

# VEX IQ Teacher Facilitation Guide

## Tug of War Unit

### **A Note about Implementing VEX IQ (2nd generation) STEM Labs:**

*STEM Labs are designed to be an interactive Unit of instruction that you can use with your students to implement VEX IQ (2nd generation) in your setting. STEM Labs are student-facing content that is designed for students to directly interact with the videos, resources, and instructional materials to complete the Lesson activities. This Facilitation Guide is the teacher-facing companion, like a teacher's manual, providing the resources, materials, and information needed to be able to plan, teach, and assess with VEX IQ (2nd generation). For more detailed information about implementing STEM Labs in your classroom, [visit VEX PD+](#) for videos, expert tips, and more.*

### **Unit Overview**

In the Tug of War Unit, students will use VEXcode IQ to drive their BaseBot as they explore forces that affect its ability to pull objects, in preparation for a game of Tug of War.

- In **Lesson 1: Introduction** students will build the BaseBot and be introduced to the challenge of Tug of War.
- In **Lesson 2: Pulling Objects with the BaseBot**, students will design a rope attachment and practice pulling objects with their robot, to learn about how forces affect the robot's motion.
- In **Lesson 3: Using a Gear Train**, students will build and test various gear trains to learn about mechanical advantage and how the gear train affects the BaseBot's ability to pull an object.
- In **Lesson 4: Adding Mass**, students will add weight to their BaseBot to explore the concept of center of mass, to see how changing the center of mass affects their robot's ability to compete in Tug of War!
- In **Lesson 5: Tug of War Competition**, student groups will participate in a classroom competition of Tug of War, applying what they have learned through the Lesson activities to try to win the game.
- The **Lesson 6: Conclusion** wraps up the Unit by introducing students to STEM careers related to the learning they did in this Unit, like Mechanical Engineer; then engages students in a debrief conversation to share their learning, and reflect on their experiences.

**All Materials needed for this Unit** can be found in the [Master Materials List](#).

### **Teacher as Facilitator in this Unit**

The Tug of War Unit is designed to be student-facing so that students can directly interact with the Lesson content. This places the teacher in the role of facilitator of learning, rather than a supplier of information, in the classroom. As such, you can choose how you want the students to move through the Lesson content, based on the needs and interests of your students, and the places where you think they may need more or less direct instruction.

When preparing to teach, decide how students will interact with the **Learn** section of each Lesson.

Suggestions include:

- Whole class instruction - You can share the content in class alongside the Lesson Summary document, for whole group instruction, and facilitate conversations to check student understanding.

- Individual student instruction - If all students can access the content outside of class, you can have students read Lesson Summary and watch the Learn content as homework, then complete the CYU questions. In class, discuss the content and answer any questions.

When preparing to teach, decide how students will interact with the **Practice and Challenge Activities** in each Lesson. Step-by-step instructions are provided in linked Google docs within the Lesson content. Each Activity sheet can be edited to best meet the needs of your students. You may want to print those Activities out ahead of time and give them to your students, or project one in the classroom for all students to access at the same time.

This Facilitation Guide will offer reminders and tips for setup and modeling positive classroom culture for each Lesson. You know your students best, so tailor your teaching and Lesson implementation to best suit your students. The Tug of War Unit is designed to be flexible, so that you can meet students where they are, giving them the time, space, and instruction necessary to make the most of their learning.

### **Troubleshooting Tips for this Unit**

- Be sure that your VEX IQ Brains and Batteries are ready to use. For more information on getting started with VEX IQ, [see this section of the STEM Library](#).
- Students will need to have access to VEXcode IQ on their computers or tablets. For more information about installing VEXcode IQ, go to [code.vex.com](http://code.vex.com).
- Students can use the built-in Help within VEXcode IQ, at any time to learn more about the commands they are using. For more information about accessing Help, [see this section of the STEM Library](#).

### **Group Size and Student Collaboration**

- A group size of 3 students per VEX IQ Kit is recommended for all Lab activities.
- [For strategies to support student collaboration throughout this Unit, see this STEM Library article.](#)
  - Encouraging students to take ownership over certain responsibilities within their groups can help group work become a more student-led process, where all members of the group are participating and engaged in the Lesson.

## **Unit Vocabulary**

The suggested vocabulary for this Unit is meant to offer teachers a vehicle for establishing a shared language in the classroom when working with VEX IQ. Encourage students to work vocabulary words into their conversations throughout the Lab, so that they can use the terms confidently and correctly not only in this Lab but also in future VEX IQ experiences. You can use these words as a base list, and adapt them to best meet the needs of your students.

- **Force** - any influence that, when unbalanced, will change the motion of an object. Can also be described as a push or a pull.
- **Traction** - the force that makes an object move by pushing against a surface.
- **Mechanical Advantage** - a measure of the ratio of output force to input force in a system
- **Gear Train** - a mechanism that is made up of two or more gears

- **Driving Gear** - the gear which is connected to the input force (such as a motor)
- **Driven Gear** - the gear which is connected to the output (such as the wheel), and moves because it's connected to the input or driving gear
- **Torque** - measure of the force that can cause an object to rotate about an axis, also known as rotational force
- **Mass** - the amount of matter or substance that makes up an object
- **Center of mass** - the point on the object where force is applied so that it moves without rotation

# VEX IQ Teacher Facilitation Guide

## Lesson 1: Introduction

### **Lesson 1: Introduction Overview**

In this Lesson students will be introduced to the culminating competition game, Tug of War, build the BaseBot and add Balloon Tires, and set up their engineering notebooks for this Unit.

### **Prepare Your Classroom:**

Have the following spaces and materials ready prior to the start of class:

- An VEX IQ Kit for each group
- A charged VEX IQ Battery for each group
- A computer or tablet with access to VEXcode IQ for each group.
- Designated space to build the BaseBot for each group
- An engineering notebook for each student
- Optional:** A 'saving space' for groups to store their VEX IQ Kit and BaseBot for the duration of the Unit.

### **Reminders and Teacher Tips:**

- **To teach the Getting Ready section in less time**, have a brief discussion to reinforce what students will be doing with their engineering notebooks in the Unit.
- **Engage students' prior knowledge** by facilitating conversations as they are building, and compare and contrast this build with those they have done previously.
- For ideas on ways to engage students who finish building their robots more quickly than others, [see this STEM Library article](#).
- For more information about coding and building with VEX IQ, [see this section of the STEM Library](#).

### **Be Mindful of Mindset:**

- **Set the expectation for respectful communication** – Students will be working in groups to build the BaseBot. (For suggested roles for building the BaseBot, [see this STEM Library article](#).) Set clear expectations for how group work should function before beginning, to help ensure that all group members are engaged and working together in respectful ways.
  - Highlight groups that work efficiently together, and let students articulate their processes for themselves. For instance, “Group B seemed to have a great system to keep everyone involved, and built their robot really fast. Can you explain how you came to this system for the class?”

# VEX IQ Teacher Facilitation Guide

## Lesson 2: Pulling Objects with the BaseBot

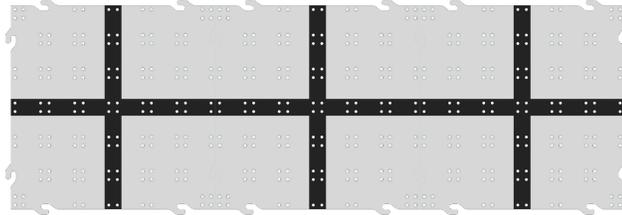
### Lesson 2: Pulling Objects with the BaseBot Overview

In this Lesson students will learn how forces affect the motion of the robot. They will explore these concepts by building a rope attachment for their BaseBot to be able to pull an object, so that they can prepare to play Tug of War.

### Prepare Your Classroom:

Have the following spaces and materials ready prior to the start of class:

- A VEX IQ Kit for each group
- A charged VEX IQ Battery for each group
- A computer or tablet with access to VEXcode IQ for each group.
- A prebuilt BaseBot from the previous Lesson for each group
- A VEX IQ Field that is 1 Tile by 3 Tiles, as shown in the image below.



- Note:** If you do not have a Field, you can tape out a 30cm (~1 ft) by 90cm (~3ft) space on a floor or other flat surface.
- An engineering notebook for each student
- Optional:** A 'saving space' for groups to store their VEX IQ Kit and BaseBot for the next Lesson.
- For Practice:** You will need 1 IQ Motion Bin to set up and complete the [Rope Attachment Practice Activity](#).
- For Compete:** You will need 1 IQ Motion Bin, and a timer or stopwatch, to set up and complete the [Robot Tractor Pull Challenge](#).
- Note for Practice or Compete:** If you would like to substitute a different object for the Motion Bin in the Practice or Compete activities, you can use the following weights as reference:
  - Empty bins - approximately 0.6 kg (1.4 lbs)
  - Motion Bin (without electronics) - approximately 1.5 kg (3.2 lbs)
  - Structure Bin - approximately 1.6 kg (3.6 lbs)

### Reminders and Teacher Tips:

- As students are learning about forces and how they affect their robots, facilitate conversations to engage their prior knowledge and draw on their experiences with balanced and unbalanced forces.
- Students should try their rope attachment in multiple positions on their BaseBot in order to make an informed decision about its location for the competition. To ensure that all students

have enough time to run multiple practice trials, allow as much class time as needed for all students to complete the Practice Activity.

- **Teacher Tip:** Have students prepare for the Challenge Activity on a similar surface to the one they will use for the challenge. Students may notice a difference in how their robot drives on a Field as compared to a carpeted surface.
- To learn more about facilitating Challenge competitions, including logistics and setup, [see this STEM Library article](#).

### **Be Mindful of Mindset:**

- **Frustration is natural, and it is ok** – It may take students several attempts to find a rope attachment and placement that is successful. This may incite a wide range of emotions in students. This is not only ok, it is encouraged! Help students to lean into the iterative process, including the potential frustration that can arise when they are not instantly successful. Celebrate perseverance, and highlight groups that tried repeatedly, worked together, and maintained focus through the frustration.
  - **What was your ‘Focus Over Frustration’ moment today?** One way to do this is to wrap up class with a moment to have students articulate for themselves the strategies they used to help them learn from their mistakes and persist, even when they felt frustrated or disappointed.

# VEX IQ Teacher Facilitation Guide

## Lesson 3: Using a Gear Train

### **Lesson 3: Using a Gear Train Overview**

In this Lesson students will learn about gears and mechanical advantage, and how that applies to their BaseBot. Students will create and test different gear trains on their BaseBot, to see how the gear trains affect the robot's mechanical advantage, and its ability to pull an object, to determine which will work best in the game of Tug of War.

### **Prepare Your Classroom:**

Have the following spaces and materials ready prior to the start of class:

- A VEX IQ Kit for each group
- A charged VEX IQ Battery for each group
- A computer or tablet with access to VEXcode IQ for each group.
- A prebuilt BaseBot from the previous Lesson for each group
- A VEX IQ Field that is 1 Tile by 3 Tiles (as in the previous Lesson)
  - Note:** If you do not have a Field, you can tape out a 30cm (~1 ft) by 90cm (~3ft) space on a floor or other flat surface.
- An engineering notebook for each student
- Optional:** A 'saving space' for groups to store their VEX IQ Kit and BaseBot for the next Lesson.
- For Practice:** Each team will need access to both bins of their IQ Kit to change the gear trains, and complete the [Comparing Gear Trains Practice Activity](#).
- For Compete:** You will need an IQ Motion Bin for each team to pull to complete the [Gear Train Tractor Pull Challenge](#).
  - Note:** If you would like to substitute a different object for the Motion Bin in the Compete activity, you can use the following weights as reference:
    - Empty bins - approximately 0.6 kg (1.4 lbs)
    - Motion Bin (without electronics) - approximately 1.5 kg (3.2 lbs)
    - Structure Bin - approximately 1.6 kg (3.6 lbs)

### **Reminders and Teacher Tips:**

- You may want to have extra gears available as students are engaging with the Learn content, so they can see and feel the differences between each, and how they mesh together.
- **If students are having trouble figuring out how to construct a gear train** - have them sketch from the example image in the Introduction in their engineering notebook, and label each part with the corresponding VEX IQ piece. Pay particular attention to how the motor and wheel will be connected through the gear train. Then, take turns to add one piece at a time to their BaseBot. Or, you may want to build a common gear train addition as a whole class, and just have students change out the gears to test each gear train.
  - If your students still need additional help constructing a gear train, [you can view these build instructions](#) that show how to create one half of the gear train for the BaseBot. Please note that this is just one possible example, you and your students can create different types of gear trains.

- To encourage all students to stay organized and engaged during Practice, have them set up a data collection format in their engineering notebook prior to starting their projects. Be sure that measuring tapes or rulers are readily available for students as well.
- **Reminder:** Remind students that their engineering notebooks are designed to be unique to them, and do not need to be perfect. Give options for how to document learning, like sketching or printing photographs of different gear combinations, or offer the class a data collection table that they can copy into their notebooks.
- For more information about the different VEX IQ Gears and gear ratios, [see this STEM Library article](#).
- To learn more about facilitating Challenge competitions, including logistics and setup, [see this STEM Library article](#).

### **Be Mindful of Mindset:**

- **There is no such thing as “I’m done.”** – There is always something that can be further iterated on in a STEM Lab Unit. Students can revisit previous decisions they made about robot design, they can add to their engineering notebooks, they can try a new design for a gear train, and more. The goal of these Lessons is not to create the ‘perfect’ robot – it is to continue to learn through iteration. As such, iteration is never complete!
  - If students say that they are ‘done’ during class, have them continue to iterate on a component of their build, or work on a new element of their robot’s design in their engineering notebooks.

# VEX IQ Teacher Facilitation Guide

## Lesson 4: Adding Mass

### Lesson 4: Adding Mass Overview

In this Lesson students will get ready to compete in the Tug of War game by adding additional weight to their BaseBot, to explore how changing the BaseBot's center of mass affects the robot's ability to pull.

### Prepare Your Classroom:

Have the following spaces and materials ready prior to the start of class:

- A VEX IQ Kit for each group
- A charged VEX IQ Battery for each group
- A computer or tablet with access to VEXcode IQ for each group.
- A prebuilt BaseBot from the previous Lesson for each group
- A VEX IQ Field that is 1 Tile by 3 Tiles (as in the previous Lesson)
  - Note:** If you do not have a Field, you can tape out a 30cm (~1 ft) by 90cm (~3ft) space on a floor or other flat surface.
- An engineering notebook for each student
- Optional:** A 'saving space' for groups to store their VEX IQ Kit and BaseBot for the next Lesson.
- [See the Practice Activity Document linked here](#) for setup and other details.
- [See the Challenge Document linked here](#) for setup and other details.

### Reminders and Teacher Tips:

- There are some Kit components, like the Controller, or the boxes of pieces, that should **not** be used to add mass, to prevent pieces from becoming broken or lost during the Tug of War. Be sure that students know which pieces are off limits, by posting a list on the board, so that your classroom is set up for success in the Lesson.
- You may want to keep a practice Field available, so that students can continue to practice while waiting for their turn to compete.
- To learn more about facilitating Challenge competitions, including logistics and setup, [see this STEM Library article](#).

### Be Mindful of Mindset:

- **Encourage Scouting** – As students are iterating on their builds throughout the Lesson, encourage them to look to other groups' builds and iterations for inspiration. Students can not only learn within their groups, but from and with other groups in the class. There is often a negative association to 'copying', but testing out another group's design and then iterating on it, builds students' capacity for problem solving, thinking flexibly, and collaborating.
  - Build this into your Lesson by having a 'BaseBot Show & Tell' time, where groups can share their builds with one another, explain their design process and the rationale behind their choices, and ask questions about how it works. Have students document

what they learned, and what ideas it prompted in their engineering notebook, which they can refer to when preparing for the classroom competition.

# VEX IQ Teacher Facilitation Guide

## Lesson 5: Tug of War Competition

### **Lesson 5: Tug of War Competition Overview**

In this Lesson students will apply what they learned to compete in a Tug of War classroom competition! Teams will compete one on one, to pull their opponent. The robot furthest from the centerline on the Field when the project stops is the winner. First, students will have an opportunity to develop a game strategy and iterate on their BaseBot, then they will compete in the competition.

- **To learn more about running a classroom competition, like logistics and setup,** [see this STEM Library article.](#)
- **To learn more about facilitation strategies for classroom competitions,** [see this STEM Library article.](#)

### **Prepare Your Classroom:**

Have the following spaces and materials ready prior to the start of class:

- A VEX IQ Kit for each group
- A charged VEX IQ Battery for each group
- A computer or tablet with access to VEXcode IQ for each group.
- A prebuilt BaseBot from the previous Lesson for each group
- A VEX IQ Field that is 1 Tile by 3 Tiles for the Competition Matches (as in the previous Lesson)
  - Note:** If you do not have a Field, you can tape out a 30cm (~1 ft) by 90cm (~3ft) space on a floor or other flat surface.
- An engineering notebook for each student
- A 'practice space' for teams to practice and refine their strategy as they get ready to compete.
- 'Team meeting' spaces, for teams to meet together, to iterate on game strategy and their robots.
- Optional:** Labels for each space in the classroom, with notes on the board for students to reference as they move through the room during the Competition
- A match schedule and leaderboard
  - To learn more about running a classroom competition, like logistics and setup, [see this Knowledge Base article.](#)

### **Reminders and Teacher Tips:**

- Encourage students to use the match schedule to set parameters and time limits for teams' iterations between matches.
- You can use the [Tug of War Competition Activity Document](#) to print or project and share with students throughout the Lesson.
- **Reminder:** Remind students that the engineering design process should be applied many times throughout the competition. In their teams, they should choose one thing at a time to iterate on, and document the changes, the test results, and the implications in their engineering notebooks.
- If students are struggling to identify a game strategy, offer some examples of robot design strategies like: putting more mass in the front of the robot, putting more mass in the back,

making the mass uniform, changing the gear train, or putting the rope attachment in the center of the robot.

- **Teacher Tip:** During the iterative process, students may make incorrect assumptions or predictions about how their changes will affect the robot's performance - that is ok. Give students the space to make mistakes and to learn from those mistakes, so that they can engage in authentic problem solving and evidence-based iteration.
- To learn more about facilitation strategies for classroom competitions, [see this STEM Library article](#).

### **Be Mindful of Mindset:**

- **Highlight the quieter voices** – It is sometimes easy for the 'loudest voice' in a group to take control over decision making or strategy. Establish practices to be sure that all voices are heard before a strategy is tried. You may want to have students document their ideas for a game strategy individually, before they begin verbally discussing it together, so that students who may be quieter can still contribute to the conversation.
  - To help ensure that **all** members of the team have a voice in developing game strategy, circulate around the room as students are working, or have them check in with you, and ask questions like:
    - Can everyone on your team explain your game strategy to me? How did you come to an agreement about your approach? Were there any other ideas that you might want to try?
    - How is each member of your team involved in strategizing? Can you show me how you are documenting your strategy so far?
- **Continue to reward process over product** – In a competition like Tug of War, students may fall into the default mindset that only the strongest robot in the class is the 'winner'. To help keep the process over product mentality alive throughout the competition reward students for unique robot designs, risk taking throughout the Unit, strong group work, persistence and perseverance, collaboration, communication, and more. This can be in the form of 'superlative' certificates, or a non-tangible reward like having an extra privilege in class. You know your students best, so tailor your positive reinforcement accordingly.

# VEX IQ Teacher Facilitation Guide

## Lesson 6: Conclusion

### **Lesson 6: Conclusion Overview**

In this lesson, students will reflect on their learning and experiences in the Unit, to share their learning with the class and see how that connects to various career paths.

### **Facilitating Career Connection**

- **Make It Personal** - There are two career connections offered in the Unit, but you can adapt those to offer different career connections that may be better suited to your students. If you know someone that works in a related field, or your students have expressed interest in a particular career path that relates to the Unit, find ways to incorporate those personal connections to deepen students' engagement.
- **Facilitating the Choice Board** - Consider how you want students to interact with the Choice Board. The goal of the Choice Board is to give students an opportunity to express voice and choice in their learning, so think about the following as your plan your lesson:
  - Will students choose activities individually or in their groups?
  - When and how will students complete the task?
  - How will they share their learning?
  - Can students complete more than one Choice Board activity?

The Choice Board can also be adapted with activities that are better suited to your students.

### **Facilitating the Debrief Conversation**

- **Be Mindful of Mindset:** Build trust with your students to support meaningful student self-assessment. Students must feel comfortable to share their learning, and the mistakes they made along the way, with their teacher, and doing this requires some vulnerability. Be mindful of how you are engaging with students throughout your class time, so that you can build a foundation for honest self-assessment.
- **Organize Debrief Conversations** - You may want to set up a schedule so that students can sign up for debrief conversations as they are ready. Be sure that students have access to the [rubric\(s\) that will be used for the Debrief Conversation](#). (These rubrics are editable Google docs, that you can customize to meet your needs and the needs of your students.)
- **Conclusion Activities** - Make sure that students have something to do while they are waiting for their debrief conversation with you. If students finish their self reflection early they can:
  - **Add to their engineering notebook** - Continue to document their final build with images or sketches, journal about the competition experience, or add to their self assessments.
  - **Clean up from Competition** - If you do not want students to bring their robots to the debrief conversation, they can begin to take them apart and put the pieces away.
  - **Explore a Career Connection** - Have students complete an additional Choice Board activity, or the same activity for a different career.
  - **Build a Bulletin Board** - Have students create a bulletin board space that reflects their learning throughout the Unit using elements from their engineering notebooks.