BEEC Share and Learn Report: February 2024

Presenter: Dr. Brian Helmke, Associate Professor, Department of Biomedical Engineering, University of Virginia

Topic: ASEE Education Showcase Deep Dive: Stomp Rockets, Tennis Balls, and Conservation of Momentum - ASEE Education Showcase Deep Dive

Resources:

Discussion and Lecture Notes:

Lecture Notes:

- Biotransport required core class with ~70 students
- Students have heard "it's hard", "it's complicated", etc.
- Difficult concept to understand is the idea behind conservation of momentum
- Mass conservation and keep track of mass flows in and out of a container, but keeping track of momentum flowing is hard
- Newton's 2nd law and conservation of momentum
- Stomp Rockets + Tennis Balls
    - Stomp Rockets is a toy where you set up a rocket with a tripod, aim it, and the use an air pocket that you stomp on and the rocket goes flying by creating a pulse of air that begins at the cushion
    - Why does the rocket go flying?
        - Air pushing the rocket, air is exerting a force on the rocket
        - If you exert a force on an object, it accelerates
        - Newton's law: Force = mass*acceleration
    - Tennis Ball:
        - Drop tennis balls, it falls because gravity causes it to fall
        - What happens to the ball as it falls?
            - It accelerates. The force of gravity is causing it to accelerate as it falls to the floor
    - Momentum:
        - Equation: P = momentum = mass * velocity
        - The velocity of the ball and stomp rocket are increasing because of a force
        - We can say the momentum of the ball or stomp rocket are increasing due to a force
        - There is a relationship between the rate of change of momentum and the force applied to the object
        - Write it down as a rate of change of momentum with relation to its force applied
        - P = mv or dp/dt = d/dt (mv)
        - dp/dt = m dv/dt = ma = F = rate of change of momentum is equivalent to a force
        - Rate of change of momentum *results* from an applied force
    - Throw ball against a wall
        - Assume it bounces off the wall and comes back at the same speed. Is the velocity constant?
            - No because it changed direction, velocity is a vector
            - Is momentum constant when it bounces off a wall?
            - A rate of change in momentum occurs because of a force acting on the wall. It still works because the momentum changes because the wall is exerting a force on the ball.
            - The ball is accelerating by the force acting on the ball when it bounces off the wall
            - So velocity is changes as acceleration is changing *direction*
        - The ball accelerates because it changed *direction* or it can change in *time*
    - Change of momentum in *space* and *time*
        - So the diff eq is now: rho (dv/dt) + rhho v \dot \delta v = \sum F

        - Where we sum the *temporal acceleration* and the *spatial acceleration* of rate of change of momentum is equal to the sum of forces
- Goal of activity is to connect messy 3d vector equations with partial derivatives to an intuitive thought like mass * acceleration.

Discussion:

- Did you see a better understanding of the concept on an exam? Did you compare with and without the example?
    - Have not done this but they mention it allows them to connect and remember back to the lecture
    - Discuss example of tubes at a t-junction, water with forces at an angle
- How do you provide enough examples for biological processes and which book would you use?
    - I don't send them to a specific book, so one strategy is to use physical examples and then send them out to find a force example with fluids and how it changes to the momentum of the fluid.
    - Example: momentum change flowing through a stenosis artery