Is This Penny Fair? (Spinning Pennies)

Penny Facts:

- In 2011, the average cost to mint a penny was about 2.4 cents. (*United States Mint, 2011 Annual Report*)
- There are three locations currently minting coins in the US: Philadelphia, Denver, and San Francisco. Of these, only the Philadelphia and Denver facilities produce coins for general circulation. (*Source*: US Mint)
- The portraits of US presidents featured on US coins face to the left, with one exception: the portrait of President Lincoln on the penny. (*Source*: US Mint)
- During World War II, copper was needed for the war effort. So, in 1943, a steel penny was minted.
- In 1943, for reasons that are not clear, about 40 copper pennies were minted. Experts speculate that they may have been struck accidentally. In 1996, one of these 1943 copper pennies was sold at auction for $82,500. (*Source*: US Mint)
- The Lincoln Memorial cent (which features the Lincoln Memorial on the reverse side), has a tiny figure of President Lincoln inside the Lincoln Memorial on the reverse side. Look closely and you can see it!

Thought-Provokers:

- If you flip a coin, what is the probability (chance) that it lands "tails up?"

- Does this probability change if you spin a penny?

Activity:

1. Suppose your friend invites you to play a game of chance by spinning a penny. You might be interested in whether or not the coin is fair (balanced). Brainstorm some ways to determine whether or not the coin is fair (balanced).

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2. In the absence of fancy equipment or techniques, we could investigate the fairness of the coin by spinning the coin repeatedly. In fact, that's what you should do right now. Your teacher will give you a penny and you should spin it 50 times. Make sure you have a hard, flat surface and that the penny spins without any obstructions. If the penny bumps into something, do not count that spin. As you spin, tally the outcome of each spin in the table below. When you are finished 50 spins, record the number of tails and heads, and the proportion of tails and heads.

	Heads	Tails	Total
Tally			50
Count			50
Proportion			1.0

3. Assume for a moment that your penny is fair. What number of tails would you expect to see in 50 spins?

4. Do you think that 50 spins will *always* produce the number of tails you answered in question number 3 above?

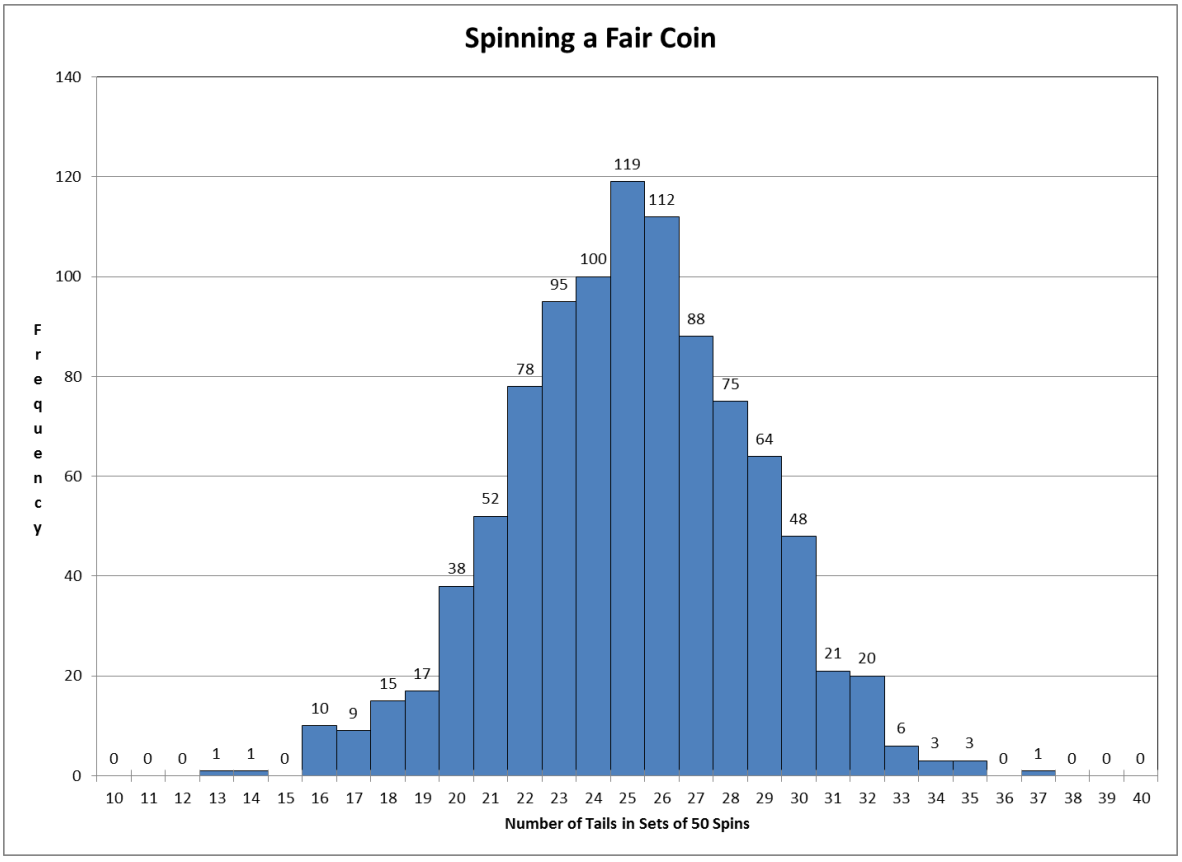
5. Suppose you spin a penny that you believe is fair, but lands tails up 26 times out of the 50 spins. Would this be enough evidence to convince you that the coin is unfair? How about 28 times? 30 times? 34 times? 45 times? Fill in the table below.

Number of Tails in 50 Spins	26	28	30	34	45
Do you believe the coin is unfair?					

6. Again supposing that you believe that you have a fair penny, what number of tails would you need to see before you would change your beliefs and conclude that the coin is unfair?

7. Is it *possible* that a fair coin would land tails up on 45 spins out of 50 just by chance? Is it *likely* that a fair coin would land tails up on 45 spins out of 50 just by chance?

8. Imagine a penny that is spun 50 times and has landed tails up 34 times. You might wonder how likely this is to happen by chance. Below is a histogram that shows the number of tails for1000 sets of 50 spins of a fair penny from a computer simulation. In how many of the 1000 sets did 34 or more tails occur? Turn that number into a percentage.



9. From the histogram in question 8, what is the probability/chance that in one set of 50 spins, a fair coin lands tails up 34 times or more (just by chance alone)?

10. If you spun a penny you believed was fair and saw 34 or more tails (out of 50 spins), would you now believe it was not fair? Explain based on your answer to question 9 above.

11. If a coin is spun and it lands tails up enough times to make you suspicious, one of two things is going to be true:
    - The coin is really fair and you got lots of tails just by chance.
    - The coin is really not fair.

    You were asked to decide between these two possibilities in question 10 above, in light of the probability you calculated in number 9. Statisticians have a rule of thumb for making this kind of decision: when the probability for some event to occur by chance is less than 5%, we tend to discard the original belief (that the coin was fair) and choose to believe the new belief (that the coin is not fair). An event that is unlikely to happen by chance is called **statistically significant.** That is, although lots of tails from a fair coin can occur by chance *sometimes*, we don't believe that it occurred by chance *this one time* because the probability is so small. Now look at the number of spins for your penny and repeat the calculation in questions 8 and 9 for your penny. Use the histogram to find a probability that a fair coin lands tails up (just by chance) as many or more times as your penny did. Do you have enough evidence to reject the belief that *your* penny is fair?

Obverse (front) of the Lincoln Memorial penny

Reverse (back) of the Lincoln Memorial penny