LEVELS OF INQUIRY LEARNING SEQUENCE

Uniform Circular Motion & Gravitation (PHY 310, 2021)

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Discovery Learning – Students name examples or situations that involve circular motion. The describe motion involving such terms as angle, angular velocity, tangential velocity, period, and frequency. They explain the role of both force and acceleration. The concept of a radian is introduced as well as $s = r\theta$. A worksheet is used to define relationships between variable using $d = vt$ as an analogue. Using the "turning marching band" analogy, students find $v = r\omega$. Students examine a point on a wheel or phonograph record and analyze its motion in two dimensions. Worksheet is used to assist in identifying concepts and finding relationships.	**Interactive Demonstration** – Teacher rolls marble around circular plate with sides (paper picnic plate). Asks students what would happen if there was no side. Teacher scribes large circle on the gym floor with chalk and gives students a bowling ball and either a broom or twirling baton and asks, "How can I use this broom (or baton) to make the bowling ball travel along the circle once it is in motion? How must I strike it?" The students then perform the action. Teacher asks students to explain, make predictions, and so forth. Teacher swings ball on string overhead and asks what would happen if the string were released. Teacher asks about twirling pail with water. What would happen at top and why.	**Inquiry Lesson** – Teacher demonstrates how to analyze circular motion using Tracker. As a group, teacher and class breaks down motion of an example of circular motion (a ball on a string aboard the Space Shuttle orbiter for instance) into x- and y-components. The teacher demonstrates how angular velocity and other parameters of motion are related to time and so forth.
Inquiry Lab – Students, experienced with inquiry-based learning, are charged with finding the relationships between various independent and dependent variables using a whirligig lab. See lab guideline for assistance.	**Real-world Applications** – Students solve end-of-chapter problems associated with circular motion and gravitation (e.g., satellite or planetary motions) both in class and for homework. Teacher addresses question of weightlessness (in space and loop-the-loops). Students design amusement park rides involving circular motion such as a roller coaster involving loop-the-loops. Students participate in an end-of-the year Amusement Park Physics field trip.	**Hypothetical Explanation** – Students might seek answers to the following questions, "Can we derive the 'form' of gravity (e.g., inverse-square, $F = GMm/r^2$) from the whirligig lab? Can we derive $P^2 = ka^3$ from whirligig lab (Kepler's third law)?