropriate definition. Discuss with them the scientific reason based on their academic background.

Impulse and Momentum

Use Newton's 2nd Law and the definition of acceleration to derive the impulse/momentum equation as follows (Δ means "change in"):

$$F=ma \quad \text{and} \quad a = \Delta v/\Delta t$$

$$\text{So, } F=m(\Delta v/\Delta t) \quad \text{which can be rearranged to give } F\Delta t = m\Delta v$$

$F\Delta t$ is the definition of "impulse"

Momentum is mass times velocity (mv), so $m\Delta v$ represents a change in momentum.

Describe what happens if the momentum stays the same and you increase the time that the force is applied (the force decreases) or decrease the time (the force increases). Have students explain why the egg does not break when it is thrown against the sheet.

Newton's Second Law

This explanation uses the idea of acceleration and Newton's Second Law but does not introduce the concept of momentum.

Newton's 2nd Law states: $F=ma$, and acceleration is defined as the change in velocity / time (Δ means "change in"): $a = \Delta v/t$

Since the mass of the egg is constant and the egg goes from a high velocity to zero in each case, the only variables that change are the force and time. Ask students what happens to the acceleration of the egg if you increase the time that it takes to change the velocity? (it decreases) What happens to the force acting on the egg if the acceleration increases / decreases? (it increases / decreases).

The egg does not break when it hits the sheet, because the flexing of the sheet increases the time that it takes to change the velocity. Since the time is greater, the acceleration is less. Since the acceleration is less, the force on the egg is smaller and it does not break!

Section Two:

The science behind the problem indicates that the students need to build a device that increases the time that the velocity change of the egg occurs over. There are many ways to do this, so let your students' imagination run wild! Review the design process of design, build, test, analyze, re-design and let them know how many chances they will have. You should give them at least two opportunities to test designs. Additionally, if you feel it is necessary, instruct students to check with you as they complete each step in the design process. The goal of the exercise is for students to see how engineers use testing data to improve their designs. Although there is a score attached to the design, you do not need to make this a competitive project. The focus should be on improving their design, not starting from scratch and copying someone else in the class!

Conclusion:

You may want to show the animation of the Mars Exploration Rover landing on Mars using its airbag system. The video clip is located in the "Classroom" section of www.spaceed.org in the "Physical Science" unit.