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| **TEAM Lesson Plan Template** |
| Teacher: Dr. Jeremy Entner |
| Subject/Grade: Probability and Statistics / 7th Grade / High School |
| Lesson Title: Gravity Wheels |
| **STANDARDS** | **Identify what you intend to teach.** State, Cocmon Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| **SMP4**. Model with mathematics.**SMP5**. Use appropriate tools strategically. **7.SP.A.1** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.**7.SP.B.3** Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. *For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team; on a dot plot or box plot, the separation between the two distributions of heights is noticeable.***S.IC.D.17** Construct the confidence interval for a mean and for a difference between two means. |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledgeStudent-Friendly (I Can Statement) |
| I can determine the mean of a data set.I can compare two data sets. I can construct a confidence interval. |
| **MATERIALS AND RESOURCES**  | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook.  |
| **Activities & Materials** Need room to set up 30 feet of car track per group of students (perhaps in hallway or outside on a sidewalk or basketball court). For each group of students: a Hot-Wheels car; race-case; 40feet of track; blue pen and black pen; Sharpie or Expo type marker; Two 2”x5’ paper strip; Measuring tape; Calculators; Recording sheet; Tape \_x\_ Laptop/Computers; Projector; \_x\_Internet Resource (See Anticipatory Set) **What if the technology is not working?** Skip the videos.**Routine for distributing materials.** After assigning group roles, call individuals to a central location to pick up materials. When they pick up materials, quickly show them how to perform their role.  |
| **ACCOCMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners** **Differentiation****----- Content** The activity is the same for all students, but some questions are tailored to individual students. Different students will discuss the appearance, range, and average of the data sets with different levels of sophistication. Different students will discuss and calculate confidence intervals with different levels of precision.**----- Process** The process is distinct for each of the different roles in each group. Careful assignment of roles should ensure that the process is suitable for each student. **-----Product** The product from each group is a paper strip which will be created the same way. Individuals will answer questions orally throughout the activity. **Accocmodations****\_\_\_ Preferential Seating** Students with mobility issues may need to have the track placed on a (long) table so that they can reach it. **\_\_\_ Peer Tutoring** This group activity lends itself to peer tutoring. Students may discuss their answers with each other. **Early Finishers:** Students in any one group will finish at the same time. If a group finishes well before another group, then the early group will be asked to conduct more trials.  |

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| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant. |
| Consider showing one of the following YouTube videos, depending on taste. Neither has anything to do with mathematics, but both introduce cars in an interesting way. Tracy Chapman singing “Fast Car” <https://www.youtube.com/watch?v=AIOAlaACuv4> orDrag Racing Real Street Cars (from 2:00 to 3:04 min) <https://www.youtube.com/watch?v=IAAIQgrxJ_c>  |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| ***Introductio*n** We have looked at data sets, and we have talked about the center and the range of a data set. Today we are going to collect some data. We will see how far various cars go on a track. We will look at the distribution of distances for a single car, and we will compare the distribution for one car to the distribution of another car. **Motivating Students** \_x\_ Verbal Reinforcement throughout the activity\_x\_ Small Rewards. To encourage consistent release of cars, the group with the smallest range of stopping positions for both cars will get a popper each (smallest range = (range for car 1) + (range for car 2)).  \_x\_ Relate to Real World The activity calls on students to make observations about something that is actually happening rather than use a set of numbers from a worksheet. **Presenting Instructional Content** \_x\_ Hands-On; \_x\_ Discussion; \_x\_ Discovery Learning***Instructional strategies:*** Before class, set up a section of track with race case, track, car, paper strip, pens, and marker for demonstration. Have the equipment for each group near this display in an equipment location. After providing the introduction, separate students into groups of 4 (or 5). Have no more groups than there are track sets available. Assign one member of each group to be the “Let the car go”-er, another to be the “Measurer,” a third to be the “Marker,” and a fourth to be the “Take the car back”-er. If a group has 5 students, the fifth student should assist the measurer (hold the tape, write on the recording sheet, and/or operate the calculator). Give each group a number or name (Group 1, Group 2, etc.). Tell the Markers to remember their group number. Have the “Let the car go”-ers come to the equipment location to pick up a race case and two cars each. They should identify one of the cars as Car 1, and the other as Car 2. While they are there to pick up the race cases, show them how to release the cars using gravity only. DO NOT USE the LAUNCHER for this activity. Place the car on the track in the same place each time, hold with a finger, and let go. Do not push. Just let go. The group with the smallest variance in their car stopping positions gets a prize. Once the “Let the car go”-ers understand what to do have them move to set up their race cases. Have the Measurers (and any 5th students in a group, who will help measure) come to the equipment location to pick up a measuring tape, calculator, and a recording sheet. Show them how to measure the distance from the end of the strip to an “x” marking where a car stops. Explain that they are to make this measurement after each time the marker marks where the car stops. They should measure, record the number on the recording sheet, and then type the number into a calculator list. They will calculate the average of these numbers at the end. Show them how to measure the range of the data set, from “x” closest to the race set to “x” furthest from race set. Once the Measurers understand what to do have them move to set up their race cases. Have the “Take the car back”-ers come to the equipment location to pick up twenty feet of track. Show them how to put track sections together and tell them to connect the first piece to the race case. Explain that their job is to wait until the marker has marked the cars’ position, then take the car back to the top of the track and give the car to the “Let the car go”-er. Once the “Take the car back”-ers understand their role, have them move to their “Let the car go”-ers and set up the track. Have the “Markers” come to the equipment location to pick up a blue pen, a black pen, a marker, and two long strips of paper. Show them how to mark the track where they place an end of the paper strip. Have them write their group number on the end of their paper strips. Tell them to use the blue pen to mark the first car. Use the black pen to mark the second car. Mark the position of the front tire each time. Once the Markers understand their role, have them move to their group. Move with them. **Modeling and Guided Practice *–***When students are in their groups and tracks are assembled, have them conduct a practice run. Let the car go down the track. Place the first paper strip beside the track so that it is centered on the location where the car stopped. Do not mark the car’s position, but have the Markers make a mark on the track to indicate the end of their paper strip. If anything gets bumped or blown away, then they can put the strip back in the same position relative to the track. Ensure that markers have their blue pens. Let the car go down the ramp, mark where it stops. Measure the distance and record. Repeat at least 25 times. If a group finishes early, then repeat at least 30 times. Measure the range of the stopping positions. Monitor student work during this part of the activity, providing encouragement and pointers as needed. Now, get the whole group’s attention. Conduct a discussion prompted by these questions:* Is the car stopping in the same place each time?
* What is the range of the stopping positions?
* Where does it stop “on average” visually? ( *each group should point to a spot for their car* )
* Where does it stop “on average” mathematically? Actually calculate the average and measure to this spot. Do the visual and mathematical average stopping locations agree? ( *Measurers should calculate the average. If they have been keeping up with typing numbers into the calculator this should not take long.*)

Have groups get out car 2. Align the second paper strips with tracks in the same position as the first strip. Do not lose the first strips of paper. Make sure that markers have their black pens out. For car 2, each group should let the car go down the ramp, mark where it stops. Measure the distance and record. Repeat at least 25 times. Measure the range of the stopping positions. Monitor student work. Now, get the whole group’s attention. Conduct a discussion prompted by these questions:* Do the results for the two cars match exactly?
* Do they look the same?
* Are the ranges the same? Are they close to the same?
* Are the average stopping locations the same? Are they close?

Have Markers bring all strips to one spot and lay them side by side. Make sure that they are oriented the same way, that is, that the ends that were close to the race case are all on the same end. Have the whole group look at the strips. There are two “good” alignments for these strips. The first is to have all of the ends aligned. This first way is good for comparing the means. The second is to align the means. This gives a better illustration of the ranges and standard deviations. Conduct a discussion prompted by these questions:* Are there some results that match?
* Were these matching results from the same car or same type of car?
* What is the standard deviation for the stopping position of Group 1’s Car 1?
* Look at Group 1’s Car 1 stopping positions and Look at Group 3’s Car 1 stopping positions. Which has the larger standard deviation?
* What are the ranges? (*The teachers needs a sheet of paper here to record the two ranges for each group and find the sum. Lowest sum gets a prize*).

Collect all data sheets and marking strips. Pick up race cases, cars, and track and return to the equipment location. Students return to desks/tables in the classroom. Display the marking strips (tape them to wall or pin to a bulletin board). * Choose a data set (one car for one group). Visually estimate the standard deviation.
* How do we calculate the standard deviation for this data sets?
* How many times would we need to run the car if we wanted a 95% confidence interval for the average stopping location accurate within 1 centimeter?

Express up to the next whole number. General formulaFormula for 95% and 1cm * Are the results normal looking? Skewed? How would you check? Do we need more observations to check the distribution?

**Check for Understanding (CFU) –** ***What am I doing for students that progress at different rates?*** Watch Measurers carefully to ensure that they are keeping up with data entry. If anyone is not, get the Marker to operate either the data collection sheet or the calculator. ***What do I do if they get it?*** Use popsicle sticks to create a different initial height for the track. Predict: Will the cars travel the same distance/farther? Will the standard deviation get bigger/smaller/stay the same? Repeat the experiment. Do the cars travel farther? Does the standard deviation for the stopping location get bigger/smaller/stay the same? ***What do I do if they don’t get it?*** Make a histogram of the data from all the trials for one of the cars. Ask the same types of questions using the histogram as the visual aid. . |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning** **Knowledge:** * Is the car stopping in the same place each time?
* (Comparing strips from different groups): Are there some results that match?
* Were these matching results from the same car or same type of car?

**Comprehension:** * Why did we mark the position of the front tire each time? Would our results have been different if we had marked the position of the back tire each time? The front bumper?
* Where does it stop “on average” visually? ( *each group should point to a spot for their car* )
* Do the visual and mathematical average stopping locations agree?

**Application:*** What is the range of the stopping positions?
* Where does it stop “on average” mathematically? Actually calculate the average and measure to this spot. (*Measurers should calculate the average. If they have been keeping up with typing numbers into the calculator this should not take long.*)
* Look at Group 1’s Car 1 stopping positions and Look at Group 3’s Car 1 stopping positions. Which has the larger standard deviation?
* How do we calculate the standard deviation for this data sets?

**Analysis:** * What is the standard deviation for the stopping position of Group 1’s Car 1?
* How many times would we need to run the car if we wanted a 95% confidence interval for the average stopping location accurate within 1 centimeter?

**Synthesis:****Evaluation:** **Thinking**  \_x\_ **Practical** –Students collect data from a real life experiment. \_x\_ **Analytical** – Students compare the results from different cars and from different groups. They classify the distribution of the car’s stopping points in terms of center and variability. **\*What am I going to do to give Students the opportunity to?** **1. Generate variety of ideas:** Students may speculate on the causes for different stopping points for different runs of the car. **2. Analyze problems from multiple viewpoints:** This activity gives students an opportunity to interpret the mean and range of a data set both visibly and numerically. **Problem Solving** **\_\_x\_ Categorization** Students are asked to categorize distribution of stopping locations as normal/skewed/etc. **\_\_x\_ Predicting Outcomes** In the extension activity, students are asked to predict what will happen for a higher launch point. They are then to **\_\_x\_ Observing and Experimenting** The bulk of the activity is about observing the behavior of the cars.**\_\_x\_ Identifying Relevant/Irrelevant Information** Students are asked whether it matters if we use the front tire or the back tire to mark the car’s stopping location.  |

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| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Students are in heterogeneous groups of 4 (or 5).
* Group roles are “Let the car go”-er, Measurer (+ assistant for group of 5), Marker,
* Members with each role will receive a mini-class on their role as they pick up equipment.
* This activity probably takes place outside the classroom, so there will be some time involved in moving. Moving students role by role allows for some students to be setting up while others are collecting equipment and instructions.
* Students produce a marked paper strip and a completed worksheet with measurements.
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| **ASSESSMENT** | **Formative and/or sucmative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction.  |
| ***Assessments: aligned with state stds; measurement criteria; measure student performance in more than 2 ways (project, experiment, presentation, essay, short answer, multiple choice test) (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)*****\_x\_\_ Questions/Answers** The teacher will assess students’ understanding throughout the activity by listening to the students’ answers to questions. **\_x\_\_ Teacher Made Test** At a later date, an exam will show (a photograph of) one of the paper strips. A question will ask students to identify the car whose stopping positions had a larger standard deviation. **\_x\_\_ Exit Ticket**  |
| **CLOSURE** | **Reflection/Wrap Up.** Sucmarizing, reminding, reflecting, restarting, connecting. |
| * ***Review/Sucmary:*** We observed differences in the stopping positions of our cars. We described the middle of these positions as the average position, and we measured the range of these positions as an indication of the spread of the values. We estimated larger standard deviations for those data sets that had larger ranges.
* ***Preview for next lesson: link what they did to day with where they are going next.***
* ***Upcoming assignments: remind them of any upcoming assignments.***

***Here is your exit ticket for today***…..Display one group’s paper strip. Which car had the larger standard deviation? Hold up one finger at chest height for car 1. Hold up two fingers at chest height for car 2. **Follow-up Activities/Extension** ***Reflection: You must reflect on every lesson you teach.*** |

**NOTES:**

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**Gravity Wheels Recording Sheet Group: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

For each run of the car, record the distance from the end of the paper strip to the car’s front tire to the nearest half centimeter.

Car 1

Run 1 \_\_\_\_\_\_\_\_ cm

Run 2 \_\_\_\_\_\_\_\_ cm

Run 3 \_\_\_\_\_\_\_\_ cm

Run 4 \_\_\_\_\_\_\_\_ cm

Run 5 \_\_\_\_\_\_\_\_ cm

Run 6 \_\_\_\_\_\_\_\_ cm

Run 7 \_\_\_\_\_\_\_\_ cm

Run 8 \_\_\_\_\_\_\_\_ cm

Run 9 \_\_\_\_\_\_\_\_ cm

Run 10 \_\_\_\_\_\_\_\_ cm

Run 11 \_\_\_\_\_\_\_\_ cm

Run 12 \_\_\_\_\_\_\_\_ cm

Run 13 \_\_\_\_\_\_\_\_ cm

Run 14 \_\_\_\_\_\_\_\_ cm

Run 15 \_\_\_\_\_\_\_\_ cm

Run 16 \_\_\_\_\_\_\_\_ cm

Run 17 \_\_\_\_\_\_\_\_ cm

Run 18 \_\_\_\_\_\_\_\_ cm

Run 19 \_\_\_\_\_\_\_\_ cm

Run 20 \_\_\_\_\_\_\_\_ cm

Run 21 \_\_\_\_\_\_\_\_ cm

Run 22 \_\_\_\_\_\_\_\_ cm

Run 23 \_\_\_\_\_\_\_\_ cm

Run 24 \_\_\_\_\_\_\_\_ cm

Run 25 \_\_\_\_\_\_\_\_ cm

Run 26 \_\_\_\_\_\_\_\_ cm

Run 27 \_\_\_\_\_\_\_\_ cm

Run 28 \_\_\_\_\_\_\_\_ cm

Run 29 \_\_\_\_\_\_\_\_ cm

Run 30 \_\_\_\_\_\_\_\_ cm

Average: \_\_\_\_\_\_\_\_ cm Car 2

Run 1 \_\_\_\_\_\_\_\_ cm

Run 2 \_\_\_\_\_\_\_\_ cm

Run 3 \_\_\_\_\_\_\_\_ cm

Run 4 \_\_\_\_\_\_\_\_ cm

Run 5 \_\_\_\_\_\_\_\_ cm

Run 6 \_\_\_\_\_\_\_\_ cm

Run 7 \_\_\_\_\_\_\_\_ cm

Run 8 \_\_\_\_\_\_\_\_ cm

Run 9 \_\_\_\_\_\_\_\_ cm

Run 10 \_\_\_\_\_\_\_\_ cm

Run 11 \_\_\_\_\_\_\_\_ cm

Run 12 \_\_\_\_\_\_\_\_ cm

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Run 28 \_\_\_\_\_\_\_\_ cm

Run 29 \_\_\_\_\_\_\_\_ cm

Run 30 \_\_\_\_\_\_\_\_ cm

Average: \_\_\_\_\_\_\_\_ cm