

# Assessment task 1

# Chuck-a-Luck

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# Activity introduction

## Quick summary

Chuck-a-Luck is a dice game that originated around the early 1800s. It has been known as Birdcage (because the dice are kept inside a birdcage-shaped device), Dice and Anchor (because the faces of the dice were: clubs, diamonds, hearts, spades, crown, and anchor) or Sweat Cloth (soldiers would play on a cloth, and pretend to wipe their forehead with it if their sergeant was about to catch them).

This assessment includes a number of questions on the Appendix A: Student assessment, as well as the answers as part of the teacher instructions, to enable students to demonstrate their understanding and learning across this unit. Students will be asked to investigate an old gambling game known as *Chuck-a-Luck*. They will calculate the probabilities of each betting option and their expected values.

## Activity introduction

### Learning intentions

Students will:

- understand that games of chance can be analysed mathematically
- understand what makes a game unfair
- understand how these games are designed to make a profit.

### Success criteria

Students can:

- convert between probability and odds
- use tree diagrams to determine the probability of different events
- calculate the expected profit or loss for different betting options in games of chance.

### Syllabus outcomes

- **MAO-WM-01** develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly
- **MA5-PRO-C-01** solves problems involving probabilities in multistage chance experiments and simulations
- **MA5-PRO-P-01** solves problems involving Venn diagrams, 2-way tables and conditional probability.

The identified Life Skills outcome that relates to this activity is **MALS-PRO-01** applies chance and probability to everyday events.

### Capabilities and priorities

Literacy  
Numeracy  
Critical and creative thinking

#### Topic

Gambling probability

#### Unit of work

Mathematics Stage 5

#### Time required

60 minutes

#### Resources required

- Appendix A: Student assessment
- Appendix B: List of outcomes
- Appendix C: Assessment rubric
- Calculators – one per student

#### Keywords

Gambling, betting, sports, casino, money, wellbeing, gaming.

# Teacher worksheet

## Teacher preparation

Gambling can be a high-risk activity and is a priority concern for young people. Therefore, before conducting the lesson on gambling, it is recommended that teachers read the Facilitator pack. The pack provides teachers and parents with essential information about gambling harm amongst young people and clarifies the nature of gambling-related behaviours and how to approach sensitive topics.

*Work through this resource material in the following sequence:*

Give each student a copy of Appendix A: Student assessment and ask them to work through the tasks. Support them as necessary. Answers have been included below, *shown in italics*, with specific explanations for each of the questions.

You may wish to share Appendix B: List of outcomes, to scaffold students.

## Instructions:

Chuck-a-Luck is played as follows:

- The players put their money on as many betting options as they like
- Three six-sided dice are rolled
- Bets are either kept or paid out by the casino.

The possible betting options and the house odds are as follows:

Name	Wager	House odds
Single	Choose a number from 1-6, and you win depending on how many dice it appears on	1 die: 1 to 1, 2 dice: 2 to 1 3 dice: 10 to 1
Triple	All three dice show the same number	30 to 1
Big	The sum of the dice is 11 or higher, and not a triple	1 to 1
Small	The sum of the dice is 10 or lower, and not a triple	1 to 1
Field	The sum of the dice is less than 8 or more than 12	1 to 1

**Note:** 10 to 1 means for every \$1 you bet, you will receive \$10 (plus your original bet) if you win. Or in other words, your profit on a win is \$10 per \$1 bet.

### Task 1

Convert the house odds into decimal odds, ie: the amount you will get paid out for a \$1 bet, and calculate the probability of getting a win.

Name	House odds	Decimal odds (Task 1)	Probability
Single	Rolling 1 die: 1 to 1	2.00	<i>HMM, MHM, or MMH:</i> $\frac{25}{216} + \frac{25}{216} + \frac{25}{216} = \frac{75}{216}$
Single	Rolling 2 dice: 2 to 1	3.00	<i>HHM, HMH, or MHH:</i> $\frac{5}{216} + \frac{5}{216} + \frac{5}{216} = \frac{15}{216}$
Single	Rolling 3 dice: 10 to 1	11.00	<i>HHH:</i> $\frac{1}{216}$
Triple	30 to 1	31.00	<i>As any matching set of three numbers is a win, the first number does not matter, only the last two. Therefore the probability is 1/36. Alternatively it's the probability of all 1s plus all 2s ... plus all 6s ie <math>6 \times \frac{1}{216} = \frac{1}{36}</math></i>
Big	1 to 1	2.00	<i>There are a total of <math>27 + 25 + 21 + 15 + 10 + 6 + 3 + 1 = 108</math> ways of scoring an 11 or higher. Out of those, three are triples (444, 555, and 666). Therefore the probability is <math>(108-3)/216 \approx 0.486</math>.</i>
Small	1 to 1	2.00	<i>10 or lower is the complement to 11 or higher so there are <math>216-108 = 108</math> possibilities. Three of those are triples (111, 222, 333), so the probability is <math>105/216 \approx 0.486</math>.</i>
Field	1 to 1	2.00	<i>50 combinations sum to 3, 4, 5, 6, 7, 13, 14, 15, 16, 17, or 18, so the probability is <math>50/216 = 0.231</math>.</i>

## Task 2

How large is the sample space when rolling three dice?

*The number of possible outcomes is  $6 \times 6 \times 6 = 216$ .*

## Task 3

How many different ways can you roll a total of 3 with 3 dice? How about a total of 4? Or 5? Can you see how easy it would be to miss one or more combinations using a trial and error type method and how it is important to be systematic. Refer to Appendix B for a list of all possible outcomes.

Complete the following table, where Sum is the outcomes possible when rolling three dice, and Combinations is the number of unique ways these outcomes can be achieved.

Sum	Combinations
3	1
4	3
5	6
6	10
7	15
8	21
9	25
10	27
11	27
12	25
13	21
14	15
15	10
16	6
17	3
18	1

## Task 4

Using tree diagrams or another method, find the probability for each type of single bet and the triple bet. List your answers in the table above.

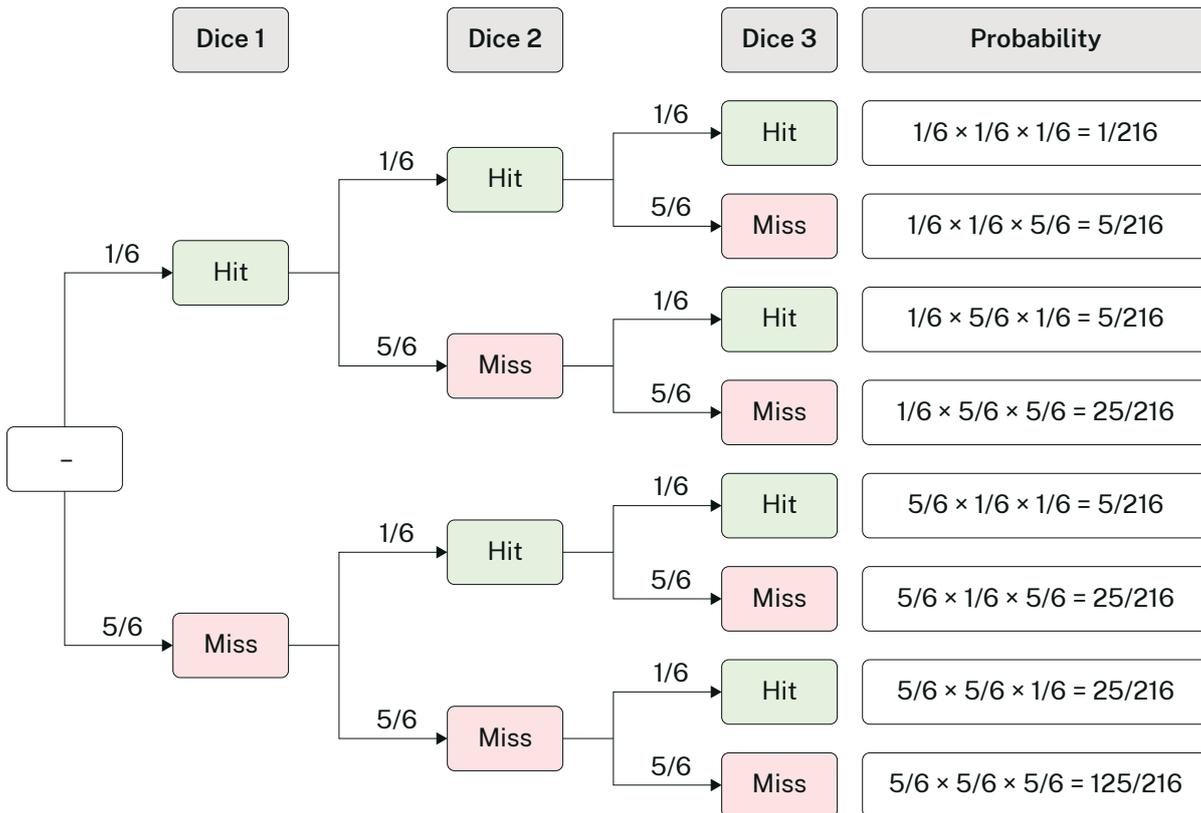
## Teacher worksheet

**Hint:** Consider each roll as a 'Hit' if you roll the number you bet on, or a 'Miss' if any other number, then work out the sample space of hits and misses.

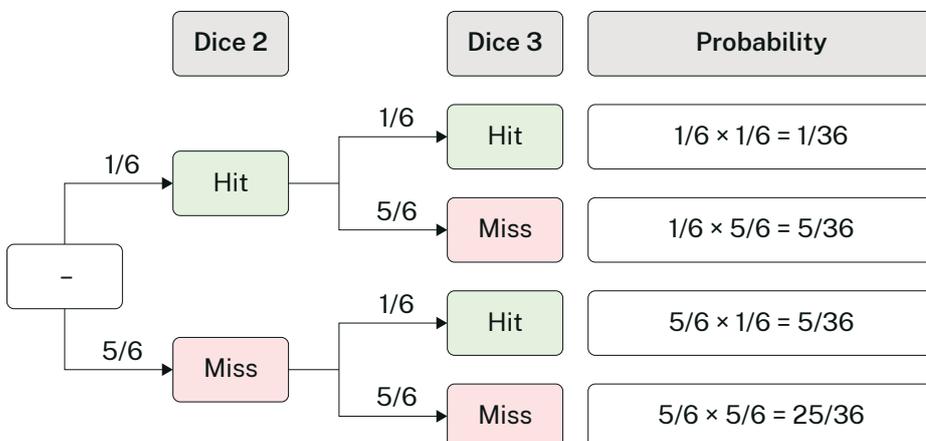
Refer also to Appendix B: List of outcomes.

HHH, HHM, HMH, HMM, MHH, MHM, MMH, MMM

### Single



### Triple



### Task 5

Using the table in Task 3, find the probability for the big, small, and field bets. List your answers in the table above.

#### Big

Out of the 216 possibilities, the only possible sums are 3-18. There is only one way of obtaining a 3, but 27 ways of obtaining a 10 or 11.

There are a total of  $27 + 25 + 21 + 15 + 10 + 6 + 3 + 1 = 108$  ways of scoring an 11 or higher. Out of those, three are triples (444, 555, and 666). Therefore the probability is  $(108-3)/216 = 0.486$ .

A simpler method is also possible, which is shown next.

#### Small

Another way of thinking of this is that a total sum of 10 or lower represents half of the possibilities, therefore there are 108 combinations. Three of those are triples (111, 222, 333), so the probability is  $105/216 = 0.486$ .

#### Field

50 combinations sum to 3, 4, 5, 6, 7, 13, 14, 15, 16, 17, or 18, so the probability is  $50/216 = 0.231$ .

### Task 6

Calculate the expected value of each bet assuming a \$1 bet.

#### Single

Outcome	Probability	Profit/Loss	Product
Miss	$125/216$	-\$1	-\$0.579
One hit	$75/216$	\$1	\$0.347
Two hits	$15/216$	\$2	\$0.139
Three hits	$1/216$	\$10	\$0.046
Expected value (sum of products):			-\$0.046

#### Triple

Outcome	Probability	Profit/Loss	Product
Win	$1/36$	\$30	\$0.833
Lose	$35/36$	-\$1	-\$0.972
Expected value (sum of products):			-\$0.139

**Big**

Outcome	Probability	Profit/Loss	Product
Win	105/216	\$1	\$0.486
Lose	111/216	-\$1	-\$0.514
Expected value (sum of products):			-\$0.028

**Small**

Outcome	Probability	Profit/Loss	Product
Win	105/216	\$1	\$0.486
Lose	111/216	-\$1	-\$0.514
Expected value (sum of products):			-\$0.028

**Field**

Outcome	Probability	Profit/Loss	Product
Win	50/216	\$1	\$0.231
Lose	166/216	-\$1	-\$0.769
Expected value (sum of products):			-\$0.537

**Task 7**

Given the above, what is the least valuable betting option for the player? Explain your answer.

*Field, because the expected average return over time (or loss, in this case), is -50c.*

# Appendix A: Student assessment

## Step 1

Read through the instructions for the Chuck-a-Luck game.

### Instructions:

Chuck-a-Luck is played as follows:

- The players put their money on as many betting options as they like.
- Three six-sided dice are rolled.
- Bets are either kept or paid out by the casino.

The possible betting options and the house odds are as follows:

Name	Wager	House odds
Single	Choose a number from 1-6, and you win depending on how many dice it appears on	1 die: 1 to 1, 2 dice: 2 to 1 3 dice: 10 to 1
Triple	All three dice show the same number	30 to 1
Big	The sum of the dice is 11 or higher, and not a triple	1 to 1
Small	The sum of the dice is 10 or lower, and not a triple	1 to 1
Field	The sum of the dice is less than 8 or more than 12	1 to 1

**Note:** 10 to 1 means for every \$1 you bet, you will receive \$10 (plus your original bet) if you win. Or in other words, your profit on a win is \$10 per \$1 bet.

## Step 2

Complete the following questions, showing your work.

### Task 1

Convert the house odds into decimal odds, ie: the amount you will get paid out for a \$1 bet, and calculate the probability of getting a win.

Name	House odds	Decimal odds	Probability
Single	Rolling 1 die: 1 to 1		
Single	Rolling 2 dice: 2 to 1		
Single	Rolling 3 dice: 10 to 1		
Triple	30 to 1		
Big	1 to 1		
Small	1 to 1		
Field	1 to 1		

## Appendix A: Student assessment

### Task 2

How large is the sample space (total possible outcomes) when rolling three dice?

### Task 3

Complete the following table, where Sum is the outcomes possible when rolling three dice, and Combinations is the number of unique ways these outcomes can be achieved.

The first one has been done for you.

Sum	Combinations
3	1

### Task 4

Using decision trees or another method, find the probability for each type of single bet and the triple bet. List your answers in the table above.

**Hint:** Consider each roll as a 'Hit' if you roll the number you bet on, or a 'Miss' if any other number, then work out the sample space of hits and misses.

## Appendix A: Student assessment

### Task 5

Using the table in Task 3, find the probability for the big, small, and field bets. List your answers in the table above.

### Task 6

Calculate the expected value of each bet assuming a \$1 bet. The first one has been done for you.

#### Single

Outcome	Probability	Profit/Loss	Product
Miss	125/216	-\$1	-\$0.579
Expected value (sum of products):			

#### Triple

Outcome	Probability	Profit/Loss	Product
Expected value (sum of products):			

#### Big

Outcome	Probability	Profit/Loss	Product
Expected value (sum of products):			

## Appendix A: Student assessment

### Small

Outcome	Probability	Profit/Loss	Product
Expected value (sum of products):			

### Field

Outcome	Probability	Profit/Loss	Product
Expected value (sum of products):			

### Task 7

Given the above, what is the least valuable betting option for the player? Explain your answer.

# Appendix B: List of outcomes

This table shows all the possible outcomes for rolling three dice.

(1, 1, 1)	(2, 1, 1)	(3, 1, 1)	(4, 1, 1)	(5, 1, 1)	(6, 1, 1)
(1, 1, 2)	(2, 1, 2)	(3, 1, 2)	(4, 1, 2)	(5, 1, 2)	(6, 1, 2)
(1, 1, 3)	(2, 1, 3)	(3, 1, 3)	(4, 1, 3)	(5, 1, 3)	(6, 1, 3)
(1, 1, 4)	(2, 1, 4)	(3, 1, 4)	(4, 1, 4)	(5, 1, 4)	(6, 1, 4)
(1, 1, 5)	(2, 1, 5)	(3, 1, 5)	(4, 1, 5)	(5, 1, 5)	(6, 1, 5)
(1, 1, 6)	(2, 1, 6)	(3, 1, 6)	(4, 1, 6)	(5, 1, 6)	(6, 1, 6)
(1, 2, 1)	(2, 2, 1)	(3, 2, 1)	(4, 2, 1)	(5, 2, 1)	(6, 2, 1)
(1, 2, 2)	(2, 2, 2)	(3, 2, 2)	(4, 2, 2)	(5, 2, 2)	(6, 2, 2)
(1, 2, 3)	(2, 2, 3)	(3, 2, 3)	(4, 2, 3)	(5, 2, 3)	(6, 2, 3)
(1, 2, 4)	(2, 2, 4)	(3, 2, 4)	(4, 2, 4)	(5, 2, 4)	(6, 2, 4)
(1, 2, 5)	(2, 2, 5)	(3, 2, 5)	(4, 2, 5)	(5, 2, 5)	(6, 2, 5)
(1, 2, 6)	(2, 2, 6)	(3, 2, 6)	(4, 2, 6)	(5, 2, 6)	(6, 2, 6)
(1, 3, 1)	(2, 3, 1)	(3, 3, 1)	(4, 3, 1)	(5, 3, 1)	(6, 3, 1)
(1, 3, 2)	(2, 3, 2)	(3, 3, 2)	(4, 3, 2)	(5, 3, 2)	(6, 3, 2)
(1, 3, 3)	(2, 3, 3)	(3, 3, 3)	(4, 3, 3)	(5, 3, 3)	(6, 3, 3)
(1, 3, 4)	(2, 3, 4)	(3, 3, 4)	(4, 3, 4)	(5, 3, 4)	(6, 3, 4)
(1, 3, 5)	(2, 3, 5)	(3, 3, 5)	(4, 3, 5)	(5, 3, 5)	(6, 3, 5)
(1, 3, 6)	(2, 3, 6)	(3, 3, 6)	(4, 3, 6)	(5, 3, 6)	(6, 3, 6)
(1, 4, 1)	(2, 4, 1)	(3, 4, 1)	(4, 4, 1)	(5, 4, 1)	(6, 4, 1)
(1, 4, 2)	(2, 4, 2)	(3, 4, 2)	(4, 4, 2)	(5, 4, 2)	(6, 4, 2)
(1, 4, 3)	(2, 4, 3)	(3, 4, 3)	(4, 4, 3)	(5, 4, 3)	(6, 4, 3)
(1, 4, 4)	(2, 4, 4)	(3, 4, 4)	(4, 4, 4)	(5, 4, 4)	(6, 4, 4)
(1, 4, 5)	(2, 4, 5)	(3, 4, 5)	(4, 4, 5)	(5, 4, 5)	(6, 4, 5)
(1, 4, 6)	(2, 4, 6)	(3, 4, 6)	(4, 4, 6)	(5, 4, 6)	(6, 4, 6)
(1, 5, 1)	(2, 5, 1)	(3, 5, 1)	(4, 5, 1)	(5, 5, 1)	(6, 5, 1)
(1, 5, 2)	(2, 5, 2)	(3, 5, 2)	(4, 5, 2)	(5, 5, 2)	(6, 5, 2)
(1, 5, 3)	(2, 5, 3)	(3, 5, 3)	(4, 5, 3)	(5, 5, 3)	(6, 5, 3)
(1, 5, 4)	(2, 5, 4)	(3, 5, 4)	(4, 5, 4)	(5, 5, 4)	(6, 5, 4)
(1, 5, 5)	(2, 5, 5)	(3, 5, 5)	(4, 5, 5)	(5, 5, 5)	(6, 5, 5)
(1, 5, 6)	(2, 5, 6)	(3, 5, 6)	(4, 5, 6)	(5, 5, 6)	(6, 5, 6)
(1, 6, 1)	(2, 6, 1)	(3, 6, 1)	(4, 6, 1)	(5, 6, 1)	(6, 6, 1)
(1, 6, 2)	(2, 6, 2)	(3, 6, 2)	(4, 6, 2)	(5, 6, 2)	(6, 6, 2)
(1, 6, 3)	(2, 6, 3)	(3, 6, 3)	(4, 6, 3)	(5, 6, 3)	(6, 6, 3)
(1, 6, 4)	(2, 6, 4)	(3, 6, 4)	(4, 6, 4)	(5, 6, 4)	(6, 6, 4)
(1, 6, 5)	(2, 6, 5)	(3, 6, 5)	(4, 6, 5)	(5, 6, 5)	(6, 6, 5)
(1, 6, 6)	(2, 6, 6)	(3, 6, 6)	(4, 6, 6)	(5, 6, 6)	(6, 6, 6)

# Appendix C: Assessment rubric

	Exemplary 4	Accomplished 3	Developing 2	Beginning 1	Not Attempted 0
<b>Application</b>	All calculations performed accurately and thoroughly.	Most calculations performed accurately and thoroughly.	Some calculations performed accurately and thoroughly.	A few calculations performed accurately and thoroughly.	Calculations not attempted.
<b>Analysis</b>	A complete level of understanding was shown regarding how to calculate the various probabilities	An excellent level of understanding was shown regarding how to calculate the various probabilities	A reasonable attempt was made to think about how to calculate the probabilities.	Some attempt was made to think about how to calculate the probabilities.	No attempt was made to consider how to think about the probabilities.
<b>Evaluation</b>	The expected values were all calculated correctly, with a good understanding of what they represent.	The expected values were mostly calculated correctly, with a good understanding of what they represent.	The expected values were mostly calculated correctly.	An attempt was made to calculate the expected values correctly.	No attempt was made to calculate the expected values.