

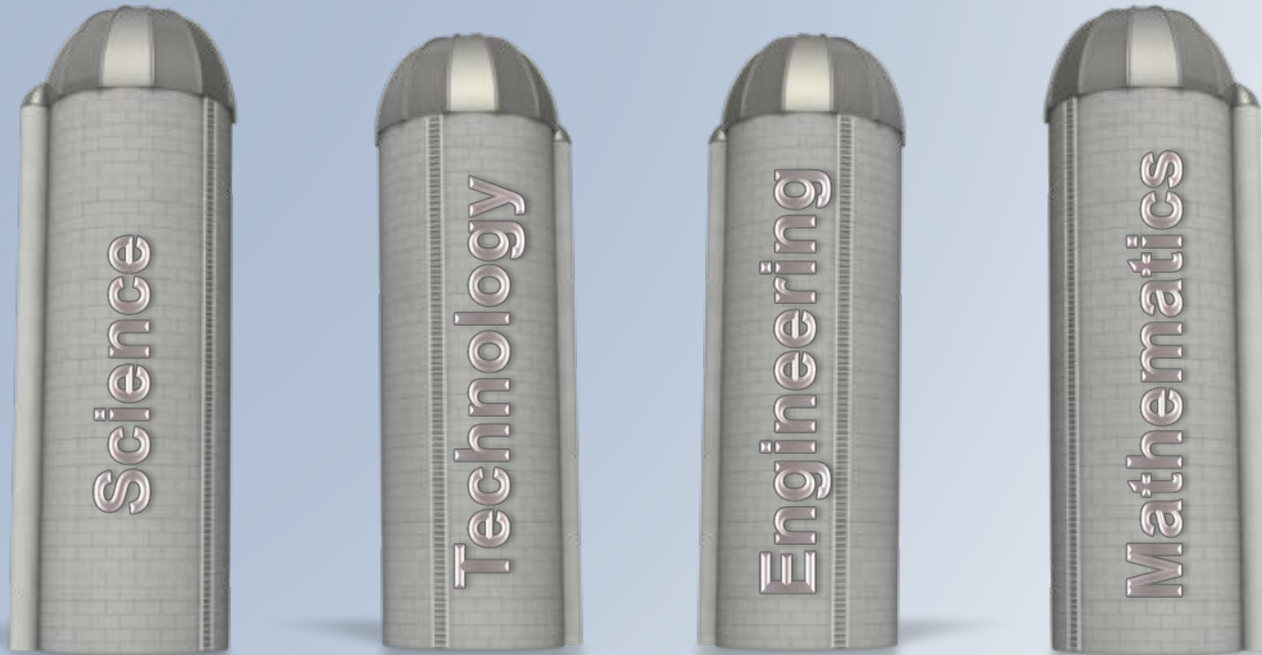
# WELCOME TO *STEM INTEGRATION:* *Statistics is the Connection*

# Why Integrate STEM?

*“Scientists use technological tools to conduct experiments and mathematics and statistics to interpret the data produced by those experiments; engineers draw on scientific knowledge and mathematical reasoning to develop and model potential design inventions and solutions; technologists who build and maintain the products and systems designed by engineers must understand the scientific and mathematical principles governing their operation. And these professionals interact with one another in increasingly diverse and multidisciplinary teams.”*

- *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research*  
National Academy for Engineering and  
National Research Council

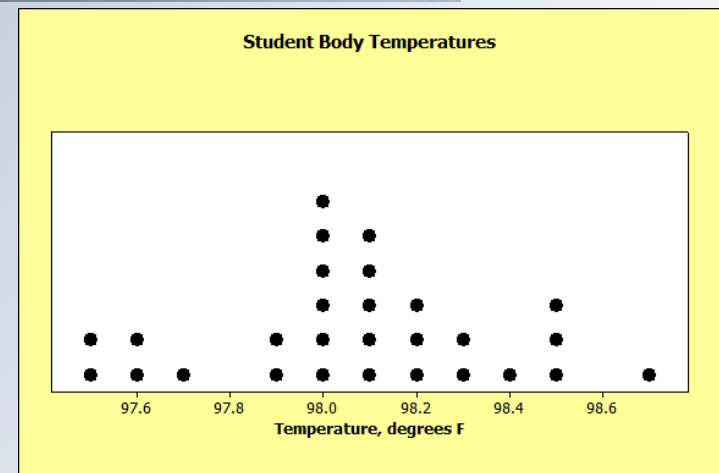
# STEM Integration



- STEM integration does not encourage teaching the four disciplines as independent silos.
- All four STEM content areas will not be integrated into all lessons, all the time.
- Look for meaningful connections and mathematical topics which can be explored using natural phenomena or design challenges.

# Analyzing Body Temperature Activity

Is the “normal” human body temperature really 98.6°F? Students will investigate this question by collecting data for their class on body temperatures using disposable student thermometers and will summarize and describe the distribution of data using numeric summaries and graphic displays.



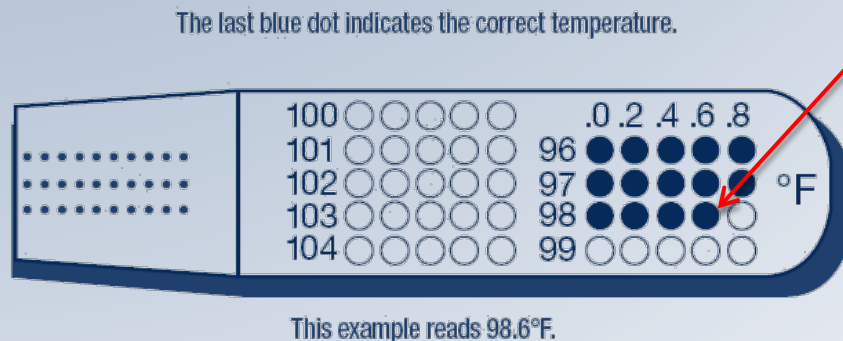
Variable	Mean	Median	Range	IQR
TEMP	98.071	98.100	1.200	0.350

# Materials and Procedure

## Per participant

- Student Pages 11-14
- One disposable thermometer
- Yellow Post-it note
- Marker

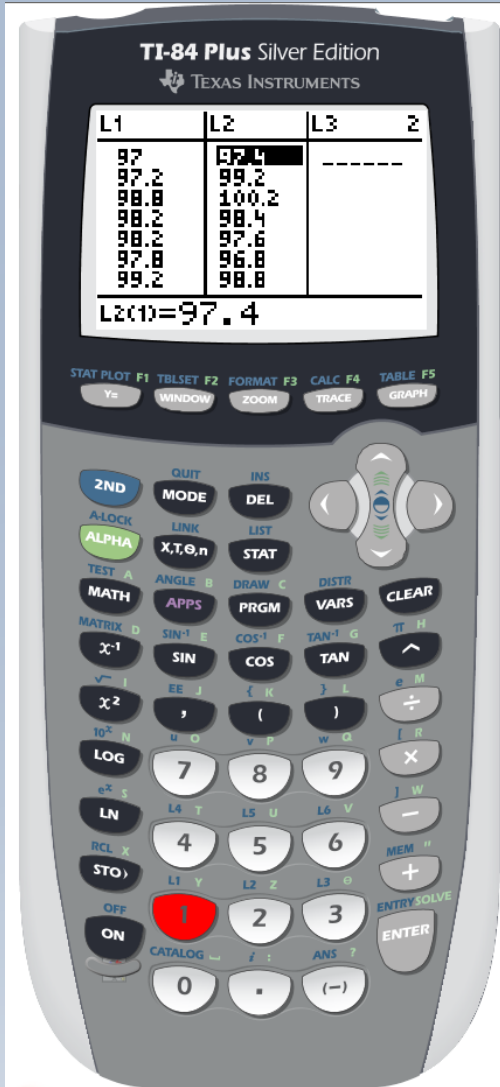
- Remove thermometer from wrapper
- Place under tongue as far back as possible and close mouth for 90 seconds
- Remove from mouth. Wait about ten seconds for device to lock in accuracy (some blue dots may disappear)
- Read temperature indicated by the last blue dot and record using the marker on both Post-its
- Throw away wrapper and thermometer







# Using the TI-84 Plus



L1	L2	L3	2
97	97.4	-----	
97.2	99.2		
98.8	100.2		
98.2	98.4		
98.2	97.6		
97.8	96.8		
99.2	98.8		

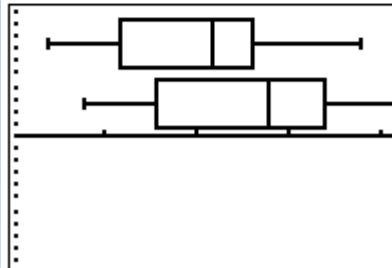
L2(1)=97.4

List

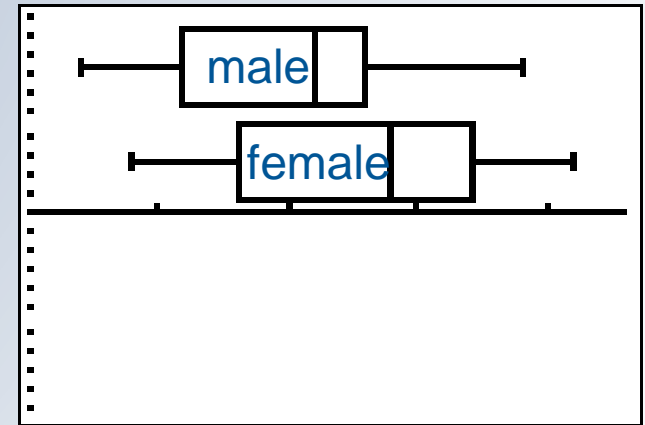
```

STAT PLOTS
1:Plot1...On
  L1  1
2:Plot2...On
  L2  1
3:Plot3...Off
  L1  L2
4:PlotsOff
    
```

Stat Plot

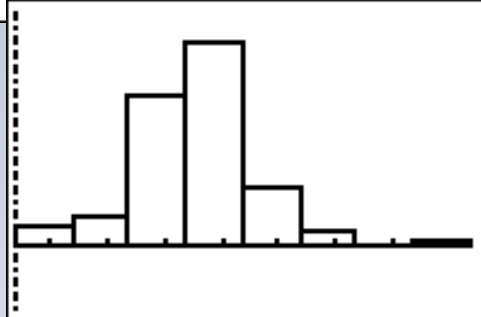
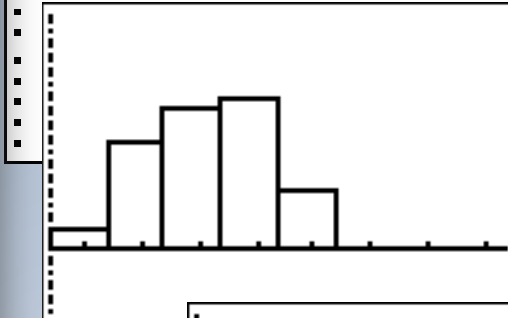
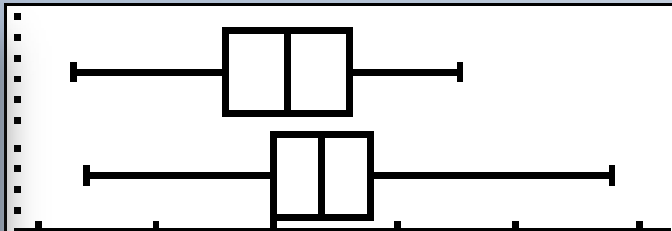
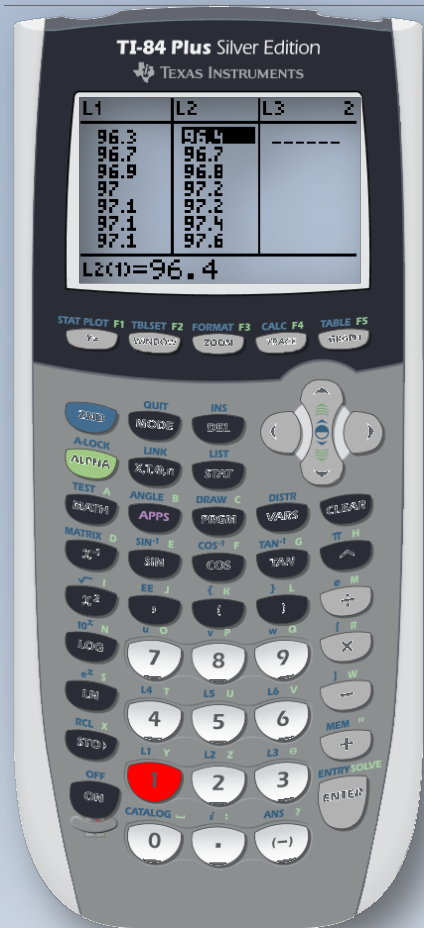


Graph

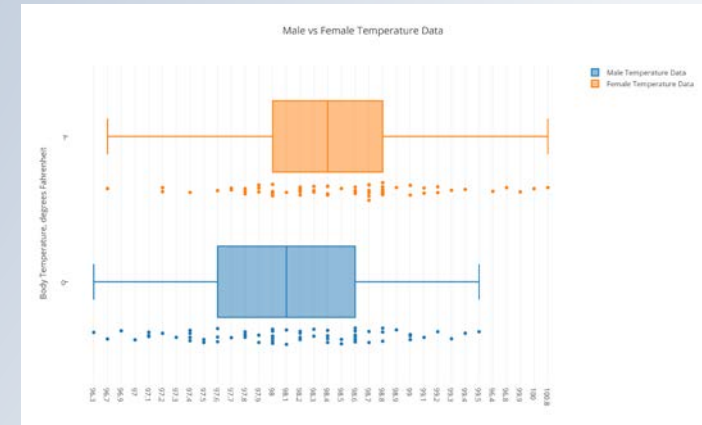


# Extension: Analyze by Gender

<http://www.statcrunch.com/app/index.php?dataid=661807>



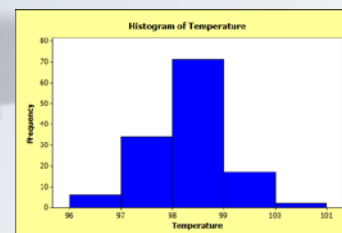
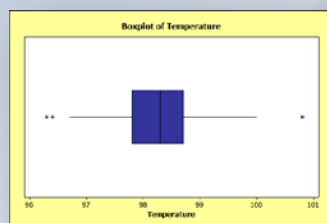
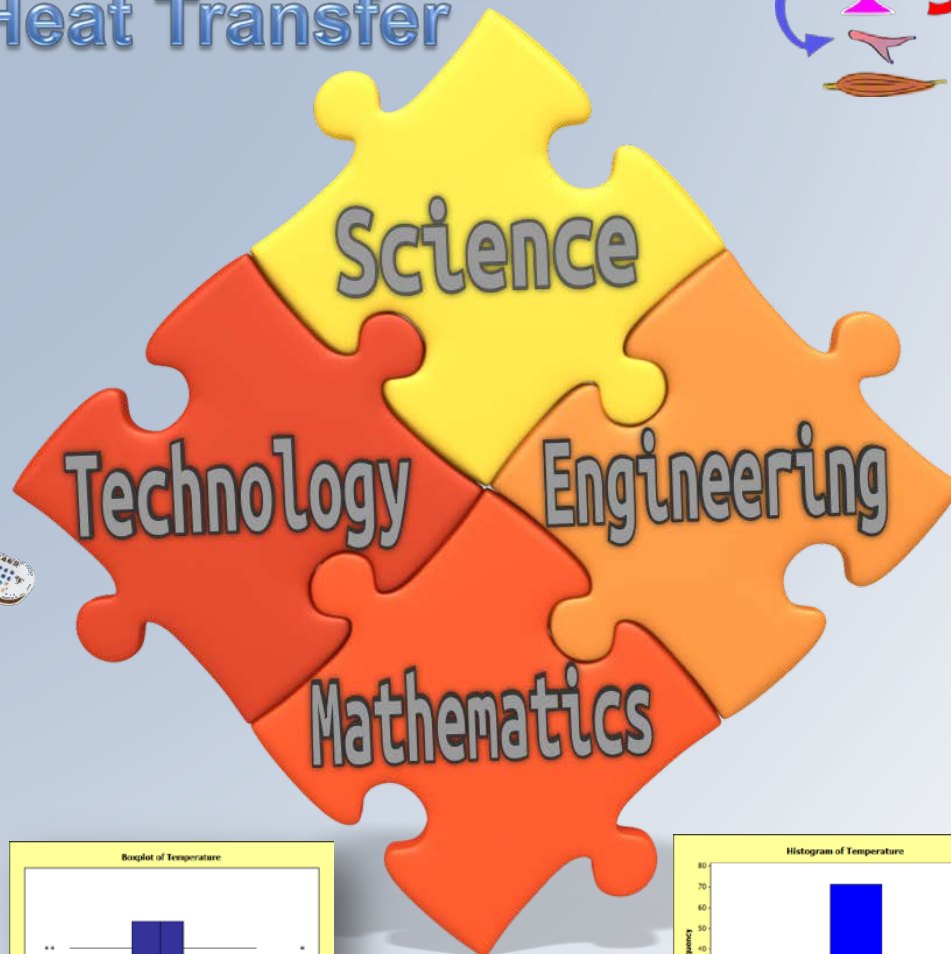
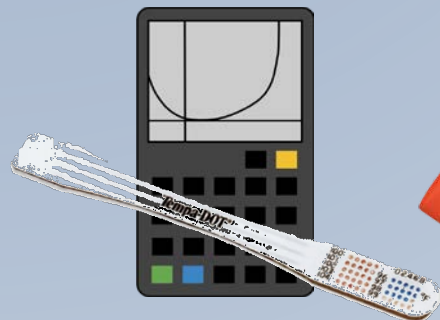
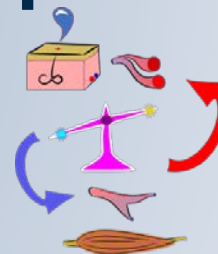
<https://plot.ly/49/~ktogliatti>





# STEM in this activity?

Thermoregulation  
Heat Transfer



# How could we incorporate “engineering” into this activity?

- Design a temperature scale to determine “normal” body temperature
- Design a temperature sensor using everyday items that will record an increase in temperature from a “normal” value.

# Science vs. Engineering

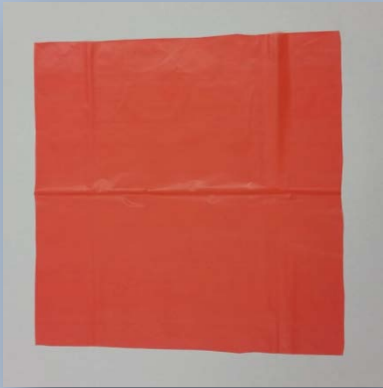
## SCIENCE

- Begins with a question about a phenomenon
- Ends with an explanation
- **Scientists** analyze data produced by investigations in order to provide meaning related to the question they are asking

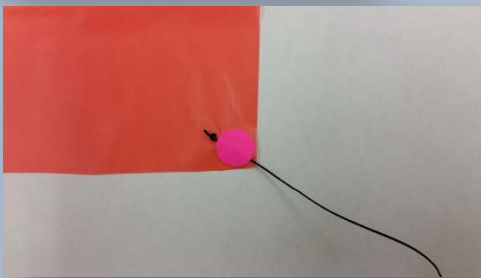
## ENGINEERING

- Begins with a problem or a need that can be solved using engineering
- Ends with a solution
- **Engineers** analyze data collected in the tests of their designs and investigations in order to refine their solution

# Parachute Construction



Cut a square canopy to size.



Cut a length of nylon bead string to size and knot one end (NOTE: already completed for this workshop).  
Attach to a corner using a sticker dot.

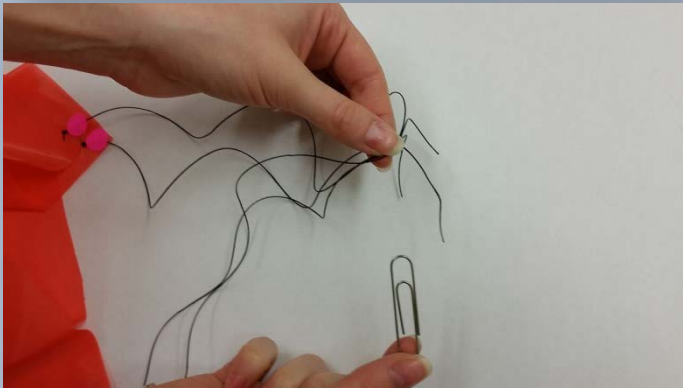


Repeat for the other three corners.

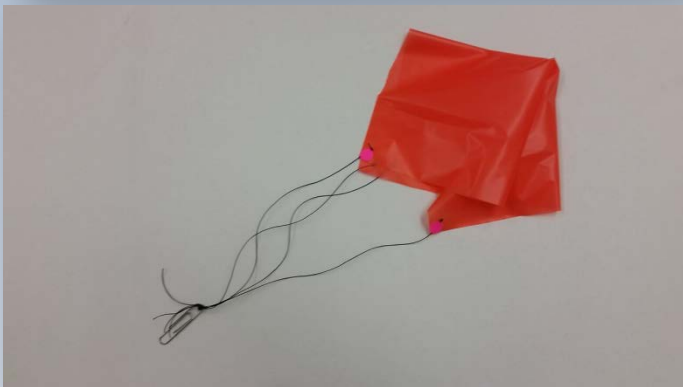
# Parachute Construction (cont.)



Measure desired length.  
NOTE: (30 cm length is marked in silver for this workshop)



Gather suspension lines (at silver mark) and tie to a jumbo paper clip at desired length.



Your parachute is ready for testing!

# Parachute Testing



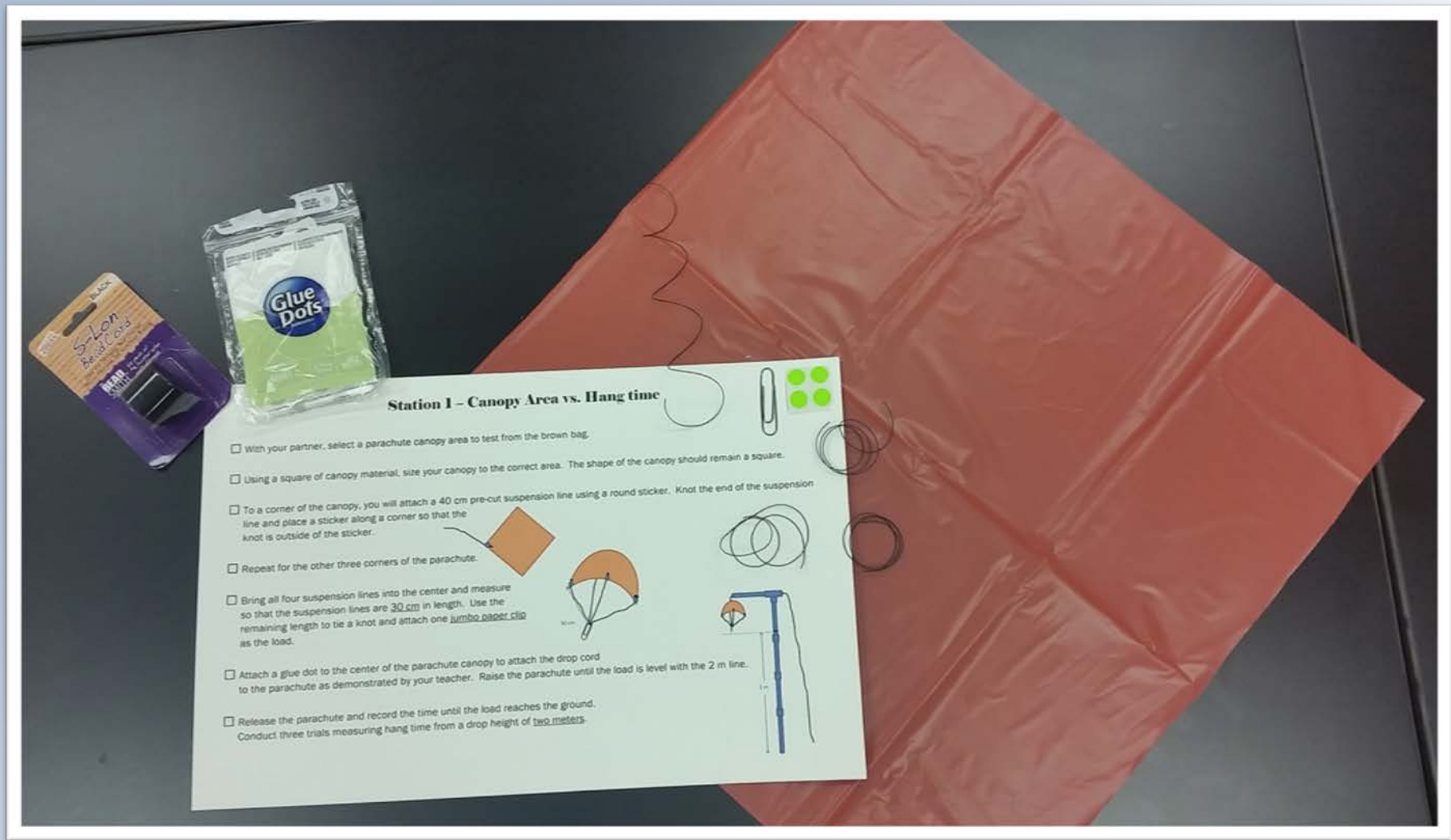
Place a glue dot in the top center of the canopy.



Attach to drop apparatus, if desired, or find a location to drop from a minimum height of 2 meters.



# Station 1 – Vary Canopy Size

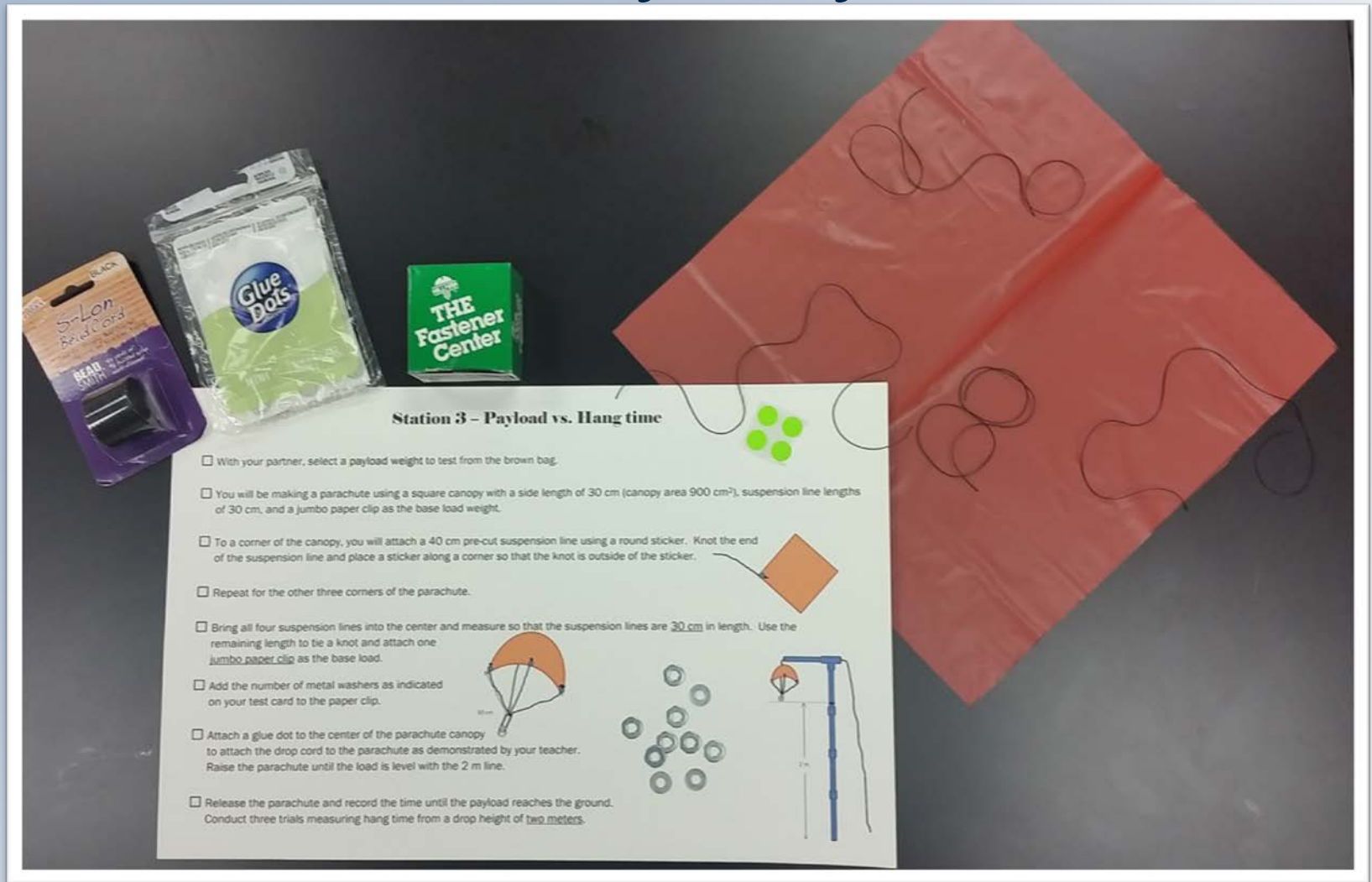


# Station 2 – Vary Suspension Line Length

**Station 2 - Suspension Line Length vs. Hang time**

- With your partner, select a parachute suspension line length to test from the brown bag.
- You will be making a parachute using a square canopy with a side length of 30 cm (canopy area 900 cm<sup>2</sup>) and a jumbo paper clip as the load.
- Cut four pieces of suspension cord at least 10 cm longer than your testable length to allow for attaching to the parachute canopy and tying together to attach the load.
- To a corner of the canopy, you will attach one suspension line using a round sticker. Knot the end of the suspension line and place a sticker along a corner so that the knot is outside of the sticker.
- Repeat for the other three corners of the parachute.
- Bring all four suspension lines into the center and measure the test length of each suspension line from the corner of the parachute. Use the remaining length to tie a knot and attach a jumbo paper clip as the load.
- Attach a glue dot to the center of the parachute canopy to attach the drop cord to the parachute as demonstrated by your teacher. Raise the parachute until the load is level with the 2 m line.
- Release the parachute and record the time until the load reaches the ground. Conduct three trials measuring hang time from a drop height of two meters.




# Station 3 – Vary Payload



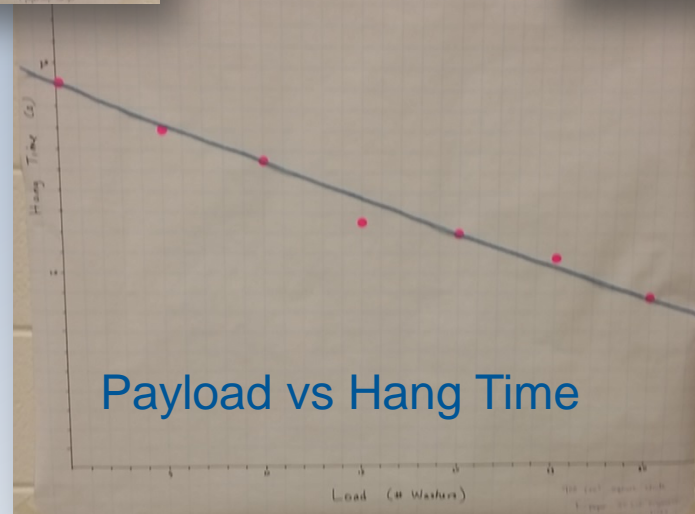
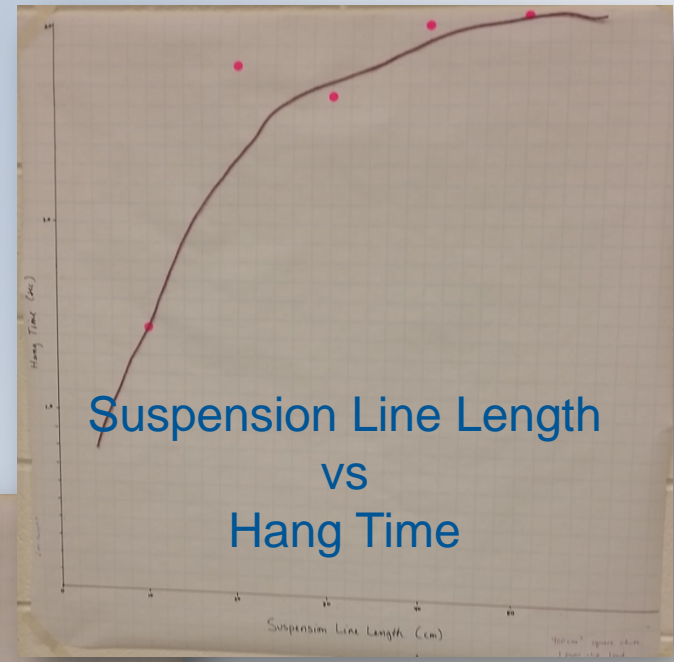
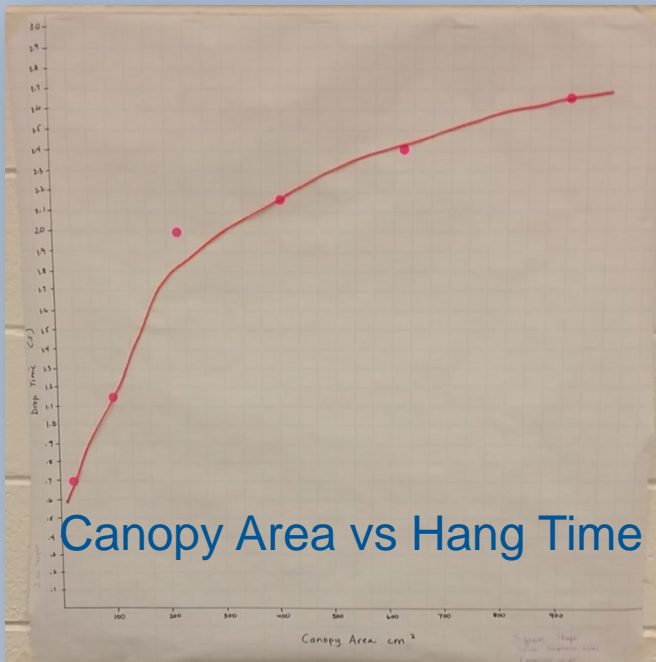
The image shows the materials for a science activity: a package of S-Lon Bead Cord, a bag of Glue Dots, a box of THE Fastener Center washers, and a large red plastic canopy with four suspension lines. A printed instruction sheet is placed in front of the materials.

**Station 3 – Payload vs. Hang time**

- With your partner, select a payload weight to test from the brown bag.
- You will be making a parachute using a square canopy with a side length of 30 cm (canopy area 900 cm<sup>2</sup>), suspension line lengths of 30 cm, and a jumbo paper clip as the base load weight.
- To a corner of the canopy, you will attach a 40 cm pre-cut suspension line using a round sticker. Knot the end of the suspension line and place a sticker along a corner so that the knot is outside of the sticker.
- Repeat for the other three corners of the parachute.
- Bring all four suspension lines into the center and measure so that the suspension lines are 30 cm in length. Use the remaining length to tie a knot and attach one jumbo paper clip as the base load.
- Add the number of metal washers as indicated on your test card to the paper clip.
- Attach a glue dot to the center of the parachute canopy to attach the drop cord to the parachute as demonstrated by your teacher. Raise the parachute until the load is level with the 2 m line.
- Release the parachute and record the time until the payload reaches the ground. Conduct three trials measuring hang time from a drop height of two meters.

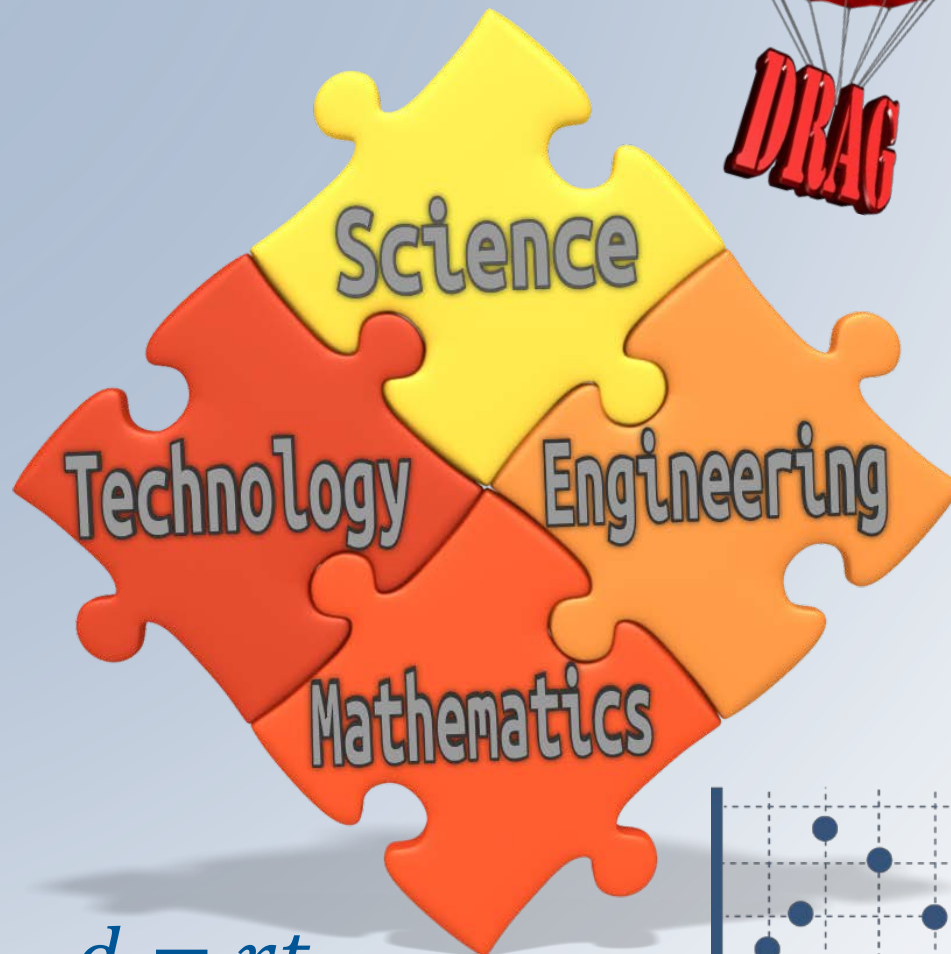
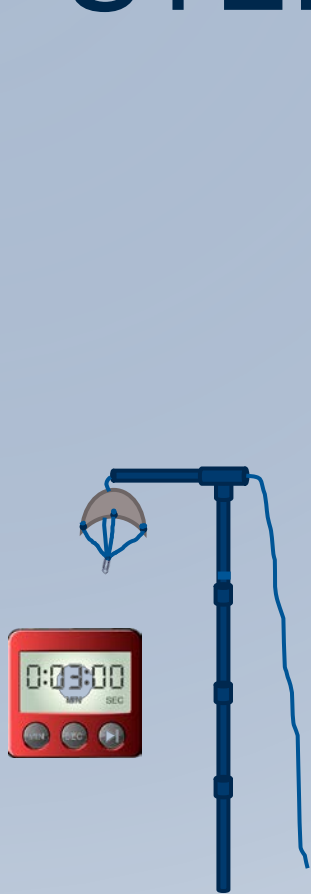


# Sample Data





# STEM in this activity?

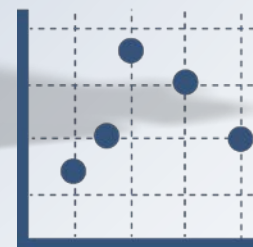


Design



Challenge

$$d = rt$$



# How could we incorporate additional “engineering” into this activity?

- Design a parachute that maximizes hang time for a given mass (additional materials provided)
- Design a parachute that when dropped from a given height will land on a target within a given tolerance.



# Data and STEM

- Design a package that could be used to safely ship a single potato chip through the mail.
- Design a device to measure wind speed and location and use the device to determine if it is safe for aircraft to land on various runways.
- Analyze streamflow data from hydrographs to predict floods, manage water allocation, and design and operate locks and dams.

# Data and STEM

- Using the properties of reflection, design a “microwave transmission” network to send a signal from a source to a destination location.
- Use an air popper and different types of microwave popcorn to explore rates of popping and statistical distributions.
- Determine a location for a new hospital to minimize the drive times for patients using a neighborhood map.

# Data and STEM

- Students can collect voltage and current data using different electric circuits to explore the idea of linearity using Ohm's Law.
- Challenge students to use materials such as wire, iron cores, batteries, and objects to pick up to design an electromagnet that could pick up one ton of steel. (scale model)

# CCSS Math: Analyzing Body Temperature

## □ CCSS.Math.Content.6.SP.A.1

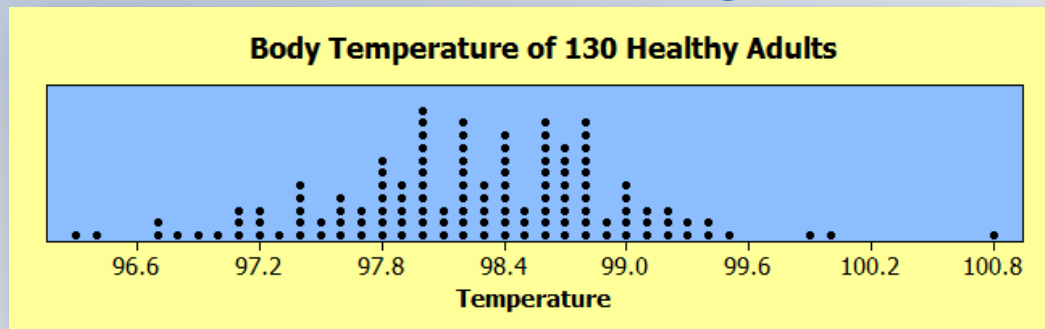
*Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.*

***Is the mean body temperature of participants 98.6°F?***

## □ CCSS.Math.Content.6.SP.A.2

*Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.*

***The distribution is bell-shaped with data clustered around the value of 98.3°F. The range of the data is about 4.5°F. One value at 100.8°F seems higher than the rest.***

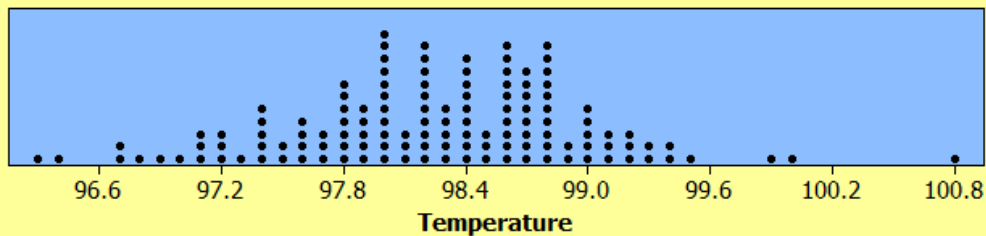


# CCSS Math: Analyzing Body Temperature

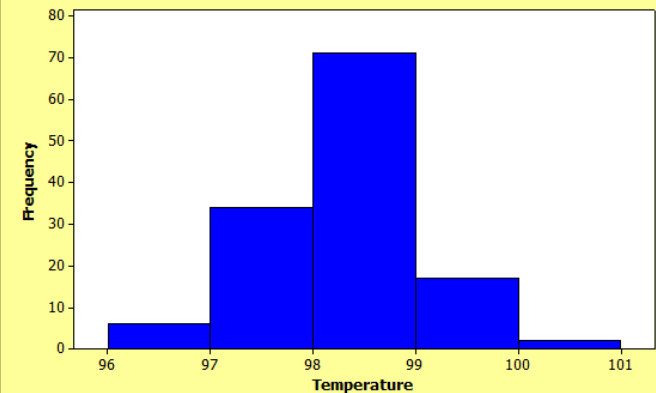
## □ CCSS.Math.Content.6.SP.B.4

*Display numerical data sets in plots on a number line, including dot plots, histograms, and box plots.*

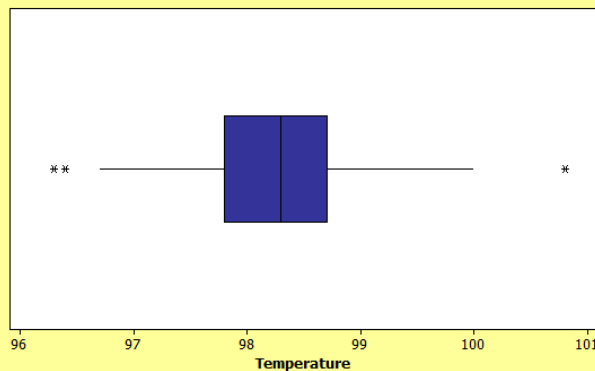
**Body Temperature of 130 Healthy Adults**



**Histogram of Temperature**



**Boxplot of Temperature**



# CCSS Math: Analyzing Body Temperature

## □ CCSS.Math.Content.6.SP.B.5

*Summarize numerical data sets in relation to their context.*

*A data set of 130 randomly selected healthy male and female adults' body temperature was taken using a disposable thermometer. The data was taken to investigate the claim that the mean body temperature for the population is  $98.6^{\circ}\text{F}$ . Our data had a median temperature of  $98.3^{\circ}\text{F}$ , lower than the "normal" body temperature, and an interquartile range of  $0.9^{\circ}\text{F}$  which means that 50% of our observations were between Q1 at  $97.8^{\circ}\text{F}$  and Q3 at  $98.7^{\circ}\text{F}$ . The number of observations at or below  $98.6^{\circ}\text{F}$  is 91/130, or about 70%. Two values seemed much lower than the others according to the boxplot, while one value seemed much larger than the others, perhaps meaning that the individual had a fever. Since there were outliers present, the median and IQR were chosen as measures of center and spread.*



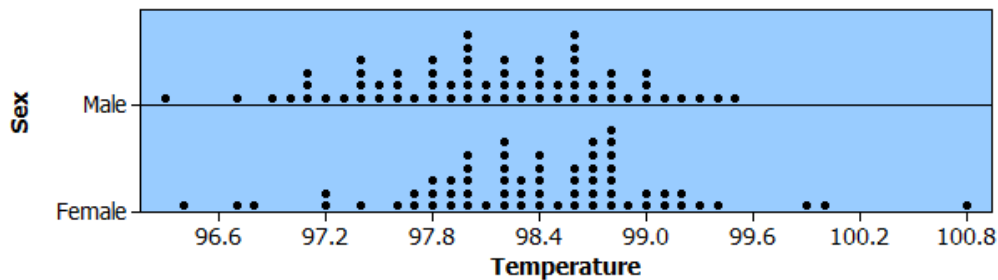
# CCSS Math: Analyzing Body Temperature

## □ CCSS.Math.Content.7.SP.B

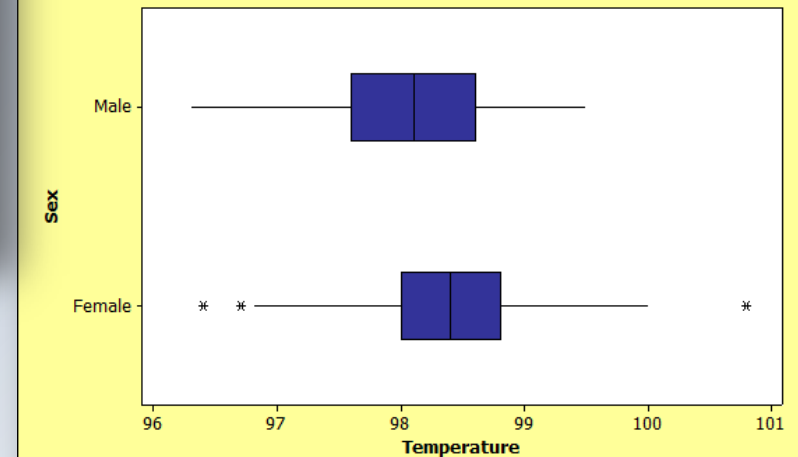
*Draw informal comparative inferences about two populations.*

***Compare the distributions of male and female body temperature data.***

■ Dotplot of Temperature ■



Boxplot of Temperature

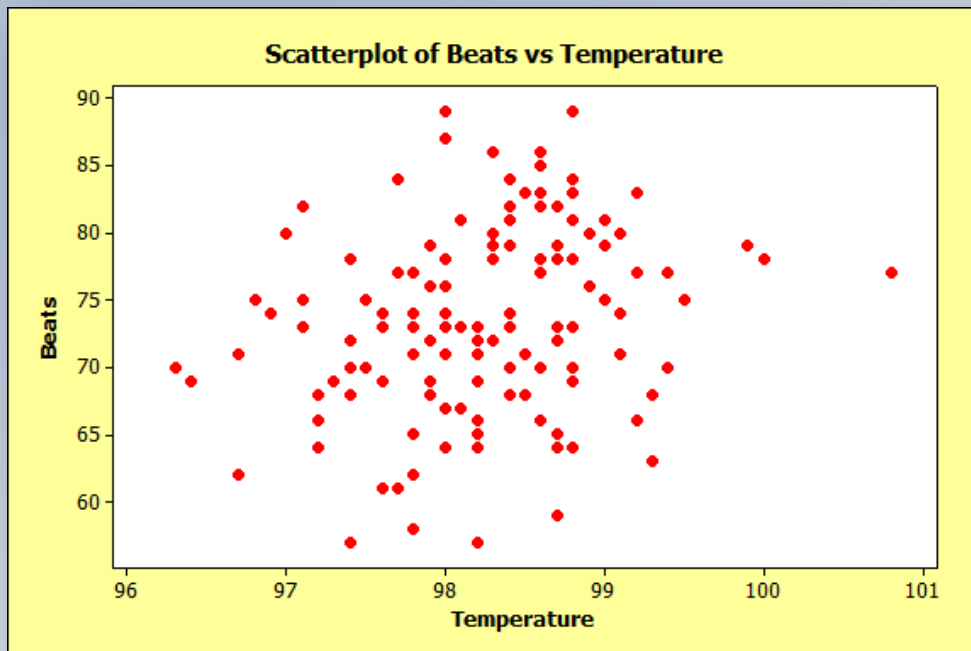


# CCSS Math: Analyzing Body Temperature

## □ CCSS.Math.Content.8.SP.A.1

*Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.*

***Is there an association between body temperature of participants and number of heart beats per minute?***

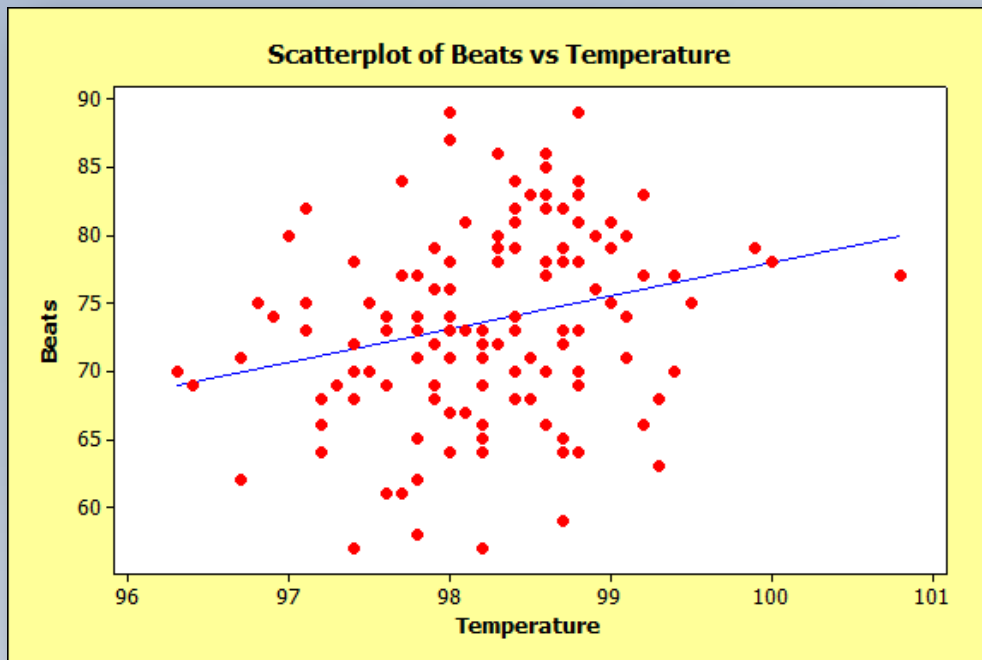


There appears to be a very weak, positive linear association between body temperature and heart rate.

# CCSS Math: Analyzing Body Temperature

## □ CCSS.Math.Content.8.SP.A.2

*Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.*



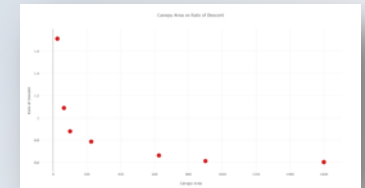
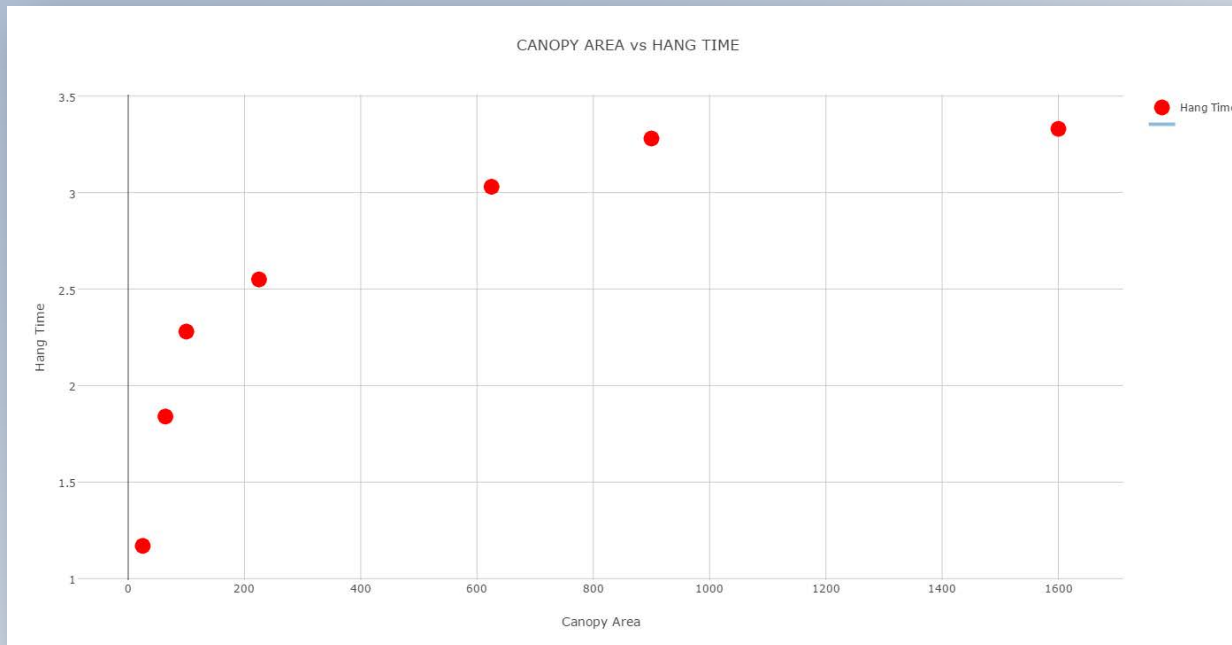
The trend line shown has a slope of about 2.4 which means that as the temperature increases by one degree Fahrenheit, the heart rate increases by about 2.4 beats per minute. I would not be comfortable using this model for prediction since the points are not very close to the line.

# CCSS Math: Slow Down! Parachute Design

## □ CCSS.Math.Content.8.SP.A.1

*Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.*

***Is there an association between the area of a parachute canopy and the hang time? How would the association change if comparing rate of descent?***

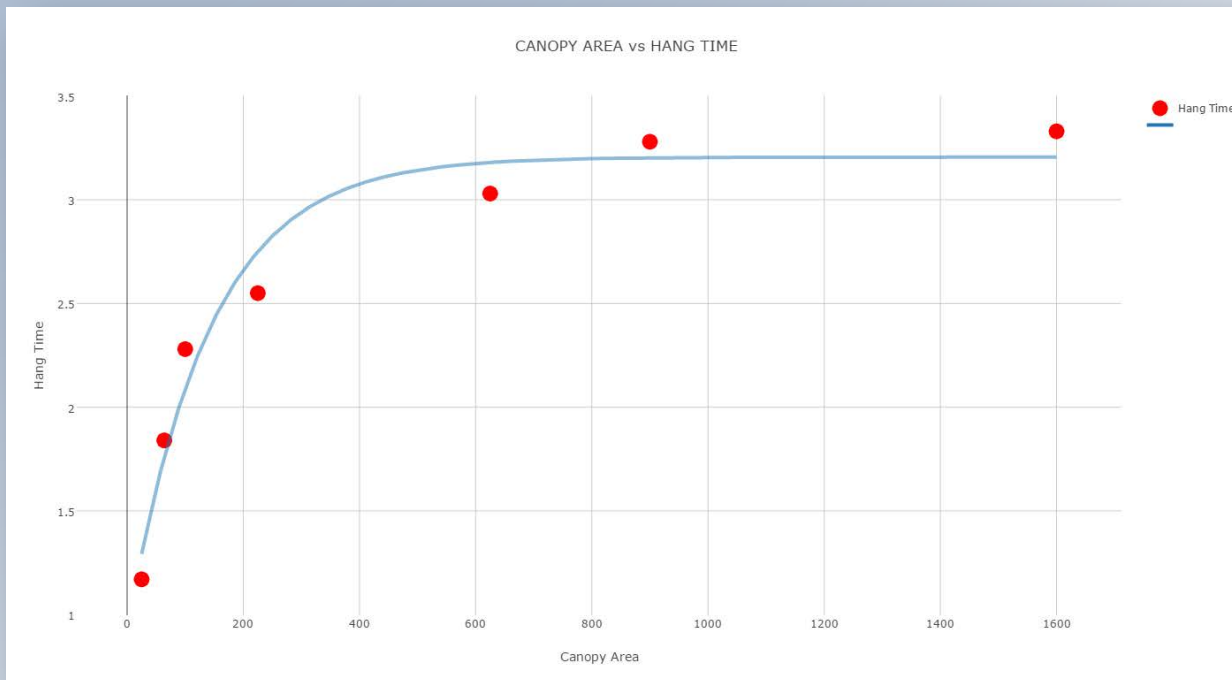


There appears to be a positive, non-linear, fairly strong association between canopy area and hang time. There are no apparent outliers.

# CCSS Math: Slow Down! Parachute Design

## □ CCSS.Math.Content.8.SP.A.2

*Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.*



A linear model does not seem to fit the data points. However, an exponential model appears to have a good fit since the data points are close to the model.

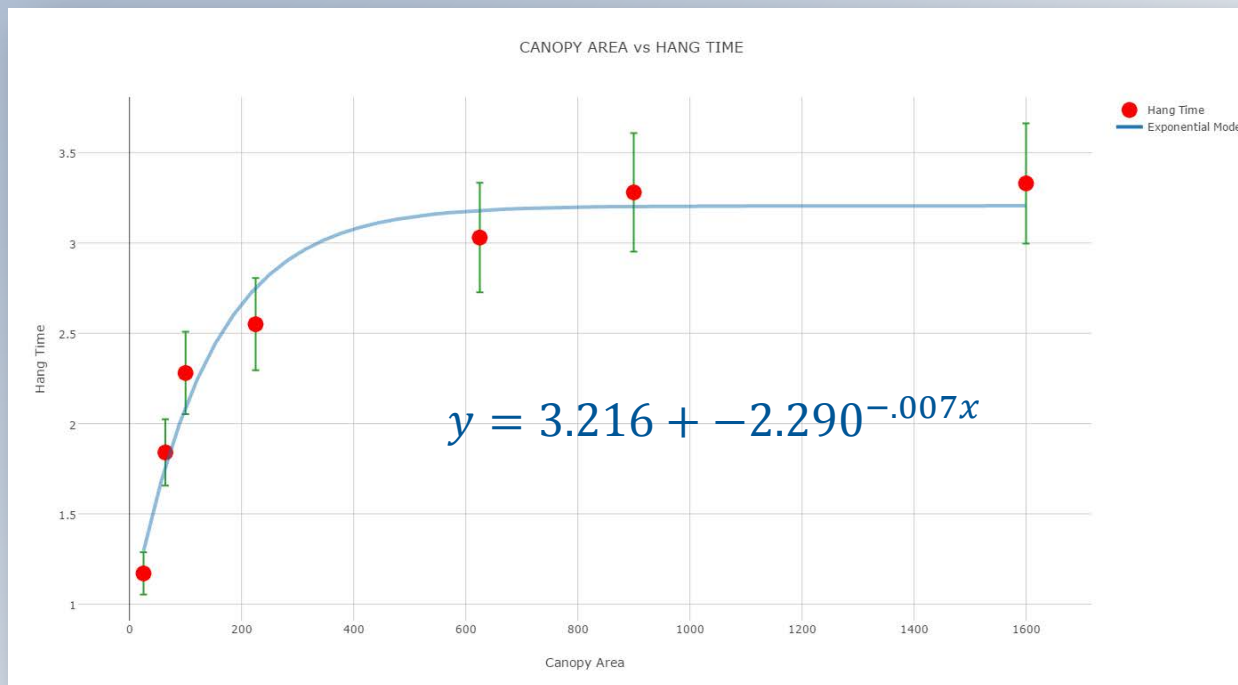
# CCSS Math: Slow Down! Parachute Design

## □ CCSS.Math.Content.HSS.ID.B.6.A

*Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.*

## □ CCSS.Math.Content.HSS.ID.B.6.B

*Informally assess the fit of a function by plotting and analyzing residuals.*



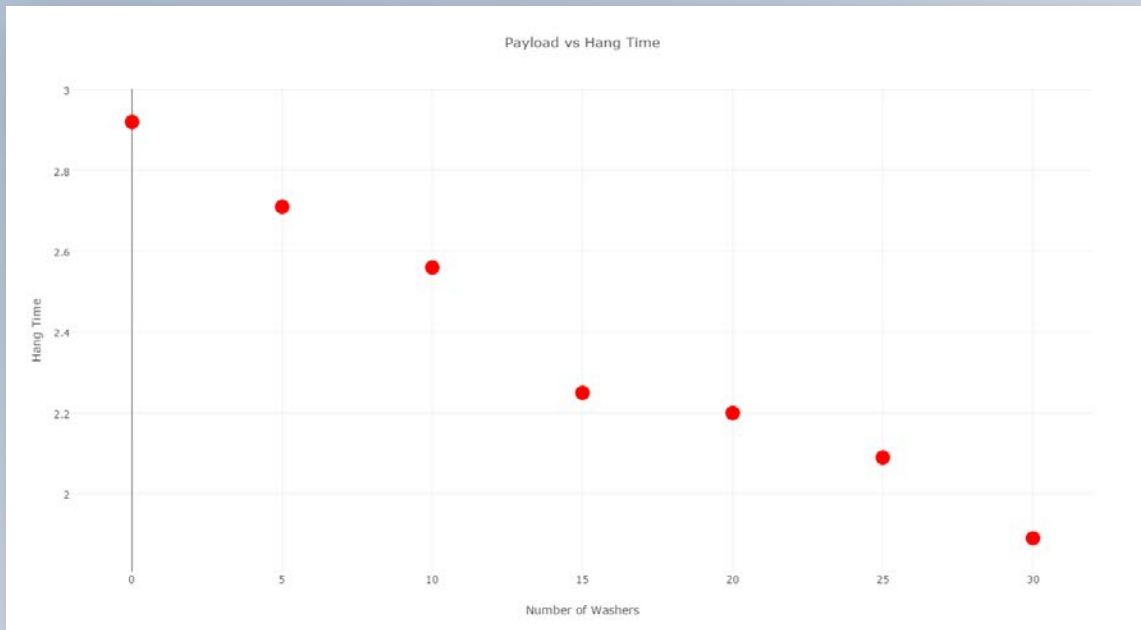


# CCSS Math: Slow Down! Parachute Design

## □ CCSS.Math.Content.8.SP.A.1

*Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.*

***Is there an association between the payload weight measured in number of washers and the hang time of a plastic parachute?***



There appears to be a relatively strong, negative, linear association between payload and hang time. The hang time for a payload of 15 washers seems lower than the other points.

# CCSS Math: Slow Down! Parachute Design

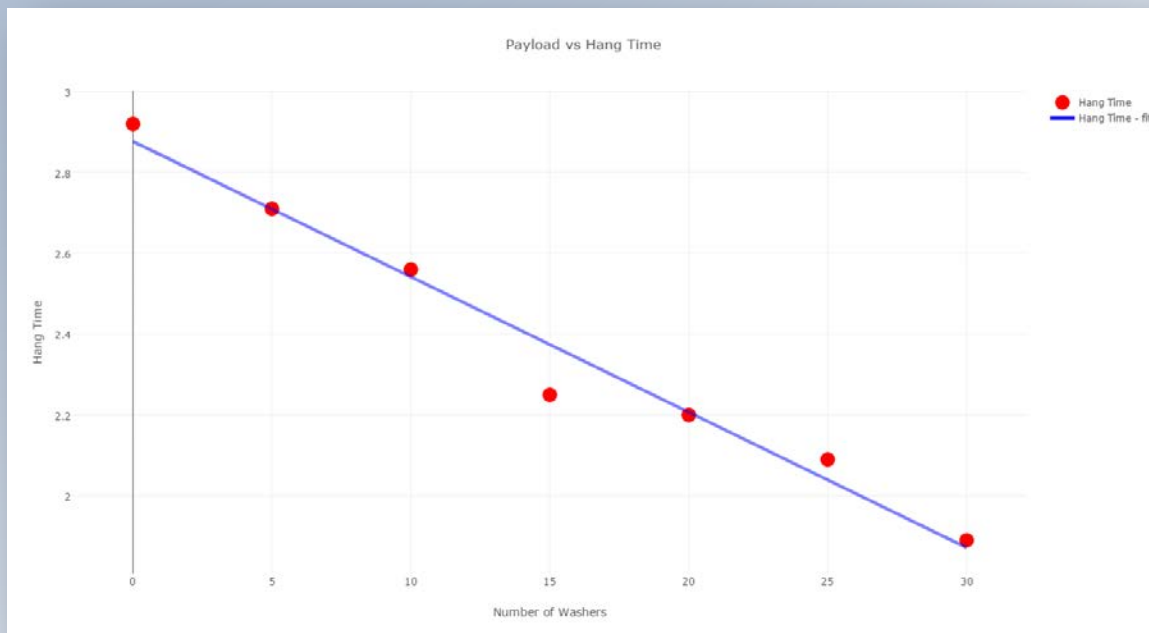
## □ CCSS.Math.Content.8.SP.A.3

*Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.*

## □ CCSS.Math.Content.HSS.ID.B.6.C

*Fit a linear function for a scatter plot that suggests a linear association.*

$$y = -0.0335x + 2.8768$$



For approximately every 2.8768 washers that are added to the payload, the hang time decreases by about 0.0335 seconds.

We can use the model to predict hang time for a parachute with a payload of 18 washers.

# CCSS Math: Slow Down! Parachute Design

## CCSS.MATH.CONTENT.7.RP.A

*Analyze proportional relationships and use them to solve real-world and mathematical problems.*

*Use ratios and proportions to scale the 1 m/s parachute design to a payload equal to a student's weight.*

*Example: A 12.3 g test sensor needed a canopy area of 1600 cm<sup>2</sup> to achieve the design challenge requirements. For a 120 lb. (54.43 kg) student:*

$$\frac{54.43 \text{ kg}}{0.0123 \text{ kg}} = 4425.3 \text{ scale factor}$$

$$\frac{1600 \text{ cm}^2}{1} \times \frac{1 \text{ m}^2}{10000 \text{ cm}^2} \times 4425.3 = 708.048 \text{ m}^2$$

$$\sqrt{708.048} = 26.6 \text{ m (about 87 feet)}$$

The scaled parachute canopy size seems large compared to actual parachutes. However, we have a relatively slow rate of descent and are comparing to parachutes made from plastic instead of nylon.

# THANK YOU!

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- Lindsey Herlehy  
[lherlehy@imsa.edu](mailto:lherlehy@imsa.edu)

