# Balancing Demonstrations

## TEKS Objectives

This lab correlates to the following TEKS objectives:

P.3 The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

B. communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials.

## Driving Question

How does an object balance, what is required to balance an object, and how can this be demonstrated?

## Background Information

Research your project topic based on the driving question above. Use any resources available to research background information that will help you to complete your project.

Below is a list of key words that may be helpful when doing your background research.

- Balance
- Center of mass
- Point of contact
- Lever arm
- Moment arm
- Rotational equilibrium
- Static equilibrium
- Center of gravity
- Torque
- Net torque
- Weight shift
- Linear equillibrium

## Safety and Maintenance

Pay attention to the following maintenance recommendations, and add these important safety precautions to your normal laboratory procedures:

- All balancing objects may fall. Use caution to ensure that none of the objects you are balancing are in danger of breaking or causing injury if they fall.
- If you choose to use any tools to help construct a demonstration system, please use extreme caution and observe all safety recommendations from the tool's manufacturer.

## Investigation

Below is a list of ten sets of demonstration equipment. Choose five sets of equipment and determine how each chosen set can be used to demonstrate how a complex system, constructed from the equipment in the set, can be balanced about a singular point. For each demonstration you must be prepared to show the complex system created from the equipment in the set and explain what requirements are necessary to balance the system, and why those requirements are necessary?

| SET # | Equipment | |
|---|---|---|
| 1 | ♦ Balancing bear, or similar toy | ♦ Thread |
| 2 | ♦ Balancing bird<br>♦ Salt shaker | ♦ Toothpick |
| 3 | ♦ Fork (2), or 1 fork and 1 spoon<br>♦ Salt shaker | ♦ Toothpick (2) |
| 4 | ♦ Soda can | ♦ Water |
| 5 | ♦ Long-necked bottle, empty or full | ♦ Wooden board, 1”× 4” × 18” |
| 6 | ♦ Jenga® blocks | |
| 7 | ♦ Inflatable, self-righting, punching toy (bop bag) | |
| 8 | ♦ Hammer<br>♦ Ruler | ♦ String |
| 9 | ♦ PASCO Stability model | ♦ Small flat wooden board, 20” x 10” |
| 10 | ♦ Board with one 9” nail driven, vertically, into the center of the board | ♦ 9” nails (10) |

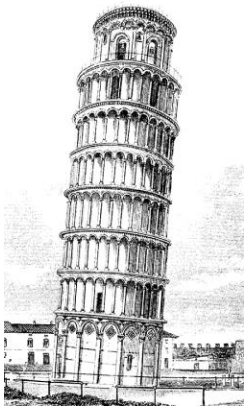
## Extension and Synthesis Questions

The answers to the following questions will guide you to further critical thinking about your project topic and will build knowledge to help answer questions your classmates may ask when you make your presentation.

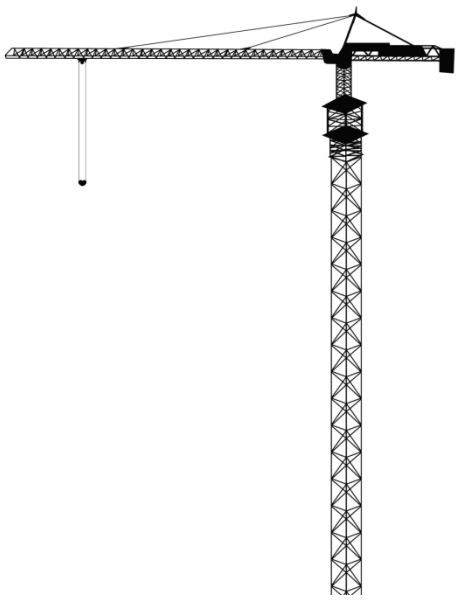
**1. What do the terms “center of gravity” and “center of mass” mean, and how are they different?**

**2. If an object is not moving (static equilibrium) what is the net force acting on it? What is the net torque? How do you know?**

**3. The Tower of Pisa is a famous cathedral bell tower in Italy. It may be most famous for its unique tilt as a result of the ground under one side of the tower being too soft to support it. To the right is an image of the Tower of Pisa. Although the tower appears as if it is about to topple over, it does not. Explain why this is so.**



**4.** **Observe the crane to the right. Assume the vertical tower is fixed and the horizontal arm can rotate freely (vertically and horizontally) atop the vertical tower. If the horizontal arm is in static equilibrium, where is its center of mass located? How do you know?**



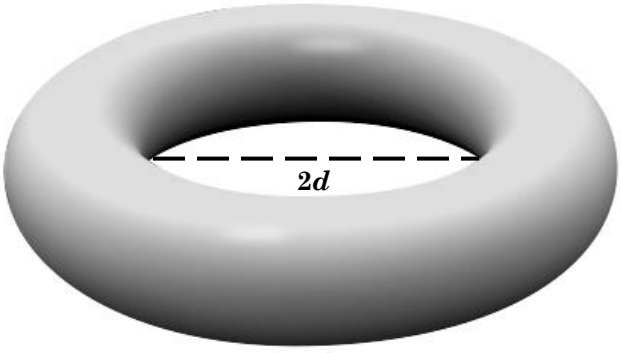
**5.** **Without moving its position, imagine the crane lifted a piece of metal whose mass was greater than that of the entire horizontal arm. How would the center of mass of the horizontal arm change once the metal was lifted? How would that change its equilibrium?**

**6.** **Assuming the horizontal arm on the crane rotates freely, what is one thing you could do to the crane to keep the horizontal arm in equilibrium when the metal from the previous question is lifted?**

**7.** **When a person opens a door is the person producing torque? If yes, how do you know?**

**8.** **Why does a person carrying a heavy package while walking lean back slightly? What would happen if the person didn't lean backward while carrying the package? Why?**

**9.** **Below is an image of a solid metal ring with an inside diameter equal to $2d$. If the ring has uniform density throughout, where is its center of mass? How can you balance the ring on a single point? Explain your answer. Would you need any additional materials to balance the ring? If yes, what would those materials be and how would you use them?**



| **Assessment Rubric**<br>**Level II** | | **Name:**<br>**Math Class:** | | | | |
|---|---|---|---|---|---|---|
| **Component** | To receive highest marks the student: | **4**<br>**Expert** | **3**<br>**Prac-titioner** | **2**<br>**Appren-tice** | **1**<br>**Novice** | **0**<br>**No Attempt** |
| 1. Preparation and Research | □ Clearly invested several hours doing relevant research<br>□ Brought and prepared all items necessary for their presentation<br>□ Prepared supporting handout for their presentation<br>□ Prepared a thorough presentation discussion for their classmates | | | | | |
| 2. Demonstrations, Models, or Experiments | □ Obtained all necessary materials and used them to thoroughly explore the guiding questions for Part 1 of the investigation<br>□ Completed and documented results, data, and observations of any guiding questions investigated in Parts 1 – 3 of the investigation<br>□ Performed experiments or demonstrations proficiently for others, or explained clearly a model and the concepts the student investigated with the model | | | | | |
| 3. Content | □ Presented written and spoken explanations that were mathematically accurate and paraphrased in the student's own words<br>□ Answered all questions posed by their teacher or classmates correctly and thoughtfully<br>□ Answered project synthesis and real-world application questions correctly and thoroughly<br>□ Communicated clearly an understanding of the connection between their model or experiments and the driving question and theory behind the over-arching concept | | | | | |
| 4. Technology | □ Prepared a **website** explaining their project and the driving question associated with it, including:<br>• A thorough, well-written explanation of the answer to the driving question and the theory behind the over-arching concept<br>• Supporting pictures, videos, and research references (including web-links)<br>□ Recorded a supporting **video** for the website<br>• Edited the supporting video in an attempt to produce a good–excellent quality video<br>• Included footage of their experimental setup with an explanation<br>• Included a thorough, well-spoken explanation of the answer to the driving question and the theory behind the over-arching concept<br>□ Produced a project **brochure** with 2 **QR codes** linking to video and to website | | | | | |
| 5. Interdisciplinary Connections | □ Chose and completed ELA option to best illustrate the project's objectives and monitor student progress<br>□ Included the ELA component on project website as separate page with appropriate design<br>□ Chose a related SS connection based on consultation with SS teacher<br>□ Included the SS connection on project website as separate page with appropriate design<br>□ Included ELA component and SS connection in video presentation | | | | | |
| 6. Real-World Application and Extension | □ Identified in written and spoken explanations the application of the topic to the real world, including specific examples<br>□ Thoroughly discussed relevance of the topic to real life | | | | | |
| 7. Presentation | □ Delivered their content clearly and thoroughly, in an organized, logical manner<br>□ Integrated their research and experimental setup into the presentation as visual support | | | | | |
| | | | | | **Total Points for Investigation (Maximum of 24 Points)** | |

Guidelines for Marks:

4 = **Expert:** Distinguished command of the topic; students show insightful and sophisticated communication of their understanding

3 = **Practitioner:** Strong command of the topic; students show reasonable and purposeful communication of their understanding

2 = **Apprentice:** Moderate command of the topic; students show adequate but basic communication of their understanding

1 = **Novice:** Partial command of the topic; students show limited and insufficient communication of their understanding

0 = **No Attempt**