Beamers Balance Balance

Trisha Ho | Fall 2025

Field(s) of Interest: Physics, Biology

Brief Overview (1-3 sentences):
Students will explore the physics of balance through various physical and hands-on activities. They should understand how center of gravity, base of support, and weight distribution influence stability and motion.

Agenda:

- Introduction (5 min)
- Module 1: T-Pose (10-15 min)
- Module 2: Tipsy Butterfly (15-20 min)
- Module 3: Twist and Turn (15-20 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- ➔ Balance
- ➔ Center of Gravity
- ➔ Body Stability
- ➔ Base of Support
- ➔ Weight Distribution
- ➔ Symmetry
- ➔ Lines of Symmetry
- ➔ Gravity
- ➔ Torque
- ➔ Angular Momentum
- ➔ Centripetal Force
- ➔ Centrifugal Force

Background for Mentors

Module 1

- Balance
- Gravity
- Center of Gravity
- Base of Support
- Body Stability

Balance is the state in which an object's center of gravity is positioned such that all the sum of all the forces is equal to zero. $\sum F = 0$. There are no rotational forces trying to tip the object over. If the torque from gravity on one side exceeds the counteracting torque on the other side, the object will tip or fall.

Gravity is the force that pulls the body or an object towards the center of the Earth. The equation for this is $F_g = m * g$. Gravity acts vertically downward through an object's **center of gravity** which is the point where the total weight of an object is considered to act. In uniform objects, the center of gravity occurs at the geometric center. For irregular or moving systems, it can shift! For example when your right arm out, your center of gravity moves to the right.

The **base of support** is the area beneath an object or person that includes every point of contact with a surface. For a person standing, their base of support would be the area between their feet. Having a larger base of support increases stability. When the center of gravity is outside of this base, the person or object will fall.

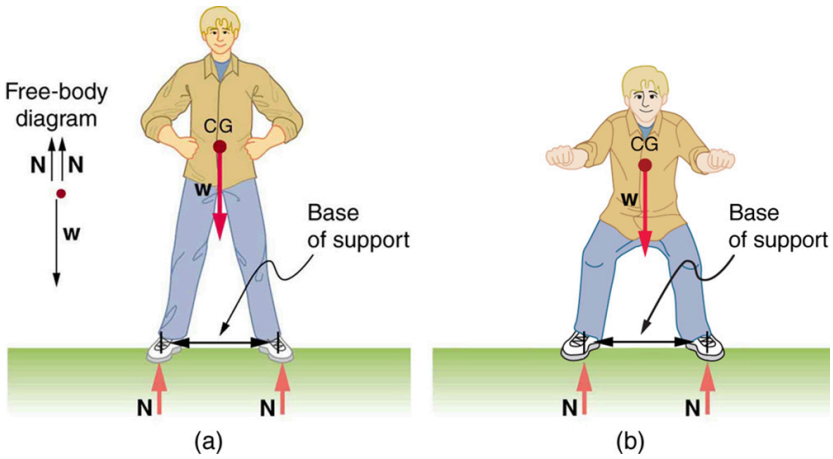
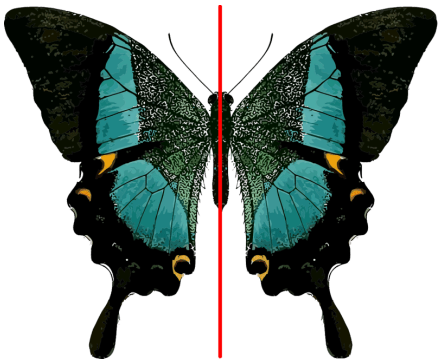


Figure 1: A diagram showing the base of support as the man moves his center of gravity downward.

Body stability is the ability to maintain balance. These factors are determined by the base of support, the height of the center of gravity, and weight distribution.

Module 2 • Weight Distribution • Symmetry • Lines of Symmetry	**Weight Distribution** refers to how an object's mass is spread across the system. This influences an object's balance and stability because weight distribution affects where the center of gravity lies in a system. If the mass is unevenly distributed, the center of gravity shifts to the heavier side which would cause the system to tip over. **Symmetry** occurs when one part looks the same as another. There are three main types of symmetry: reflectional symmetry, rotational symmetry, and translational symmetry. Reflectional symmetry occurs when an object can be mirrored across a line and look the same. This is a **line of symmetry**. Rotational symmetry is when an object looks the same after being rotated. Translational symmetry occurs when a pattern repeats itself as it is moved or shifted. For the context of this lesson, reflectional symmetry is important for an object to maintain its balance.  **Figure 1:** The line of symmetry shown on a butterfly A line of symmetry divides an object into two identical, mirroring halves. In order for an object to be balanced, its mass must be distributed symmetrically on both sides.

Module 3

- Torque
- Angular Momentum
- Centripetal Force
- Centrifugal Force

Torque is force that causes an object to rotate around a pivot. The equation for this is $\tau = r \times F$ where τ is torque, r is the distance from the pivot point, and F is the applied force. Applying force further from the pivot creates a larger torque. In balance, torque determines whether an object will fall or stay upright.

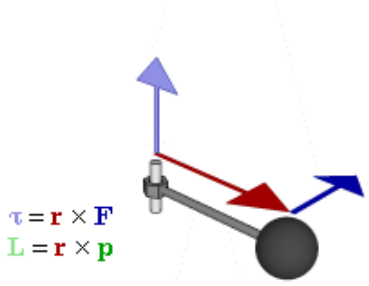


Figure 1: Torque animation

When the torque on all sides are balanced $\sum\tau = 0$. The system is in rotational equilibrium and will stay balanced.

Angular momentum is a measure of how much rotational motion an object has. The equation would be $L = I\omega$. It is the moment of inertia times the angular velocity which is how fast the object is spinning. It is important to note that angular momentum is conserved meaning it is constant unless acted on by an outside force.

Centripetal force is the inward force that keeps an object moving in a circular path. Without centripetal force, the object would move in a straight line due to inertia which is an object's resistance to change in motion. The equation for centripetal force is: $F_c = \frac{mv^2}{r}$

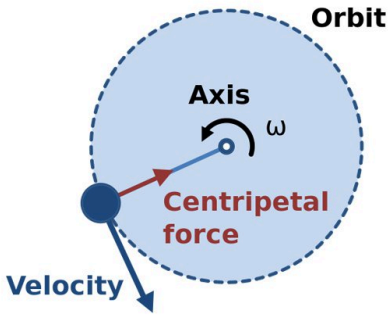


Figure 2: Centripetal force diagram

Centrifugal force is NOT a real force, rather it is a perceived force that is experienced in a rotating frame. This perceived force feels like being pushed outwards from the center of rotation, but it is actually just the object's inertia resisting the inward pull of centripetal force.

Introduction

Balance is everywhere from how we walk or dance to how objects stay upright over time. The concept of balance connects physics with biology and engineering, allowing the mentees to understand how structure and forces shape movement.

Concepts to Introduce ● Center of Gravity ○ A point in the system where all the weight is evenly distributed ● Base of Support ○ The area beneath a person or object with a supporting surface ● Weight Distribution ○ How weight affects stability and movement	**Questions to Pique Interest** ● Can anyone do a handstand? ● What happens when you spin around really fast? ● Why do figure skaters pull their arms in to spin faster? ● Why is it easier to balance on two feet rather than one?
Scientists, Current and Past Events ● **Archimedes** was the first to study center of gravity, but later **Girolamo Cardano** and **Galileo Galilei** refined his ideas and applied them to mechanics ○ **Isaac Newton** further developed the concept	**Careers and Applications** ● Structural Engineering deals with the base of support and weight distribution across the structure. ● Physical Therapy/Sports Science try to optimize body stability and balance. ● Mechanical Engineering uses torque and angular momentum in systems that involve rotation (such as **gyroscopes)**

Module 1: T-Pose

Through a series of poses, mentees will test their body stability by changing their center of gravity and base of support.

Teaching Goals	**Materials**
1. **Balance:** An even distribution of weight that allows someone or something to remain upright and steady 2. **Gravity:** the force that attracts a body toward the center of the earth, or toward any other physical body having mass. 3. **Center of Gravity:** The point in a system where its weight is evenly balanced in all directions 4. **Base of Support:** The area beneath an object or person that includes every point of contact with a supporting surface. 5. **Body Stability:** The ability to maintain balance by keeping your center of mass over your base of support.	• None

Different Methods for Teaching

Real-life Examples: Have the mentees test out the concept themselves, have a mentor draw a diagram showing center of gravity. Ask the mentees why they think one pose allows them to remain upright while another causes them to fall.

For Older Sites: Mentees might find this really easy. Try to think of more difficult poses they can try and turn it into a game!

Procedure

1. Mentees will stand up and try out different poses that test their balance and their knowledge of the teaching goals
    a. High vs. low center of gravity
    b. Wide vs. small base of support
    c. On one foot with arms in vs. out
    d. Both arms and one leg extended in front of the body
    e. Both arms extended in front and 1 leg in the back
2. Optional:
    a. To make it more difficult have the

Figure 1: *Tree pose*

mentees close their eyes while trying to balance b. Turn it into a simon says balancing game!	 **Figure 2:** *Crane Pose*

Classroom Notes

Make sure mentees have enough space so they don't hit each other.

Module 2: Tipsy Butterfly

Mentees will move the center of gravity of a paper butterfly by using pennies to change the weight distribution.

Teaching Goals	**Materials**
1. **Weight distribution:** How an object mass is spread out across its structure. 2. **Symmetry:** being made up of exactly similar parts facing each other or around an axis. 3. **Lines of symmetry:** The line(s) over which an object experiences reflectional symmetry	• 2 pennies per student • 1 toothpick per student • Cardstock butterfly templates • Markers • Scissors • Tape

Different Methods for Teaching

How might symmetry benefit balance? If an object is perfectly symmetrical what will the weight distribution be like? How did the center of gravity change once the pennies were added?

Tying the activity back to teaching goals:

1. Adding pennies to the butterfly changes where the mass is spread out.
2. Encourage the mentees to predict what will happen to the center of gravity when the weights are added.
3. Try placing pennies in asymmetrical positions; at different heights from one another.

Real life examples:

1. **Weight Distribution**:
    a. Have mentees think about holding their backpack with only one shoulder vs. both.

Procedure

1. Mentees will decorate and cut out their butterfly
2. Try to balance the paper on one finger, noting that the center of gravity is in the middle of the butterfly
3. Tape the toothpick along the line of symmetry, with a bit of the toothpick sticking out of the head
4. Tape the pennies near the top of the wings
5. Try to balance the butterfly again, noting that the center of gravity has shifted forward due to

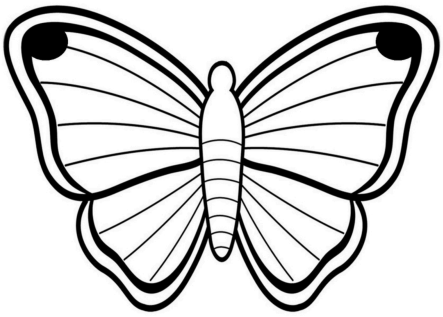
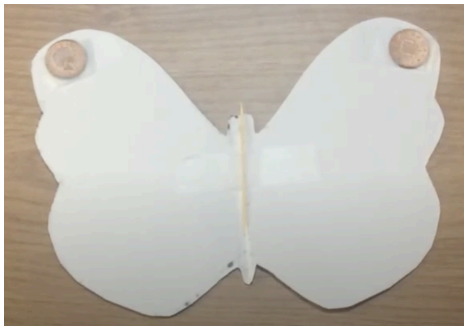


Figure 1: *Butterfly template*

a change in weight distribution.	 **Figure 2:** *Final result! This is what the butterfly should look like once.*

Classroom Notes

Ensure the pennies are placed in the exact same spot on both wings.

Module 3: Twist and Turn

Mentees will create their own top to see what shapes and weights allow the top to spin the longest.

Teaching Goals

1. **Torque:** Twisting or turning force that causes an object to rotate around a point or axis
2. **Angular Momentum:** The tendency of a spinning object to keep spinning unless acted on by another force.
3. **Centripetal Force:** Inward force that keeps an object moving in a circular path.
4. **Centrifugal Force:** Fictional outward force that seems to push an object away from the center of a circle. The effect of inertia making the object want to move straight while being pulled in a circle.

Materials

- 3”x3” cardboard sheet per mentee
- 1 toothpick per mentee
- Sheet of paper
- Pencil
- Glue Dot

Different Methods for Teaching

1. Experiment with weight distribution and encourage the mentees to predict what will happen before each trial
    a. Start with no pennies
    b. Add on one penny - watch as it wobbles
    c. Add the second one on the opposite site
2. Experiment with different shapes and have mentees cut out circles, stars, triangles, etc to test which spins best
    a. Symmetrical shapes usually spin longer because the mass is evenly distributed
    b. Uneven shapes create unbalanced torque causing the top to fall faster.

Highlight that centrifugal force is not an actual force, rather it is the effect of inertia wanting to move the object straight.

Procedure

1. In order to mark the center of the cardboard sheet, fold the paper in half and then half again.
2. Draw a design along the folded corner to ensure the mentor can easily find the center. Get creative with the designs! This is where the mentor will poke the toothpick through.

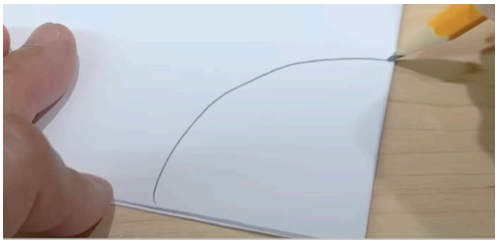


Figure 1: *Drawing a circular design*

3. Unfold the sheet and tape it to the cardboard.
4. Cut out the design.
5. Use the toothpick of a skewer to poke a hole through the center of the cardboard.
6. Place a glue dot over the hole and place the toothpick through.
7. If using the toothpick doesn't puncture the cardboard, use a skewer then cover both ends with tape. Then push the toothpick through.
8. Optional: Take the pennies from the butterfly and add it onto the sides of the top to affect the weight distribution.

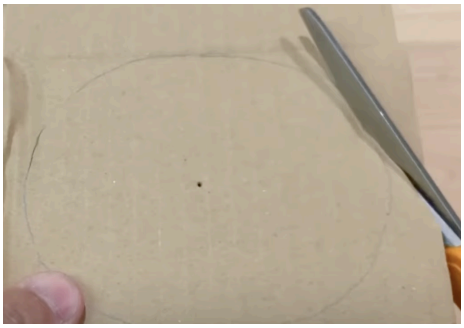


Figure 2: *Cutting out the top*

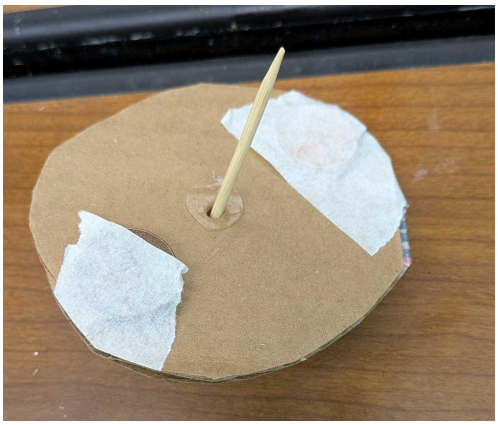


Figure 4: *Completed top with pennies taped to it*

Figure 4: *Tape placed over the hole the skewer made*

Classroom Notes

Only the mentors should be puncturing the cardboard. Make sure to take the pennies back after the lesson.

Conclusion

Wrap up with a class-wide review of how balance depends on the relationship between center of gravity and base of support. Reinforce how symmetry, weight distribution, and angular momentum can increase stability in systems.

Summary Materials Table

Material	**Amount per Site**	**Expected $$**	**Vendor (or online link)**
Toothpick	2 per student	5	Amazon
Cardstock	½ sheet per student	13.50	Amazon
Markers	1 per student		McL
Pencil	1 per student		McL
Tape	2 rolls		McL
Scissors	5 per site		McL
Pennies	2 per student		McL
Paper	1 per student		McL
Skewers	5 per site		McL
Glue Dot	1 per student		McL