UNIT DESCRIPTION:
Students will build a Lou-Vee-AirCar to apply their skills and knowledge to:
- graphing linear equations using slope-intercept, point-slope, and x- and y-intercept techniques;
- determining the slope of a line when given the graph of a line, two points on the line, or the equation of the line; and
- determining the equation of a line when given the graph of the line, the slope and a point on the line, or two points on the line.

Students will fill out an Engineering Journal that shows:
- the data the group collected from their Lou-Vee-AirCar;
- student-created graph with slope of the line and equation for prototype; and
- student-created graph with slope of the line and equation for final.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):
- Linear equations can represent real-world relationships
- The Engineering Design Process involves designing, testing, and improving a product or process

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):
- What can the slope and y-intercept of a line tell us?
- How can the Engineering Design Process be used to improve a product?

<table>
<thead>
<tr>
<th>BENCHMARKS/STANDARDS/LEARNING GOALS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
</tr>
<tr>
<td>HCPS III SC.PH.4.4: Analyze motion in terms of positions, time, velocity and acceleration, both quantitatively and qualitatively</td>
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<tr>
<td><strong>Technology</strong></td>
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<tr>
<td>HCPS III CTE:9-12.2.3: Apply appropriate and safe behaviors and practices in the school, community, and workplace</td>
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<tr>
<td>CCSS Mathematical Practices 5: Use appropriate tools strategically</td>
</tr>
</tbody>
</table>
| **Engineering** | **The Engineering Design Process**  
**Ask:** Understand the problem; state the conditions and limitations; obtain information from prior knowledge  
**Imagine:** Brainstorm ideas (don’t spend too much time here)  
**Plan:** Choose a testable idea; draw a useable prototype; use obtainable, affordable, and safe materials  
**Create:** Follow the plan and make it work  
**Experiment:** Collect, record, and analyze data accurately  
**Improve:** Review data and use data to repeat the process to optimize a product or process |
| **Mathematics** | **(HCPS III)**  
MA.Al.8.1: Graph Linear equations using slope-intercept, point-slope, and x- and y-intercept techniques  
MA.Al.8.2: Determine the slope of a line when given the graph of a line, two points on the line, or the equation of the line  
MA.Al.10.4: Determine the equation of a line when given the graph of the line, the slope and a point on the line, or two points on the line  
**(Math CCSS)**  
F.IF.7: **Analyze functions using different representations.** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*  
  a. Graph linear and quadratic functions and show intercepts, maxima, and minima.  
A.CED.2: **Create equations that describe numbers or relationship.** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.*  
S.ID.7: **Interpret linear models.** Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. |
| **English Language Arts and Literacy** | **CCSS 9-10.SL.4:** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. |
| **STEM Competencies** | **Indicator 3.3:** Generates new and creative ideas and approaches to developing solutions  
**Indicator 5:** The ability to communicate effectively |
<table>
<thead>
<tr>
<th>Lesson Sequence</th>
<th>Lesson Title/Description</th>
<th>Learning Goals (What Students Will Know and Be Able to Do)</th>
<th>Assessments</th>
<th>Time Frame</th>
</tr>
</thead>
</table>
| 1               | Slopes and linear equations | - Graph position vs. time data  
- Graph a linear equation  
- Determine the slope of a line  
- Determine the equation of a line from a graph  
- Explain how a linear equation represents a real-world relationship | Practice Graphing Worksheet | 1 hour |
| 2               | Lou-Vee-AirCar           | - Construct a Lou-Vee-AirCar  
- Modify a Lou-Vee-AirCar to make it go faster  
- Become familiar with the Engineering Design Process  
- Communicate their results with both a written and oral report | - Lou-Vee-AirCar that moves at least 1 meter  
- Engineering Journal  
- Oral Presentation | 5 hours |
**Unit Title:** How Fast Can You Go?  
**Lesson Title:** Slopes & Linear Equations  
**Date Developed/Last Revised:** 8/28/12  
**Unit Author(s):** L. Hamasaki, J. Nakakura, R. Saito  
**Lesson #:** 1  
**Grade Level:** 9-10  
**Primary Content Area:** Math  
**Time Frame:** 1 hour

### PLANNING (Steps 1, 2, & 3)

#### 1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

**HCPS III Algebra**
- MA.Al.8.1: Graph Linear equations using slope-intercept, point-slope, and x- and y-intercept techniques
- MA.Al.8.2: Determine the slope of a line when given the graph of a line, two points on the line, or the equation of the line
- MA.Al.10.4: Determine the equation of a line when given the graph of the line, the slope and a point on the line, or two points on the line

**CCSS Math**
- F.IF.7: **Analyze functions using different representations.** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*
  - a. Graph linear and quadratic functions and show intercepts, maxima, and minima.
- A.CED.2: **Create equations that describe numbers or relationships.** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.*
- S.ID.7: **Interpret linear models.** Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.*

#### 2A. Criteria- What Students Should Know and Be Able to Do:

Students can-
- graph position vs. time data
- graph a linear equation
- determine the slope of a line
- determine the equation of a line from a graph
- explain how a linear equation represents a real-world relationship

#### 2B. Assessment Tools/Evidence:

**Formative:**
- Conversations
- Observations
- Practice graphing worksheet
- Math practice problems (optional)

**Summative:** (please attach copies of rubrics and/or other assessment tools)
- Lou-Vee-AirCar Engineering Journal (in the next lesson of this unit)
3. **Learning Experiences (Lesson Plan)**

**Materials:**
- Sample graph such as wages earned vs. working hours (see below)
- Graphing calculators (optional)

**Handouts/Other Resources:** (please attach copies)
- Practice Graphing Worksheet
- Extra practice problems (optional)

**Procedure:**

Instruct students in:
- **a)** Graphing linear equations
- **b)** Determining the slope of a line
- **c)** Determining the equation of a line

**EXAMPLE**
- Show students a graph with two lines, like wages earned vs. working hours.
- Ask students about the graph: What does each line represent? Who earns more per hour? How do you know? How much does person A earn per hour? How much does person B earn per hour? How do you know? Why does the line go through (0,0)? What would it mean if the line went through (0,6) instead?
- Show students how to calculate slope.
- Explain what the y-intercept is.
- Show students how to write an equation for each line.
- Pass out the Practice Graphing Worksheet. On this worksheet, students will:
  1) create a graph from a set of data
  2) determine the slope of the line
  3) write the equation of the line
- Optional: can use graphing calculators

**Homework Activity (Optional):**
- Problems in textbooks or other extra practice as needed

**TEACHING & ASSESSMENT (Steps 4, 5, 6, & 7)**

4. **Teaching and Collecting of Evidence of Student Learning:**
   Teacher Notes:

5. **Analysis of Student Products/Performances - Formative:**
   Teacher Notes:

6. **Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):**
   Teacher Notes:

7. **Teacher Reflection: Replanning, Reteaching, Next Steps:**
   Teacher Notes:
Unit Title: How Fast Can You Go?
Lesson Title: Lou-Vee-AirCar
Date Developed/Last Revised: 8/29/12
Unit Author(s): L. Hamasaki, J. Nakakura, R. Saito

Lesson #: 2
Grade Level: 9-10
Primary Content Area: Math
Time Frame: 5 class periods (1 hour each)

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:
   Science: HCPS III
   - SC.PH.4.4: Analyze motion in terms of positions, time, velocity and acceleration, both quantitatively and qualitatively
   Technology: HCPS III
   - CTE:9-12.2.3: Apply appropriate and safe behaviors and practices in the school, community, and workplace
   Engineering: Framework for K-12 Science Education
   - ETS 1: Engineering Design

STEM Competencies:
- Indicator 3.3: Generates new and creative ideas and approaches to developing solutions
- Indicator 5: The ability to communicate effectively

2A. Criteria- What Students Should Know and Be Able to Do:
Students can-
- Construct a Lou-Vee-AirCar.
- Modify a Lou-Vee-AirCar to make it go faster.
- Become familiar with the Engineering Design Process.
- Communicate their results with both a written and oral report.

2B. Assessment Tools/Evidence:
Formative:
- Conversations: Walk around and ask students if they need help with constructing cars and ask what step they are on. Ask students to explain how cars work and which step of the Engineering Process they are on. Ask students if they understand how the cars work.
- Observations: Check to see if students are having difficulty with construction of cars and if cars move.
- Verbal or written feedback on the Engineering Journal before it is turned in.

Summative: (please attach copies of rubrics and/or other assessment tools)
- Products:
  - Working Lou-Vee-AirCar that moves at least 1 meter
  - Lou-Vee-AirCar Engineering Journal
  - Oral Presentation
3. Learning Experiences (Lesson Plan)

**Materials:**
- 1 sheet of $8\frac{1}{2}'' \times 11''$ paper
- 3 standard (small) paperclips
- 1 large paperclip
- 2 plastic straws
- 2 index cards, $5'' \times 8''$
- Masking tape
- 3 rubber-bands (size 32)
- Pencil
- Drawing Compass
- Scissors
- Pliers
- Hammer
- Meter stick
- Stopwatch or Motion detector such as Vernier Go!Motion Probe

**Handouts/Other Resources:** (please attach copies)
- Lou-Vee-AirCar Handout ([www.smartcenter.org/sciencechallenge/lou-vee-air.html](http://www.smartcenter.org/sciencechallenge/lou-vee-air.html))
- Engineering Journal
- Rubric and/or Evidence Checklist

**Procedure:**

**Introduce the Project (60 minutes)**

**Hook:** Show the car in action or a video (e.g. [http://www.youtube.com/watch?v=mSQ1FRdyD7k](http://www.youtube.com/watch?v=mSQ1FRdyD7k))

**Performance task: (What students will be doing)**
You are an engineer that has been asked to design the fastest Lou-Vee-AirCar that travels in a straight line. You will log all of your plans and thoughts in an Engineering Journal. You will then present your findings to the Board of Directors of a toy car design company. Final judging will be done based on the Engineering Journal and presentation. Thank you for delving into your creativity as you build the fastest Lou-Vee-AirCar ever!

**Engineering Design Process:**

**Question:** Why do people design cars? Why do people continually redesign cars?

1) Introduce the Lou-Vee-AirCar. Show examples/non-examples of the cars that they will be building. Notice the placement of the straw, propeller, and wheels.

2) Tell students they will build a car that can travel at least 1 meter. Then they will record data to determine average speed of the car and graph and analyze data. (Stopwatches and meter sticks will be available for students to use.) Briefly discuss average speed and formula to use: average speed = (total distance)/(total time).
3) Show two objects that move at different speeds. Demonstrate Vernier Go!Motion Probe and measure speed of the two objects. Project graph (with the two lines) on a screen for all students to observe difference in slopes of lines.

Question: What makes the car move fast? What makes the car move in a straight line?

4) Students will be going through the Engineering Design Process as they build these cars. Have students record their progress in the Lou-Vee-AirCar Engineering Journal.

   Ask:
   - Understand the problem
   - State the conditions and limitations
   - Obtain information from prior knowledge

   Imagine:
   - Brainstorm ideas (don’t spend too much time here)

   Plan:
   - Choose a testable idea
   - Draw a useable prototype
   - Use obtainable, affordable, and safe materials

   **Build the car and collect data (180 minutes)**

   Create:
   - Follow the plan and make it work

   Experiment:
   - Collect, record, and analyze data accurately

   Improve:
   - Review data
   - Use data to repeat process to optimize (how to overcome forces such as weight, friction, etc.)

   **Teacher:** Review pitfalls and successes of the Car designs. Discuss effect of forces on speed of car and how graph can be used to predict speed of car. Check for understanding and clear misconceptions.

5) Students will complete the Engineering Journal containing a graph of their Lou-Vee-AirCar data, slope of the line, and the equation of the line for their prototype and final cars. Students should also be able to explain how they can make predictions, i.e., “If car travels 4 meters in 6 seconds, then how long will it take to travel 2 meters?”

   **Communicate Results (60 minutes)**

6) Students will then report out to the class (summarize their findings from their Engineering Journal).
7) Other notes:

- Students will be given written directions and materials for the Lou-Vee-AirCar. Students must use the one rubber band given to them by the teacher. (Replacement rubber bands will cost 10 cents.)
- Students will work in pairs to construct cars in class. If students need more time, they can come in at lunch or afterschool to complete cars. Students may also take cars home to complete.
- Students will be allowed to modify cars as long as cars are safe and propelled by the energy from the rubber band.
- If students have difficulty:
  - Show them the exemplar car
  - Suggest looking at Troubleshooting section in directions
  - Suggest they do research
  - Have students use the Engineering Design Process to modify car or make a new car
  - Discuss possible problems with car design/ construction and provide guidance to help students fix problems.
    - Discuss workmanship and quality of products with students. Students may have to make new cars if workmanship of original car is poor—e.g., wheels are crooked, propeller is not designed properly, directions were not accurately followed, etc...
    - Review Physical Science concepts of friction, mass, and force with students.
      - Friction (between propeller and shaft, wheels and ground, rubber band and paperclips, etc.) may be hindering progress of car.
      - Car parts may be too heavy or unbalanced (propeller, wheels).
      - Rubber band may not be twisted enough to produce enough force to move the car. If rubber band is twisted too much, the rubber band may get stuck together and the car may not move.
- If motion detectors are available, multiple data points for position and time can be used to determine car speed instead of using only total distance and total time.

Homework Activity (Optional):
- Students may need more time (at home, afterschool, etc.) to complete/remake cars.

**TEACHING & ASSESSMENT (Steps 4, 5, 6, & 7)**

**Completed by teacher after instruction has taken place**

4. **Teaching and Collecting of Evidence of Student Learning:**
   
   **Teacher Notes:**

5. **Analysis of Student Products/Performances - Formative:**
   
   **Teacher Notes:**

6. **Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):**
   
   **Teacher Notes:**

7. **Teacher Reflection: Replanning, Reteaching, Next Steps:**
   
   **Teacher Notes:**
Practice Graphing Worksheet

1. Data from a Lou-Vee-AirCar is shown below.

   Table 1: Position (m) and time (s) for a Lou-Vee-AirCar

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Position (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>1.50</td>
</tr>
<tr>
<td>3</td>
<td>2.25</td>
</tr>
</tbody>
</table>

   a. Graph position vs. time for the data shown above.
   b. Determine the slope of the line.
   c. Write a linear equation for the line.
2. The data for a second Lou-Vee-AirCar produced the equation \( y = 0.35x + 1 \).
   a. Graph position vs. time for this car.
   
   b. What is the slope of this line?
   
   c. What does the slope of the line tell you about the car?
   
   d. What is the y-intercept of this line?
   
   e. What does the y-intercept of this line tell you about the car?
Problem: You are an engineer that has been asked to design the fastest Lou-Vee-AirCar that travels in a straight line. You will log all of your plans and thoughts in this Engineering Journal. You will then report your findings to the car design panel. Final judging will be done based on your Engineering Journal and presentation. Thank you for delving into your creativity as you build the fastest Lou-Vee-AirCar ever!!

Criteria: You will be provided the following materials to build your prototype and final cars. You may bring in your own supplies from home if you choose.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Tools</th>
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</thead>
<tbody>
<tr>
<td>One sheet of 8.5&quot;x11&quot; size paper</td>
<td>Pencil</td>
</tr>
<tr>
<td>Three standard paper clips</td>
<td>Drawing compass</td>
</tr>
<tr>
<td>One large paper clip</td>
<td>Scissors</td>
</tr>
<tr>
<td>Two plastic straws</td>
<td>Pliers</td>
</tr>
<tr>
<td>Two index cards (5&quot; x 8&quot;)</td>
<td>Hammer</td>
</tr>
<tr>
<td>Narrow masking tape</td>
<td>Meter stick</td>
</tr>
<tr>
<td>Three rubber bands-size 32</td>
<td>Stopwatch or motion detector such as Vernier Go! Motion Probe</td>
</tr>
</tbody>
</table>

Due dates:
- Prototype design: ________  Final design: ________
- Prototype build: ________  Final build: ________
- Prototype test: ________  Final test: ________

STEP 1: Ask- Form questions about the project that you want to know more about. Ask your questions during the class discussion and write down your answers.

STEP 2: Imagine- Draw your ideas of a possible design(s).

Write down ideas for modifications to the basic design given to you that you may want to try (e.g. different materials, dimensions, etc.).

STEP 3: Plan- Think about which design would work best and make your choice. Write it down in the space below.
**STEP 4: Create**- Build your prototype Lou-Vee-Air Car.

**STEP 5: Experiment Prototype**- Measure the distance and time your car travels.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Distance (m)</th>
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<tr>
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</table>

Other Observations:

Graph your data.

Calculate the slope of the line.

Determine the equation of the line.

Explain what the slope and the intercept from your graph tell you about your car.

**STEP 6: Improve**- Make it better!

Ask: Write down what worked.

Write down what didn’t work.
**Imagine/Plan** - Write down and/or draw your plan to improve what didn’t work.

**Create** - Build your final Lou-Vee-AirCar.

**Experiment Final** - Measure the distance and time your car travels.

<table>
<thead>
<tr>
<th>Time (s)</th>
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</tbody>
</table>

**Other Observations:**

Graph your data.

Calculate the slope of the line.

Determine the equation of the line.

Explain what the slope and the intercept from your graph tell you about your car.

Assuming your car travels at a constant speed indefinitely, predict how long it would take your car to go 17.5 m. Show your work or explain how you got your prediction.
## How Fast Can You Go? Checklist

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Criteria (Learning Target # in Parentheses)</th>
</tr>
</thead>
</table>
| Practice Graphing Worksheet | Problem #1 on worksheet:  
- □ Appropriate type of graph is drawn. (1)  
- □ Position is on the y-axis and time is on the x-axis. (1)  
- □ x and y axes are accurately subdivided into scale. (1)  
- □ Position vs. time is accurately graphed, given position and time data. (1)  
- □ The slope of a line is accurately determined. (3)  
- □ An appropriate linear equation is determined from a graph. (4)  
- □ Graphs are labeled with an appropriate title, axis labels, and units. (1) |
| | Problem #2 on worksheet:  
- □ Appropriate type of graph is drawn. (2)  
- □ Position is on the y-axis and time is on the x-axis. (2)  
- □ x and y axes are accurately subdivided into scale. (2)  
- □ Position vs. time is accurately graphed, given a linear equation. (2)  
- □ The slope of a line is accurately determined. (3)  
- □ Graphs are labeled with an appropriate title, axis labels, and units. (2) |
| Lou-Vee-AirCar | □ Car moves at least one meter. (6)  
□ Modified car moves faster than the original car. (7) |
| Engineering Journal | □ All steps of the Engineering Design Process are completed and documented in the journal. (8)  
- □ Information is clear, accurate, and complete. (9)  
- □ A reasonable rationale is provided for re-design decisions. (8, 9)  
- □ Appropriate type of graph is drawn. (1)  
- □ Position is on the y-axis and time is on the x-axis. (1)  
- □ x and y axes are accurately subdivided into scale. (1)  
- □ Position vs. time is accurately graphed, given position and time data. (1)  
- □ The slope of a line is accurately determined. (3)  
- □ An appropriate linear equation is determined from a graph. (4)  
- □ Graphs are labeled with an appropriate title, axis labels, and units. (1)  
- □ Connections are accurately made and explained between the slope and y-intercept of the graph and what they represent about the car. (5) |
| Oral presentation | □ Voice is loud enough to easily hear. (9)  
□ Enunciation of words is clear enough to easily understand. (9)  
□ Pacing is fluent and appropriate—not too fast to follow or so slow that listeners get restless. (9) |

**Learning Targets:**

1. Graph position vs. time data (Practice graphing worksheet, Journal)  
2. Graph a linear equation  
3. Determine the slope of a line  
4. Determine the equation of a line from a graph  
5. Explain how a linear equation represents a real-world relationship  
6. Construct a Lou-Vee-AirCar that goes at least 1 meter  
7. Modify a Lou-Vee-AirCar to make it go faster  
8. Become familiar with the Engineering Design Process  
9. Communicate results with both a written and oral report
### How Fast Can You Go?

<table>
<thead>
<tr>
<th>Practice Graphing Worksheet</th>
<th>Advanced</th>
<th>Proficient</th>
<th>Beginning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Appropriate type of graph is drawn.</td>
<td>• Appropriate type of graph is</td>
<td>• May have an inappropriate type of</td>
</tr>
<tr>
<td></td>
<td>• Position is on the y-axis and time is</td>
<td>drawn.</td>
<td>graph drawn.</td>
</tr>
<tr>
<td></td>
<td>• Position is on the x-axis.</td>
<td>• Position is on the y-axis and</td>
<td>• Position may be on the x-axis and</td>
</tr>
<tr>
<td></td>
<td>• x and y axes are accurately subdivided into</td>
<td>• x and y axes are accurately</td>
<td>time on the y-axis.</td>
</tr>
<tr>
<td></td>
<td>• Position vs. time is accurately graphed, given</td>
<td>subdivided into scale.</td>
<td>• x-and y axes may not be</td>
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<td>• Position and time data may be</td>
</tr>
<tr>
<td></td>
<td>linear equation.</td>
<td>data.</td>
<td>plotted inaccurately.</td>
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<tr>
<td></td>
<td>• The slope of a line is accurately determined.</td>
<td>• The slope of a line is accurately</td>
<td>• The y-intercept and/or slope may</td>
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<tr>
<td></td>
<td>• An appropriate linear equation is determined</td>
<td>determined.</td>
<td>be plotted inaccurately, given a</td>
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<tr>
<td></td>
<td>from a graph.</td>
<td>• An appropriate linear equation is</td>
<td>linear equation.</td>
</tr>
<tr>
<td></td>
<td>• Graphs are labeled with an appropriate title,</td>
<td>determined from a graph.</td>
<td>• There may be errors in calculating</td>
</tr>
<tr>
<td></td>
<td>axis labels, and units.</td>
<td>• Work is completed with some</td>
<td>the slope of a line.</td>
</tr>
<tr>
<td></td>
<td>• Work is completed independently.</td>
<td>assistance.</td>
<td>• There may be errors in</td>
</tr>
<tr>
<td>Lou-Vee-AirCar</td>
<td>• Car consistently moves more than one meter.</td>
<td>• Car moves at least one meter</td>
<td>determining the linear equation for</td>
</tr>
<tr>
<td></td>
<td>• Modified car moves consistently faster than the</td>
<td>some of the time.</td>
<td>a graph.</td>
</tr>
<tr>
<td></td>
<td>original car.</td>
<td>• Modified car sometimes moves</td>
<td></td>
</tr>
<tr>
<td>Engineering Journal</td>
<td>All steps of the Engineering Design Process are</td>
<td>All steps of the Engineering</td>
<td>Some steps of the Engineering</td>
</tr>
<tr>
<td></td>
<td>completed and documented in the journal.</td>
<td>Design Process are completed and</td>
<td>Design Process are completed and</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>• A reasonable rationale is provided for re-design</td>
<td>• A rationale is provided for</td>
<td>• A rationale may not be provided</td>
</tr>
<tr>
<td></td>
<td>decisions.</td>
<td>re-design decisions.</td>
<td>for re-design decisions.</td>
</tr>
</tbody>
</table>

- Advanced: 
  - Car consistently moves more than one meter.
  - Modified car moves consistently faster than the original car.

- Proficient: 
  - Car moves at least one meter some of the time.
  - Modified car sometimes moves faster than the original car

- Beginning: 
  - Car is not able to move one meter.
  - Modified car moves the same speed or slower than the original car.
<table>
<thead>
<tr>
<th>Engineering Journal (cont.)</th>
<th>Advanced</th>
<th>Proficient</th>
<th>Beginning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Appropriate type of graph is drawn.</td>
<td>• Appropriate type of graph is drawn.</td>
<td>• May have an inappropriate type of graph drawn.</td>
<td></td>
</tr>
<tr>
<td>• Position is on the y-axis and time is on the x-axis.</td>
<td>• Position is on the y-axis and time is on the x-axis.</td>
<td>• Position may be on the x-axis and time on the y-axis.</td>
<td></td>
</tr>
<tr>
<td>• x and y axes are accurately subdivided into scale.</td>
<td>• x and y axes are accurately subdivided into scale.</td>
<td>• x-and y axes may not be accurately subdivided into scale.</td>
<td></td>
</tr>
<tr>
<td>• Position vs. time is accurately graphed, given position and time data.</td>
<td>• Position vs. time is accurately graphed, given position and time data.</td>
<td>• Position and time data may be plotted inaccurately.</td>
<td></td>
</tr>
<tr>
<td>• The slope of a line is accurately determined.</td>
<td>• The slope of a line is accurately determined.</td>
<td>• There may be errors in calculating the slope of a line.</td>
<td></td>
</tr>
<tr>
<td>• An appropriate linear equation is determined from a graph.</td>
<td>• An appropriate linear equation is determined from a graph.</td>
<td>• There may be errors in determining the linear equation for a graph.</td>
<td></td>
</tr>
<tr>
<td>• Graphs are labeled with an appropriate title, axis labels, and units.</td>
<td>• Connections are accurately made between the slope and y-intercept of the graph and what they represent about the car.</td>
<td>• Connections between the slope and y-intercept of the graph and what they represent are incorrect or not made.</td>
<td></td>
</tr>
<tr>
<td>• Connections are accurately made and explained between the slope and y-intercept of the graph and what they represent about the car.</td>
<td>• Work is completed independently.</td>
<td>• Work is completed with some assistance.</td>
<td></td>
</tr>
</tbody>
</table>

| Oral presentation-Communication | Voice is loud enough to easily hear. Enunciation of words is clear enough to easily understand. Pacing is fluent and appropriate—not too fast to follow or so slow that listeners get restless. | Voice is loud enough to hear most of the time. Enunciation of words is clear enough to understand most of the time. Pacing is generally appropriate. | Voice is too soft to hear. Words are mumbled and difficult to understand. Pacing is either too fast to follow or too slow to keep the attention of the audience. Speech is not fluent and may include cut-off sentences, partially repeated sentences, or frequent use of fillers (like, um, well, you know). |
Practice Graphing Worksheet

1. Data from a Lou-Vee-AirCar is shown below.

**Table 1: Position (m) and time (s) for a Lou-Vee-AirCar**

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Position (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>1.50</td>
</tr>
<tr>
<td>3</td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Position vs. Time for a Lou-Vee-AirCar**

a. Graph position vs. time for the data shown above.

b. Determine the slope of the line.

\[
\frac{y_2-y_1}{x_2-x_1} = \frac{2.25-0}{3-0} = \frac{2.25\text{ m}}{3\text{ s}} = 0.75 \text{ m/s}
\]

(c. Write a linear equation for the line.

\[
y = 0.75x + 0
\]

If \( x \) = position \( t \) = time, then \( x = 0.75t \)
2. The data for a second Lou-Vee-AirCar produced the equation \( y = 0.35x + 1 \).
   a. Graph position vs. time for this car.
      
      \[
      \text{Position vs. Time for a Lou-Vee-Aircar}
      \]
      
      \[
      \begin{array}{c|c|c|c|c|c}
      \text{Time (s)} & 0 & 1 & 2 & 3 & 4 \\
      \hline
      \text{Position (m)} & 0 & 1 & 1.5 & 2 & 2.5 \\
      \end{array}
      \]
      
   b. What is the slope of this line?
      
      \[0.35 \text{ m/s}\]
      
   c. What does the slope of the line tell you about the car?
      
      \text{The car moves at a speed of 0.35 m/s.}
      
   d. What is the \( y \)-intercept of this line?
      
      \[1 \text{ m}\]
      
   e. What does the \( y \)-intercept of this line tell you about the car?
      
      \text{The car starts 1 m away from the start line.}
Position m

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Position (m)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.168</td>
</tr>
<tr>
<td>2</td>
<td>0.10</td>
<td>0.168</td>
</tr>
<tr>
<td>3</td>
<td>0.15</td>
<td>0.168</td>
</tr>
<tr>
<td>4</td>
<td>0.20</td>
<td>0.168</td>
</tr>
<tr>
<td>5</td>
<td>0.25</td>
<td>0.168</td>
</tr>
<tr>
<td>6</td>
<td>0.30</td>
<td>0.168</td>
</tr>
<tr>
<td>7</td>
<td>0.35</td>
<td>0.175</td>
</tr>
<tr>
<td>8</td>
<td>0.40</td>
<td>0.188</td>
</tr>
<tr>
<td>9</td>
<td>0.45</td>
<td>0.193</td>
</tr>
<tr>
<td>10</td>
<td>0.50</td>
<td>0.220</td>
</tr>
<tr>
<td>11</td>
<td>0.55</td>
<td>0.245</td>
</tr>
<tr>
<td>12</td>
<td>0.60</td>
<td>0.257</td>
</tr>
<tr>
<td>13</td>
<td>0.65</td>
<td>0.296</td>
</tr>
<tr>
<td>14</td>
<td>0.70</td>
<td>0.333</td>
</tr>
<tr>
<td>15</td>
<td>0.75</td>
<td>0.394</td>
</tr>
<tr>
<td>16</td>
<td>0.80</td>
<td>0.371</td>
</tr>
<tr>
<td>17</td>
<td>0.85</td>
<td>0.408</td>
</tr>
<tr>
<td>18</td>
<td>0.90</td>
<td>0.431</td>
</tr>
<tr>
<td>19</td>
<td>0.95</td>
<td>0.459</td>
</tr>
<tr>
<td>20</td>
<td>1.00</td>
<td>0.482</td>
</tr>
<tr>
<td>21</td>
<td>1.05</td>
<td>0.528</td>
</tr>
<tr>
<td>22</td>
<td>1.10</td>
<td>0.584</td>
</tr>
<tr>
<td>23</td>
<td>1.15</td>
<td>0.621</td>
</tr>
<tr>
<td>24</td>
<td>1.20</td>
<td>0.671</td>
</tr>
<tr>
<td>25</td>
<td>1.25</td>
<td>0.714</td>
</tr>
<tr>
<td>26</td>
<td>1.30</td>
<td>0.745</td>
</tr>
<tr>
<td>27</td>
<td>1.35</td>
<td>0.764</td>
</tr>
<tr>
<td>28</td>
<td>1.40</td>
<td>0.776</td>
</tr>
</tbody>
</table>

Linear Fit for Latest | Position
\[ x = mx + b \]
- \( m \) (Slope): 0.5785 m/s
- \( b \) (Y-Intercept): -0.98632 m
- Correlation: 0.9915
- RMSE: 0.04936 m

Name: Example w/Vernier Sensor Per: ___ Date: ____________

Problem: You are an engineer that has been asked to design the fastest Lou-Vee-AirCar that travels in a straight line. You will log all of your plans and thoughts in this Engineering Journal. You will then report your findings to the car design panel. Final judging will be done based on your Engineering Journal and presentation. Thank you for delving into your creativity as you build the fastest Lou-Vee-AirCar ever!!

Criteria: You will be provided the following materials to build your prototype and final cars. You may bring in your own supplies from home if you choose.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>• One sheet of 8.5&quot;x11&quot; size paper</td>
<td>• Pencil</td>
</tr>
<tr>
<td>• Three standard paper clips</td>
<td>• Drawing compass</td>
</tr>
<tr>
<td>• One large paper clip</td>
<td>• Scissors</td>
</tr>
<tr>
<td>• Two plastic straws</td>
<td>• Pliers</td>
</tr>
<tr>
<td>• Two index cards (5&quot; x 8&quot;)</td>
<td>• Hammer</td>
</tr>
<tr>
<td>• Narrow masking tape</td>
<td>• Meter stick</td>
</tr>
<tr>
<td>• Three rubber bands-size 32</td>
<td>• Stopwatch or motion detector such as Vernier Go! Motion Probe</td>
</tr>
</tbody>
</table>

Due dates:
Prototype design: ___ Final design: ___
Prototype build: ___ Final build: ___
Prototype test: ___ Final test: ___

STEP 1: Ask- Form questions about the project that you want to know more about. Ask your questions during the class discussion and write down your answers.

Are we working in groups?

STEP 2: Imagine- Draw your ideas of a possible design(s).

Write down ideas for modifications to the basic design given to you that you may want to try (e.g. different materials, dimensions, etc.).

- Shorter body for the car
- Bigger wheels
- Thicker material for wheels
- Straight wire instead of paper clips

STEP 3: Plan- Think about which design would work best and make your choice. Write it down in the space below.

Shorter body for the car (2" shorter)
STEP 4: Create - Build your prototype Lou-Vee-Air Car.

STEP 5: Experiment Prototype - Measure the distance and time your car travels.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>1.5</td>
<td>0.722</td>
</tr>
<tr>
<td>1.0</td>
<td>0.520</td>
</tr>
<tr>
<td>1.5</td>
<td>0.755</td>
</tr>
<tr>
<td>2.0</td>
<td>1.040</td>
</tr>
</tbody>
</table>

Other Observations:

The car veered left.

Calculate the slope of the line.

\[
\frac{y_2-y_1}{x_2-x_1} = \frac{1.0-0}{1.9-0} = \frac{1.0}{1.9} = 0.52 \text{ m/s}
\]

Determine the equation of the line.

\[
y = 0.52x + 0
\]

If \( x = \text{position, } t = \text{time} \), then \( x = 0.52t \)

Explain what the slope and the intercept from your graph tell you about your car.

Slope: The car moves at a speed of 0.52 m/s.
Intercept: The car starts at the starting line, not ahead of or behind it.

Graph your data.

Graph: Position vs. Time for Lou-Vee-Air Car Prototype

STEP 6: Improve - Make it better!

Ask: Write down what worked.

The car moved forward 1 m.

Write down what didn’t work.

The car veered left.
The car was slow.
Imagine/Plan - Write down and/or draw your plan to improve what didn’t work.

- We will try re-taping the back wheels to be more centered to make it go straight.
- We will try different shapes and materials for the propeller to make the car faster.

Create - Build your final Lou-Vee-AirCar.

Experiment Final - Measure the distance and time your car travels.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>0.333</td>
</tr>
<tr>
<td>1.0</td>
<td>0.776</td>
</tr>
<tr>
<td>1.5</td>
<td>1.133</td>
</tr>
<tr>
<td>2.0</td>
<td>1.521</td>
</tr>
</tbody>
</table>

Calculate the slope of the line.

\[ \frac{y_2 - y_1}{x_2 - x_1} = \frac{1.2 - 0}{1.6 - 0} = \frac{1.2}{1.6} = 0.75 \text{ m/s} \]

Determine the equation of the line.

\[ y = 0.75x + 0 \]
\[ y = 0.75x \]

If \( x \) = position \& \( t \) = time, then \[ x = 0.75t \]

Explain what the slope and the intercept from your graph tell you about your car.

Slope: The car moves at 0.75 m/s.
Intercept: The car starts at the starting line, not ahead of or behind it.

Other Observations:

Graph your data. Position vs. Time for Lou-Vee AirCar Final

Assuming your car travels at a constant speed indefinitely, predict how long it would take your car to go 17.5 m. Show your work or explain how you got your prediction.

\[ x = 0.75t \]
\[ t = \frac{x}{0.75} \]
\[ t = \frac{17.5}{0.75} \]
\[ t = 23.3 \text{ sec} \approx 23 \text{ seconds} \]