**Activity 7.5.4A – Finding Areas Under Normal Curves**

Normal curves model continuous random variables that have a bell-shaped and symmetric distribution. This activity will explore how *z*-scores can be used to find areas below normal curves. As we saw previously, areas below normal curves correspond to percentages and probabilities.

**Modeling SAT Writing Scores**

In a recent year SAT writing scores for high school seniors in a state were normally distributed with a mean of 480 and a standard deviation 85. The normal curve below models this distribution. The numbers on the *x*-axis indicate the location of the mean and the scores that are one, two and three standard deviations from the mean.



Suppose we want to find the percent of scores that are less than 400. We can use the population parameters ($μ=480, σ=85)$ to find the *z*-score of $x=400$. Then we can find the area to the left of the *z*-score in the *standard normal distribution*.

The standard normal distribution is a normal distribution with mean $μ=0$ and standard deviation $σ=1$. This is a distribution of *standardized* values.

Here is the calculation of the z-score for $x=400$:

$$z=\frac{x-μ}{σ}=\frac{400-480}{85}=\frac{-80}{85}=-0.94$$

The area to the left of 400 below the normal curve models SAT writing scores is approximately equal to the area to the left of *z* = -0.94 below the standard normal distribution curve.

 

Using the *z*-score table, we see that the area to the left of *z* = -0.94 is 0.1736. We can conclude that approximately 17.3% of SAT writing scores are less than 400.

1. For each question below: calculate the *z*-score for each value of *x*, shade in the area corresponding to the percentage on the standard normal curve below, and use the *z*-scores to find the percentages. Round *z*-scores to two decimal places. Round percentages to three decimal places.
2. What percent of scores are less than 380?
3. What percent of scores are between 460 and 550?
4. What percent of scores are greater than 700?



1. What is more likely: randomly selecting a SAT writing score greater than 700 or randomly selecting a SAT writing score less than 380? Explain.

A normal random variable value is considered *unusual* if it is two or more standard deviations from the mean of its distribution (in either direction).

1. What SAT writing scores are considered unusual?
2. What is the probability of randomly selecting a SAT writing score that is considered unusual?

**Modeling Major League Baseball (MLB) Players’ Batting Averages**

A baseball player’s batting average is found by dividing the player’s total number of hits by their total number of at-bats. So, for example, if a player made 36 hits in 150 at-bats, the player’s batting average is 36/150 = 0.240. Batting averages are typically expressed as decimals.

In a recent year batting averages in major league baseball were normally distributed with a mean 0.260 and a standard deviation of 0.017.

1. Label the mean and the batting averages that are one, two and three standard deviations from the mean below the *x*-axis on the diagram below.



1. What does the Empirical Rule tell us about batting averages in this distribution?
2. Find the percent of batting averages that are less than 0.250? Shade in the corresponding area on the curve above. Round your answer to three decimal places.
3. What percent of batting averages are between 0.275 and 0.300? Shade in the corresponding area on the curve above. Round your answer to three decimal places.
4. A sports reporter states that players with batting averages over 0.300 are exceptional and deserve higher salaries. Make an argument using evidence to refute or support his position.