

# Unit: Introduction to Engineering Design

## LEGO ENGINEERING

Age: Early Elementary

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# LESSONS

## Lesson: Intro to Engineering and Partner Building

Estimated time: 1 class period

Learning Objectives:

- Introduce engineering and what an engineer does
- To assist students in their ability to work with others
- To learn how to plan, share, and discuss ideas for building a simple structure

The Challenge: To cooperatively use 20 LEGO Blocks to build a creation.

Materials:

20 LEGO pieces in a small paper/plastic bag per pair

What Do Engineers Do book

Optional - Books about sharing and taking turns, such as Dandelion Warriors (Little Bill Books) or It's Mine by Leo Lionni

Vocabulary

- Compromise
- Share
- Respect
- Cooperative
- Evaluate

Piece Names:

- Brick
- Beam
- Plate

Procedure:

Introduce the unit to the students. Explain that the class will be exploring engineering using LEGO bricks. To introduce engineering, read the book What Do Engineers Do? Focus on the importance of teamwork in engineering and discuss strategies for working together: planning, compromise, taking turns, etc.

Introduce the pieces they will work with today. The brick, the beam, and the plate. Then, give the students their first challenge - to build a LEGO creation as a team. Give each team of students a bag containing 20 LEGO pieces. Explain that their challenge today is to cooperatively build a structure with all 20 pieces with their partner. Students should try to use the Engineering behaviors modeled (planning, compromising, and respectful behavior).

Sharing:

After the students have constructed their object, bring everyone together. Objects can be displayed on a LEGO shelf to be viewed later. Be sure to have the students label their structures. Arrange the students in a circle. The students take turns going around the circle starting with the phrase "I was a cooperative partner because I \_\_\_\_\_".

Extensions:

***Students may need extra pieces to do extension projects***

- Give each student a bag of 10 identical pieces. In pairs, have one student build a structure and the other student copy the structure with his or her pieces.
- Give the students a bag with a mystery number of pieces and have them count and name the pieces
- Place a piece in a paper bag, box, or something else where the students can't see the piece. Have them take turns guessing what piece is inside by only feeling it and not looking at it.

Troubleshooting:

If students are not working well in the team, try role play the following situations with another adult:

- Grabbing pieces
- Working on separate projects (with lack of communication)
- Arguing

Have students evaluate the adult role playing and give suggestions. Continue role playing until the students have identified all of the inappropriate behaviors. Model the desirable behavior.

Standards:

# Lesson: Build a Sturdy Wall

Estimated time: 1 class period

## Learning Objectives:

- To familiarize the students with specific Lego building strategies and the vocabulary.
- To learn the basic building strategies with the Lego blocks.

The Challenge: To build a sturdy wall that will withstand the 'flick test' and the drop test.

## Materials:

- Lego Simple Machine kits or other Lego building pieces
- Engineer's Final Report worksheet

## Vocabulary:


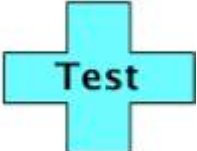
- Sturdy
- Overlapping
- 'Flick test'
- 'Drop test'



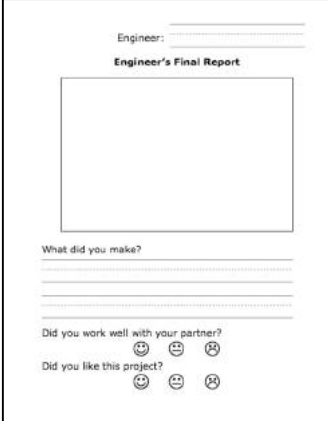
## Piece Names:

- Plate
- Beam
- Brick

## Procedure:

- Introduce the LEGO pieces you will be using (plate, brick, beam)
- Discuss how you talk about LEGO pieces (in terms of studs) (2x2 brick, 1x10 beam)
- Introduce the piece rule - "We only use the pieces in the kits that are listed on the board for the day"
- Give the challenge in terms of the engineering design process (build a wall that can survive the drop test and the flick test)

	A Sturdy Wall
	Your Wall Needs to Pass the Following Tests <ul style="list-style-type: none"><li>• Flick Test</li><li>• Drop Test (from the knee)</li></ul>

	<p>Think! Troubleshoot! Why did it break? Where did it break? How could I fix it?</p>
	<div data-bbox="646 262 972 680" data-label="Form">  </div> <p>Students must carefully complete the Engineer's Final report. Model how to complete it and how to answer the questions.</p>

- Give building tips:
  - Overlapping beams and bricks are stronger than non-overlapping ones.
  - Three stacked plates are the same height as one beam or one brick.
  - Discuss overlapping beams and bricks on the corners of houses.
- Make sure to leave enough time for clean-up. Students will need instructions on how to properly care for, put away, and store Lego materials.

#### Sharing:

This is a good lesson to share as a class if there is time (end of this class or beginning of next class). Save the walls and talk about each one at the end of the session.

- What building technique made a sturdy wall?
- Call attention to the way the bricks are placed on the classroom walls.

#### Extensions:

All extensions should have to pass the same tests

- Build a sturdy corner (2 walls)
- Build a sturdy house (4 walls)

#### Trouble Shooting:

- Some students will be very familiar with vocabulary and building while for others this will be a new experience
- Students might need help reading the questions on the Engineer's Final Report when completing it.

#### Standards:

## Lesson: Building Strong Shapes

Estimated Time: 1 Class Period

Learning Objectives:

- To familiarize the students with specific Lego building strategies
  - How to use connector pegs
  - Building a triangle
  - Building a square
  - Bracing with beams
- To learn the names of Lego building pieces.
- To reinforce knowledge of shapes

The Challenge: After guided building of a triangle, a squared, and a braced square, students will build a sturdy box from LEGO pieces

Materials:

- Lego Simple Machine kits or other Lego building pieces

Piece Names:

Old: Beam, Brick, Plate

New: Connector Peg, Friction Peg, Axle, Bushing, Axle Extender

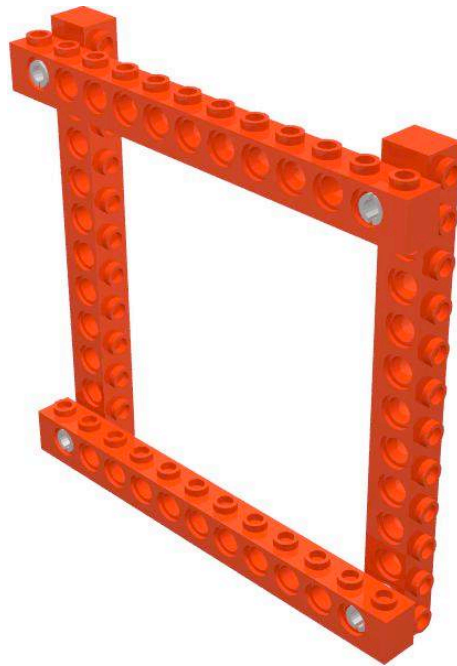
Procedure:

- Take a moment before today's lesson and see if the children can recall the LEGO Tips that were talked about in the last lesson.
  - Overlapping beams and bricks are stronger than non-overlapping ones.
  - Three stacked plates are the same height as one beam or one brick.
  - Discuss overlapping beams and bricks on the corner of a structure
- Introduce the new pieces. Show students how they can use pegs, axles, and bushings.
- Have the students make a triangle with beams.
  - They can either use connector pegs or axles and bushings to hold it together
  - Push on the sides of the triangle to show how strong it is.

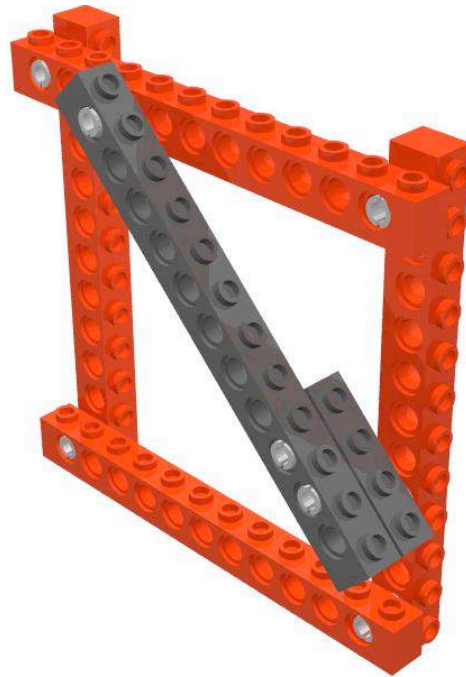





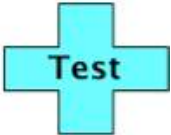


- Have the students make a square with beams. This time, when the students push on it, it will “collapse” - the sides will move.



- Have the students brainstorm how they can keep the square sturdy. Can they add a triangle?
- Have the students add a brace to the square so that it doesn't collapse.



- Introduce today's challenge - Have the students build a box with LEGO pieces. The sides of the box do not need to be closed.

	<p>Have the students build a box. If they struggle, review the pieces and building techniques with the students:</p> <ul style="list-style-type: none"> <li>• Beams + Connector Peg</li> <li>• Beam + Friction Peg</li> <li>• Beam + 2 Connector or Friction Pegs (making things long and sturdy)</li> <li>• Beam + 2 plates + 2 Connector or Friction Pegs</li> <li>• Beam + 2 bushings + Axle</li> <li>• 2 axles + Axle Extender</li> </ul>
	<p>Explain to the students their box will need to pass 2 tests</p> <ol style="list-style-type: none"> <li>1. <b>Flick Test</b> (It won't collapse when it's pushed)</li> <li>2. <b>Drop Test</b> (From the ankle)</li> </ol>
	<p>Figure out ways to make your box stronger. What pieces fell off? How could we attach them to make the box stronger? What should we add?</p>
	<p>As a class, students can discuss:</p> <ul style="list-style-type: none"> <li>• What was hard?</li> <li>• How did you fix your design when it fell apart?</li> <li>• What pieces did you use?</li> <li>• What shapes make up your box?</li> <li>• Why did you use certain pieces?</li> </ul>

Sharing:  
This is a good lesson for class discussion.

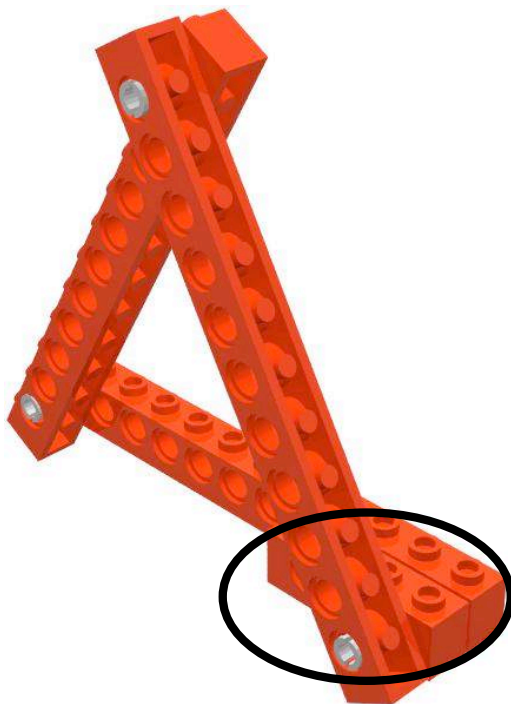
- What difficulties did you encounter today?
- What pieces were helpful to make things strong?
- Where do you see triangles in the classroom? Where are squares?

#### Extensions:

- Introduce measurement and have the students measure their creations using different units - LEGO studs, inches, centimeters, tiles on the floor, etc.
- Build the widest/longest structure
- Build the shortest structure using 10 pieces

#### Troubleshooting & LEGO Hints:

- On triangles and braces for squares, the LEGO beams may have a hard time snapping together. This may be because of the spacing of the beams, with beams trying to be in two planes. If this is the case, you may need to add an additional spacer in between beams so that the cross piece can be snapped in flat.



- Because the shapes rely only on holes lining up, you may find that students' squares have each beam facing a different direction. This may make it hard for students to turn their squares into boxes. Remind them of how pieces connect (studs go into the bottom of pieces) or encourage them to use pegs or axles if they get frustrated.

#### Standards:

## Lesson: Build a Tower

Estimated Time: 1 Class Period

Learning Objectives: To familiarize the students with specific Lego building strategies

- How to make a sturdy structure
- Building a structure
- Building vocabulary

The Challenge: In this activity, students design and construct a tower that is at least 4-6 inches high. The tower must be strong enough to withstand the weight of a stack of books.

Materials:



- Lego Simple Machine kits or other Lego building pieces
- Engineer's Planning Sheet

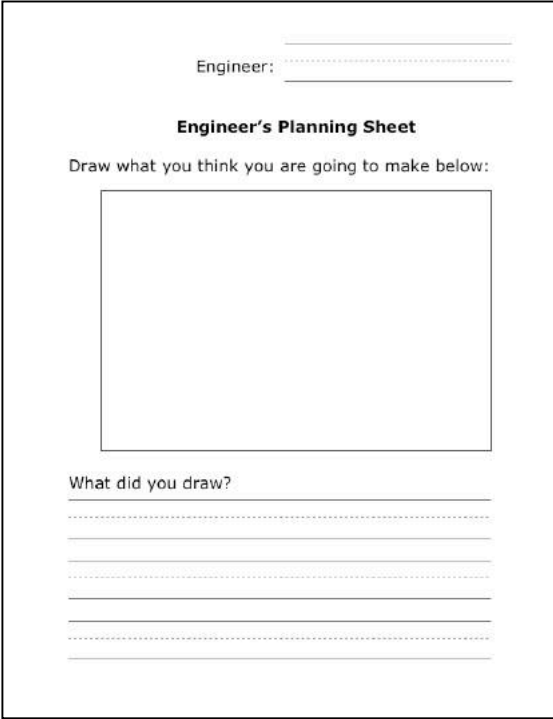

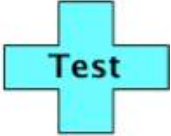


Piece Names:

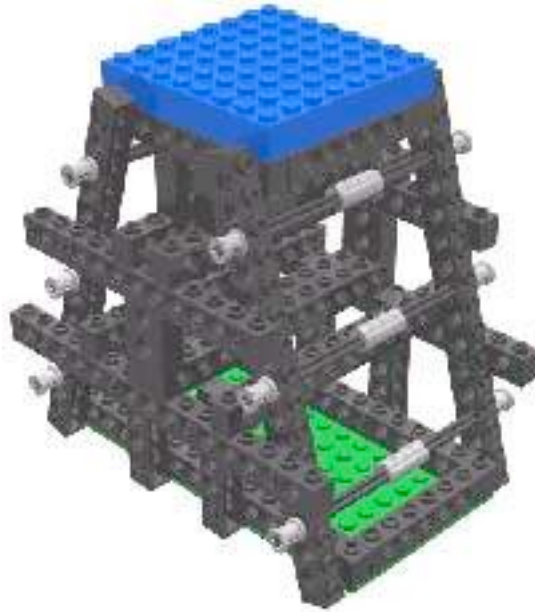
Old: Beam, Brick, Plate, Connector Peg, Friction Peg, Axle, Bushing, Axle Extender

Procedure:

- Take a moment before today's lesson and see if the children can recall the Lego Tips that were talked about in the last lesson.
  - Overlapping beams and bricks are stronger than non-overlapping ones.
  - Three stacked plates are the same height as one beam or one brick.
  - Discuss overlapping beams and bricks on the corner of a structure
  - How to use connector pegs
  - The difference between the (gray) connector peg and (black) friction peg
  - How to use axles and bushings
- Talk about the new engineering challenge

 <p>Brainstorm</p>	<p>Let's think about some different ways we've used to build sturdy structures - stacking beams and bricks, using pegs, bushings and axles.</p> <p><i>"You will need to think about how you will build a tower to hold up books, you will need to talk with your partner (compromise) about how you two will build a tower."</i></p>
 <p>Choose &amp; Plan</p>	<p><i>"You and your partner will need to agree on what you will build. Should your picture look the same as your partner's? (YES)"</i></p>

		<p>Model filling out the planning sheet for the students. Ask them to have each partner circle the part they will build.</p>
	<p>Have the students build towers. If they struggle, review the pieces and building techniques with the students:</p> <ul style="list-style-type: none"> <li>• Beams + Connector Peg</li> <li>• Beam + Friction Peg</li> <li>• Beam + 2 Connector or Friction Pegs (making things long and sturdy)</li> <li>• Beam + 2 plates + 2 Connector or Friction Pegs</li> <li>• Beam + 2 bushings + Axle</li> <li>• 2 axles + Axle Extender</li> </ul>	
	<p>Explain to the students their design will need to pass 2 tests</p> <ol style="list-style-type: none"> <li>3. <b>Height Test</b> (Is the tower at least 4 inches tall?)</li> <li>4. <b>Weight Test</b> (Can the tower hold a stack of books without falling down?)</li> </ol>	
	<p>Talk to the students about:</p> <ul style="list-style-type: none"> <li>• how their towers will break many times (that's what happens to engineers)</li> <li>• How to look for problems - <i>"If one piece keeps falling off should you put it back on the same way? Think about how to make it sturdier, connect with more pieces etc..."</i></li> </ul>	
	<p>Students should fill out an Engineer's Final Report for their tower and any extensions. Model for the students how to fill out the final report.</p>	



### Sharing:

This is a good lesson to share as a class. Save the towers and talk about each one at the end of the session. This is also a good lesson to photograph and then write about another day.

- What building technique made a sturdy tower?
- What difficulties did you encounter today?
- Describe how you found problems and fixed them.

### Extensions:

***Students may need extra pieces to do extension projects***

- Build your tower so that it will support you when you stand on it
- Can you make your tower taller?
- Build something that will hold the books together so they are easy to move when testing the towers

### Troubleshooting & LEGO Hints

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed.
- If available, extra plates may be helpful for this lesson.
- If available, giving each group a baseplate for their tower may be helpful.

### Standards:

## Lesson: A Chair for Mr./Ms. Bear

Estimated Time: 2 Class Periods

Lesson Type: Design Challenge

Learning Objectives: To expose students to the full engineering design process and allow them to practice their building techniques

- What is Mr. Bear's problem that we need to design a solution for?
- How will we know if we solved his problem?
- Building vocabulary

The Challenge: In this activity students will be asked to design a sturdy chair that keeps Mr. Bear seated upright

Materials:

- Lego Simple Machine kits or other Lego building pieces
  - Extra LEGO pieces and Materials (mini cups, post-it note pads) for extensions
- Engineer's Planning Worksheet
- Engineer's Final Report Worksheet
- Stuffed Teddy Bear or other stuffed animal

Vocabulary:

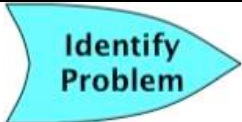
- Problem
- Solution
- Design





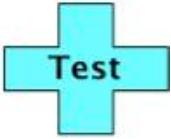


Piece Names:

Old: Beam, Brick, Plate, Connector Peg, Friction Peg, Axle, Bushing, Axle Extender

Procedure:

- Take a moment before today's lesson review what was done in the last lesson (Towers). *What was a good way to connect the LEGO pieces to make the tower taller? What was a good way to connect the LEGO Pieces to make the tower sturdier? What LEGO piece was really important for tower building?*
- Talk about the new engineering challenge

 Identify Problem	Mr. Bear needs somewhere to sit that is sturdy and will keep him sitting upright
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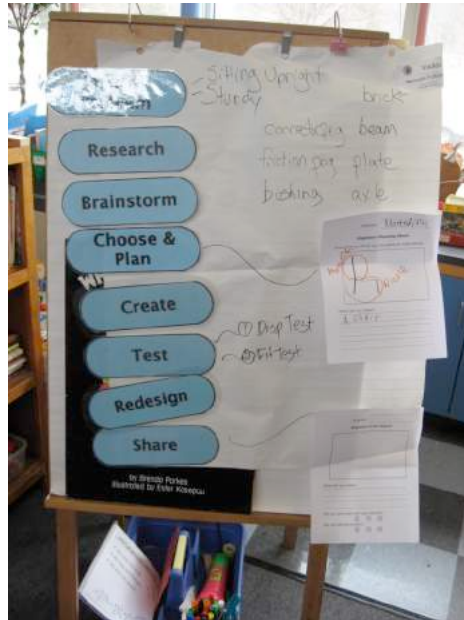
 <p style="text-align: center;"><b>Research</b></p>	<p>Let's think about some different things we've seen that might help him (Chairs) Optional: Provide Chair Research</p>
 <p style="text-align: center;"><b>Brainstorm</b></p>	<p><i>"You will need to think about how you will build a chair and you will need to talk with your partner (compromise) about how you two will build a chair."</i></p>
 <p style="text-align: center;"><b>Choose &amp; Plan</b></p>	<p><i>"You and your partner will need to agree on what you will design and build..."</i></p> <p>Model filling out the planning sheet for the students. Ask them to have each partner circle the part they will build.</p> <div data-bbox="1208 396 1453 714" style="border: 1px solid black; padding: 5px;"> <p style="text-align: right;">Engineer: _____</p> <p style="text-align: center;"><b>Engineer's Planning Sheet</b></p> <p style="text-align: center;">Draw what you think you are going to make below:</p> <div style="border: 1px solid black; width: 100%; height: 100%; margin: 5px 0;"></div> <p style="text-align: center;">What did you draw?</p> <p>_____</p> <p>_____</p> <p>_____</p> </div>
 <p style="text-align: center;"><b>Create</b></p>	<p>Have the students design and build. If they struggle, review the pieces and building techniques with the students:</p> <ul style="list-style-type: none"> <li>• Beams + Connector Peg</li> <li>• Beam + Friction Peg</li> <li>• Beam + 2 Connector or Friction Pegs (making things long and sturdy)</li> <li>•</li> </ul>
 <p style="text-align: center;"><b>Test</b></p>	<p>Explain to the students their design will need to pass 2 tests</p> <ol style="list-style-type: none"> <li>5. <b>Drop Test:</b> Your design needs to survive a drop from the ankle</li> <li>6. <b>Fit Test:</b> Mr. Bear needs to be able to fit into your chair</li> <li>7. <b>Sit Up Test:</b> Your design needs to keep Mr. Bear seated upright</li> </ol>
 <p style="text-align: center;"><b>Redesign</b></p>	<p>Talk to the students about:</p> <ul style="list-style-type: none"> <li>• how their chairs will break many times (that's what happens to engineers)</li> <li>• How to look for problems - <i>"If one piece keeps falling off should you put it back on the same way? Think about how to make it sturdier, connect with more pieces etc..."</i></li> </ul>
 <p style="text-align: center;"><b>Share</b></p>	<p>Each student should fill out an Engineer's Final Report</p> <p>Class discussion of...</p> <div data-bbox="1208 1612 1453 1929" style="border: 1px solid black; padding: 5px;"> <p style="text-align: right;">Engineer: _____</p> <p style="text-align: center;"><b>Engineer's Final Report</b></p> <div style="border: 1px solid black; width: 100%; height: 100%; margin: 5px 0;"></div> <p style="text-align: center;">What did you make?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p style="text-align: center;">Did you work well with your partner?</p> <p style="text-align: center;">😊 😐 😞</p> <p style="text-align: center;">Did you like this project?</p> <p style="text-align: center;">😊 😐 😞</p> </div>



## Sharing:

This is a good lesson to share as a class. This is also a good lesson to photograph and then write about another day.

- What difficulties did you encounter today?
- Describe how you found problems and fixed them.
- Ask for students to come up with 1 compliment and 1 question for each chair



## Extensions:

***Students may need extra pieces to do extension projects***

- Build a foot rest for Mr. Bear (some students do this in their original design anyway)
- Build a cup holder for Mr. Bear (provide students with mini drinking cups)
- Build a easel for Mr. Bear (provide students with mini post-it note pads)

## Troubleshooting & LEGO hints:

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed. (See Appendix)
- Students some times get stuck by thinking their chair needs to have arms and legs. Encourage them to be creative and reiterate that if their design solves Mr. Bear's problem it doesn't need to have every piece.

## Standards:

-

Chair Research





## Lesson: Pulley Wall

Estimated Time: 1 Class Period

Lesson Type: Skill Building

Learning Objectives: To introduce the students to pulleys and how they work

- What LEGO pieces make a pulley? (pulley wheel, pulley band)
- How do pulleys work?

The Challenge: Each student builds a 2-pulley wall (a beam with 2 pulley wheels, 2 axles, 2 bushings and a pulley band). Then each team of students connects their pulley walls together so that 1 driver turns all of the pulley wheels.

Materials:

- Lego Simple Machine kits or other Lego building pieces
- Engineer's Final Report Worksheet

Vocabulary:

- Driver
- Follower
- Tension

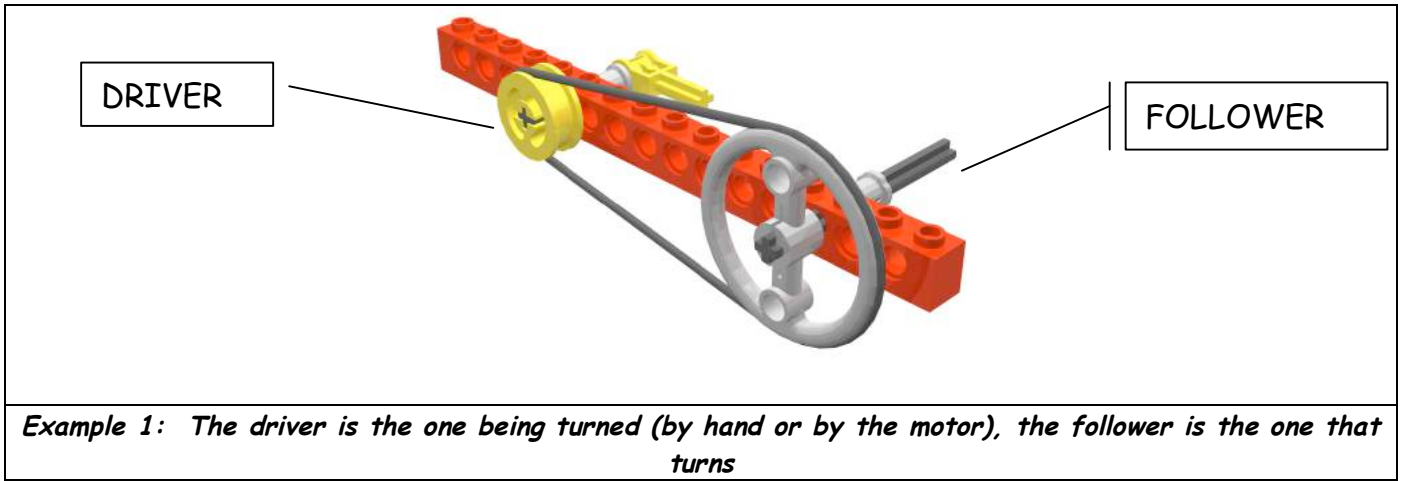
Piece Names:

New: Pulley Wheel, Pulley Band

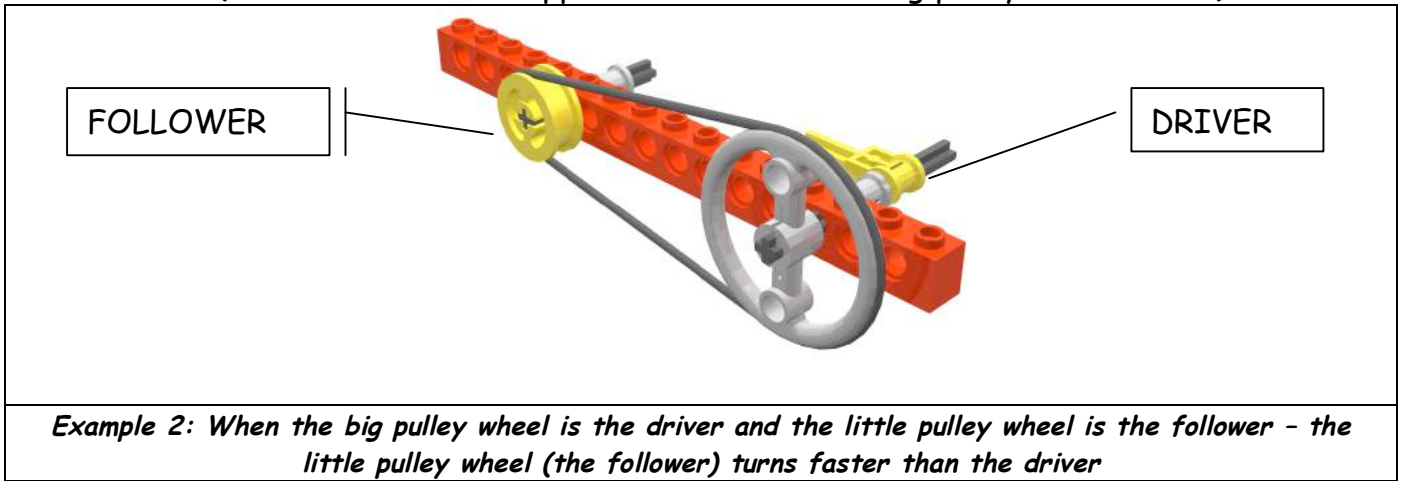
Procedure:

Introduce Pulleys

- Explain to students that today they will be learning how to use some new LEGO Pieces that help things to move
  - Introduce students to new pieces and their names (Pulley Wheel, Pulley Bands)
    - Point out that there are different size pulley wheels and pulley bands
  - Demonstrate how to put pulleys onto a beam (use a small one and a large one) and how to attach 2 pulleys with a pulley band.
- 
- Ask the students to explain how the one pulley moves the other pulley

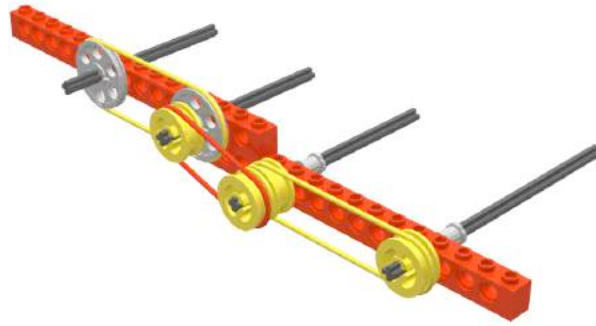


- Introduce vocabulary (the one I'm turning is called the driver, the one that gets turned without anyone touching it is called the follower)
- Ask the students to observe which pulley moves faster when the small pulley is the driver (and what about the opposite case when the big pulley is the driver)



### Introduce Challenge

- Explain to the students that each student will be building a 2-pulley wall.
- Review all the pulley vocabulary and pieces by building a second 2-pulley wall.
- Explain that once each student has a 2-pulley wall they need to figure out how to connect them to make 1 pulley wall - where 1 driver turns all the pulleys
- Demonstrate how to connect the two separate pulley walls (use beams or plates to connect the 2 beams, add pulley wheels on 1 axles on each wall and add band).
  - Time permitting have students help brainstorm ways that they could connect the two separate pulley walls



*Example 3: Combine 2 pulley walls by adding additional pulley wheels to 1 axle on each pulley wall and attaching them with a pulley band. All the pulley wheels should turn when one axle is turned*

- Explain that if there is more time, students will build pulley walls with more and more pulleys (3x3 pulley wall, 4x4 pulley wall etc...)

#### Final Report

- Have each student complete and Engineer's Final Report on the final pulley wall constructed by the group

**\*HAVE STUDENTS KEEP THEIR PULLEY WALLS ASSEMBLED FOR THE NEXT LESSON - INTRODUCTION TO MOTORS\***

#### Sharing:

- Have the students demonstrate their pulley walls and explain how they work (which pulley turns after you turn the driver)

#### Extensions:

*Students may need extra pieces to do extension projects*

- Have students build pulley walls with additional pulleys (depending on how many pulleys are involved they may need additional pulley wheels, pulley bands, axles, and/or beams)

#### Troubleshooting & LEGO hints:

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed.
- The amount of tension on the pulley band is important. Sometimes you may need to choose a smaller or larger pulley wheel in order to get the right tension. You may also change the pulley wheel's position on the beam to get the right tension.

#### Standards:

-

## Lesson: Introduction to Motors

Estimated Time: 1 Class Period

Lesson Type: Skill Building

Learning Objectives: To familiarize the students with how the LEGO motor, wires, and battery pack function.

The Challenge: In this activity students will connect the LEGO motor, wire, and battery pack to make a piece of art work spin. They will also will connect the motor to their previously built pulley wall.

Materials:

- Lego Simple Machine kits or other Lego building pieces
- Engineer's Surprise Worksheet
- Batteries
- Scissors
- Tape
- Markers, Crayons or Colored Pencils

**\*Prior to this lesson it is useful to load the batteries into the battery pack and make sure each battery pack, motor, and wire set are in working order\***

Vocabulary:

- Connection
- Electricity

Piece Names:

Old: Axle extender, Pulley wheel,

New: Motor, Wire, Battery Pack

Procedure:

Introduce Motorized Pieces

- Explain that they will be learning about some new pieces today that will require them to be EXTRA CAREFUL and that if these pieces are not used properly then they will have to stop using them
- Introduce pieces - motor, wire, battery pack
- Demonstrate how to properly connect wire to motor (metal to metal) and wire to battery pack. Show how to operate battery pack by pressing red buttons (forward, backwards, and stop)

- Show mistakes that students often make (connecting wire in the wrong place). Ask students to help figure out mistakes.
- Review rules of using the motors
  - Motors (and things connected to them) NEVER touch people
  - Motors should be run at your seat or on the floor (Don't walk around with your motor running)

#### Introduce Challenge

- Show students Engineer's Surprise Worksheet. Demonstrate how to color and cut out circles. Show how to attach the circle to the pulley wheel with tape and spin
- Demonstrate how to attach motor to pulley wall using axle extender (students may need to separate large pulley walls into smaller components). Show how they can display all 4 of their color wheels on 1 pulley wall

#### Sharing:

Students are often so excited during this lesson it can be impossible to share or do Engineer Final Reports. It's often easiest to review at the beginning of the next lesson.

#### Extensions:

- Students are usually eager to do extra designs on their Engineer Surprise Sheet (or to trade with other students)

#### Troubleshooting & LEGO hints:

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed.
- It can be useful to warn your neighboring teachers that you'll be doing this lesson as it can get loud (it can also be good to ask students to talk in whispers)

#### Standards:

-



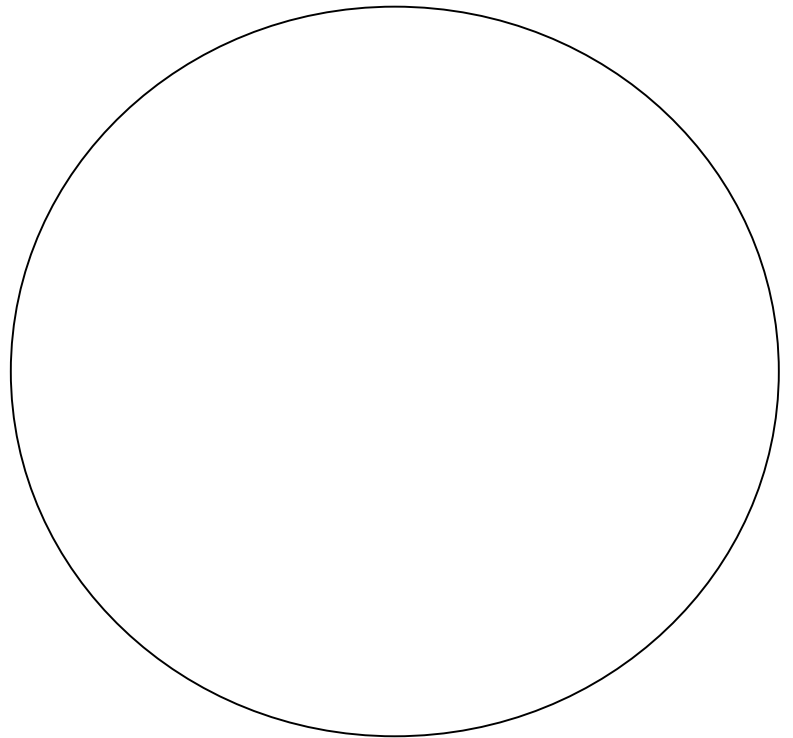
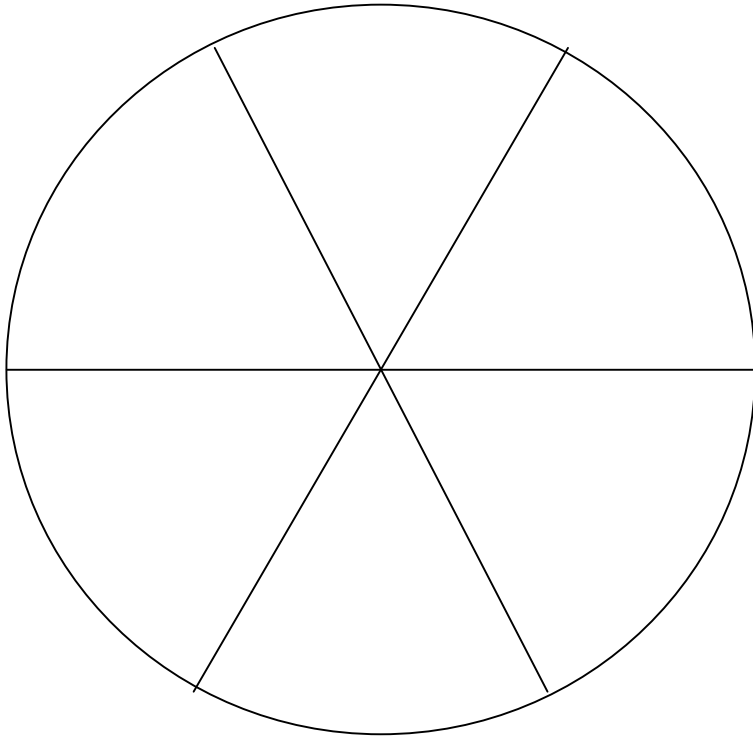
Engineer: \_\_\_\_\_

Date: \_\_\_\_\_

Partner: \_\_\_\_\_

### Engineer's Surprise

Color your circle with two primary colors that can be mixed together to make a new color. Cut out the circles. Push a large gear on your motor. Tape the circle to the motor and see what happens!



# Lesson: Sturdy Vehicle

Estimated Time: 2 Class Periods

Lesson Type: Design Challenge

Learning Objectives:

- To introduce students to building vehicles using motors and pulleys
- To explore pulley combinations that facilitate ramp climbing

The Challenge: In this activity students will build a sturdy vehicle (that can pass the drop and drive test). Time permitting they will work to make their vehicle be able to climb ramps.

Materials:

- Lego Simple Machine kits
- Engineer's Planning Sheet
- Engineer's Final Report
- Batteries
- Poster Board (or sturdy book) for ramps
- Wooden Blocks or other block manipulatives (for carts)

Vocabulary:

- 



Piece Names:




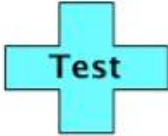
Review: Motor, Wire, Battery Pack



New: Wheels and Hubs

Procedure:

- Take a moment before today's lesson and see if the children can recall how to connect the LEGO Motor, Wire and Battery Pack
- Introduce some new pieces - wheels and hubs
- Present today's Design Challenge

	Your LEGO person needs a sturdy vehicle to transport them from place to place (as well as over hills and mountains)
	Let's think about what we've done so far that might help us design a vehicle (pulleys, motors)

	<p><i>Brainstorm as a class how you might</i></p> <ol style="list-style-type: none"> <li>1) <i>Make the frame for a vehicle (beams, axles, busings and wheels)</i></li> <li>2) <i>How you might attach the motor so it will make the wheels move (pulleys!)</i></li> <li>3) <i>How will we keep our motor from falling off the vehicle during the drop test?</i></li> </ol> <p><i>*See Teacher Reference for Guiding Ideas. You may want to demonstrate their ideas by building a class car*</i></p>
	<p><i>"You and your partner will need to agree on what you will build..."</i></p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <p style="text-align: center;">Engineer: _____</p> <p style="text-align: center;">Engineer's Planning Sheet</p> <p style="text-align: center;">Draw what you think you are going to make below:</p> <div style="border: 1px solid black; width: 200px; height: 100px; margin: 0 auto;"></div> <p style="text-align: center;">What did you draw?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> </div> <p>Model filling out the planning sheet for the students. Ask them to have each partner circle the part they will build.</p>
	<ul style="list-style-type: none"> <li>• Have the students build a sturdy car</li> <li>• Students may need help connecting pulley bands</li> </ul>
	<p>Explain to the students their design will need to pass 2 tests</p> <ol style="list-style-type: none"> <li>8. <b>Drop Test:</b> Drop the vehicle from their ankles</li> <li>9. <b>Drive Test:</b> Their vehicle needs to move using the battery pack</li> </ol> <p>Time Permitting - Optional Tests</p> <ol style="list-style-type: none"> <li>1. <b>Ramp Test(s)</b> - Use posterboard or sturdy, large books to create ramps around the classroom of varying inclines</li> <li>2. <b>Cart Test</b> - Have students design a cart for their vehicle to pull that will carry 2 or 3 wooden blocks (or other classroom materials)</li> </ol>

	<p>Talk to the students about:</p> <ul style="list-style-type: none"> <li>• How to look for problems - <i>"If one piece keeps falling off should you put it back on the same way? Think about how to make it sturdier, connect with more pieces etc..."</i></li> </ul>
	<p>Students should fill out an Engineer's Final Report...</p>

**Sharing:**

This is a good lesson to share as a class. This is also a good lesson to photograph and then write about another day.

- What difficulties did you encounter today?
- Describe how you found problems and fixed them.

**Extensions:**

***Students may need extra pieces to do extension projects***

- Ramp Test - have poster board at various inclines around the classroom for students to try their cars on
  - Students will need to maximize their pulley ratio to climb ramps (smallest possible pulley on the motor, largest possible pulley on the axles with the wheels)
  - Students may also need to add additional weight to their cars (over the tires attached to the pulley) to climb the ramp (the weighted brick works well here)
- Cart Test - have students construct a cart/trailer to hold 2 or 3 wooden blocks that their vehicle can pull
  - For very advanced students have them try pulling their cart up the hill

**Troubleshooting & LEGO hints:**

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed.
- It's great if you can have an extra battery pack or two in case any batteries go dead you can simply swap out the battery pack (instead of having to reload the batteries)
- You may want to make rules about where in your classroom the cars can be tested.

**Standards:**





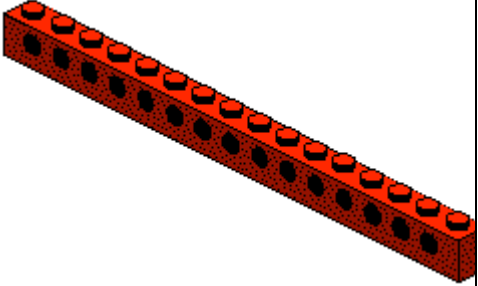
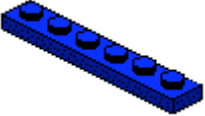
-

**Teacher reference:**

Steps to build a sturdy vehicle

STEP 1: Build a basic frame for the car

The frame of a car is made from:

	Tire	Wheels are made from tires and axel hubs
	Hub	Hubs are the center part of tires
	Bushing	Bushings keep
	Axle	Wheels are attached (using the hubs) to the axle
	Beam	Beams form the structure of the car and can support the photo
	Plates	Plates form a base for the motor

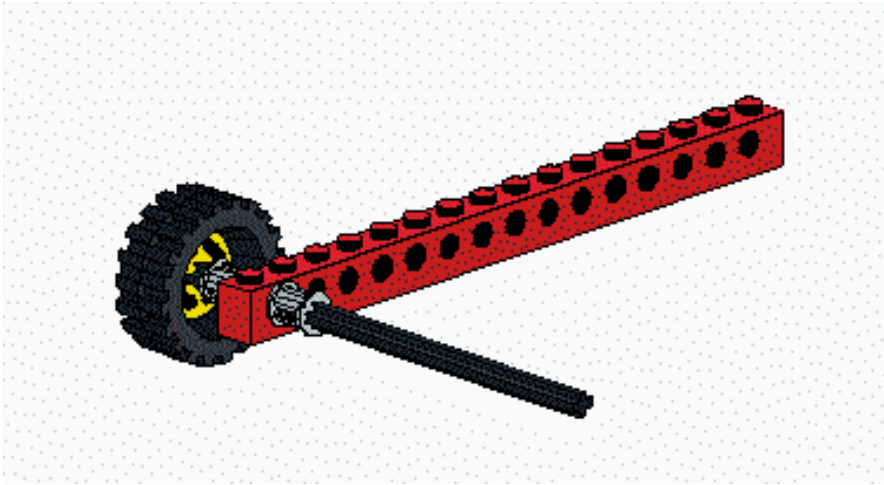


Figure 1: Partial Car Frame

Bushings are put on each side of the beam to keep the tires from sliding back and forth. They should be close to the beam but not TOO close. If they are too close the axle will not be able to turn (and hence the car will not be able to move).

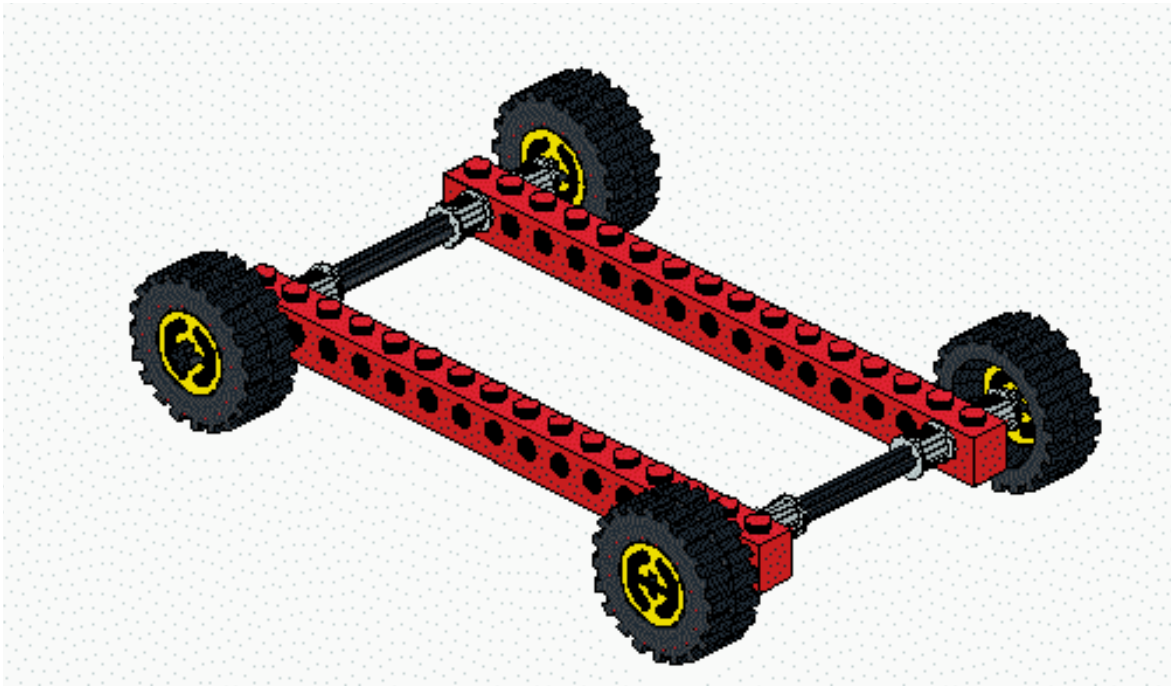


Figure 2: Sturdy Car Frame

It is important that the frame be as rectangular and symmetric as possible. If there is more friction on one side the car will tend turn in that direction.

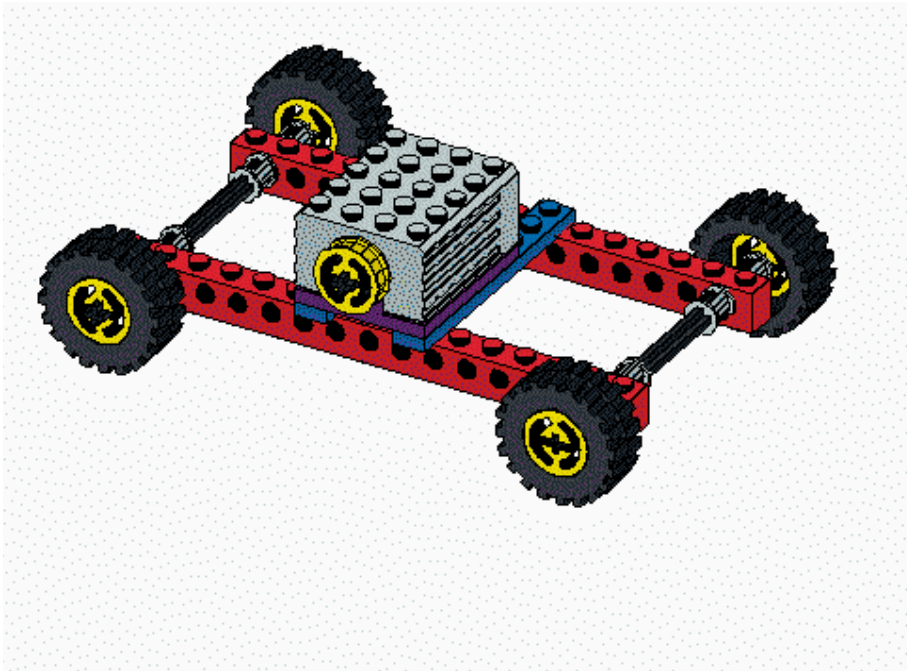


Figure 3: Add Motor to Car

You can attach the motor to the frame using plates or beams.

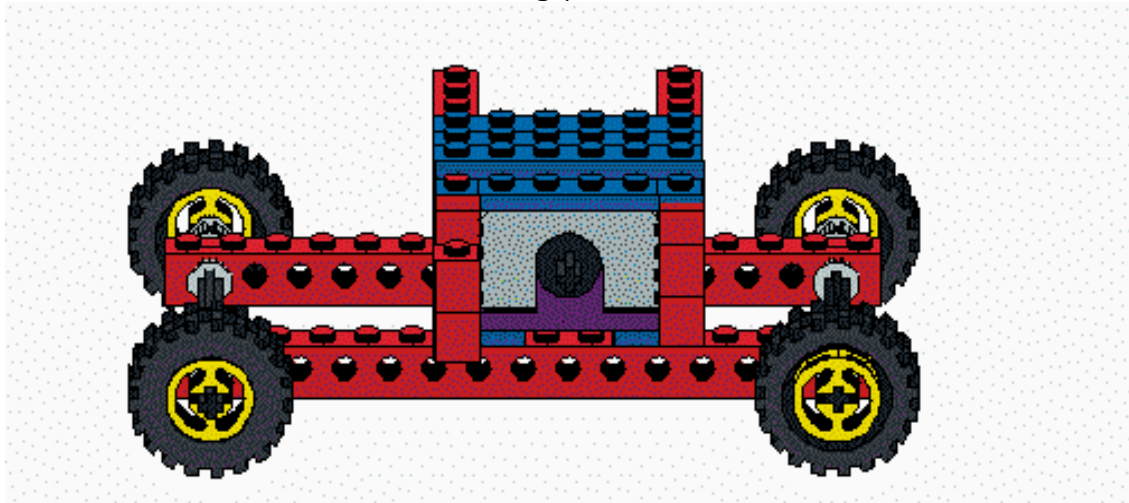


Figure 4: Car with Motor boxed in

To keep the car from breaking when it is dropped from the knee you need to box the motor in on all sides so it's supported in all directions.

## Lesson: Snow! Snow! Snow!

Estimated Time: 2 Class Periods

Lesson Type: Design Challenge

Learning Objectives: To engage students in an open-ended engineering design challenge that utilizes their motorized vehicles

The Challenge: In this activity students will be tasked with designing a vehicle that will clear snow from a path

Materials:

- Lego Simple Machine kits or other Lego building pieces
- Engineer's Planning Sheet
- Engineer's Final Report
- Packing Peanuts or Craft Cotton Puffs (for light snow)
- Extra LEGO Bricks (to serve as medium snow)
- Paper Towels (to make wet snow)

Vocabulary:




- 

Piece Names:



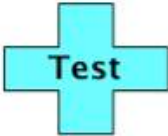


- No new pieces

Procedure:

- Talk about the new engineering challenge

	Problem: The town's people need a vehicle that can drive around and clear the roads of snow so that cars can drive.
	Let's think about vehicles we've seen that clear the road of snow. (Have students look at Snow Research Pictures)
	<i>Brainstorm as a class how you might build some of the ideas in research out of LEGO materials</i>



	<p><i>"You and your partner will need to agree on what you will build..."</i></p> <div data-bbox="583 149 1135 863" style="border: 1px solid black; padding: 10px;"> <p>Engineer: _____</p> <p><b>Engineer's Planning Sheet</b></p> <p>Draw what you think you are going to make below:</p> <div style="border: 1px solid black; width: 200px; height: 100px; margin: 10px auto;"></div> <p>What did you draw?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> </div> <p>Model filling out the planning sheet for the students. Ask them to have each partner circle the part they will build.</p>
	<ul style="list-style-type: none"> <li>• Have the students build a snow removal vehicle</li> <li>• Help students solve design challenges</li> </ul>
	<p>Explain to the students their design will need to pass # tests</p> <p>10. <b>Pick-Up Test:</b> Students must be able to pick up their design and have it stay together</p> <p>11. <b>Snow Test:</b></p> <ol style="list-style-type: none"> <li>a. <b>Light Snow</b> - Your vehicle must be able to clear a path in light snow (cotton craft puffs) <i>all vehicles must complete this test</i></li> <li>b. <b>Medium Snow</b> - Your vehicle must be able to clear a path in medium snow (LEGO Bricks) <i>this is a bonus test</i></li> <li>c. <b>Heavy Snow</b> - Your vehicle must be able to clear a path in heavy snow (Wet paper towels) <i>this is a bonus test</i></li> </ol>
	<p>Talk to the students about:</p> <ul style="list-style-type: none"> <li>• How to look for problems - <i>"If one piece keeps falling off should you put it back on the same way? Think about how to make it sturdier, connect with more pieces etc..."</i></li> <li>•</li> </ul>
	<p>Students should fill out an Engineer's Final Report...</p>

### Sharing:

The resulting snow vehicle designs can be used to explore categories, dimensions, and class counting.

- How many snow plows used a straight plow? A V-plow? Something else
- How many snow plows are bigger than 6 inches (or other units)?
- How many snow plows used 0-10 beams? 10-20 beams? 20 or more beams?
- How many wheels did the class use altogether? Beams? Bricks? Motors?

### Extensions:

- Only a few advanced students tend to finish all 3 types of snow. It's difficult to do LEGO extensions with this project if you want students to compare and count their designs as a class at the end.
  - This can be a good opportunity for advanced students to act as helpers
  - Students could create an advertisement for their snow plow (drawing/writing)

### Troubleshooting & LEGO hints:

- To help keep track of which students have passed which tests it's useful to have a clipboard with a chart with all the group's names and the tests being assessed.
- If the snow plows are too low to the ground the vehicle may have difficulty moving
- If the snow lows are too heavy they may tip the vehicle forward (and it may have difficulty moving).
  - Adding additional weight on the back of the vehicle (with the weighted brick or additional LEGO bricks) can help
  - Depending on the design, students can add another set of tires near the plow to help support the structure.
- Sometimes students design vehicles that are so large and heavy they may have trouble moving at all (encourage students to continually test their designs before adding pieces)

### Standards:

## Snow Vehicle Research











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## Lesson: Transportation Design

Estimated Time: 3-4 Class Periods

Learning Objective: To learn how to design and build an invention that answers a specific client problem using the Engineering Design Process

The Challenge: To design a vehicle that solve a problem for a client

Materials:

Lego Simple Machine kits or other LEGO building pieces

'Client Design Bags'

Pieces:

Beam, Brick, Plate, Connector Peg, Friction Peg, Axle, Bushing, Axle Extender, Tire, Hub, Motor, Pulley, Rubber bands

Procedure:

- Take a moment before today's lesson and see if the children can recall the LEGO Tips that were talked about in previous lessons.
  - Overlapping beams and bricks are stronger than non-overlapping ones.
  - Three stacked plates are the same height as one beam or one brick.
  - Discuss overlapping beams and bricks on the corner of a structure
  - Review pulley wheels and motors
  - Discuss friction from tires on too tightly
  - Review how to 'box in' a motor

Day 1:

- Introduce students to the challenge: "Today you and your partner are going to be given a problem just like a real engineer. The two of you will choose one of the bags I have up here. Today we will be planning. There will be no LEGO building"
  - Each pair of engineers will have a different problem with props to design a solution for. You may need to explain what the props are.
- Demonstrate for the class how they will take the problem and props in the bag and design a solution for it. Explain that they will have to write in their Transportation Design Book. ( It can help to have a copy of the pages in the Transportation Design Book taped up to write on.)
  - Emphasize that an Engineer always plans and Brainstorms with others before she/he actually starts building.
- Students should read their problem, examine their props and complete pages 1-6 of the Transportation Design Book .



- Students should not draw on page 1 - that's for a photograph of their final design (take a picture of your final design for that).
- The Check Boxes on Page 6 are for the teacher or assistant to check once they have seen the design pass that test (there are 2 required tests and 2 tests the students can decide on)
- Remind students to read the problem in the bag and talk with their partner about possible solutions.
- Students generally need all of Day 1 to complete the writing piece. If students finish early they should do other work (as it can be distracting to have some groups start building)






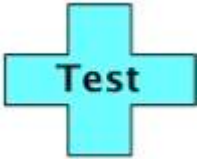


Day 2- Meet with the class to go over the goals for the transportation design project. Ask if any groups are having trouble coming up with a good idea.

- Groups should start building on Day 2 if they are finished with the writing piece.
- Try to save time at the end of the day to discuss problems that groups add
  - Ask questions: "Did anyone else have this problem and how did you solve it?"
- PICTURES! - It's essential to take pictures of the groups as they work for their books.

Day 3- Continue Building. Remember to take pictures.

Day 4- Finish up loose ends. Children who are completely done can work on Extensions or their Engineers Puzzle Book. Prepare to share as a class.

## The Engineering Design Process

	<p>What is your problem? What do your props tell you about your problem? (size, shape, terrain...)</p>
	<p>Let's think about some different things we've seen that might help. (use the pictures provided)</p>
	<p><i>"You need to think about what you will build to solve the problem and you will need to talk with your partner (compromise) about how you two will build it together."</i></p>
	<p><i>"You and your partner will need to agree on <b>what and how</b> you will build. Should your picture look the same as your partner's? (YES)" ENGINEERS WORK TOGETHER!!</i> Model how to fill out the first few pages in the Transportation Invention Book for the students.</p>
	<p>Remind the children about the LEGO Tips discussed in previous lessons. Be sure to think about the problem and use your props when building for size.</p>
	<p>Explain to the students their design will need to pass 4 tests</p> <ol style="list-style-type: none"> <li>12. <b>Shake Test (your invention can not fall apart when shaken)</b></li> <li>13. <b>Drive Test (It must move by motor power)</b></li> <li>14. _____</li> <li>15. _____</li> </ol>
	<p>Talk to the students about:</p> <ul style="list-style-type: none"> <li>• How their inventions will break many times (that's what happens to engineers)</li> <li>• How to look for problems - <i>"If one piece keeps falling off should you put it back on the same way? Think about how to make it sturdier, connect with more pieces etc..."</i></li> </ul>
	<p>Students should complete their Transportation Design book.</p>

## IMPORTANT NOTES

- Each pair of engineers is responsible for his/her own props. Remind the children that Engineers always work together. They can share ideas with other groups but not props in this lesson.
- This is a good lesson to share as a class, or even have a 'Design Convention' and invite other classes (or parents) to come.
- Take lots of pictures while the children are working. These pictures can also be used another day to write about this activity. You will need pictures of the children building, taking tests, and sharing, etc. for the Transportation Book.
- To help each child be more independent and organized there could be a check list stapled on the front of his/her folder that contains the paperwork for the Transportation Invention Book. As she/he completes one task he/she can check it off. An example is attached to the end of this lesson titled 'keep track sheet'.

Some questions to ask the children

- What building technique made your invention sturdy?
- What difficulties did you encounter?
- Describe what it was like to build your invention to size.
- What was the best part of this activity?

Extensions:

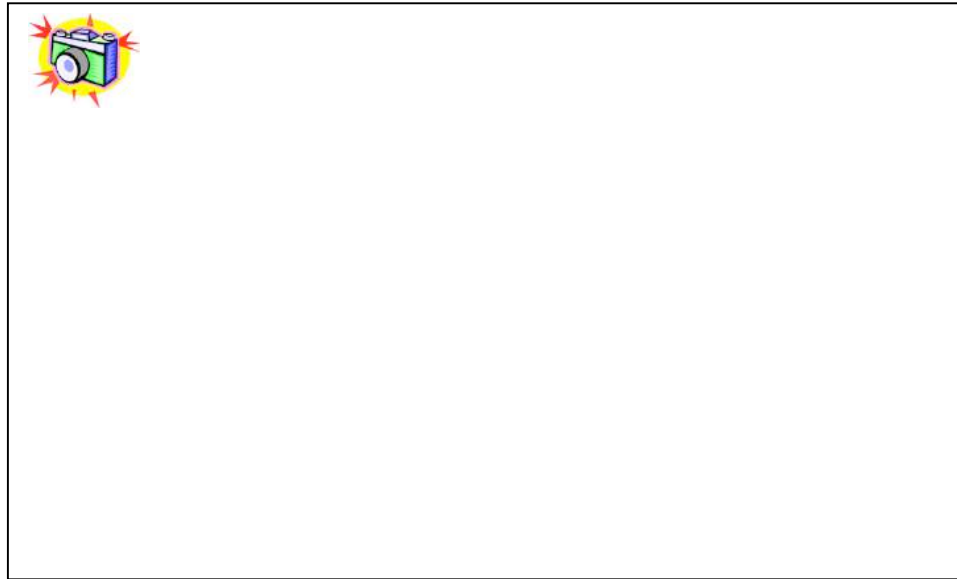
Building/Design

- Change the terrain for your invention to go over
- Can your invention go up a steep incline
- Create specific challenges that relate to the individual problem

Writing and Art

- Have students create an advertisement for their design
- Have students create an engineering design company and make their own business cards

# My Transportation Design



Engineered by

---

and

---



What problem does your client have?

A series of horizontal lines for writing, consisting of solid top and bottom lines with a dashed midline, repeated multiple times.

Research

Brainstorm



Cut out and paste or draw pictures that gave you a good idea for your design

Choose  
& Plan



We are going to design and build a...

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I will build

My partner will  
build



Our invention has to  
pass these tests

1. Lift & Shake Test

2. Drive Test

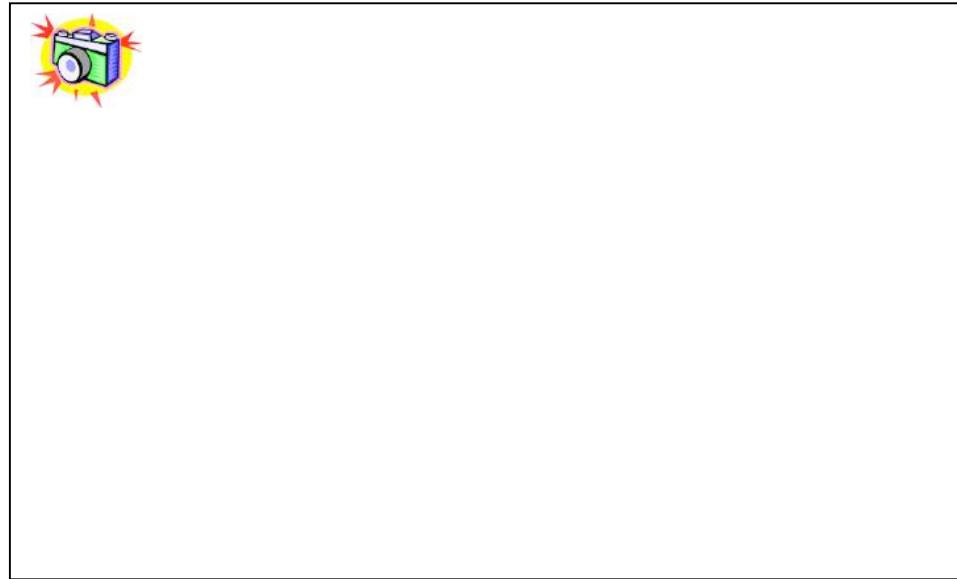
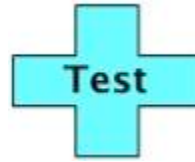
3.

4.

Create



This is a photo of us building our invention.



This is a picture of us testing our invention.



Describe one part of your invention you had to redesign

Handwriting practice lines consisting of solid top and bottom lines with a dashed midline. There are eight sets of these lines provided for writing.

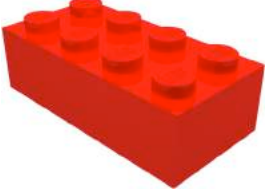






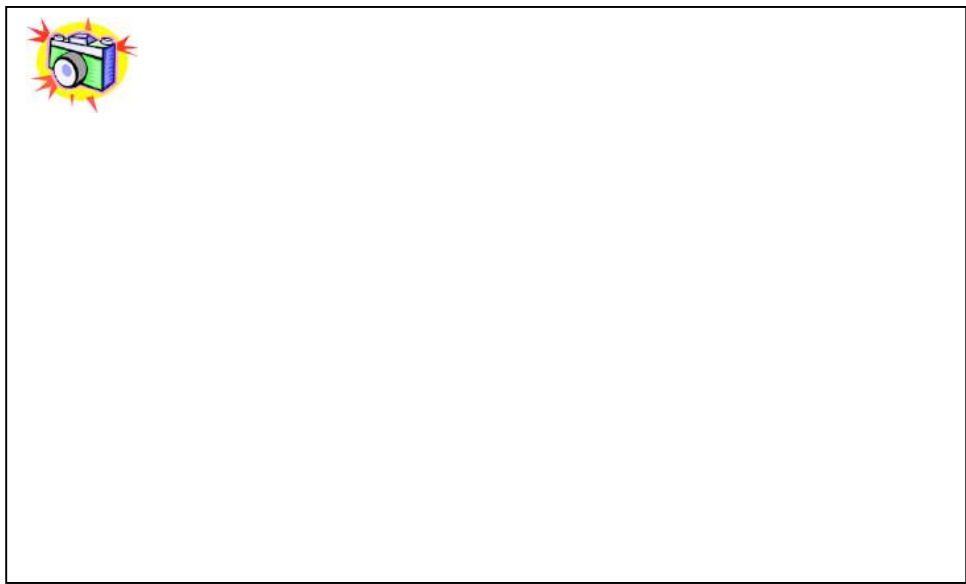
# Draw a picture of your invention





Write the number of each type of piece that you used

 <p>Bricks</p>	<p>-----</p>	 <p>Plates</p>	<p>-----</p>
 <p>Beams</p>	<p>-----</p>	 <p>Tires</p>	<p>-----</p>
 <p>Axles</p>	<p>-----</p>		<p>-----</p>



This is a picture of

Handwriting practice lines consisting of four sets of horizontal lines. Each set includes a solid top line, a dashed middle line, and a solid bottom line, providing a guide for letter height and placement.

# Transportation Design Research











## Client Problems

Your client is a fireman. He has a new dog that does not like to ride in the fire truck. Design an invention to help your client get his dog to the fire.

- materials: dog

Somerville has a new toy store. Design an invention that will bring new toys to the toy store. The toys are in the boxes.

- materials: two boxes (pretend they are full of toys) with stickers on them

Your client has a dog and a cat. They do not get along. They can not get wet. Your client needs to take them to the vet. Design an invention that will carry the dog and cat safely to the vet.

- materials: dog and cat

Your client needs to move his bulldozer to a new town. Design an invention to carry his bulldozer safely to the new town.

- materials: Toy bulldozer

Your clients want to take their motorcycles to a new town. Design an invention that can carry two motorcycles. The motorcycles can not get wet.

- materials: Two motorcycles

Your client's garage is very little. Design a car that holds 2 people and is very small.

- materials: people (cardboard garage for size - maybe a shoebox)

Your client wants to build a log cabin. Design an invention to carry the logs to his new land. How will he get the logs off the invention?

-materials: logs

Your client needs to go across a bumpy path to get to school. Design an invention to carry her safely to school.

- materials: Bumpy terrain

Your client needs to go through a narrow (thin, skinny) tunnel on his way to work. Design an invention that will go through a tunnel 3 inches wide.

- materials: Ruler, cardboard tunnel

The bridge on the way to your client's house is only 3 inches tall. She needs to go under the bridge to his house. Design an invention to carry her under the bridge to his house.

- materials: Ruler, cardboard bridge

# **CLASSROOM INFO & LOGISTICS**



## Sample Curriculum Outline

This outline is for a 45-60 minute engineering session once a week.

**Week 1** - Intro to Engineering and Partner Building

**Week 2** - Build a Sturdy Wall

**Week 3** - Building Strong Shapes

**Week 4** - Build a Tower

**Week 5** - A Chair for Mr./Ms. Bear

**Week 6** - A Chair for Mr./Ms. Bear

**Week 7** - Pulley Wall

**Week 8** - Introduction to Motors

**Week 9** - Sturdy Vehicle

**Week 10** - Sturdy Vehicle

**Week 11** - Snow! Snow! Snow!

**Week 12** - Snow! Snow! Snow!

**Week 13** - Transportation Invention

**Week 14** - Transportation Invention

**Week 15** - Transportation Invention

**Week 16** - Transportation Invention (Presentation)

**Week 17** - Clean-up and Sort Kits

## Assessment Ideas

### Opportunities for Assessment during the Engineering Design Process:

- Identify Problem
  - Reading comprehension of written client needs
- Research
  - Collecting pictures of other designs
- Brainstorm
  - Written brainstorms
  - Class discussion
- Choose & Plan
  - Written description of plans
  - Sketches of designs
  - Teamwork with partners
- Create
  - Teacher observation
  - Questioning Students about design decisions
- Test
  - Rubric for completion of design challenge
  - Completion of tests
- Redesign
  - Identification of problems
  - Finding solutions to address problems
- Share
  - Journal sheets
  - Class discussion
  - Posters/Ads

### Other Assessment Areas:

- Vocabulary
  - Naming learning pieces
  - Engineering terms
  - Teamwork terms
- Math
  - Counting pieces
  - Size & Shape of pieces and constructions
  - Identifying patterns
  - Measurement

## Creating a Healthy Classroom Culture for Engineering Education

Engineering involves designing, testing, and redesigning a solution to an open-ended problem. In this way, engineering can differ from some traditional math and science environments in that engineering problems do not have a singular "correct" answer. In fact, engineering values multiple solutions and the use of multiple approaches to solve a problem. In the K-12 classroom, engineering activities often involve hands-on projects and students working together to solve a challenge. It is important to foster an environment that values creativity, collaboration, and teamwork in order for all students to benefit from such activities.

Tips for fostering an engineering classroom:

- Encourage sharing of ideas! Collaboration is an important aspect of engineering. While students typically view sharing answers as "cheating" or "copying", the idea of sharing strategies is encouraged in an engineering environment.
- Recognize innovation! At the same time, a student may feel upset if someone else gets credit or praise for an idea that they developed first. Encourage the students to recognize each other's work and how they were able to share ideas. In that way, students who find an innovative technique are recognized, while other students are able to benefit.
- Make student experts! When a student has come up with an innovative solution, make them the "expert" at that topic. Did Suzy find a good way to attach the sensor to her car? Call it the "Suzy method" and encourage other students with the same problem to ask her for advice.
- Embrace failure and redesign! Engineers expect that their first try isn't going to work perfectly. They have many trials and modifications before they develop a final solution. Tell the students that it is not only ok if things don't work right away, but that it is expected. At the same time, encourage students to reflect on *why* something isn't working, and ask if they can't figure it out. Each trial should lead to a way to improve the design, and each design change should be motivated by the result of a trial. This tactic encourages students to

think about their building while relieving some of the frustration when things don't work correctly.

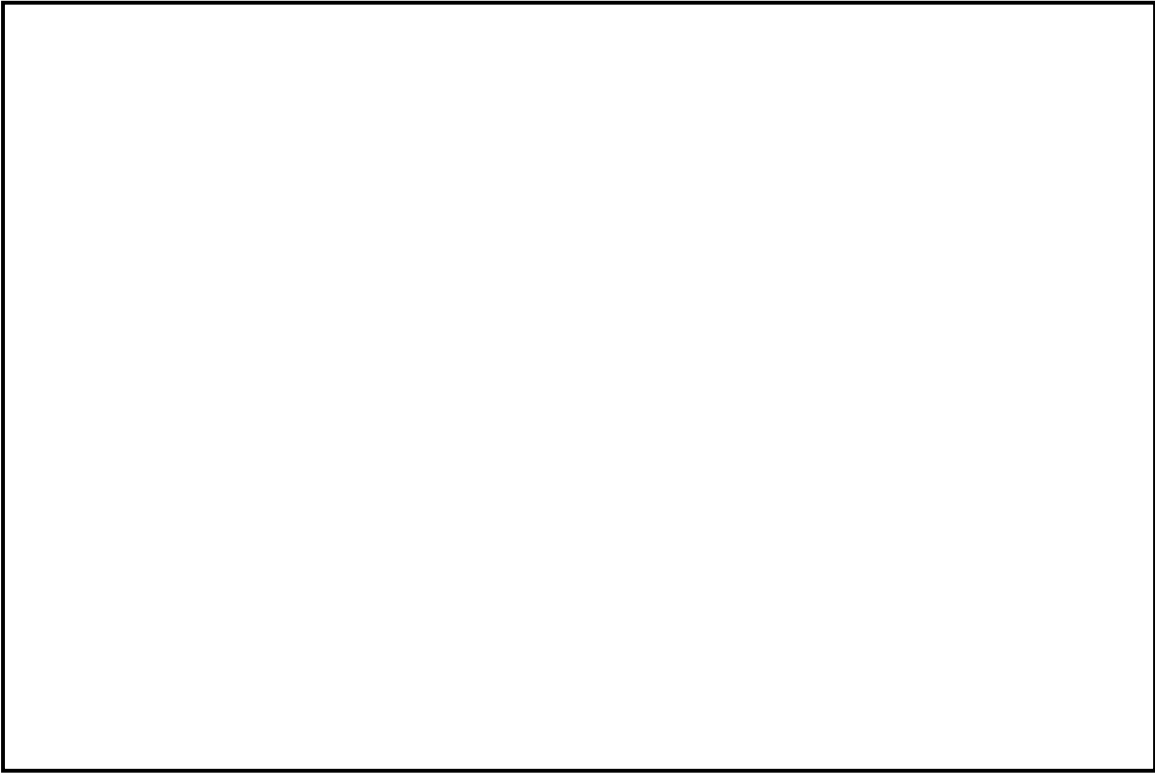
- Emphasize the end of class discussion! While it may sometimes seem like it would be easier to just end a lesson without gather students together for reflection, the end of class discussion is critical to developing students' understanding and ability to describe their design. It also allows the teacher a chance to assess the progress of the class. Additionally, it gives students a daily motivation to make progress on their project if they know they will have to show it to the class.
- Allow for ridiculous brainstorming. Many projects begin with a class or group brainstorming session. Remind students that there are no bad ideas during brainstorming. Even silly ideas can sometimes inspire good, creative solutions.
- Competition vs. Collaboration. Some students thrive in competitive challenges. Other students may become shy if they have to compete with classmates, or will be less willing to share their ideas. With the right environment, a friendly classroom competition can be fun and motivating for the students. Though, it is best if the competition isn't viewed as high-stakes. If grades or big prizes are on the line, a competition can quickly make a classroom unwelcoming. However, if the challenge is just for fun, students may embrace it. Also, students may prefer a competition where they are facing a standard or a goal rather than facing off with another student. If the challenge is to make a car go a certain distance, it might be better to assign ranges different values (gold medal range, silver medal range, etc) than to simply see who gets closest. This way, the success of one group doesn't hurt the success of another, but there is still a final goal to achieve.
- Don't be negative! Students are not allowed to "trash talk" or insult any of the designs (their own or those of another group). No one laughs at a design failure or says things like "that one sucks". Instead, we cheer for each others success and can give sympathetic "awwws" when things don't work.

# APPENDICES

Engineer:	<hr/> <hr style="border-top: 1px dashed;"/> <hr/>
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Engineer's Planning Sheet

Draw what you think you are going to make below:



What did you draw?

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Engineer:	<hr/> <hr style="border-top: 1px dashed;"/> <hr/>
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Engineer's Final Report

What did you make?

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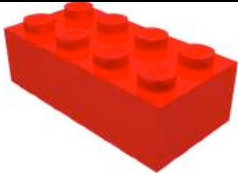





Did you work well with your partner?



Did you like this project?



Write the number of each type of piece that you used

 Bricks	-----
 Beams	-----
 Plates	-----
 Axles	-----
 Bushings	-----
 Connector & Friction Pegs	-----
<b>TOTAL NUMBER OF PIECES</b>	-----



**TESTING RECORD SHEET**

**Lesson:** \_\_\_\_\_

**Date:** \_\_\_\_\_

<i>Engineers' Groups</i>	<i>Test 1:</i>	<i>Test 2:</i>	<i>Test 3:</i>	<i>Test 4:</i>	<i>Comments</i>
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					

## Introduction to LEGO pieces

### **Bricks and Beams**












#### **Facts:**

- Bricks and beams are the most fundamental building blocks that LEGO™ has.
- Bricks are solid; beams have holes in them.
- Bricks and beams are named by how many studs (the little bumps) they have on top of them.

#### **Fitting together:**

- The studs of one beam can be inserted into the holes of a larger beam.
- The axles will slide through the holes in the beams.
- Increase the length of a beam by adding another beam and a connector peg.

---

Brick 1x2	Brick 2x4	Beam 1x2	Beam 1x4	Beam 1x6	Beam 1x8
					
Beam 1x10	Beam 1x12	Beam 1x16	Weight	Roof Tile	
					

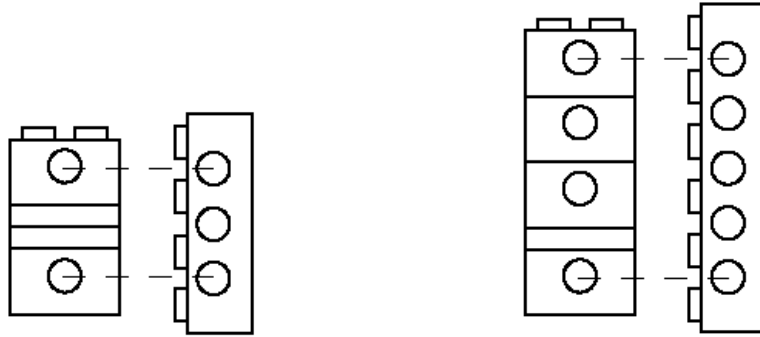


Figure 2: Creating Vertical Spacings with Two-Unit and Four-Unit Horizontal Measures











## Plates and Tiles

### Facts:

- The Plates and Tiles are 1/3 of the height of the Bricks and Beams.

### Fitting together:

- The cross-shaped end of the bushing can be inserted between the studs of a 2x4 or 2x8 plate with holes. An axle can then pass through the bushing and a tight fit is created.

Plate 1x2	Plate 1x4	Plate 1x8	Plate 1x10	Plate 2x6	Plate 6x8
					
Baseplate	Plate 2x4	Plate 2x8	Flat Tile		
					

## Gears and Pulley Wheels

### Facts:

- There are many different types of gears, each with its own purpose.
- Pulleys are best in high speed, low torque situations (beginning of gear train). This is due to the fact that the belt is able to slip allowing the












motor to spin freely even if the model gets stuck or caught up on something.

- Chain links are best used in low speed because they create friction.
- Gears can be mounted either on an axle or on a bush/cross axle (see Axles).
- To have a high power, low speed motor, a worm gear should be used (gearing down).

**Fitting together:**

- Gears of various sizes fit together on a beam differently.
- Establishing the relationship between the diameter of the gear and the gear ratio is the key to understanding how the gears fit together.
- There are mainly four different size gears (not including bevel, worm, or crown gears).
- The cross-axles will slide through the holes in the beams.
- You can also place more than one gear on an axle, which can be helpful when gearing up and down.



8 tooth gear	12 tooth conical gear	16 tooth gear	24 tooth gear	24 tooth crown gear	40 tooth gear
					
Pulley Wheel	Pulley Wheel	Steering Wheel	Gear rack	Worm gear	
					

**Connectors**









**Facts:**

- Connector pegs are used to keep beams together. Connector pegs with friction do not allow the beams to move.

- Stop bushings are necessary to make sure pieces do not slide off of the axle (two small bushings are the size of one large bushing).

**Fitting together:**

- Connectors are used to hold various pieces together firmly.

Connector peg	Stop bush	Connecting rod	Catch	Connector peg with friction	Crank
					
1x5 arm with studs	Cam-wheel				
					









**Axles**

**Facts:**

- Axles come in various sizes suitable for each project that you encounter.
- Axle extenders can be used if the axle you have is not long enough.
- Axles are named by the number of stud lengths (the bumps on the beams) they are.
- The bushing/cross axle is used very effectively for idling gears in a gear train.

**Fitting together:**

- Axles are used to connect motors to wheels and other LEGO™ equipment.
- The cross-axles will slide through the holes in the beams.












Cross axle: 3 studs	4 studs	6 studs	8 studs	10 studs	12 studs
					
Extender	Bush/cross axle				
					

**Special Facts:**

- There are many special LEGO™ pieces that you will encounter in your set.
- Gear boxes are used to hold worm gears and make using them easy as a medium sized gear fits in the gear box tightly.
- The belt is used in pulley systems and can be found of various lengths.
- The wires are used to connect motors to the outputs and sensors to the inputs.

**Fitting together:**

- Each of these pieces fit together differently.

Gear box	Lever	Chain link	Belt	Belt (small)	String
					
Rubber band	Crane hook	Technic motor	Technic battery box	Wire with 2x2 plates	
					

# Engineering Design Process Prompts



**Identify  
Problem**



**Research**





**Brainstorm**



**Choose  
& Plan**

**Create**

**Test**



**Redesign**



**Share**