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# Catapults and Angry Birds

Josh Bon and Jake Moline

Introduction: Names, Engineering Students/Majors (Josh)

- Question: What is Engineering?
- Engineers are problem solvers, individuals who use knowledge of science, mathematics and economics to solve technical problems that confront society!
- Question: How many have taken a physics class already?

(Show Angry Birds Video)

Question: Who has played Angry Birds before?

Question: What physics concepts can you see at work in Angry Birds?

The Physics of Angry Birds: (Jake)

- Projectile Motion
- ***Collisions and Momentum
- Kinetic and Potential Energy
- Spring/Elastic Physics
- Explosive Physics

Newton's Laws (Josh) (Jake writes important vocab and definitions)

- Sir Isaac Newton Apple story
    - He came up with the 3 fundamental laws of physics by thinking about an apple that fell on his head
    - We can do the same thing looking at Angry Birds (open the floor for what they observed in the video)
- Angry Birds: Fortresses will stay standing until the birds knock them down
    - Newton took credit for being the first to say something really obvious:
    - $1^{st}$ Law: Inertia – An object at rest will stay at rest, and an object in motion will stay in motion unless something else happens.
        - Question: Which block will be move the easiest?
        - Chair demonstration – Moving
- Angry Birds: Birds hitting the structure knocks it down
    - Newton observed that when something hits something else, it tends to move
    - $2^{nd}$ Law: Force=mass x Acceleration
        - Question: How do we make the object move?
        - Definition of acceleration, leading to definition of force
        - Force needs "effort"
- Angry Birds: When the birds hit the structure, they stop moving

- Newton recognized that there was a balance
- 3rd Law: Equal and Opposite Reactions
    - Block demonstration – Pushing on block
        - No Acceleration
        - Question: Why?

Physics Equations (Jake)

- Displacement: Distance from starting point (x)
    - Angry Birds: The distance the birds travel
- Velocity: Speed or movement
    - Angry Birds: How fast the birds fly
- Acceleration: Adding or subtracting speed
    - Angry Birds: Catapult accelerates bird
- Mass: Similar to weight
    - Angry Birds: Size matters
- Force: Push
    - Force = Mass × Acceleration (F = ma)
    - Angry Birds: Pushing blocks over
- Momentum: A measure of motion of a body
    - Will be discovered later

Catapult Activity (Both)

- Questions to ask during/after activity (incorporated in next sections)
    - Which projectiles did the most damage?
    - Which projectiles flew the furthest?
    - Which projectiles work best?
    - Did anyone launch multiple small marshmallows at once?
    - Which catapult type did you like the best and why?
    - How far back did you pull the arm on the catapult back?
        - Same every time or different?
        - Why? What effect did it have?

Physics of Catapult: (Josh)

- Overall goal question: How can we increase projectile displacement/damage?
- What did you notice that was different about the three types of catapults?
    - Write students answers on board
        - Try to set up groups
            - Moment/Force Related
            - Energy related
            - Other design criteria
    - Optional: Move to topics below as they answer—topic relation in ()
- **Moments** (2x spoon length = Increase arm)

- Rotational Motion: Force → Moments
    - Moments = Force × Arm
        - Point of Rotation
- Example: Tipping over vs. sliding water bottle
- Example: Door

- **Energy** (Increased windings = Higher spring constant, increased pullback =Higher displacement)
    - Question: After we load the spoon, where does the launch force come from?
    - Potential Energy: Storage of force
        - Relate to Slingshot (Angry Birds)
    - Spring Potential Energy = ½ × Spring Constant × Displacement ($E = ½ kx^2$)
        - Units: Joules (J)
    - Question: Where does the energy go after the launch?
    - Energy transfer from potential to kinetic-like the rock
        - Relate to Pull-back displacement (Angry Birds)
        - Relate to Impact Force
- **Increasing Distance** (summary and extrapolation)
    - Question: How can we increase the projectile displacement?
    - Give more energy
        - Increase lever displacement
        - Increase the spring constant
    - Give it more force
        - Increase arm length
    - Other Types of Catapults
        - Four Bar Linkage
            - Mechanical Advantage = Force Out / Force In

Physics of Projectiles: (Jake)

- To have momentum, you must be a body, and have motion
- To break through the fortress, the birds must have a high momentum (Create chart)
- Question: How does each bird knock down the fortress?
- Angry Birds Projectiles
    - Red Bird: momentum , body, motion
        - Question: What characteristics of this bird give it an increase in momentum?
        - The Red Bird does not change its body or motion, has a low momentum
        - The Red Bird is the "control" bird (We compare other birds to this one)
    - Yellow Bird: momentum(↑), body, motion(↑)
        - Question: What characteristics of this bird give it an increase in momentum?
        - The Yellow Bird increases its motion, and therefor increases its momentum
    - Jumbo Red Bird: momentum(↑) , body(↑), motion
        - Question: What characteristics of this bird give it an increase in momentum?
        - The Dark Red Bird has a bigger body, and therefor increase its momentum

- Blue Bird: momentum(↑), body(↑), motion
  - Question: What characteristics of this bird give it an increase in momentum?
  - The Blue Bird increases its body and therefor increases its momentum
  - Blue Bird also creates a force over a larger area
  - (Diagram of force over larger area on a block)
- Black Bird: momentum(↑), body, motion(↑)
  - Question: What characteristics of this bird give it an increase in momentum?
  - The Black Bird creates an explosion
    - The explosive force causes an increase in momentum
  - (Draw Explosion Diagram)
- White Bird: momentum(↑), body, motion(↑)
  - Question: What characteristics of this bird give it an increase in momentum?
  - The White Bird also creates an explosion
    - The explosive force causes an increase in momentum
  - (Draw White Bird/Bomb diagram)

- Question: Which definitions of physics do body and motion apply to?
- Write momentum equation: p=mv

Question: Anymore questions from the audience?