Science First®

611-1820 (5-110) Greek Waiters Tray

- Experiments
- Applications
- Activities

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain or small parts that can be choking hazards. Adult supervision is required.

Our **Greek Waiter's Tray is** a small wooden disc with a long aluminum handle. A small glass of water is placed at the center of the plate. The plate can now be swung around in any direction, and the surface of the water in the glass will always stay parallel to the plate. The plate can also be swung overhead without spilling a drop. Waiters in Greece use similar trays to deliver drinks to tables and are able to turn sharp corners without spilling a drop.

How to Teach with Greek Waiters Tray:

Concepts Taught: Newton's Laws of Motion; inertia, velocity and acceleration; rotational motion; uniform circular motion; mathematical calculations (e.g. unit cancellation, algebra).

Curriculum Fit: Physics Sequence; Force and Motion. **Grades 6-8 and up.**

Additional Materials Needed:

- 250ml plastic beaker
- Small Phillips head screwdriver

Background: Newton's First Law (*The Law of Inertia*), states that an object in motion will travel in a straight line unless an outside force changes its direction. For an object to stay in a circular motion, a force must act upon the object continuously as it is pulled toward the center. Any force acting in this way is called Centripetal Force.

Centripetal force

Centripetal force means "center seeking" force. It is the force that keeps an object in its uniform circular motion. We determine this force by using Newton's second law of motion, $F_{net} = ma$, where F_{net} is the net force acting on the object (this is the centripetal force, F_c, of an object in uniform circular motion), m is the mass of the object, and a is the acceleration of the object. Since the acceleration of the object in uniform circular motion is the centripetal acceleration, we can substitute v^2 / r or $(4\pi^2 r) / t^2$ for a. This gets us $F_c = (mv^2) / r$ or $F_c = (4m\pi^2 r) / t^2$

The centripetal force can be provided by many different things, such as tension (as in a string), and friction (as between a tire and the road) or in the case of the Greek Waiter's Tray, it is your arm that provides the force required to keep the tray spinning in a circle.

An example of tension being the centripetal force is tying a mass onto a string and spinning it around in a horizontal circle above your head. The tension force is the centripetal force because it is the only force keeping the object in uniform circular motion.

The m is the mass of the object, and the tension force is the centripetal force because it is keeping the object in uniform circular motion.

VELOCITY

Centripetal Force
(Tension in string)

DIRECTION OF MOTION

CUT STRING

VELOCITY
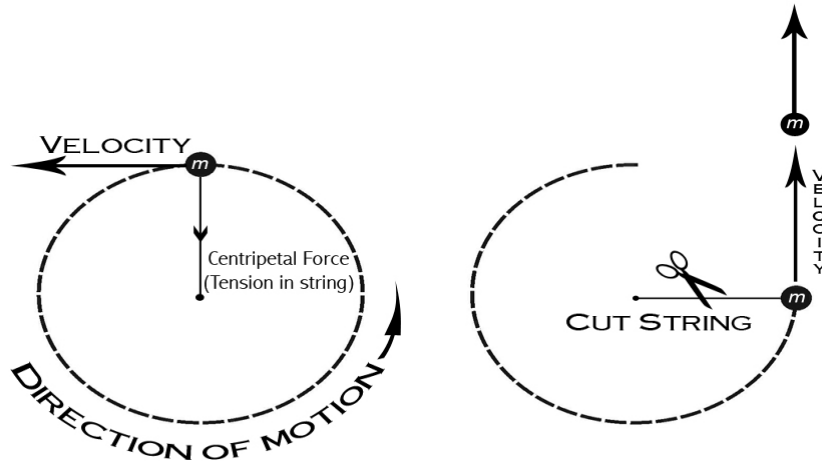
How to use the Greek Waiter's Tray

1)   Put ANSI Z87.1 approved safety goggles on yourself and all viewers of the demonstration.
2)   Using a Phillips Screwdriver, Unscrew and remove the simple pendulum bob if attached.
3)   Place a 250ml plastic beaker filled with 100ml of water onto the very center of the wooden base. Do not use a larger container or you will bend the handle!
4)   Pick up the tray such that the opened end of the handle is facing toward you.
5)   Begin swinging the tray gently back and forth. With practice, you will be able to swing it all the way around.

To demonstrate that the net force on the glass of water is always directed radially, attach the pendulum bob to the aluminum stand with the screw provided. Swing the pendulum as before. You will see that the pendulum bob remains nearly stationary on the tray.

Experiment Suggestions:

Try this experiment with different liquids. See if different liquids affect the outcome of the experiment.

Place different materials taped onto the board underneath where the cup of liquid goes. See if the friction of these other materials affect the results.

Sample related problem:

Find the centripetal force required to cause a 900-kg automobile traveling at 28 m/s (63 miles/hour) to turn on an unbanked curve having a radius of 100m.

ANS. $F_C = (mv^2)/r$

$= (900kg * (28m)^2)/100$

$= 7056$ N

If the force of friction is less than 7056 N, the car will not follow the curve and will skid in the direction it was traveling when the tires broke loose from the road.

Benchmarks and Standards

This investigation provides support for the *Benchmarks for Science Literacy* and *National Science Education Standards* shown in the table below.

Benchmarks for Science Literacy				*National Science Education Standard*
			Grades 5 – 8 **Physical Science Content Standard B.1** – Motions and Forces	"The motion of an object can be described by its position, direction of motion and speed. The motion can be measured and represented on a graph." (p. 154)
Grades 3 – 5 **The Physical Setting**	**4B.1**	"Changes in speed or direction of motion are caused by forces. The greater the force is the greater the change in motion will be."	Grades 5 – 8 **Physical Science Content Standard B.2** – Motions and Forces	"An object that is not being subjected to a force will continue to move at a constant speed and in a straight line." (p. 154)
Grades 6 – 8 **The Physical Setting**	**4B.3**	"An unbalanced force acting on an object changes its speed or direction of motion, or both."	Grades 5 -8 **Physical Science Content Standard B.3** – Motions and Forces	"If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in speed or direction of an object's motion." (p. 154)
Grades 9 – 12 **The Physical Setting**	**4B.1**	"The change in motion of an object is proportional to the applied force and inversely proportional to the mass."	Grades 9-12 **Physical Science Content Standard B.1** – Motions and Forces	"Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object." (p. 180)