Lesson Title: Torque

Total Time: 60 Minutes

Brief Description: In this lesson, students will watch ***The House That STEM Built*** video titled *"Torque"*. This video demonstrates the concept of dynamic and static torque including how to use the Torque equation. Students will complete a Phet Simulation where they can create their own scenario and use the equation to solve for Torque.

Curriculum Outcomes: Taken from the New Brunswick Physics 12 Curriculum

General Curriculum Outcomes: Force and Motion

Specific Curriculum Outcomes: ACP-1: Use vector analysis in two dimensions for systems involving two or more masses, relative motions, static equilibrium, and static torques

New Brunswick Global Competencies Achieved:
https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc
Critical Thinking and Problem Solving:

- Learners engage in an inquiry process to solve problems, as well as acquire, process, interpret, synthesize, and critically analyze information to make informed decisions.
- Learners construct, relate, and apply knowledge to all domains of life, such as school, home, work, friends, and community.
- Learners solve complex problems by taking concrete steps to design and manage solutions.

Learning Objectives:
The learner will be able to:

- Use the equation for Torque to solve for various values such as Torque, Force, and Radius

Materials:

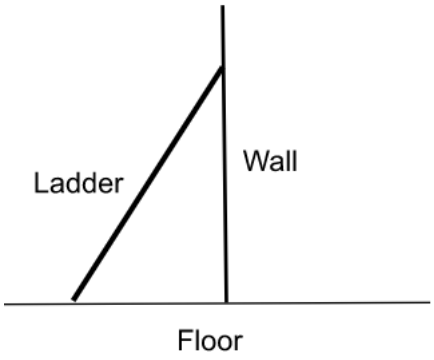
- Pencil/Pen
- Loose Leaf
- Calculator
- Electronic Device
- Handout titled Balancing Act Torque Lab

Before Class:

- Print **one** copy of the Balancing Act Torque Lab handout for **each** student

Warm-up: 5 Minutes

- In order get students thinking about torque and forces needed, ask students to draw a diagram of a ladder leaning on a wall. The diagram can look something like this:



- Once the diagram is drawn, have students draw arrows to represent the forces they think are acting on the ladder in order to keep it leaning against the wall.
- The answer will be revealed later in the video while discussing static torque

Activity: 50 Minutes

- Start watching ***The House That STEM Built*** video titled "*Torque"*
- At minute 0:55, pause the video and have students write out a definition of Torque in their notes. This activity should last **approx. 5 minutes**
    - Since there is no written out definition in the video that can be directly copied, ask students to come up with their own definition
    - After a few minutes, ask students to share what they wrote down
    - After a few students have shared their own definition, work together as a class to create a final definition
    - Take this final definition and copy it on the whiteboard so that students who are struggling to write their own can have something to copy
    - A good definition that the teacher can use is, **Torque is the twisting or turning effect when a force is applied to an object that rotates or spins on an axis**
- At minute 1:42, pause the video and have students copy the equation for torque and what each value represents
    - Equation: $\boldsymbol{\tau} = F \times r$
    - $\boldsymbol{\tau}$ = Torque in Newton Meters (Nm).
        - This represents the amount of torque
    - F = Force in Newtons (N)
        - This represents the applied force
    - R = Radius in meters (m)
        - This represents the distance from the pivot point (fulcrum) the force is being applied
- At minute 2:26, pause the video and ask students what they think will happen if two people of the **same weight and distance** from the pivot point (fulcrum) sit on a seesaw

    - **Answer**: the seesaw does not move because the net torque is zero
- At minute 2:51, pause the video and have students copy the definition of static torque in their notes.
    - **Definition:** Static torque occurs when the net torque is equal to zero.
    - $\tau 1 + \tau 2 = 0$
- At minute 3:14, pause the video and ask students the following question:
    - If the weight on one side of the fulcrum increases, what must happen for the net torque to remain zero?
        - **Answer**: the weight on that side of the fulcrum needs to move closer to the pivot point
- At minute 3:30, pause the video and have students copy the definition of Dynamic Torque in their notes
    - **Definition:** Dynamic Torque occurs when the net torque is **not** equal to zero
- At minute 8:41, pause the video and have students take out the diagram that they drew for the warm up activity.
    - The teacher should draw a couple of example diagrams on the board
    - Have a few students come to the board and draw where they think the arrows representing forces should be
- At minute 9:00, pause the video and have students draw the diagram on the screen in their notes. This diagram shows all the proper forces needed for static torque to keep a ladder in place. Discuss each of these forces.

Now that students have finished watching ***The House That STEM Built*** video titled *"Torque",* they will use a **Phet Simulation** to practice using the equation for torque

- Before students can begin the Phet Simulation, they will need to know how to convert weight into a force with units of Newtons. Students will write the following notes on a piece of looseleaf. This activity should take **approx. 5 Minutes**
    - Whenever we have a mass but would like to convert it into a force (Newton), we must multiply the mass by 9.8 m/s^2
    - **Example**:
        - We have a mass of 16 kg and we want a force in Newtons
        - 15 kg X 9.8 m/s^2 = 147N

Phet Simulation Activity. This activity should last **approx. 25 minutes**

- Have students log on to their electronic devices
    - If there are students who do not have an electric device, the activity can be done in pairs/groups
- Have students go to https://phet.colorado.edu/
- Once on the home screen, students should select the physics circle
- Once students have selected the physics circle, it will redirect them to a page full of online simulations. Students should scroll until they find the one called **Balancing Act** and select it
- Once **Balancing Act** is selected, students will hit the play button on the screen and select **Balance Lab**
- Once the simulation is on the screen, students should select **Rulers** under the **Position** tab

- Notice the ruler that appears on the screen gives measurements in meters. Meters are needed to solve for Torque!
- Students will place blocks of various weights on one side of the seesaw
- Students will solve for the torque being applied by using the equation, $\tau = F \times r$
- Students will solve for Torque 5 different times with various weights used. All work will be shown on the associated handout
  - Students must draw a diagram of the seesaw and the weights being used
  - Students must show all work
  - Alternative: students can take a screenshot of each scenario they create and submit the screenshot to the teacher

Conclusion: 5 Minutes

- The teacher will collect the handout from all students
- The teacher will decide if the worksheet will be used for marks or as a formative assessment tool

Differentiation:

Content:

- Use ***The House That STEM Built* – Torque** video to discuss other examples and jobs where torque is used
  - For example
    - Mechanic
    - Physicist
    - Industrial Engineers
    - Figure Skaters, gymnasts, and football players

Practice:

- Instead of students creating their own scenario with weights on the Phet Simulation, the teacher can provide the weight values to the students.

Product:

- Some students may prefer to complete the Phet Simulation worksheet online and insert screen shots vs hand drawings of the seesaw. If this is the case, the teacher should create a drop box on the schools preferred platform or have students email the worksheet to them

Extension:

- During the Phet simulation activity, the teacher can give a word problem that tells the students how much weight to put on the seesaw
- The teacher can provide their own values for the torque equation and have students solve for the missing value. For example, the teacher can provide the value of torque and radius and the students must solve for the force

Name: _____ Class:_____ Date:_____

Balancing Act Torque Lab

Directions:

- Use your personal device and go to https://phet.colorado.edu/
- Once on the home screen, select the physics circle
- Scroll until you find a simulation called **Balancing Act** and select it
- Once **Balancing Act** is selected, hit the play button on the screen and select **Balance Lab**
- Once the simulation is on the screen, select **Rulers** under the **Position** tab
- Place blocks of various weights on one side of the seesaw
- Solve for the torque being applied by using the equation, τ= F x r
- Draw the diagram of the seesaw with the weights
- All work will be shown on the associated handout
- Repeat this process 5 different times

Please Show All Work

Scenario 1:

Scenario 2:

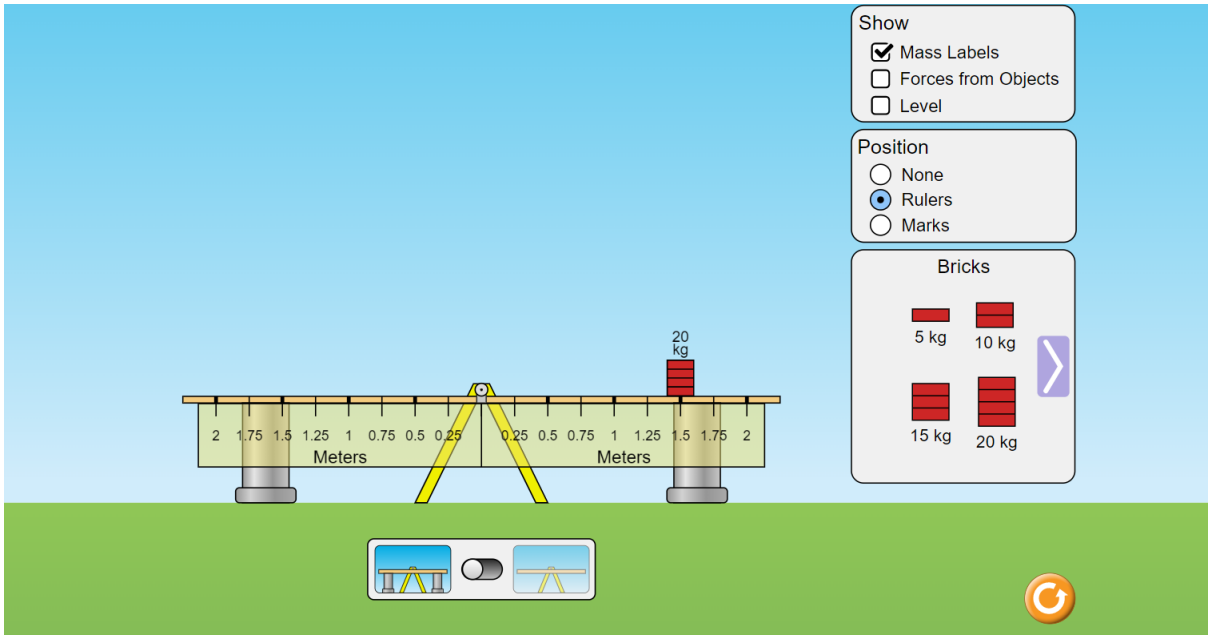
Scenario 3:

Scenario 4:

Scenario 5:

Name: _____ Class:_____ Date:_____

Balancing Act Torque Lab Exemplar



Solve for Force in Newtons:

Total mass on the seesaw is 20 kg
20kg X 9.8 m/s^2 = 196 N

Solve for Torque:

τ= F x r
τ = 196 N x 1.5 m
τ = - 294 Nm

Please Note:

Since the force of gravity is acting downward on the weights in this diagram and they are on the right hand side of the fulcrum, it will result in the seesaw rotating in a clockwise direction. A clockwise rotation is represented with a –'ve sign. Therefore, in this created scenario, the final torque should be expressed as -294Nm.