Olin College of Engineering

Teacher's Guide for **Carnival Games**

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## Workshop Description

Step right up and discover which carnival games are scams and which are worth your money. Flip some coins, pick some ducks, pop virtual balloons, and learn the math of it all!

We will be introducing probability and conditional probability in the framework of various carnival games, including an activity at the end for students to create their own version of a game!

## Workshop Requirements

- **Runs about 45-60 minutes** depending on class size and student engagement
- **Required or suggested materials**
    - A coin if possible
    - Paper and pencil
    - Markers or other coloring implements
- **Suggested ages/grades:** middle school → early high school
- **Prerequisite Knowledge:**
    - Basic multiplication
    - Familiarity with fractions and simplifying them
    - Percentages/decimals/fractions and their relations to each other
- Workshop slides

## Learning Goals

- How to build, understand, and utilize an event tree
- The difference between dependent and independent events
- How to calculate the probability of simple events
- How to calculate the probability of two events happening sequentially
    - via hand calculation
    - via multiplication of each individual event's probability
- General probability notation: P(A) and P(A|B)
- How to apply this knowledge to create a new game
- Familiarity with the relationships between fractional and percentile probabilities

## Please use these materials and tailor them to your students!

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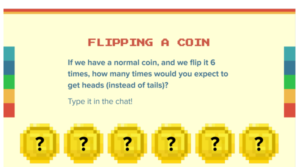
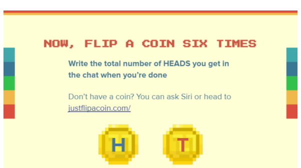
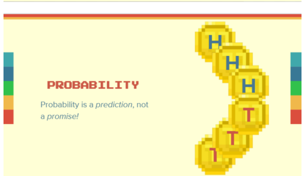
## Suggested Notes and Tips for Running

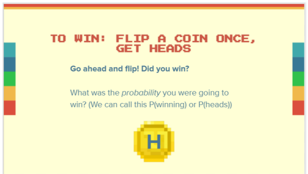



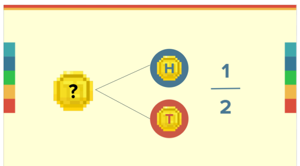




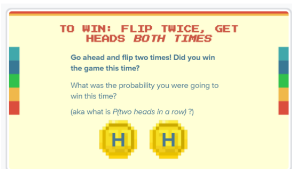

- **Slide 1**: As an ice breaker, ask about what carnival games people know, and wait for responses live or in the chat if you are online.
- **Slide 3:** This slide isn't to get "right" answers, and can in fact be used as a good temperature check for what probability concepts students may be familiar with.
- **Slide 4**: If you're teaching in person, you can provide coins to students, or perhaps just flip one coin and have students tally the results. This is to show that even if the probability of getting heads is 50%, that's just a prediction, and won't happen perfectly every time
- **Slide 5:** Based on the responses from slide 3, this may need more of an explanation. If students aren't familiar with the concept of a coin being 50/50, explain that both sides are evenly weighted, etc.
- **Slide 6:** An important concept to drive home - make sure students understand that even with these numbers that we'll calculate, it isn't a promise of the future. Real life is messy!
- **Slide 8:** Reinforce what was said on slide 5, but in the framing of a "game". Ask students to report back if they won or not - tally results or let it be seen in chat what the results were



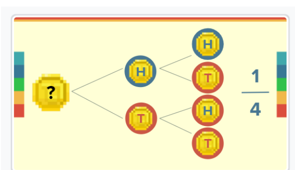

- **Slide 9:** Explain what's happening here before calling it an "event tree" - very simply, this shows us that there are two options that are equally likely. We call this an event tree.




- **Slide 10:** Run the same as slide 8, asking students to say out loud or in chat if they won. Emphasize this notation of P(two heads in a row).



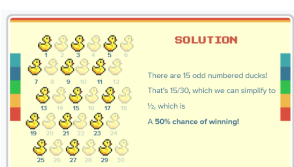

- **Slide 11:** The animations of this slide allow it to first look like slide 9. Talk through the second round of branching, allow students to count the branches to see that it's out of four.



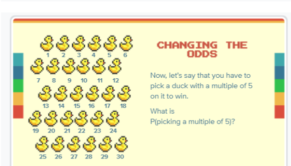

- **Slide 12:** To emphasize the "randomness" of this game, make sure you explicitly state that you can't see the numbers on each duck. This assumption is *why* we can make probability calculations.


- **Slide 13:** In person, have them talk to a student next to them. Make sure you give them time to solve it on their own before revealing the answer or having students shout out their calculations. Have them share out before advancing the slide.

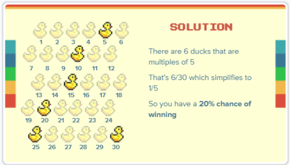

- **Slide 14:** If students don't remember simplification of fractions or the conversion of fractions to percentages, this is a good place to reinforce those concepts.




- **Slide 15:** Run in the same manner as slide 13

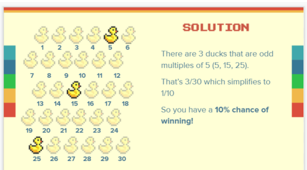



- **Slide 16:** Similar to slide 14

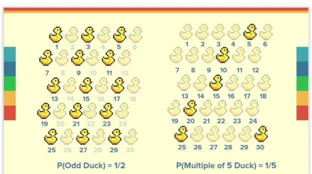



➢ **Slide 17:** Run the same as slide 13 and 15, but consider not having them talk to a partner - allow each student to come to their own conclusion.

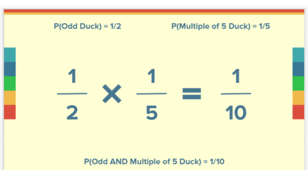

➢ **Slide 18:** Similar to slides 16 and 14. Ask the students if they noticed any similarities to this probability and the previous two probabilities.



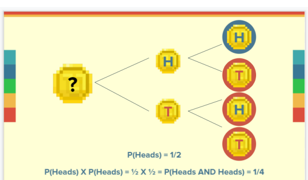

➢ **Slide 19:** This is a visual reminder of the first two duck problems they solved.



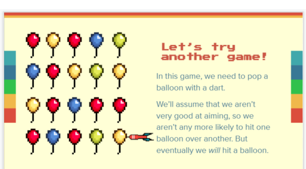

➢ **Slide 20:** Walk through the multiplication of fractions if necessary, but show that the first two solutions multiplied together (ie happening concurrently) are equal to the third solution.




➢ **Slide 21:** Callback to the earlier coin slides - we "unintentionally" did this same multiplication by using the event tree.



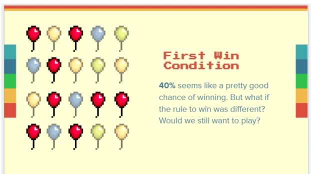

➢ **Slide 22:** Emphasize the assumption that allows us to do our calculations here - we aren't good at aiming, *and* we always hit a balloon. Ask students what changing these assumptions may mean for our probability.



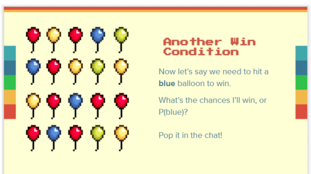

➢ **Slide 23:** Depending on the general level of understanding the students have by this point, this slide can be run as a group or by letting the students ponder it on their own.


➢ **Slide 24:** For additional engagement, ask students if those are odds they'd be willing to play.

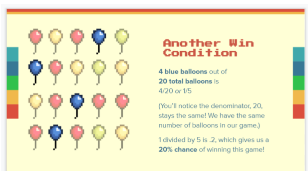

- **Slide 25:** Remind them that this probability is assuming we always hit a balloon - real odds would be different!

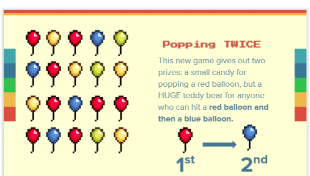



- **Slide 26:** Have students try and solve this one on their own, then share out as a class or in chat. This should go fairly quickly, as it's the same process as before.

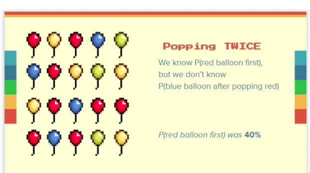



- **Slide 27:** Only the numerator of the fraction changed. While this may seem obvious to students, pointing it out now helps to segue to the third win condition.

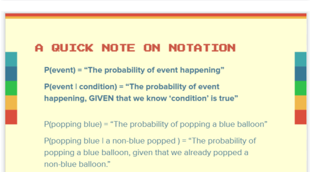


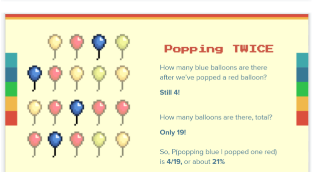

- **Slide 29:** Make sure to read notations as "Probability of [event]" to continue cementing the notation



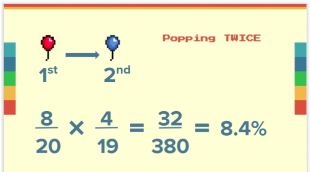

- **Slide 30:** This slide can be a bit clunky to read at first, but by reading the examples out loud, students understand much easier.

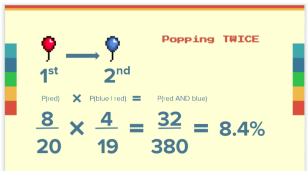


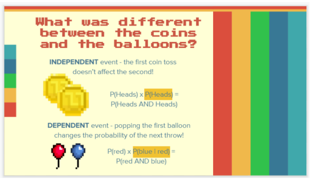

- **Slide 31:** The animations of this slide function so that each answer will phase in as you advance. Ask the question to the students and have them answer out loud/in chat, then reveal. Should be fairly straight forward, but make sure students understand that because we aren't replacing balloons, popping a red balloon changes the probability of popping blue.

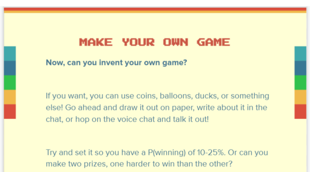



- **Slide 32:** The numbers get big here, which can be a bit scary, but remind students that 8/20 is 2/5, and that 32/380 can also be simplified. Can also emphasize why sometimes percentages are easier to read/understand than fractions are.




- **Slide 33:** This slide simply phases in the notation that was outlined on slide 30. The "AND" is the only thing that's new, but there's no need for an explanation of set notation if students aren't familiar.

- **Slide 34:** This is a crucial learning point. If this is confusing, show that P(Heads | Heads on first throw) = P(Heads), so when in doubt, students can treat events as dependent and see if things change.

- **Slide 35:** Doing this activity alongside students helps them feel less self-conscious about their own creations. Have a teacher's assistant share out first, or share your own, to show that low-caliber is ok. Have all willing students share out, and encourage everyone to share what they've done. Expand on this activity by having them add a second "prize" that needs to be a different probability of success. Can also be done in partners or small groups.