Learning the Empirical Rule: Worked Examples and Practice Problems

Authored by

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November 9, 2025

```
@import url('https://fonts.googleapis.com/css?family=Droid+Serif|Raleway');

h1 {
color: black;
text-align: center;
margin-top: 15px;
margin-bottom: 0px;
font-family: 'Raleway', sans-serif;
}

h2 {
color: black;
font-size: 20px;
text-align: center;
margin-bottom: 15px;
margin-top: 15px;
font-family: 'Raleway', sans-serif;
}

p {
color: black;
text-align: center;
margin-bottom: 15px;
margin-top: 15px;
font-family: 'Raleway', sans-serif;
}

#words_intro {
color: black;
font-family: Raleway;
max-width: 550px;
margin: 25px auto;
line-height: 1.75;
}

#solution_div {
color: black;
font-family: Raleway;
max-width: 550px;
margin: 25px auto;
line-height: 1.75;
```

```
}

#words_output {
text-align: center;
color: black;
font-family: Raleway;
max-width: 550px;
margin: 25px auto;
line-height: 1.75;
}

#words_outro {
color: black;
font-family: Raleway;
max-width: 550px;
margin: 25px auto;
line-height: 1.75;
}

#words {
color: black;
font-family: Raleway;
max-width: 550px;
margin: 25px auto;
line-height: 1.75;
padding-left: 100px;
}

#calcTitle {
text-align: center;
font-size: 20px;
margin-bottom: 0px;
font-family: 'Raleway', serif;
}

#hr_top {
width: 70%;
margin-bottom: 15px;
margin-top: 15px;
border: none;
height: 2px;
```

```
color: black;
background-color: black;
}

#hr_bottom {
width: 30%;
margin-top: 15px;
border: none;
height: 2px;
color: black;
background-color: black;
}

.input_label_calc {
display: inline-block;
vertical-align: baseline;
width: 350px;
}

#button_calc {
border: 1px solid;
border-radius: 10px;
margin-top: 20px;
padding: 10px 10px;
cursor: pointer;
outline: none;
background-color: white;
color: black;
font-family: 'Work Sans', sans-serif;
border: 1px solid grey;
/* Green */
}

#button_calc:hover {
background-color: #f6f6f6;
border: 1px solid black;
}

.label_radio {
text-align: center;
}
```

Introduction to the Empirical Rule: The Cornerstone of Normal Data

The ability to quickly characterize the spread and central tendency of a dataset is crucial in statistical analysis. At the introductory level, few concepts are as fundamental and immediately useful as the Empirical Rule, often known by its descriptive name: the 68-95-99.7 rule. This powerful principle provides a rapid, reliable estimate of the percentage of observations that fall within specific ranges of the dataset's center, provided the underlying data exhibits a symmetrical, bell-shaped form, technically known as a normal distribution. Mastering this rule is essential because it bridges theoretical probability with practical data interpretation, allowing analysts to rapidly assess data variability and identify potential outliers without resorting to complex computational methods. It is the foundation upon which many higher-level statistical methods are built.

The core significance of the Empirical Rule lies in its direct relationship with the concept of standard deviation, which quantifies the average amount of dispersion or variability within a data set. When data is normally distributed, the Empirical Rule precisely dictates the percentage of observations expected to fall within one, two, or three standard deviations from the arithmetic mean (mu). This predictable and consistent pattern is what makes the normal distribution so central to inferential statistics. By understanding these predefined percentages, we gain immediate insight into the distribution's shape. Before diving into specific practice problems, it is vital to establish a firm grasp of the theoretical prerequisites and the strict conditions under which this rule accurately applies.

Throughout this guide, we will systematically explore the components of the Empirical Rule, detail its application across diverse scenarios, and work through practical exercises designed to solidify your comprehension. While the rule offers high precision only for perfectly normal datasets, it serves as an excellent and widely accepted approximation tool even for data that is only approximately normal. Our goal is to transform your basic understanding of the rule into a proficient skill set, enabling you to accurately estimate population parameters based on sample statistics and quickly solve common interval probability questions encountered in academic and professional settings.

The Prerequisite: Understanding the Normal Distribution

The successful utilization of the Empirical Rule hinges entirely upon the assumption that the dataset follows a normal distribution. Graphically, the normal distribution is represented by the iconic bell curve, which is characterized by its perfect symmetry around the center. In an ideal normal scenario, the mean, median, and mode all coincide at the exact central peak of the curve. This mathematical symmetry is not merely aesthetic; it is the property that ensures the predictable percentages defined by the Empirical Rule are accurate. Numerous natural and standardized phenomena, including human heights, blood pressure readings, manufacturing errors, and standardized test scores, naturally tend toward this distribution, making the rule highly applicable in fields ranging from quality control to biological research.

A defining feature of the normal distribution is the clustering of the majority of data points near the central tendency, represented by the mean (mu). As observations move progressively farther away from the mean--in either the positive or negative direction--the frequency of those data points diminishes rapidly, creating the characteristic tapering tails of the bell curve. The standardized measure of this dispersion is the standard deviation ($sigma$). Critically, every interval defined by adding or subtracting standard deviations from the mean ($mu pm sigma$, $mu pm 2sigma$, $mu pm 3sigma$) corresponds precisely to a fixed percentage of the total area under the curve. This area, in turn, represents the proportion of the total data set found within that specific range.

It is important to formally differentiate the Empirical Rule from Chebyshev's Theorem. While Chebyshev's Theorem provides universal bounds applicable to any distribution, regardless of its shape (skewed, uniform, or bimodal), its estimates are significantly less precise. The high degree of precision offered by the Empirical Rule (68%, 95%, 99.7%) is a direct consequence of the unique and known mathematical properties of the normal curve. Furthermore, establishing how data relates to the mean using these standard deviation increments is foundational for calculating Z-scores, which allow us to standardize and compare any normal distribution, thereby enabling the determination of the exact probability associated with any raw score.

The Three Critical Percentages of the 68-95-99.7 Rule

The utility of the Empirical Rule is captured entirely by three fundamental percentages that define the concentration of data around the central mean (mu) in any normal distribution. These three statements form the essential core of the rule and must be understood for accurate interpretation:

The 68% Interval: Approximately **68%** of the data values are expected to fall within one standard deviation ($sigma$) of the mean. This range, mathematically represented as $$, captures roughly two-thirds of all observations and is frequently used to define the typical, expected range of values within a population.

The 95% Interval: Approximately **95%** of the data values are expected to fall within two standard deviations ($2sigma$) of the mean. The interval $$ is highly significant in statistical practice, particularly in areas like quality control and hypothesis testing. Data points falling outside this 95% range (the remaining 5%) are generally considered statistically unusual or significant discoveries.

The 99.7% Interval: Approximately **99.7%** of the data values are expected to fall within three standard deviations ($3sigma$) of the mean. This implies that virtually all data points in a normal distribution lie within this interval, $$. Data located outside this extremely broad range (the remaining 0.3%) is exceptionally rare and often suggests a measurement error or a genuine anomaly, making this boundary critical for strong outlier detection.

These percentages allow for rapid and precise calculation of probabilities for specific segments of the curve due to the distribution's symmetry. For instance, because 68% of the data lies symmetrically within one standard deviation, exactly 34% (68% divided by 2) is found between the mean and one standard deviation above the mean, and 34% is found between the mean and one standard deviation below the mean. Likewise, the 95% rule dictates that 47.5% (95% divided by 2) lies between the mean and two standard deviations away. This ability to segment the curve is crucial for solving interval problems involving "less than," "greater than," or specific non-symmetric ranges, requiring only basic arithmetic once the boundaries are accurately established. The remaining 0.3% of the data that lies beyond three standard deviations is split evenly into the two extreme tails, with 0.15% in the far left tail and 0.15% in the far right tail.

Practical Applications: Real-World Inferences

In applied settings, the Empirical Rule enables swift and effective inferences about a large population based on sample data, provided that sample data exhibits normality. Consider a scenario involving manufacturing processes: if a machine producing bolts yields an average length (mean) of 10 mm and the standard deviation is 0.1 mm, a manager can immediately conclude that 68% of the bolts produced will measure between 9.9 mm (10 - 0.1) and 10.1 mm (10 + 0.1). Furthermore, 99.7% of all bolts will fall within the range of 9.7 mm to 10.3 mm. This rapid assessment is invaluable for quality control specialists who need to define acceptable performance tolerances without relying on lengthy computational analyses, providing immediate feedback on manufacturing variance and consistency.

Another significant application is the determination of statistical rarity or unusualness. Imagine standardized test scores for a major college entrance exam are normally distributed with a mean of 500 and a standard deviation of 100. A student who achieves a score of 700 is exactly two standard deviations above the mean (since $500 + 2 times 100 = 700$). Based on the 95% rule, we know that 95% of all students score between 300 and 700. If a student scores 700 or higher, they fall into the top 2.5% tail of the distribution. This application demonstrates the rule's power in identifying statistically rare events, a concept that is foundational to setting significance levels in hypothesis testing.

When preparing to solve complex problems using the Empirical Rule, the most effective initial step is to calculate the precise numerical boundaries for one, two, and three standard deviations around the mean. These calculated points correspond to the integer Z-scores of -3, -2, -1, 1, 2, and 3. By clearly defining these numerical anchors, you translate abstract statistical parameters into concrete, measurable ranges relevant to the problem's context (e.g., test points, weight in kilograms, or time in seconds). This numerical preparation simplifies the subsequent steps of applying the fixed 68-95-99.7 percentages based on the specific question, whether it asks for data "between" two points or "greater than" a single cutoff.

Step-by-Step Methodology for Solving Practice Problems

Successfully solving problems that rely on the Empirical Rule requires a structured and systematic approach. After confirming that the dataset is approximately normally distributed, the primary focus must be on clearly defining the population parameters: the mean (mu) and the standard deviation ($sigma$). The following sequence outlines the critical methodology necessary for accurately tackling the interactive problems presented below:

Parameter Identification: Extract and note the given values for the mean (mu) and the standard deviation ($sigma$) relevant to the particular dataset under consideration.

Boundary Determination: Calculate the six specific data values that correspond to the intervals $mu pm 1sigma$, $mu pm 2sigma$, and $mu pm 3sigma$. These six numerical boundaries serve as the critical demarcation points on the bell curve.

Question Alignment: Compare the range or cutoff point specified in the problem to the calculated standard deviation boundaries. This step determines the corresponding Z-score multiplier (1, 2, or 3) relevant to the problem's data points.

Rule Application: Apply the corresponding percentage (68%, 95%, or 99.7%) directly if the question asks for the percentage of data located **between** two symmetrical standard deviation boundaries. If the question asks for a single-sided event, such as "less than" or "greater than" a specific boundary, utilize the segmented percentages, remembering that exactly 50% of the data lies on either side of the mean. For example, the area between the mean and 3 standard deviations is $99.7% / 2 = 49.85%$.

To illustrate, consider the practice problem below concerning plant height. If the mean height is 12.3 inches and the standard deviation is 4.1 inches, and we are asked to find the percentage of plants between 8.2 and 16.4 inches. Following Step 2, we calculate the boundaries: $12.3 - 4.1 = 8.2$ inches (one standard deviation below the mean) and $12.3 + 4.1 = 16.4$ inches (one standard deviation above the mean). Since the requested range (8.2 to 16.4) aligns perfectly with the $mu pm 1sigma$ interval, we apply the 68% rule directly. Thus, **68%** of plants are between these two heights.

For problems that require calculating the percentage in the extreme upper or lower tails, remember the curve's perfect symmetry. If a question asks for the percentage of data less than two standard deviations below the mean (a Z-score of -2), we know that 95% is within $mu pm 2sigma$. The remaining $100% - 95% = 5%$ is split equally between the two tails. Therefore, the lower tail contains $5% / 2 = 2.5%$ of the data. Understanding how to use the cumulative distribution and the inherent symmetry of the bell curve is crucial for correctly answering these single-sided probability questions, which often require careful calculation of the remaining area outside the central range.

Limitations and Transition to Advanced Statistical Analysis

While the Empirical Rule is an exceptionally powerful tool for rapid estimation, its effectiveness is bound by specific limitations that must be acknowledged. The primary constraint is the rigid requirement that the data set must conform to a truly normal distribution. If a data set is significantly skewed (asymmetrical), or if it exhibits multiple peaks (multimodal), the 68%, 95%, and 99.7% percentages will not accurately represent the distribution of the data, potentially leading to incorrect statistical conclusions. In such instances, one should either rely on Chebyshev's Theorem, which provides broader but universally applicable probability bounds, or employ non-parametric statistical methods that do not assume any specific distributional shape.

A second key limitation is that the Empirical Rule provides exact, fixed probabilities only at integer multiples of the standard deviation (1, 2, and 3). If a problem requires finding the percentage of data between the mean and, say, 1.8 standard deviations above the mean, the Empirical Rule cannot provide the precise answer. For these non-integer standard deviation values, analysts must calculate the specific Z-score and then consult a standard normal distribution table (often referred to as a Z-table) or use specialized statistical software to find the exact area under the curve. This necessity to move beyond the rule of thumb to precise calculation marks the transition to a more advanced level of statistical analysis, utilizing the continuous nature of the standard normal distribution rather than discrete approximations.

In conclusion, the Empirical Rule remains an indispensable concept in introductory statistics, offering immediate, visual, and quantifiable insight into the concentration and spread of data when normality is assumed. Its simplicity and robust utility provide a powerful framework for understanding data variability. By completing the practice problems provided below, you will gain essential confidence in translating real-world scenarios into statistical parameters and accurately applying the 68-95-99.7 ratios to solve complex probability and data interpretation questions with both speed and accuracy. Use the interactive section below to test your newly acquired knowledge.

The height of plants in a certain garden are normally distributed with a mean of 12.3 inches and a standard deviation of 4.1 inches.
Use the Empirical Rule to estimate what percentage of plants are between 8.2 and 16.4 inches tall.

%

Check Answer

Show Solution

New Problem

```
var globalThing= {}; // Globally scoped object

function check() {
if(globalThing.q_selected=="between") {
if(globalThing.sd_multiplier==1) {
var solution = 68;
}
if(globalThing.sd_multiplier==2) {
var solution = 95;
}
if(globalThing.sd_multiplier==3) {
var solution = 99.7;
}
} //end between
if(globalThing.q_selected=="less than") {
if(globalThing.sd_multiplier==1) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 84;
} else {
var solution = 16;
}
}
if(globalThing.sd_multiplier==2) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 97.5;
} else {
var solution = 2.5;
}
}
if(globalThing.sd_multiplier==3) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 99.85;
} else {
var solution = 0.15;
```

```
}
}
} //end less than
if(globalThing.q_selected=="greater than") {
if(globalThing.sd_multiplier==1) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 16;
} else {
var solution = 84;
}
}
if(globalThing.sd_multiplier==2) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 2.5;
} else {
var solution = 97.5;
}
}
if(globalThing.sd_multiplier==3) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 0.15;
} else {
var solution = 99.85;
}
}
} //end greater than

//check if user-entered solution matches correct solution
var user_answer = document.getElementById('answer').value;
if (user_answer == solution) {
document.getElementById('output').innerHTML = "Correct!"
} else {
document.getElementById('output').innerHTML = "Not quite yet..."
}

//toggle answer showing
var result_display = document.getElementById("words_output");
result_display.style.display = "block";
} //end massive check() function
```

function solution() {
if(globalThing.q_selected=="between") {
if(globalThing.sd_multiplier==1) {
var solution = 68;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 68% of data values fall within one standard deviation of the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located one standard deviation below the mean and " + globalThing.sd_above.toFixed(1) + " is located one standard deviation above the mean.

Thus, **68% of plants are between " + globalThing.sd_below.toFixed(1) + " and " + globalThing.sd_above.toFixed(1) + " inches tall.";**
}
if(globalThing.sd_multiplier==2) {
var solution = 95;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 95% of data values fall within two standard deviations of the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located two standard deviations below the mean and " + globalThing.sd_above.toFixed(1) + " is located two standard deviations above the mean.

Thus, **95% of plants are between " + globalThing.sd_below.toFixed(1) + " and " + globalThing.sd_above.toFixed(1) + " inches tall.";**
}
if(globalThing.sd_multiplier==3) {
var solution = 99.7;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 99.7% of data values fall within three standard deviations of the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located three standard deviations below the mean and " + globalThing.sd_above.toFixed(1) + " is located three standard deviations above the mean.

Thus, **99.7% of plants are between " + globalThing.sd_below.toFixed(1) + " and " + globalThing.sd_above.toFixed(1) + " inches tall.";**
}

} //end between
if(globalThing.q_selected=="less than") {
if(globalThing.sd_multiplier==1) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 84;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 68% of data values fall within one standard deviation of the mean. This means that 34% of values fall between the mean and one standard deviation above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located one standard deviation above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 34% = **84% of values fall below " + globalThing.sd_above.toFixed(1) + ".**

Thus, **84% of plants are less than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 16; document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 68% of data values fall within one standard deviation of the mean. This means that 34% of values fall between the mean and one standard deviation below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located one standard deviation below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 34% = 84% of values fall above " + globalThing.sd_below.toFixed(1) + ". This means that 100% - 84% = **16% of values fall below " + globalThing.sd_below.toFixed(1) + ".**

Thus, **16% of plants are less than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
if(globalThing.sd_multiplier==2) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 97.5;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 95% of data values fall within two standard deviations of the mean. This means that 47.5% of values fall between the mean and two standard deviations above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located two standard deviations above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 47.5% = **97.5% of values fall below " + globalThing.sd_above.toFixed(1) + ".**

Thus, **97.5% of plants are less than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 2.5;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 95% of data values fall within two standard deviations of the mean. This means that 47.5% of values fall between the mean and two standard deviations below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located two standard deviations below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 47.5% = 97.5% of values fall above " + globalThing.sd_below.toFixed(1) + ". This means that 100% - 97.5% = **2.5% of values fall below " + globalThing.sd_below.toFixed(1) + ".**

Thus, **2.5% of plants are less than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
if(globalThing.sd_multiplier==3) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 99.85;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 99.7% of data values fall within three standard deviations of the mean. This means that 49.85% of values fall between the mean and three standard deviations above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located three standard deviations above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 49.85% = **99.85% of values fall below " + globalThing.sd_above.toFixed(1) + ".**

Thus, **99.85% of plants are less than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 0.15;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 99.7% of data values fall within three standard deviations of the mean. This means that 49.85% of values fall between the mean and three standard deviations below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located three standard deviations below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 49.85% = 99.85% of values fall above " + globalThing.sd_below.toFixed(1) + ". This means that 100% - 99.85% = **0.15% of values fall below " + globalThing.sd_below.toFixed(1) +**

".

Thus, **0.15% of plants are less than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
} //end less than
if(globalThing.q_selected=="greater than") {
if(globalThing.sd_multiplier==1) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 16;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 68% of data values fall within one standard deviation of the mean. This means that 34% of values fall between the mean and one standard deviation above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located one standard deviation above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 34% = **84% of values fall below " + globalThing.sd_above.toFixed(1) + ". This means that 100% - 84% = 16% of values fall above " + globalThing.sd_above.toFixed(1) + ".**

Thus, **16% of plants are greater than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 84;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 68% of data values fall within one standard deviation of the mean. This means that 34% of values fall between the mean and one standard deviation below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located one standard deviation below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 34% = **84% of values fall above " + globalThing.sd_below.toFixed(1) + ".**

Thus, **84% of plants are greater than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
if(globalThing.sd_multiplier==2) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 2.5;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 95% of data values fall within two standard deviations of the mean. This means that 47.5% of values fall between the mean and two

standard deviations above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located two standard deviations above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 47.5% = **97.5% of values fall below " + globalThing.sd_above.toFixed(1) + ". This means that 100% - 97.5% = 2.5% of values fall above " + globalThing.sd_above.toFixed(1) + ".**

Thus, **2.5% of plants are greater than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 97.5;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 95% of data values fall within two standard deviations of the mean. This means that 47.5% of values fall between the mean and two standard deviations below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located two standard deviations below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 47.5% = **97.5% of values fall above " + globalThing.sd_below.toFixed(1) + ".**

Thus, **97.5% of plants are greater than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
if(globalThing.sd_multiplier==3) {
if(globalThing.sd_selected==globalThing.sd_above) {
var solution = 0.15;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that for a given dataset with a normal distribution, 99.7% of data values fall within three standard deviations of the mean. This means that 49.85% of values fall between the mean and three standard deviations above the mean.

In this example, " + globalThing.sd_above.toFixed(1) + " is located three standard deviations above the mean. Since we know that 50% of data values fall below the mean in a normal distribution, a total of 50% + 49.85% = **99.85% of values fall below " + globalThing.sd_above.toFixed(1) + ". This means that 100% - 99.85% = 0.15% of values fall above " + globalThing.sd_above.toFixed(1) + ".**

Thus, **0.15% of plants are greater than " + globalThing.sd_above.toFixed(1) + " inches tall.";**
} else {
var solution = 99.85;
document.getElementById('solution_words').innerHTML = "The Empirical Rule states that

for a given dataset with a normal distribution, 99.7% of data values fall within three standard deviation below the mean.

In this example, " + globalThing.sd_below.toFixed(1) + " is located three standard deviations below the mean. Since we know that 50% of data values fall above the mean in a normal distribution, a total of 50% + 49.85% = **99.85% of values fall above " + globalThing.sd_below.toFixed(1) + ".**

Thus, **99.85% of plants are greater than " + globalThing.sd_below.toFixed(1) + " inches tall.";**
}
}
} //end greater than

//toggle hide/show solution
var solution_div = document.getElementById("solution_div");
solution_div.style.display = "block";
} //end massive solution() function

function gen() {
var mean = Math.round(jStat.uniform.sample(20, 50)*10)/10;
var sd = Math.round(jStat.uniform.sample(2, 6)*10)/10;

var sd_options = ;
globalThing.sd_multiplier = sd_options;

globalThing.sd_above = mean - (-globalThing.sd_multiplier*sd);
globalThing.sd_below = mean - (globalThing.sd_multiplier*sd);

sd_above_below = ;
globalThing.sd_selected = sd_above_below;

var q_options = ;
globalThing.q_selected = q_options;

if (globalThing.q_selected == "less than") {
document.getElementById('scenario').innerHTML = "less than " + globalThing.sd_selected.toFixed(1);
} else if (globalThing.q_selected == "greater than") {
document.getElementById('scenario').innerHTML = "greater than " + globalThing.sd_selected.toFixed(1);
} else {
document.getElementById('scenario').innerHTML = "between " + globalThing.sd_below.toFixed(1) + " and " + globalThing.sd_above.toFixed(1);

```
}

//fill in mean and sd in initial question
document.getElementById('mean').innerHTML = mean;
document.getElementById('sd').innerHTML = sd;

//toggle answer & solution to hide and clear input field
var result_display = document.getElementById("words_output");
result_display.style.display = "none";
var solution_div = document.getElementById("solution_div");
solution_div.style.display = "none";
document.getElementById('answer').value = "";
} //end massive gen() function

//generate initial question
gen();
```