OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

	Online (ideally before the class)	Hands-On (in class)
1	TCH 201.01 -- Six Simple Machines	Inclined Plane
2	TCH 201.02 -- Inclined Plane	Wedge
3	TCH 201.03 -- Wedge	Screw & Wheel & Axle Part 1
4	TCH 201.04 -- Screw	Wheel & Axle Part 2
5	TCH 201.05 -- Wheel & Axle	Wheel & Axle Part 3
6	TCH 201.06 — Pulley	Pulley
7	TCH 201.07 -- Gears (Bilingual)	Gears Part 1
8	TCH 201.08 — Levers Class 1	Gears Part 2
9	TCH 201.09 — Levers Class 2 & 3	Levers Class 1
10	TCH 201.10 — Simple Machines Review	Levers Class 2

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

	Online (ideally before the class)	Hands-On (in class)
1	TCH 201.01 -- Six Simple Machines	Inclined Plane, Wedge, Screw
2	TCH 201.02 -- Inclined Plane	Wheel & Axle Part 1
3	TCH 201.03 -- Wedge	Wheel & Axle Part 2
4	TCH 201.04 -- Screw	Pulleys
5	TCH 201.05 -- Wheel & Axle	Gears Part 1
6	TCH 201.06 — Pulley	Gears Part 2
7	TCH 201.07 -- Gears (Bilingual)	Levers Part 1
8	TCH 201.08 — Levers Class 1	Levers Part 2

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

Lesson 1: Inclined Planes

This unit is taught using K'Nex materials but can also be done with real-world objects with a little creativity.

1. Print the instructional materials you need from these K'Nex Education Guides:

http://media.knex.com/education/teachers-guides/78620-TG-Wheels-Axles-and-Inclined-Planes.pdf

- Intro to Inclined Planes, pages 23-25 (really 25-27 when printing)
- Steep & Long Ramps, pages 27-30 (print pages 29-32), laminate 27/28 and 29/30 back-to-back

http://media.knex.com/instructions/instruction-books/Education-Exploring-Machines-Teachers-Guide-78600.pdf

- Dump Truck, pages 36-37 (print 37-38), laminate page 36
- Inclined Plane, pages 38-41 (print 39-42), laminate pages 38-39 back-to-back

http://media.knex.com/instructions/instruction-books/Education-Simple-Machines-Deluxe-Inclined-Planes-Teachers-Guide-79520.pdf

- Intro to Inclined Planes, pages 8-13 (save some for screws & wedges)
- The Roller Coaster, pages 14-16 (laminate 14 & 16 back-to-back)
- The Moving Truck, pages 17-19 (laminate 17 & 19 back-to-back)
- The Playground Station, pages 38-40 (laminate 38 & 40 back-to-back)

2. Make student copies of the Journal pages (or have them record answers in blank journals):

- Dump Truck Worksheet (page 37) above
- Inclined Plane Worksheet (pages 40-41) above
- Playground Station Worksheet by OnSchooler (in this packet)
- Roller Coaster Ramp Worksheet by OnSchooler (in this packet)
- Moving Truck Worksheet by OnSchooler (in this packet)
- Steep & Long Ramps Worksheet by OnSchooler (in this packet)

Notes:

- Pre-printed packets are very handy if you are having the students complete ALL of the projects, and for younger students. Older students may be able to organize their thoughts in blank journals. Another option is to provide several copies of the worksheets in folders; students can take one worksheet for each model they have time to study; most students can only build one model and complete 1-2 worksheets in a typical class period.
- Some of the K'Nex instructional materials are set up for students to read on their own, while others are meant to be teacher-led and include comments or answers directly on them. Depending on your setup, you may need to highlight just the items you want students to complete and cross out some information.
- Materials List is on the next page.

3. Divide students into teams.

- Consider putting at least one strong reader and one strong mathematician in each group.
- Have each team build just one model. (Adjust based on the number of students and K'Nex sets.)
- After completing the model, the team completes the Worksheet or Journaling for that model.
- Teams circulate throughout the room using other completed models to complete other worksheets.

4. **Clean up.**

- This unit is excellent for "spare time" studies. Place the completed models off to the side so students can access them whenever they have completed their other assignments early. (This is also a great motivator to use time efficiently in other subjects!)
- Take a picture of the models for your classroom scrapbook.
- Return all unused K'Nex to their containers.
- Have students file their Worksheets or Journals properly.

5. Homework

- OnSchooler online lesson: TCH 201.01 — Six Simple Machines
- Photo Scavenger Hunt for simple machines in real life.

Materials Needed:

<u>Dump Truck</u>

- 100-150 Paperclips
- Paper or foil

<u>Inclined Plane</u>

- Spring scale (5-10 Newtons)
- Mass *or* paper cup with pennies or marbles

<u>Playground Station</u>

- Ruler
- Flexible measuring tape (or string)

<u>Roller Coaster Ramp</u>

- Spring scale or K'Nex Rubber Band Scale
- Cardboard or cardstock
- Waxed paper
- Sandpaper
- Ruler
- Scissors
- Small cup
- Small objects (i.e. pennies, pebbles, chalk, paper clips)

<u>Moving Truck</u>

- Ruler
- Spring scale or K'Nex Rubber Band Scale

<u>Steep & Long Ramps</u>

- Ruler/tape measure
- 3 gram weights (or secured rolls of pennies, or other weighted objects)
- A piece of heavy rubber band, approximately 4-6 inches long
- 400 gram or 10 Newton spring scale

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

Playground Station Worksheet

1. Find two simple machines in your model (one is an inclined plane and one is a screw). Explain how these change the ***effort*** or ***distance*** to help you (use the words "effort" or "distance" in your explanation).

   Inclined Plane:

   How it Helps:

   Screw:

   How it Helps:

2. Measure from the top of the monkey bars (yellow rods) to the ground: __________ cm
3. Measure the length of the spiraling slide with a flexible tape or string: __________ cm
4. Measure the length of the sloping ladder: __________ cm / in
5. Calculate the Mechanical Advantage:

   Mechanical Advantage **equals** slope length **divided by** slope height

Equation	$MA = \frac{\text{Slope Length}}{\text{Slope Height}} =$
Spiral Slide	$MA = \frac{\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_} =$
Sloping Ladder	$MA = \frac{\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_} =$

6. If you added a pointed roof to keep off snow and rain, what type of simple machine would it be?

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Technology Unit 1 — Simple Machines

Moving Truck Worksheet

1. Find these measurements:

    ________ cm   Top of the ramp to the ground

    ________ cm   Length of the ramp

2. Calculate the Mechanical Advantage:

Equation	$MA = \dfrac{\text{Slope Length}}{\text{Slope Height}} =$
Truck Ramp	$MA = \dfrac{\_\_\_\_\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_\_\_\_\_} =$

3. Connect an object to the Spring Scale or K'Nex rubber band scale and measure:

    ________ N   Lifting the object directly from the ground to the top of the ramp

    ________ N   Pulling the object up the ramp

4. Make the ramp longer and measure again:

    ________ N   Pulling the object up the longer ramp

5. Which ramp made the work easier? Why?

6. Imagine that you are tiny: small enough to drive the K'Nex Moving Truck. You have a pile of 100 boxes of oranges on the ground. How much farther would you have to move each box with the ramp than if you just lifted the boxes into the back of the truck? Draw a diagram to explain.

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Technology Unit 1 — Simple Machines

Roller Coaster Ramp Worksheet

1. Measure your two ramps:

Ramp A	Height _________ cm	Length _________ cm	Ramp Length ________ cm
Ramp B	Height _________ cm	Length _________ cm	Ramp Length ________ cm

Calculate the Mechanical Advantage:

Equation	$MA = \dfrac{\text{Slope Length}}{\text{Slope Height}} =$
Ramp A	$MA = \dfrac{\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_} =$
Ramp B	$MA = \dfrac{\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_} =$

2. Place the both ramps at the edge of a table with their backs (high point) at the edge.
   - Hold your car at the bottom of one ramp with the string running over the pulley and hanging down past the edge of the table.
   - Let the car go (it should be pulled up the ramp).
   - Which ramp does the car go up best? Why?
3. Replace the weight on the string with a spring scale or K'Nex Rubber Band Scale. Weigh down the car with a cup of pennies in the front half. Measure how much force it takes to pull the car up each ramp:

   Ramp A ________ N Ramp B ________ N
4. How does the height of an inclined plane affect the work done?
5. Add a piece of cardboard (about 9 x 22 cm) to each ramp to make it into a slide. (Both pieces of card-board should be the same length even if the longer ramp is not completely covered.)
6. Race small objects down the slides (pennies, erasers, marbles) and note your results on the back.
7. Make slides with sandpaper and repeat. Note your results on the back.

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

Lesson 2: Wedges

This unit is taught using K'Nex materials but can also be done with real-world objects with a little creativity.

1. Print the instructional materials you need from these K'Nex Education Guides:

http://media.knex.com/education/teachers-guides/78620-TG-Wheels-Axles-and-Inclined-Planes.pdf

- The Splitting Wedge (pages 31-34 but print 33-36)

http://media.knex.com/instructions/instruction-books/Education-Simple-Machines-Deluxe-Inclined-Planes-Teachers-Guide-79520.pdf

- The Splitting Wedge (22-24)
- The Chisel (pages 23-25)
- The Axe (pages 26-28)

2. Make student copies of the Journal pages (or have them record answers in blank journals):

- The Splitting Wedge Worksheet by OnSchooler (in this packet)
- The Chisel Worksheet by OnSchooler (in this packet)
- The Axe Worksheet by OnSchooler (in this packet)

3. Materials

Stack of paper plates or folders; foam block, clay or dough; small piece thin cardboard/cardstock; stack of books

4. Homework

- OnSchooler online lesson: TCH 201.02 — Inclined Plane
- Continue photo scavenger hunt

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Technology Unit 1 — Simple Machines

Splitting Wedge Worksheet

1. Set the point of your K'Nex Splitting Wedge between the green connectors of the Log. Push the Wedge down a short way.

   How much do the halves of the Log separate? ______ cm
   (Measure the distance between the green connectors.)

   Push the Wedge in farther and measure again. They separated ______ cm

   Draw a diagram to show which direction the Wedge moves and which direction(s) the halves of the Log move. Label your diagram to show how far they move:

2. Make a stack of books and use your Splitting Wedge to open a crack between two books.

   When you tap the Wedge in, which way do the books move?

   Explain how a wedge works as a moving inclined plane:

3. (Skip)

4. What are other uses for a Wedge besides splitting wood? Think of at least 3 examples:

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Technology Unit 1 — Simple Machines

The Axe Worksheet

1. Use the K'Nex Axe to chop a model of a tree (i.e. a stack of paper plates). What happens as the tips of the blade hit the tree?

   Now use the same amount of force to chop the "tree" with the back side of the Axe (the wide part). What happens?

   Explain how the wedge side of the Axe makes it easier to chop wood.

2. Think of at least 3 more examples of tools that use a sharp wedge for cutting;

3. Extra credit: Research early human tools that used stones carved into wedge shapes. Bring pictures to class next week.

The Chisel Worksheet

1. Draw two sketches: a knife and a chisel. Label the part that is a wedge.

   Knife: Chisel:

   To change a knife into a chisel, what would you need to change?

2. Use your K'Nex Chisel to make cuts to a foam block, clay or dough:

   Try making a smooth, flat edge.

   Try making a hole.

   Try making a shape like a hand or a cloud.

3. If you could add a more pointy end to the chisel, would the tool be longer or shorter?

   Would that make work harder or easier?

   Use cardboard to add a more pointy end to the chisel and repeat step #2. Do you see a relationship between the sharpness and width of the wedge? If so, what?

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

Lesson 3: Screws and Wheel & Axles

This unit is taught using K'Nex materials but can also be done with real-world objects with a little creativity.

1. **Print the instructional materials you need from these K'Nex Education Guides:**

http://media.knex.com/instructions/instruction-books/Education-Simple-and-Compound-Machines-77053.pdf

- Screwdriver (page 23)
- Paddle Wheel Boat (pages 24-26)
- Sawmill (pages 27-29) (aka Water Wheel)
- Archimedes Screw (pages 32-34)

http://media.knex.com/instructions/instruction-books/Education-Simple-and-Compound-Machines-Teachesr-Guide-77053.pdf

- Screwdriver (pages 33-37) instructions w/ worksheet
- Paddlewheel Boat (pages 38-43) instructions w/ worksheet
- Archimedes' Screw (pages 50-53) instructions w/ worksheet
- Teachers' Answer Sheets (page 76-78)

http://media.knex.com/instructions/instruction-books/Education-Exploring-Machines-Teachers-Guide-78600.pdf

- Screwdriver (pages 25-29)
- Paddlewheel Boat (pages 31-35)
- Archimedes Screw (pages 42-45)
- Teachers' Answer Sheets (pages 68-70)

http://media.knex.com/instructions/instruction-books/Education-Intro-to-Wheels-and-Axles-and-Inclined-Planes-Teachers-Guide-78620.pdf

- About Wheels & Axles (pages 3-6 but print 5-8)
- The Well (pages 7-13 but print 9-15)
- The Paddleboat (pages 15-18 but print 17-20)
- The Steering Wheel (pages 19-22 but print 21-23)

http://media.knex.com/instructions/instruction-books/Education-Simple-Machines-Class-Set-Teachers-Guide-79008.pdf

- About Wheels & Axles (pages 39-41)
- The Well (pages 42-45)
- The Screwdriver (pages 46-48)

http://media.knex.com/instructions/instruction-books/Education-Simple-Machines-Deluxe-Wheels-and-Axles-Teachers-Guide-79520.pdf

- About Wheels & Axles (page 8-13)
- Spinning Top (pages 14-16)
- Wishing Well (pages 17-21)
- Wrench (pages 22-24)
- Screwdriver (pages 25-27)
- Ferris Wheel (pages 28-30)
- Water Wheel (pages 31-33)
- Paddlewheel Boat (pages 34-36)
- Windmill (pages 37-39)
- Measuring Wheel (pages 40-42)
- Wagon (pages 43-45)
- Carousel (pages 46-48)

2. Print the instructions and pre-build the models.

3. Make student copies of the Journal pages (or have them record answers in blank journals):

- The Splitting Wedge Worksheet by OnSchooler (in this packet)
- The Chisel Worksheet by OnSchooler (in this packet)
- The Axe Worksheet by OnSchooler (in this packet)

4. Materials

Day 1:

Archimedes Screw: ping pong balls, flexible measuring tape

Wishing Well: Cup, pennies, spring scale, ruler, labels for 6 axles (dot stickers?)

Ferris Wheel: Tape measure or string, ruler

Steering Wheel: —

Measuring Wheel: chalk, large map with roads, large wheel (bicycle wheel, hula hoop, etc.)

Wagon: spring scale, small heavy box (punch a hole in it to attach spring scale)

Spinning Top: stopwatch, calculator, extra K'Nex pieces

Wrench: modeling clay or dough, large sheet of paper (or tape some together)

Screwdriver: wood screws and some wood (or use your imagination)

Day 2:

Wind Mill: Paper, scissors, tape, wind/electric fan/blow dryer

Tow Truck: Spring scale, gram weights

Carousel: extra K'Nex pieces

5. Homework

- OnSchooler online lesson: TCH 201.02 — Inclined Plane
- Continue photo scavenger hunt

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Technology Unit 1 — Simple Machines

Archimedes Screw Worksheet

1. Put the ball at the bottom and turn the handle to see how the ball moves up the ramp from the force of the screw.

2. Remove the screw from the inclined plane and measure just the inclined plane (the distance the ball will move from bottom to top.

Plane Length: _____________________cm

3. Use a string or flexible measuring tape to measure the length of the screw (the distance the ball moves up the screw).

Screw Length: _____________________ cm

4. When using the screw, the ball actually travels up the entire length of the screw as it is pushed up the ramp. Thus it travels a farther distance but the work is easier. Calculate the mechanical advantage.

$$MA = \frac{\text{Screw Length}}{\text{Plane Length}} = \frac{\qquad\qquad}{\qquad\qquad} =$$

5. If you could not turn the machine faster, how could you increase the number of balls moved to the top of the ramp in one minute?

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Technology Unit 1 — Simple Machines

Wishing Well Worksheet

1. Places the Wishing Well across the backs of two chairs so that the bucket hangs down.
2. Fill a cup filled with pennies or other small weights and measure the force required to lift it: ________ N
3. Build each wheel & axle combination and use it to lift the weight. Record your results:
   A. Turn the wheel one time and measure how far the bucket moved up.
   B. Attach the spring scale to the wheel and measure how much force it takes to move it.
   C. Attach the spring scale to the axle and measure how much force it takes to move it.
   D. Count how many turns it takes to move the bucket to the top of the well.

Model	One turn (cm)	Wheel Force (N)	Axle Force (N)	Turns to Top
1				
2				
3				
4				
5				
6				

4. Which wheel and axle model makes lifting the bucket easiest? Why?

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Spinning Top Worksheet

1. Spin the top five times and measure how long it spins in seconds.
2. Add up all the seconds and divide by 5 to get the average.
3. Make a mini-top as shown in the picture and do the experiment again.
4. Try changing the regular top so it's extra wide. Do the experiment again.
5. Try changing the axle to an extra tall one. Do the experiment again.
6. Which type of top works best? Should the axle be tall or short? Should the wheel be small or large?

Regular Model	
Turn	Seconds
1	
2	
3	
4	
5	
Average	

Mini Top	
Turn	Seconds
1	
2	
3	
4	
5	
Average	

Wide Model	
Turn	Seconds
1	
2	
3	
4	
5	
Average	

Tall Axle	
Turn	Seconds
1	
2	
3	
4	
5	
Average	

The Screwdriver Worksheet

1. Look at the picture with the screws and screwdrivers. Which are the Phillips, hex and slot types? Ask your teacher if you don't know.

2. Create a new tip for your Screwdriver. If a white connector is the head of a screw, what tip could you add to your Screwdriver that would fit with it? Build it and draw a picture here:

3. How could you modify the Screwdriver to turn its axle with more force? Build a Screwdriver like this.

4. Why is it easier to drive a real screw into a piece of wood with a screwdriver than with your hand?

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The Wagon Worksheet

1. Remove the wheels from your Wagon so you just have a sled.
   A. Put a small stack of books in a box on top; connect the spring scale directly to the model (sled/ wagon) and pull it. Record the result.
   B. Now connect the spring scale to the box and pull it. Record the result.
   C. Put the wheels back on and the same box of books; pull it (connected to the box) with the spring scale. Record the result.
   D. Now connect the spring scale directly to the Wagon and pull. Record the result.

2. Rebuild the wagon to have eight wheels instead of four. Do the whole experiment again and record the results.

	Sled (no wheels) plus books	4-Wheel Wagon plus books	8-Wheel Wagon plus books
Connected to the model	N	N	
Connected to the box	N	N	

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Measuring Wheel Worksheet

1. Use a piece of chalk to draw a line across the wheel. You can count how many times the wheel turns by counting each time that mark returns to its starting point.
2. Measure the circumference (all the way around) the wheel: _________________________ cm
3. Measure the following distances. You will count the number of turns of the wheel then multiply that by the circumference (distance around the wheel) to get the actual distance.

	Turns of the wheel	* the circumference in cm	= the distance in cm
Table length			
Squiggly line on the board			
A to B on the map (on a road)			

4. Compare your results with your partner or another student. If your numbers are very different, measure again together to find out what went wrong. Fix your numbers in the table above.
5. Use a bigger wheel to measure something bigger (like the length of the gym). Mark the starting point on the wheel with chalk or tape. Then measure the same distance with a meter stick. If the results are not close, re-measure both ways to find out what went wrong.

	Turns of the wheel	* the circumference in m	= the distance in m
Gym length w/ wheel			
Gym length w/ meter stick			

6. Which way was easier? The measuring wheel or the meter stick?

Ferris Wheel Worksheet

1. What is the circumference (distance around) of the axle? ________________________ cm
2. What is the circumference of the wheel? ______________________________ cm
3. Spin the Ferris Wheel and watch how far the axle moves compared to the wheel.
4. What could you add to the Ferris Wheel to make it easier to turn?
5. Try hooking up the Ferris Wheel to a motor to turn it.
6. What is the circumference of the axle? __________________________cm
7. What is the circumference of the wheel? _______________________________ cm
8. Is the second version easier to turn than the first Ferris Wheel, or harder?

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Technology Unit 1 — Simple Machines

The Wrench Worksheet

1. Tape four pieces of paper together (just use small pieces of tape). Get a piece of clay or dough about the size and shape of your thumb and set it up near the center. This is the “screw”.

2. Put the Nut (the square part of the model) around the “screw” so it rests on the paper. It should be possible to turn the Nut but there should be some resistance from the screw; you may have to change the size or shape of the screw to make this possible.

3. Use your finger to push the corner of the Nut so it turns around the screw. Now put the Wrench around the nut and use your finger to push **at the end of the handle** so it turns the screw. Which is easier?

4. Use a pencil to push the end of the handle of the Wrench around the nut, drawing on the paper until you get back to the starting point. What shape did you make?

5. Optional Bonus: use a Spring Scale to measure how many Newtons it takes to move the Nut by itself versus with the Wrench.

Corner of the Nut: ________________________ N

End of the Wrench Handle: ______________________ N

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Technology Unit 1 — Simple Machines

Steering Wheel Worksheet

1. Push the car and turn the steering wheel to make the wheels turn. Then take off the steering wheel and do it again, just using the blue rod (the axle) to make the wheels turn. Which is easier?

2. Why do you think it's easier?

3. If you were driving a big, heavy truck would it be easier with a small steering wheel or a big one?

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Technology Unit 1 — Simple Machines

Wind Mill Worksheet

1. Use paper or cardboard to make sails for the Windmill and tape them to the blades. (Think of a pinwheel and how the blades tilt.)
2. Use air (wind, hair dryer, a fan or blowing like on a pinwheel) to apply force to the sails. Which works best?

3. Using the best method, try turning the windmill in different directions. Draw a diagram marking the direction from which the air should come to spin it the best.

4. What types of jobs could a real windmill do that would make work easier for people?

OnSchooler Knowledge Series

Technology Unit 1 — Simple Machines

Carousel Worksheet

1. Turn the crank to spin the Carousel. Then, instead of using the crank, turn the axle to which the crank is attached. Which is easier?

2. The horizontal gray axle turns the _______________, which uses friction to grip the _______________-colored connector and make the carousel turn.

3. Every time the small wheel turns, the Carousel turns _____________________ times.

4. If the wheel were larger, the carousel would turn (a) more or (b) less times for each turn of the wheel. (Circle one)

5. If you were riding on the platform, and the wheel always moved at the same speed, do you move faster near the center of the platform or near the edge?

6. If the platform were twice as big but the wheel still moved at the same speed, would you move faster near the edge of the bigger platform or the current one?

7. Name another amusement park ride that spins riders in a circle.   How could you make the ride more exciting?

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Technology Unit 1 — Simple Machines

Water Wheel Worksheet

1. Cover each paddle with plastic wrap or foil; include a rim to help catch the water.

2. Pour water over the paddles of the Water Wheel on one side (not right on top of the wheel). Find out which side moves better.

3. When the Water Wheel turns, what else does it make move inside the house?

4. Think of three types of work the Water Wheel could do:

5. Attach a string and a weight to the axle and make the Water Wheel do some work. How could this be used in real life?

Paddlewheel Boat Worksheet

1. With the Paddlewheel Boat, the effort is applied to the axle. It takes a lot of force to move the axle, but then it turns the wheel pretty far.
2. To run the Paddlewheel Boat, loop the end of the rubber band over the purple Connector, then turn the paddlewheels so that the rubber band wraps all the way around the axle one time. You might need to hold the rubber band in place to get it started. Then let go over the paddlewheels and watch them spin.
3. To do this experiment, you will wind up the rubber band one more turn each time, up to four times. You will need a partner for this experiment.
   A. After doing one turn, measure the Load Force by connecting the spring scale to one of the paddle-wheel spokes, (on the orange Connector or on the yellow Connector that connects to the spoke). Write down the force in Newtons.
   B. Then put the Paddlewheel Boat on the floor at the start of the meter stick and let it go; measure how far it goes in centimeters. Write it down.
   C. Then repeat both of those steps but with TWO turns of the rubberband around the axle. The next time, do THREE turns, and the final time do FOUR turns. Be careful not to break the rubber band.

Turns around the axle	Load Force (N)	Distance (cm)
1		
2		
3		
4		

4. Place the front and back of the boat on something that floats (like Styrofoam or a small piece of wood) in a sink or tub with some water. Wind the rubber band around the axle four times and let it go. What happens?

Inclined Planes										
Steep & Long Ramps										
Moving Truck										
Roller Coaster										
Playground Station										
Inclined Plane										
Dump Truck										
Splitting Wedge										
Chisel										
Axe										
Archimedes Screw										

Wheels & Axles										
Archimedes Screw										
Wishing Well										
Spinning Top										
Screwdriver										
The Wagon										
Measuring Wheel										
Ferris Wheel										
Wrench										
Steering Wheel										
Wind Mill										
Carousel										
Water Wheel										
Paddle Boat										

Pulleys & Gears										
Flagpole										
Clothesline										
Elevator										
Crane										
Conveyor Belt										
Crank Fan										
Car Window										
Eggbeater										
Rack & Pinion										
Transmission										
Carousel #2										
Stationary Bicycle										

Student Project Instructions:

All: http://media.knex.com/instructions/instruction-books/

Intro to Simple Machines

http://media.knex.com/instructions/instruction-books/Education-Introduction-to-Levers-and-Pulleys-78610.pdf

http://media.knex.com/instructions/instruction-books/Education-Introduction-to-Wheels-Axles-and-Inclined-Planes-78620.pdf

http://media.knex.com/instructions/instruction-books/Education-Introduction-to-Gears-78630.pdf

Exploring Machines

http://media.knex.com/instructions/instruction-books/Education-Exploring-Machines-Book-1-78600.pdf

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Power & Play—Motorized

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Pulleys

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https://www.hunker.com/12393122/3-types-of-pulleys

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Clothesline Worksheet

1. Is a Clothesline a fixed or moveable pulley?

2. Get a small piece of paper, about 1 inch by 2 inches and fold it in half. Pretend it's a towel and drape it over the bottom line of Clothesline at the right side.

3. Pull the top line to the right. Which direction does the "towel" move?

4. Imagine that you are hanging up a big load of towels on a Clothesline to dry outside. (This what people did for hundreds of years before Clothes Dryers!) You are standing at the right side of the Clothesline and after you hang each towel you pull on the top rope to move all the towels down the line. If you didn't have a pulley, what would you have to do instead?

5. Homework: In big cities, people used to set up Clotheslines between buildings, many stories up. They would lean out the window, attach clothes to the rope, use the pulley to move the clothes down the line, then repeat. After the clothes were dry they would move the pulley in the opposite direction to bring all the laundry back in. Find at least one picture of this in a book, encyclopedia or internet search. Bring it to class!

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Technology Unit 1 — Simple Machines

Flagpole Worksheet

1. Is a Flagpole a fixed or moveable pulley? (Look at the chart if you don't know.))

2. Attach a K'Nex tire, connector or other small weight to one end of the rope and drape it over the Flagpole's top pulley. That weight is the LOAD. Pull down on the other end of the rope; that is the EFFORT.
3. When you pull down, which direction does the load move?

4. Cut a small rectangle of paper, about 1 inch x 2 inches. Hold it horizontally, like a flag. Fold over a little bit of the left edge; this will wrap around the rope. Draw a picture on your flag. Attach it to the rope on the flagpole (wrap the folded edge around the rope and tape it to the back of the big part of the flag; use enough tape that the flag attaches to the rope).

5. When you pull down on the other section of the rope (not the part to which the flag is attached), which direction does the flag move?

6. If you did not have a pulley, how else could you fly a flag from the top of a pole each day?

7. Would it be easier that way, or with a pulley?

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Technology Unit 1 — Simple Machines

Elevator Worksheet

1. Look at the two elevators. Figure out which uses a *fixed* pulley system (label it car A) and which uses a *moveable* pulley system (label it car B).

2. Open both paper clips, forming into an S. Slip one end *through* the rope of the fixed pulley, just below the pulley. Do the same with the moveable pulley. (See the teacher's diagram for help.)

3. Near the paper clips, put a sticker on the third rod down from the top (it's yellow) on each elevator. This rod will be about 22 cm above the floor of the elevator car.

4. Hook the spring scale to Car A's center beam and lift it up to the rod with the sticker. Record the results.

5. Hook the spring scale to Car A's paper clip and pull down until the car lifts to the same heights as in step #4. Record two results: Newtons of force required, and distance you pulled.

6. Repeat steps 4 and 5 for Car B.

Elevator Car	Load Force (lifting straight up) in N	Effort Force (lifting with pulley) in N	Distance pulled with pulley to lift the car 22 cm (in cm)
A			
B			

7. Car A uses a fixed pulley. How do the Load Force and Effort Force compare?

(a) they are the same (b) it's easier with the pulley (c) it's harder with the pulley

8. Car A uses a fixed pulley. How does the distance change?

(a) they are the same (b) it's shorter with the pulley (c) it's longer with the pulley

9. Car B uses a moveable pulley. How do the Load Force and Effort Force compare?

(a) they are the same (b) it's easier with the pulley (c) it's harder with the pulley

10. Car B uses a moveable pulley. How does the distance change?

(a) they are the same (b) it's shorter with the pulley (c) it's longer with the pulley

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Technology Unit 1 — Simple Machines

Crane Worksheet

1. Attach a weight to the Crane's string and try different ways to life it:
   A. Wind the upper crank to roll up the string.
   B. Wind the lower crank to lift the arm.

2. Which is easier?

3. The Crane could tip over if attempting to lift a heavy weight. Add some weights and outriggers (legs that stick out) to the Crane and see how much weight you can lift without it tipping over.

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Technology Unit 1 — Simple Machines

Lawnmower Worksheet

1. Push the Lawnmower model across a desk or table. What causes the cutting blades to turn?

2. How many teeth are on the inside ring of the green gear?

3. How many teeth are on the other gear that causes the wheels to turn?

4. Calculate the gear ratio: big number divided by small number =

5. What kind of gears are used in the Lawnmower? Circle the answer(s):

   (a) Spur gear

   (b) Crown gear

   (c) Rack and pinion

   (d) Worm gear

   (e) Sprocket gear

6. Make some tissue paper "grass" to mow (see the picture for an example. Try to mow it. Draw a diagram showing how the blades move:

Crank Fan Worksheet

1. Turn the crank and watch how the fan blades move. This model uses a Spur Gear System in which the gears are in the same line or plane.
2. Find the following parts in the model. Sketch and label them here: crank, driven gear, driver gear, fan blades.

3. Is the input motion (to the crank) circular or linear?

4. Is the output motion (of the fan blades) circular or linear?

5. On the sketch above, use arrow to show which direction each part moves when you turn the crank. If your first sketch wasn't very good, make a better one.
6. When you turn the crank one turn, how many turns do the fan blades make?

7. What do you think would happen if your crank was attached to a larger gear?

8. If you have extra time at the end of class, try changing the sizes of the gears to see what happens. See examples in the folder (by #8 on the K'Nex worksheet printout).

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Technology Unit 1 — Simple Machines

Car Window Worksheet

1. Have you ever heard someone say they would "roll up" the car window? In the olden days, everyone really used a crank! Turn the crank in the model and see how it moves. This is a spur gear system.

2. Is the input motion (to the crank) circular or linear?

3. Is the output motion (of the window) circular or linear?

4. Now let's collect some data about how this simple machine makes work easier (either multiplying the force or increasing the distance). Start with the first gear train.

   A. Lower the window to the bottom. Turn the blue crank one complete turn to raise it partway.

   B. While you are turning the crank, have your partner count how far the tan 14-tooth gear turns.

   C. Repeat those two steps but count how far the yellow 34-tooth gear turns.

FIRST GEAR TRAIN		
	14-tooth tan gear	34-tooth yellow gear
Type of gear (driver or driven)		
Result of 1 turn of the blue crank		
Fastest gear		
Force gained		

5. Repeat for the second gear train.

SECOND GEAR TRAIN		
	14-tooth tan gear	82-tooth yellow gear
Type of gear (driver or driven)		
Result of 1 turn of the blue crank		
Fastest gear		
Force gained		

6. Bonus: calculate the mechanical advantage of each gear train (see the handout for instructions).

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Technology Unit 1 — Simple Machines

Eggbeater Worksheet

1. Turn the crank to see how the eggbeater moves. This model uses a crown gear system.
2. Draw a diagram labeling the following parts and how they move (using arrows): crank, driver gear, driven gear, and mixing blades.
3. Is the input motion (to the crank) circular or linear?
4. Is the output motion (of the eggbeater) circular or linear?
5. What's different about their motion?
6. Where does the motion change from a vertical (up and down) plane to a horizontal (flat) plane?
7. Does this machine (a) increase speed or (b) change direction of motion? (Circle one)
8. Why do you think this type of gear is called a crown gear?

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Stationary Bicycle Worksheet

1. Sketch a Spur Gear system (gears touching) and a Chain and Sprocket system (like in this model). Label which direction each piece moves.

2. How is the motion of the axles different in a Chain & Sprocket system as compared to a Spur Gear?

3. On a bicycle, is the input motion (pedals) linear or circular? (Circle one)

4. On a bicycle, is the output motion (wheels) linear or circular? (Circle one)

5. What does the chain do in a Chain and Sprocket system?

6. What is the gear ratio in this model? (driven gear teeth / driver gear teeth) ______________________

7. Why do you think mountain bikes use different sizes of gears?

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Technology Unit 1 — Simple Machines

Transmission Worksheet

1. Position the transmission so the two upright orange pieces are in front of you and the blue crank is on the right; a gray rod sticks out from the left. Find neutral: the yellow rod is between the two orange uprights. When you spin the big blue crank, the two Driving Gears (on the red rod) spin but they don't move anything else.

2. Shift into "first gear": lift the yellow rod, move it to the right of the two orange uprights, and let it back down. Now when you spin the big crank, the driving gear color is ________________ and it moving a driven gear that is color __________________.

3. Shift into "second gear": lift the yellow rod, move it to the left of the two orange uprights, and let it back down. Now when you spin the big crank, the driving gear color is __________________ and it is moving a driven gear that is color ___________________.

4. How many teeth are on the yellow gear? ____________________________

5. How many teeth are on the blue gear? ____________________________

6. Calculate the "gear ratio", which is the number of teeth on the driven gear divided by the number of teeth on the driver gear..

   Gear ration: driven teeth / driver teeth = answer

   First gear: _____________ / _______________ = ______________________________

   Second gear: _____________ / _______________ = ______________________________

7. Which is easier to turn, first gear or second gear?

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Technology Unit 1 — Simple Machines

Rack & Pinion Worksheet

1. Find the rack (purple and orange). Find the pinion (white with green teeth). Find the crank (blue). Put a stick on one tooth of the pinion.

2. Make the following measurements and calculations:

   Diameter (distance across) of the pinion: ______________________ cm

   Circumference (distance around) of the pinion: (diameter x 3.14): ______________________ cm

3. Now, you will turn the pinion half a turn and measure how far the rack moves:

   Distance the rack moves: ______________________ cm

   Distance the pinion moves (circumference divided by 2): ______________________ cm

4. What is the Mechanical Advantage of this system?

   Input distance divided by output distance: ______________________

5. Is the input motion circular or linear? (Circle one)

6. Is the output motion circular or linear? (Circle one)

7. Replace the green teeth with white teeth. Turn the pinion half a turn. (You're repeating the same experiment but with a bigger gear.)

   Diameter (distance across) of the pinion: ______________________ cm

   Circumference (distance around) of the pinion: (diameter x 3.14): ______________________ cm

   Distance the rack moves: ______________________ cm

   Distance the pinion moves (circumference divided by 2): ______________________ cm

   Mechanical Advantage (Input distance / output distance: ______________________

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Conveyor Belt Worksheet

1. The Conveyor Belt uses a sprocket system; sketch a diagram of the moving parts:

2. Use a sticker to mark one point on the tooth of the belt gear (see the picture in the folder).
3. Get a stopwatch and measure how long it takes to turn the belt gear 20 times with these three methods:

   A. With the crank (make sure it's moving smoothly before you start the timer)

   B. Remove the crank and turn the shaft (axle) to which it was connected

   C. Use your fingers to turn the belt gear itself.

	Complete Rotations	Time (in seconds)
Crank	20	
Shaft	20	
Belt Gear	20	

4. Which of the three methods required the most force?

5. Is the input motion circular or linear?

6. Is the output motion circular or linear?

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Technology Unit 1 — Simple Machines

Carousel Worksheet

1. Try rotating the Carousel two different ways:

   A. Turn the crank (you may need to hold the base of the carousel in place)

   B. Rotate the blue rod at the peak of the Carousel

2. Which requires more force?

3. Count the number of teeth on the gears:

   Driver gear: ____________________________

   Driven gear: ____________________________

4. Calculate the Mechanical Advantage:

   driven gear teeth # / driver gear teeth # = ___________________________

5. A "crown gear" system provides a change in direction by setting two gears at 90=degree angles. In other words, one gear is horizontal and the other is perpendicular. How does the crown gear system make work easier?

6. Draw two sketches: this design (crown gear) and how the Carousel would work with a spur gear.

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Blender Worksheet

1. Sketch the following parts of the blender and label them: crank, driver gear, driven gear, chopper.
2. Use arrows to mark which direction each part turns in your diagram.
3. To which part is the effort applied?
4. Is the input motion rotational or linear?
5. Is the output motion rotational or linear?
6. How are the input and output motions the same?
7. How are the input and output motions different?
8. Mark on your diagram the point at which the motion changes from a vertical plane to a horizontal one with the word "change" and an arrow pointing to the point.
9. Does this gear system change the direction of motion or the speed?
10. What type of gear system is used in the Blender?

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Technology Unit 1 — Simple Machines

Crown Gear Worksheet

1. Turn the crank to see how the gears move. Draw a sketch here with arrows showing the direction of movement:

2.

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Technology Unit 1 — Simple Machines

Scissors Worksheet

1. Sketch the scissors and label the effort (E), fulcrum (F) and load (L). Important note: scissors are *double levers*, so there is one fulcrum but two effort points and two load points.

2. Using the model of the scissors (not real scissors), squeeze the “blades” on your fingers in three places: near the fulcrum, near the tips, and in between. Where did you feel the most pressure?

3. Now do the same thing with modeling clay. Do you get the most force near the fulcrum, near the tips, or halfway in between?

4. What other simple machine is included in real scissors (but not in the model)?

5. Scissors are good for cutting through something thin like paper. If you wanted to cut through something much harder, like a branch, how would you change the model to give you more Mechanical Advantage?

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See-Saw & Lifters Worksheet

1. Sketch the see-saw and label the fulcrum (F), resistance (R) and effort (E). Tip: Draw the see-saw with a person sitting on one end already.

2. What class of lever is the See-Saw?
3. Put some pennies in a cup and measure the force needed to lift with a spring scale: _____________ N
4. Slide the gray connectors to the ends of the arms. Hang the cup from one arm. Attach the spring scale to the other arm with a paperclip. Place the see-saw on the corner of a desk so the pennies can hang down. Measure how much force it takes to lift it up.
5. Slide the cup halfway to the fulcrum. Measure how much force it takes now and record below:

	Force to lift cup at end (N)	Force to lift cup halfway to end (N)
See-saw		
2nd Class Lifter		
3rd Class Lifter		

6. Repeat steps 4 & 5 with the 2nd Class Lifter and the 3rd Class Lifter.
7. Which of the six options required the LEAST amount of force, and why?

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Technology Unit 1 — Simple Machines

The Balance Worksheet

PART ONE

1. Label one hanging pain with an E for effort force and one with an L for load force.
2. Attach the load force pan (L) 3 cm from the end of the balance arm. Attach the other load pan and slide it into a position where the balance arm is horizontal (balanced equally).

Trial	Load distance (cm)	Effort distance (cm)	Mechanical Advantage
1			
2			
3			

3. Measure how far each pan is from the fulcrum and record them in the table.
4. For the second trial, move the load force to a new place; slide the effort force until the system is balanced. Measure the distance from the fulcrum to the to pans. Repeat for a third trial.
5. Calculate the Mechanical Advantage: Effort Distance divided by Load Distance.

PART TWO

6. Slide the load pan (L) to the end and measure the distance; slide the effort pan (E) to half that distance.

   Load Distance: ________________________cm   Effort Distance: _______________________ cm

7. Add pennies to the effort pan (E) until the system is balanced.
8. Add four pennies to the load pan (L) and see what happens. How many pennies do you think you will need to add to the effort pan (E) to rebalance the system? Write down your guess then try it.

   Guess: ______________________ pennies   Actual answer: _____________________ pennies

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Catapult Worksheet

1. Sketch the catapult and label the Fulcrum (F), Effort arm (E) and Load arm (L).

2. Choose three small objects and launch each three times with the catapult. Measure how far they go and write down the results.

Type of Object	Distance # 1 (cm)	Distance # 2 (cm)	Distance # 3 (cm)

3. Now choose the object that went the farthest. Change the catapult so that it will go even farther.

Type of Object	Distance # 1 (cm)	Distance # 2 (cm)	Distance # 3 (cm)

4. Bonus project: change the catapult from a 1st class lever to a 3rd class lever. Remove the short ar. Attach a large rubber band to the middle of the long arm, stretch it around a point in the front of the catapult and then pull the arm back to launch. Does it take more or less effort to launch your object?

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Oars Worksheet

1. Sketch the boat and oars; label the fulcrum, resistance and effort of the oars.

2. Imagine you are sitting in the rowboat with the pointed end in front of you and you pull the oars toward yourself. Circle which direction everything is moving.
   A. The handle of the oar is moving: (a) forward (b) backward
   B. The paddle of the oar is moving: (a) forward (b) backward
   C. You and the boat are moving: (a) forward (b) backward

3. What would make rowing the boat easier?
   (a) longer handles   (b) longer paddles

4. what class of lever is an oar of a rowboat?

5. Bonus: look at pictures of other types of boats that use oars, such as canoes, kayaks, galleys and racing sculls. How are they different from a rowboat's oars?

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Technology Unit 1 — Simple Machines

Hand Cart Worksheet

1. Sketch the handcart; label the fulcrum, resistance and effort.

2. What class of lever is a hand cart?

3. What is unusual about the shape of the hand cart as compared to a typical lever?

4. Put a small object on the handcart; lift it up and roll it around.

5. Change the yellow rods to red rods. Using a small book, try laying it down and standing it up. In which position is it easier to lift?

   (a) laying down (b) standing up against the handles

6. If you wanted to lift heavier objects, which dimension would you change to make the work easier?

   (a) make it taller (b) make it wider (c) make it stronger

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Wheelbarrow Worksheet

1. Make a liner for the wheelbarrow with paper or foil and fill it with little objects (i.e. paperclips or small K'Nex pieces).
2. Lift, move and dump the load.
3. Sketch the wheelbarrow; label the fulcrum (F), resistance (R) and effort (E).

4. What class of lever is a wheelbarrow?

5. Change the length of the resistance arm (from the wheel to the load). Does this make lifting easier?

6. Change the length of the effort arm (from the load to the end of the handles). Does this make lifting easier?

7. You could move things with a wheelbarrow or a handcart.
   (a) What is something that would be easier to move with a wheelbarrow? Why?

   (b) What is something that would be easier to move with a handcart? Why?

8. Bonus: research a "travois" and find out how it's like a wheelbarrow and how it's different.

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Technology Unit 1 — Simple Machines

The Door Worksheet

1. Sketch the door; label the fulcrum (F), resistance (R) and effort (E).

2. What class of lever is a door?

3. Tape a piece of spring to the back of the door and run the strung under the bottom of the door. Attach a spring scale to the spring.
4. How much force does it take to open the door? ____________________________ N
5. Now tape the string close to the hinge and measure again: _______________________ N
6. Now tape the string close to the outside edge and measure again: _______________________ N
7. Now try the same thing with a real door; you might need a longer piece of tape to keep the string attached to the back side of the real door. Just like before, run the string under the door.

   Near the outside edge: _______________________________ N

   Near the middle: ____________________________________ N

   Near the hinge: _______________________________________ N

8. If the door wasn't attached with a hinge, how would you open and close the door?

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Technology Unit 1 — Simple Machines

The Hammer Worksheet

1. Sketch the hammer; label the fulcrum (F), resistance (R) and effort (E).

2. What class of lever is a hammer?

3. Get three balls of clay about the same size. Hold the hammer near the end of the handle and hit the first ball of clay three time, trying to flatten it. Now hold the hammer near the head and hit the second ball of clay three times, trying to flatten it. Which hand position worked better?

4. Change your hammer and hammer the third ball of clay. Did you find a way to make your hammer even more powerful?

5. If so, what change did you make that made the hammer more powerful?

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Tweezers Worksheet

1. Sketch the tweezers; label the fulcrum (F), resistance (R) and effort (E).

2. What class of lever are tweezers? Hint: Tweezers are two levers connected by a flexible hinge.

3. Get a small ball of clay. Try to pick it up without squeezing the tweezers into the clay, by using two different hand positions. First, squeeze the tweezers near the hinge. Now try again, squeezing the tweezers near the tips. Which made it easier to pick up the clay very gently?

4. If the tweezers were actually a tool to punch a hole in a piece of cardboard, would it be easier to apply lots of force by squeezing near the hinge or near the tips?

5. Make another pair of tweezers with a longer or shorter effort arm. Explain how this makes it easier to do work.

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Technology Unit 1 — Simple Machines

Fishing Rod Worksheet

1. Sketch the fishing rod; label the fulcrum (F), resistance (R) and effort (E).

2. What class of lever is a fishing rod?

3. Tie a string around the reel, run it through the gray connector at the end of the rod, and hang an open paperclip to the end of the string for a fishing hook. Make a couple of "fish" by snapping a rod to a connector (this gives you something to grab onto).

4. Catch a fish with your fishing rod and lift it out of the pond by tilting the fishing rod. Which moved farther: your hands or this fish?

5. How does a fishing rod make catching a fish easier? (try to think of at least 2 ways).

6. Try lifting a heavier fish. How would you need to change the fishing rod for a REALLY heavy fish?

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Knowledge Series

TCH 201.01

Simple Machines

Student Notebook for ______________________________

Please bring this notebook to class with you each week and return to the teacher at the end of the term.

