Two Track Race

Amount of time Demo takes: 1-2 minutes

Try this in the classroom!

Lesson's Big Idea

- The shortest distance isn't necessarily the fastest. The ball on the valley track will accelerate as it goes downhill, then return to its original horizontal velocity due to the Conservation of Energy. It will have a higher average velocity than the straight track and will win the race.
- Kinematics can be used to predict/estimate the motion of an object. It uses four basic variables: (1) distance, (2) velocity, (3) acceleration, (4) time.

Materials

- Dual-track setup
- Identical pool balls (2)
- Spring mechanism

SAFETY!

- Keep hands off of the track! This will prevent the pool balls from coming off or hitting hands.

Background Information

- Race Description
    - When the balls are launched by the springs, they have the same initial velocity (due to an equivalent force acting on identical masses; F=ma).
    - The ball on the dipped (valley) track rolls down the ramp picking up speed. When it reaches the bottom it has a much higher velocity.
    - It will continue along the track, until it goes back up the other side- returning to its initial velocity.
    - The valley-track ball will end up several inches ahead of the ball that had a constant velocity the entire time, since its velocity was

always greater than or equal to the flat-track ball.

- **Kinematics:** motion mechanics; a type of physics used to describe object motion. The initial force causing the motion (ex. Spring on ball) is ignored.
    - Basic kinematic equations considers 4 main variables
        - **Distance** (x): the change in position of an object (Δx).
        - **Velocity** (v): the speed of an object (Δx/Δt).
        - **Acceleration** (a): the change in speed of an object ($\Delta x/\Delta t^2$).
        - **Time** (t): reference variable, how long the object moved, stayed at a speed, or accelerated (Δt)

$$x = x_o + v_o t$$
$$v = v_o + at$$
$$x = x_o + v_o t + \tfrac{1}{2} a t^2$$
$$v^2 = v_0^2 + 2a(\Delta x)$$

- **Conservation of Energy:** energy cannot be created or destroyed, so it will convert from one form to another (ex. Kinetic to potential). The total energy in an isolated system will remain constant.
    - **Kinetic Energy:** energy from motion
        - $KE=0.5mv^2$, where m is the mass and v is the velocity.
        - Highest at bottom of ramp (highest velocity).
    - **Potential Energy:** stored energy (ex. Due to position).
        - PE=mgh, where m is mass, g is gravitational acceleration, and h is the height relative to a surface.
        - Highest at top of ramp (lowest velocity, highest height).
- The balls experience negligible friction, so the flat-track ball remains at constant velocity according to Newton's 1st Law of Motion.
    - **Newton's 1st Law of Motion:** An object at rest will remain at rest and an object in motion will remain in motion (constant velocity), unless acted upon by an outside force.
    - The valley-track ball accelerates due to the outside force of gravity when it reaches the decline.

Setup Instructions

1. Remove the balls and pushing device.
2. Mount the spring mechanism to the track using a Philips screwdriver.
3. Position the track on a level surface. Use the levels built-in to the track to ensure it is flat.

Instructional Procedure

1. Pull the spring mechanism back until it locks. Push both pool balls against the launcher.
2. Ask the students what they think will happen.
3. Launch the balls.
4. Discuss what happened and why.

Tips & Tricks

- Let a student launch the balls, so they know you didn't tamper with the results.

Assessment Questions

1. When is the KE highest?
    a. When PE is the lowest (Conservation of Energy)
    b. Point of highest velocity (bottom of valley due to acceleration)
2. What are the four variables of kinematic motion?
    a. Distance, velocity, acceleration, and time.

Careers & Real-World Applications

- **Running:** Ever run long distance on a flat track? It can feel more difficult than an equal distance on a hill cross-country course because of kinematic motion. The downhills help you accelerate, giving you extra speed when you reach the uphill.
- **Orbits:** Kinematic motion can be used to predict the time of an object to complete an orbit or reach a particular position. This is how astronomers can easily determine the night of a full moon.
- Careers
    - Aerospace Engineer
    - Civil Engineer
    - Astronomers

Clean Up

- Separate track and spring mechanism. Place everything in its bin.

References

- http://en.wikipedia.org/wiki/Conservation_of_energy
- https://lecdem.physics.umd.edu/question-of-the-week-archive/101-qotw-001-with-answer.html

- http://www.physicsclassroom.com/class/1DKin/Lesson-6/Kinematic-Equations

Related Next Generation Science Standards

- K-5
  - K-PS2 Motion and Stability: Forces and Interactions
  - 3-PS2 Motion and Stability: Forces and Interactions
  - 4-PS3 Energy
  - 5-PS2 Motion and Stability: Forces and Interactions
- 6-8
  - MS-PS2 Motion and Stability: Forces and Interactions
  - MS-PS3 Energy
- 9-12
  - HS-PS2 Motion and Stability: Forces and Interactions
  - HS-PS3 Energy