TEACHER LESSON PLAN

Physics oph Phlying Phish

Grade	Length	Subjects/strands	Topics
High school	About 1 hour	Invasive species, biology, ecology, environmental sciences, social sciences	Physics, math, geometry, ecology

LEARNING OBJECTIVES

Just how dangerous are those flying carp? Students will learn about the invasive Asian carp and then apply their knowledge of principles of physics (Motion and Stability: Forces and Interactions) to calculate the speed and potential impact of an Asian carp when it jumps from the water. If you were a passenger in the boat, would you want to duck?

INTRODUCTION

This articulated exercise is designed for students who have studied or are studying ballistics (free motion of an object in a gravitational field). Taken in order, the parts make up a fairly easy exercise with emphasis on discussion and simple computations.

For a more challenging exercise, or for proficient students, start in Part B or Part C. The discussion may then uncover alternate methods, such as starting in Part A and reasoning by symmetry versus solving more-difficult algebra arising from more-complicated initial conditions.

BACKGROUND

While most Asian carp reach about 10-30 pounds in weight, the grass carp and black carp can grow in excess of 150 pounds! They are able to jump barriers such as low dams, and have been known to jump into boats and hit fishermen when disturbed by boat engines. The four different Asian carp species were initially introduced into the United States in the 1970s to help control weed and parasite growth in aquatic farms. Once fish escaped into the natural systems, they successfully outcompeted native species for food and space, reduced water quality by uprooting vegetation, and have caused the loss of native species. They lay hundreds of thousands of eggs at a time and easily spread into new habitats, affecting fisheries in more than 31 states. (See species guide for more specifics on Asian carp.)

Fishing provides both enjoyable recreation and an excellent opportunity to sit back and explore physics. Whether dropping bait into the water or watching fish jump, one can better understand what is happening and how by applying Newton's Laws of Motion. The incredible acrobatic movements of invasive carp are easily documented by video when the fish are disturbed by boat engines. Watch the video, "Thousands of fish leap out of the water at the same time—Slo-mo!" (http://www.youtube.com/watch?v=tLmJjRqXDCo), to see this aerobatic phenomenon.

VOCABULARY

Acceleration of gravity, drag, force, free fall, gravity, projectile.

MATERIALS NEEDED

Internet access and a projector for showing video clips

PREPARATION

- **View** a video clip of Asian carp jumping out of the water. You can find a video clip at MenaceToTheWest.org
- **Discuss** the laws of physics demonstrated in the video.
- **Explore** the questions in Parts A, B, and C.

PROCEDURE

Part A. Dropping Bait

The fishing boat Arcadia has a railing 8 feet above the water. An angler drops a piece of bait over the railing into the water on a slack line.

A1. How much time will elapse before the bait strikes the water?

8 feet = distance = $gt^2/2g$ = 32 feet/sec^2, $t = \sqrt{2}/2$ sec, or about 0.7 sec

A2. How fast is the bait moving when it strikes the water?

$gt = 16\sqrt{2}$ feet/sec, about 15 mph or the speed of a fast runner

Part B. Jumping Fish

The fishing boat Arcadia has a railing 8 feet above the water. A carp jumps straight up from the water, flops over the railing and onto the deck.

B1. How long does the carp take to reach the railing?

8 feet = distance = $gt^2/2g = 32$ feet/sec^2, $t = \sqrt{2}/2$ sec, or about 0.7 sec (same as A1: time reversal invariance)

B2. How fast is the carp moving when it leaves the water?

$gt = 16\sqrt{2}$ feet/sec, about 15 mph or the speed of a fast runner (same as A2). Can you run this fast? Probably not for long—that's a 100-yard dash in 13 seconds, or a 4-minute mile!

Part C. Leaping Fish

The fishing boat Arcadia has a railing 8 feet above the water. A carp leaps out of the water at a 45 degree angle from the water's surface, and just clears the railing before landing on the deck. Although the fish appears to "fly," you may neglect the force of the air on the carp because it is very streamlined—its fins are made to move it in dense water, not thin air!

C1. What factors influence the "flight" of the fish?

Initial vertical velocity, projection angle, relative projection height

C2. How long does the carp take to reach the railing?

$gt = 16\sqrt{2}$ feet/sec, about 15 mph or the speed of a fast runner, or about 0.7 seconds (same as B1; horizontal and vertical motion components are independent)

C3. How fast is the carp moving when it reaches the railing?

$gt = 16\sqrt{2}$ feet/sec, about 15 mph or the speed of a fast runner (same as B2; horizontal and vertical velocity components initially equal, horizontal remains unchanged as vertical vanishes at top of trajectory). How do you think it would feel to be struck by a jumping carp? (Ouch!)

VOCABULARY WORKSHEET KEY

- **Acceleration of gravity:** The acceleration caused by the gravitational attraction of massive bodies in general.
- **Drag:** A force that is always opposite to the object's motion.
- **Force:** Any interaction that, when unopposed, will change the motion of an object.
- **Free fall:** Downward movement under the force of gravity only.
- **Gravity:** The force that attracts a body toward the center of the Earth, or toward any other physical body having mass.
- **Projectile:** A body projected or impelled forward, as through the air.

RESOURCES

- ***Problem Solving Exercises in Physics: Conceptual Physics***, by Jennifer Bond Hickman (2002). Available at http://assets.pearsonschool.com/asset_mgr/current/20126/problem-solving-exercises-conceptual-physics.pdf
- Newton's first law of motion (law of inertia), an object in motion in a horizontal direction would continue its horizontal motion with the same horizontal speed and direction unless acted upon by an unbalanced horizontal force.
- When projection angle and other factors are constant, projection speed determines length of trajectory (range).
- h = height, g = gravity, t = time, v = velocity

  $h = 1/2gt^2$ $\quad 1/2v^2 = gh$ $\quad g = 9.8$ m/s^2

STANDARDS ADDRESSED

Common Core Standards

Mathematics

- Reasoning with Equations and Inequities HS A1 A REI

Speaking and Listening

- Comprehension and Collaboration: 9.1, 10.1, 11.1, 12.1
- Presentation of Knowledge and Ideas: 9.4, 10.4, 11.4, 12.14

Next Generation Science Standards

Motion and Stability: Forces and Interactions

- HS-PS2-1, HS-PS2-2