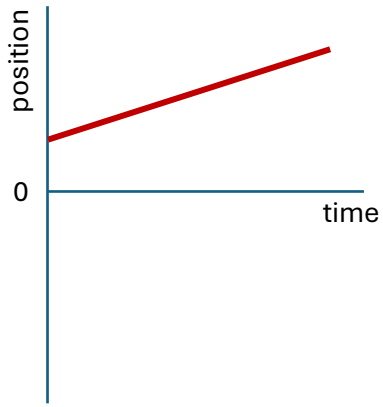
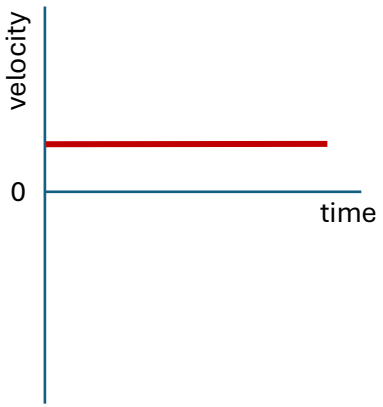
p vs t graph



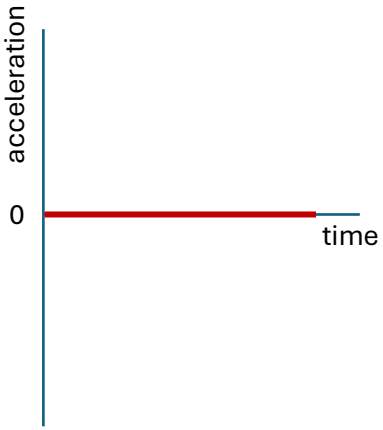
Card 15

v vs t graph



Card 18

a vs t graph



Card 26

Scenario 1

Object moving in the **positive** direction at constant velocity

Answer key on reverse side

Velocity

Positive Velocity

Card 8

Acceleration

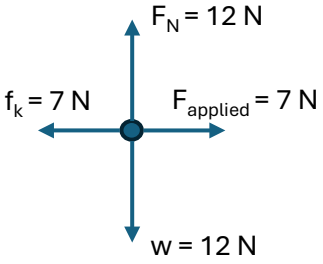
Zero Acceleration

Card 9

Motion diagram

Card 2

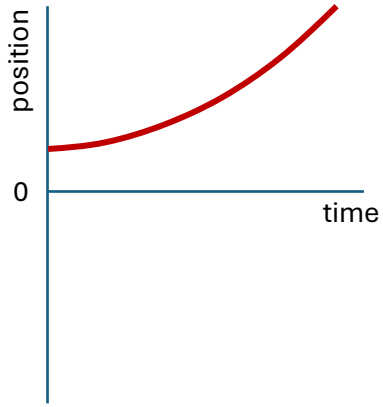
Free Body Diagram



Card 29

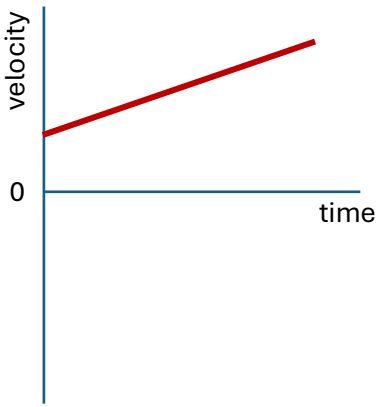
Case 1

p vs t graph



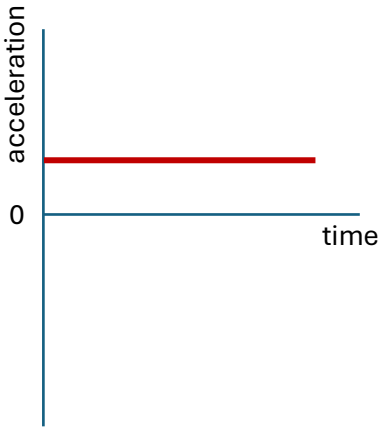
Card 12

v vs t graph



Card 23

a vs t graph



Card 24

Scenario 2

Object moving in the **positive** direction at increasing speed

Answer key on reverse side

Velocity

Positive Velocity

Card 8

Acceleration

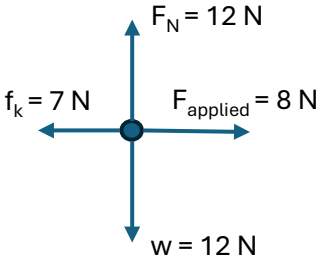
Positive Acceleration

Card 11

Motion diagram

Card 3

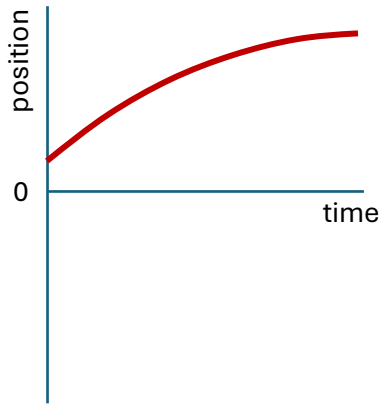
Free Body Diagram



Card 31

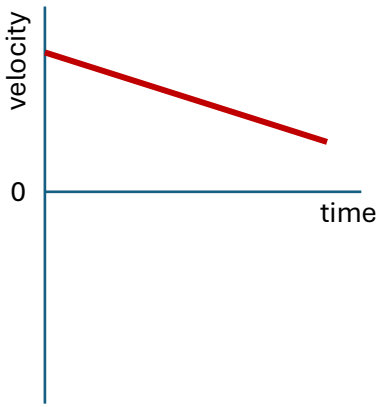
Case 2

p vs t graph



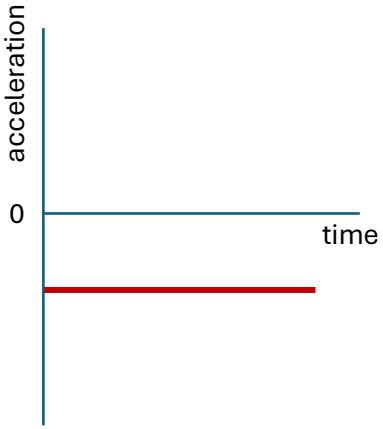
Card 13

v vs t graph



Card 19

a vs t graph



Card 25

Scenario 3

Object moving in the **positive** direction at decreasing speed

Answer key on reverse side

Velocity

Positive Velocity

Card 8

Acceleration

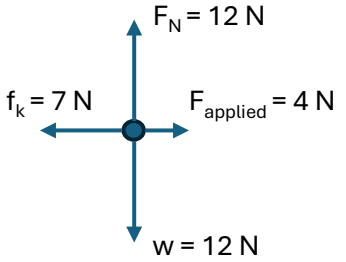
Negative Acceleration

Card 10

Motion diagram

Card 6

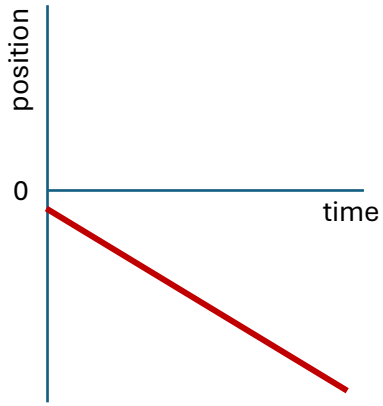
Free Body Diagram



Card 30

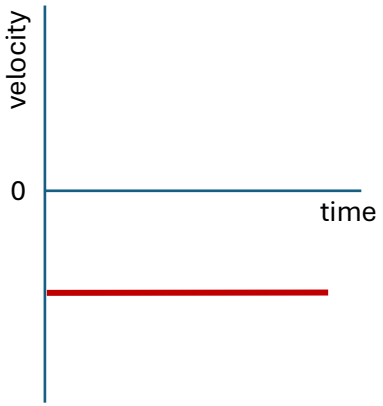
Case 3

p vs t graph



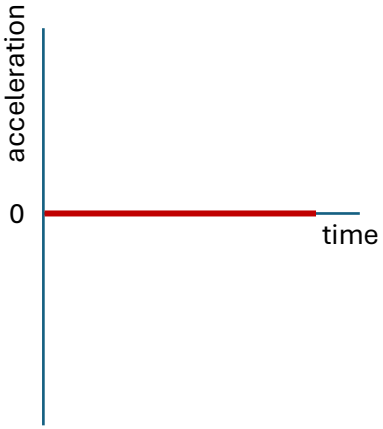
Card 16

v vs t graph



Card 22

a vs t graph



Card 26

Scenario 4

Object moving in the **negative** direction at constant velocity

Answer key on reverse side

Velocity

Negative Velocity

Card 7

Acceleration

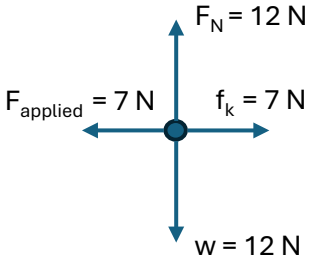
Zero Acceleration

Card 9

Motion diagram

Card 5

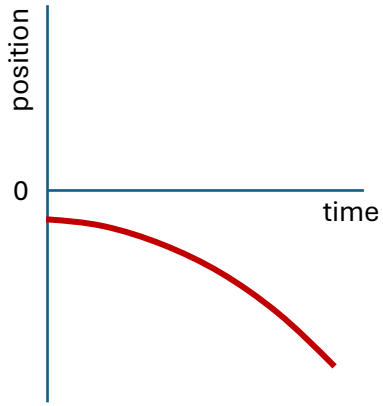
Free Body Diagram



Card 28

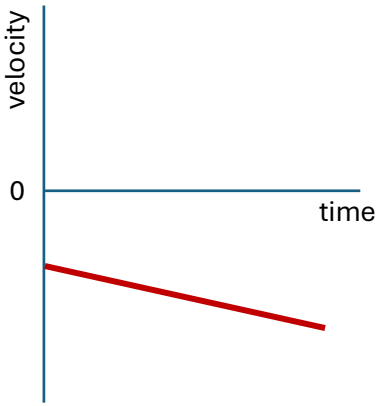
Case 4

p vs t graph



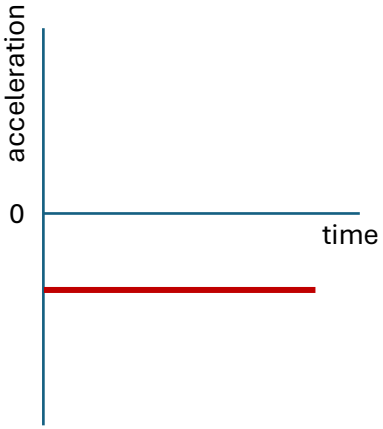
Card 17

v vs t graph



Card 20

a vs t graph



Card 25

Scenario 5

Object moving in **negative** direction at increasing speed

Answer key on reverse side

Velocity

Negative Velocity

Card 7

Acceleration

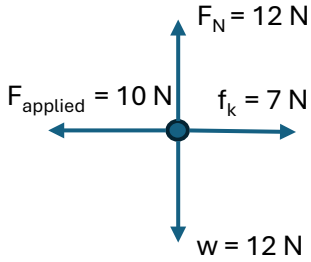
Negative Acceleration

Card 10

Motion diagram

Card 1

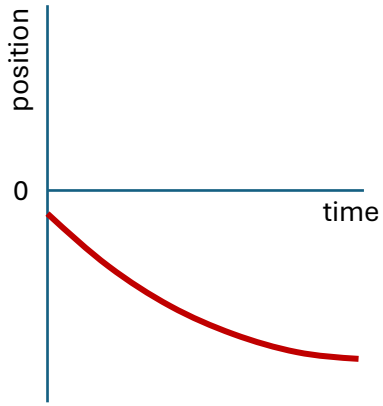
Free Body Diagram



Card 32

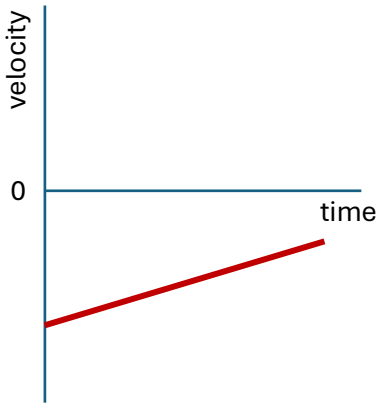
Case 5

p vs t graph



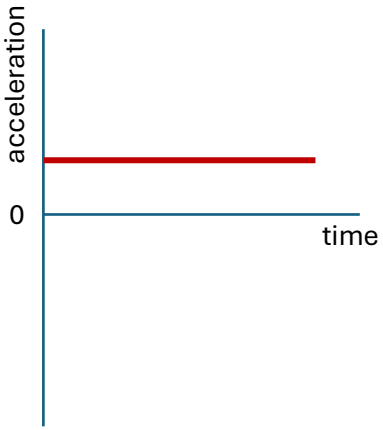
Card 14

v vs t graph



Card 21

a vs t graph



Card 24

Scenario 6

Object moving in the **negative** direction at decreasing speed

Answer key on reverse side

Velocity

Negative Velocity

Card 7

Acceleration

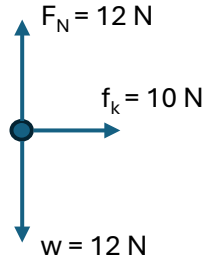
Positive Acceleration

Card 11

Motion diagram

Card 4

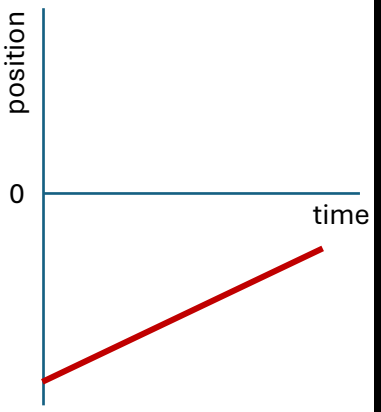
Free Body Diagram



Card 27

Case 6

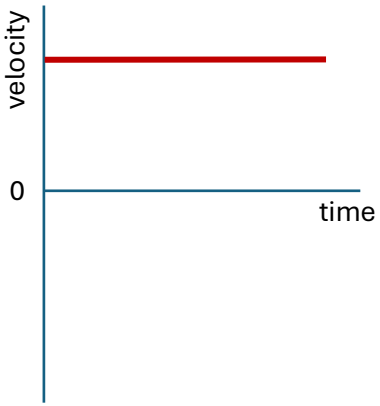
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

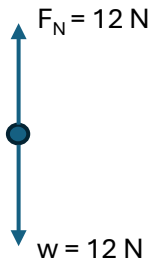
Vertical scenario

Card x

Advanced

Free Body Diagram

Vertical scenario

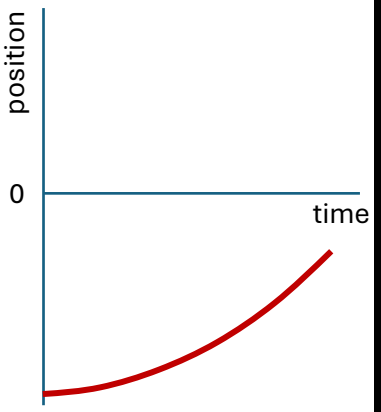


Card x

Advanced

Case 1

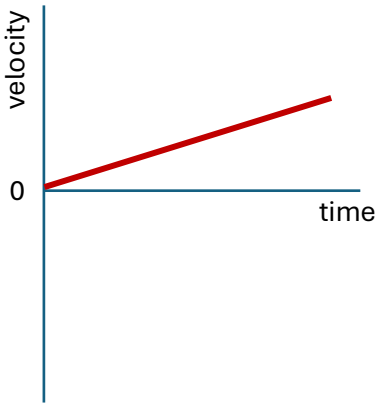
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

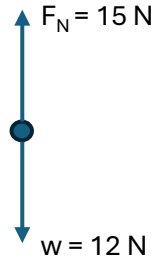
Vertical scenario

Card X

Advanced

Free Body Diagram

Vertical scenario

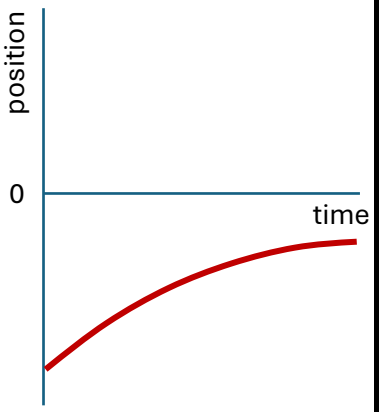


Card x

Advanced

Case 2

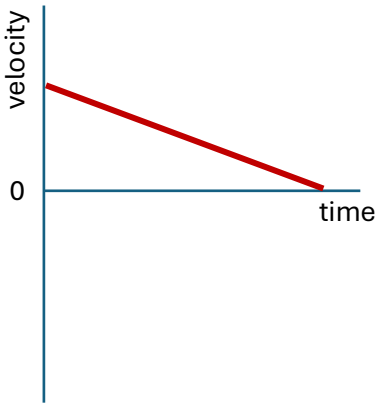
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

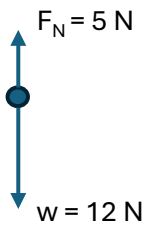
Vertical scenario

Card x

Advanced

Free Body Diagram

Vertical scenario

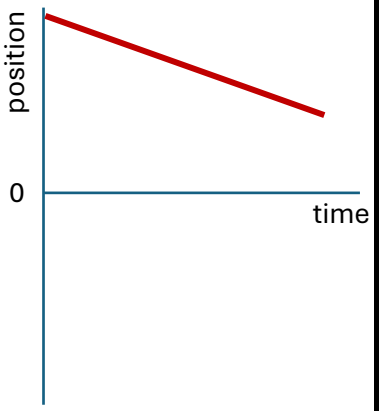


Card x

Advanced

Case 3

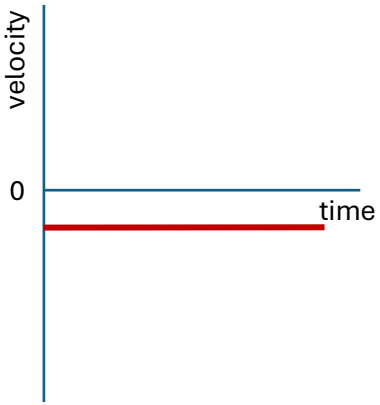
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

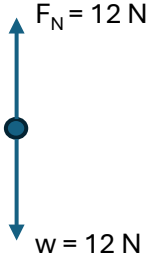
Vertical scenario

Card X

Advanced

Free Body Diagram

Vertical scenario

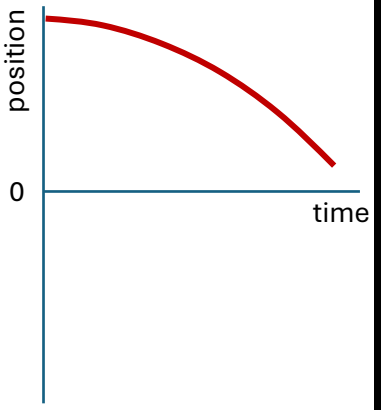


Card x

Advanced

Case 4

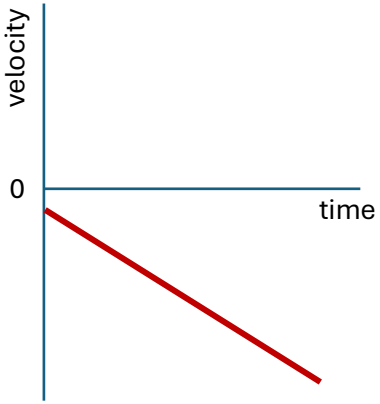
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

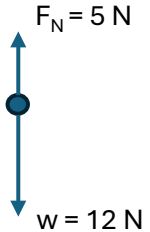
Vertical scenario

Card x

Advanced

Free Body Diagram

Vertical scenario

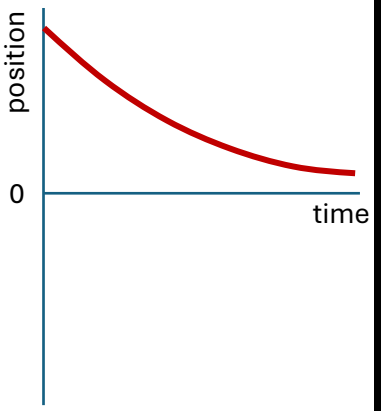


Card x

Advanced

Case 5

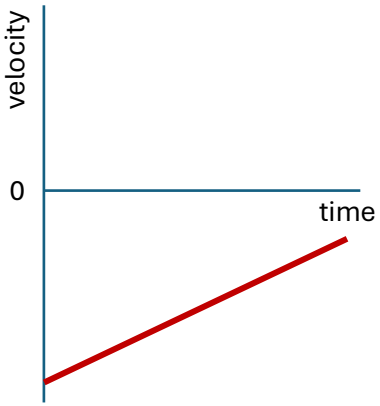
p vs t graph



Card x

Advanced

v vs t graph



Card x

Advanced

Motion diagram

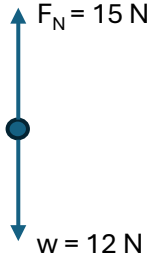
Vertical scenario

Card X

Advanced

Free Body Diagram

Vertical scenario



Card x

Advanced

Case 6

Action!

Reverse

Action!

Draw and Share

- Pull two additional cards from the draw pile
- Put them in your hand
- Give any two cards from your hand away to other player(s)

Action!

Break time

- Pick any player to lose their next turn

Action!

Double play

- Playing this card allows you to take an extra turn

Action!

Pass one to the left

- Every player passes a card from their hand, of their choosing, to the left
- Cards should all be passed at the same time

Action!

Thievery

- You may pick one player to steal a card from
- They will fan out their cards, with the backs facing you. You pick one of their cards without knowing what it is
- Choose one of your cards to give to that player.

Action!

Spread the love

- Choose one card from your hand and give it to a player on your left or right

Action!

Trade

- Take one of your cards and put it on top of the deck
- Take the card from the bottom of the deck and put it in your hand

Help!

Reference guide

Motion Diagrams

- The dots are always equally amounts of time apart
- Use the numbers to determine which direction the object is going
- Look at the spacing of the first two dots and the last two dots
- Think about how the speed is changing (or not)

Velocity

- When an object moves in the positive direction, the velocity is positive
- When an object moves in the negative direction, the velocity is negative

Acceleration and Velocity

- When velocity and acceleration are in the same direction (and have the same sign), the object is speeding up
- When velocity and acceleration are in opposite directions (and have opposite signs), the object is slowing down

Position vs time graph

- The slope of the position vs time graph is equal to the velocity
- Look at the slope of the graph near the beginning
- Look at the slope of the graph near the end
- Think about how the slope (velocity) changes over time

Velocity vs time graph

- The slope of the velocity vs time graph is equal to the acceleration
- Look at the slope of the graph near the beginning
- Look at the slope of the graph near the end
- Think about how the slope (acceleration) changes over time

Acceleration vs time graph

- Are the values of acceleration positive, negative, or zero?
- The sign of the acceleration does not tell you if the object is speeding up or slowing down
- The direction of acceleration and the direction of net force are always the same

Free Body Diagrams

Newton's 1st Law:

- When net force is zero, the velocity is constant
- When net force is not zero, the velocity is changing

Newton's 2nd Law: The direction of acceleration and the direction of net force are always the same

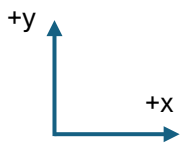
Help Sheet (print one for each player/team on regular paper and fold)

Rules Summary

- Each player is dealt 7 cards (8 cards for 2-player game)
- Each turn, you draw a card or pick up the top card, play a card (or cards) if you are able, and end your turn by discarding one card
- Playing an Action card counts as a discard
- The first person with no cards remaining in their hand wins

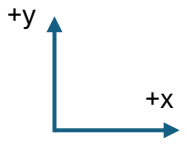
- Once you have 3 corresponding cards in your hand, you can lay them down

Coordinate System



Rules Summary

Coordinate System



Rules Summary Cards

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- Once you lay down a set of 4 (or more) cards, the next 4 game turns may only be used to play more cards that match that set
- After 4 game turns, players may choose to lay down their own set of 4 (or more cards) or may continue to play on any sets previously played
- Playing an Action card counts as a discard

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Rules, Notes, and Recommendations

The main idea

- Players practice their knowledge of kinematics, interpreting graphs, and Newton's Laws by creating sets of cards that all describe the same scenario
- Best suited for high school or college age students, with some physics knowledge
- This game is ideal for a practice or review activity for high school or college physics students.
- Can be played in solitaire mode at home
- Free body diagram cards can be removed from the deck to focus purely on kinematics
- Motion diagrams and/or free body diagrams for vertical motion can be added in, for more advanced students
- Extra position versus time and velocity versus time graphs for each scenario are provided for more advanced students
- It is recommended that all cards marked 'Advanced' should be left out initially

Technical notes

- A standard Cartesian coordinate system is used throughout the game, with right at the positive x-direction and upward as the positive y-direction. Note that position versus time graphs are intentionally generic and could be x vs t graphs or y vs t graphs. Velocity versus time and acceleration versus time graphs are also intentionally generic.

Rules for two to three players (or teams)

How to win

- Be the first person to get rid of all your cards by creating sets of 3 or more cards or playing on other players' sets

Getting started

- All players should be on the same side of the table, so they can always view played cards upright.
- Lay out the Scenario Cards in a column, on the left side of the playing area.
- Place a coordinate system card on the table
- Distribute a help sheet to each player
- Deal 7 cards to each player (8 for 2 player game)
- Place the deck in the center of the table and turn over the top card to begin the discard pile
- The player whose birthday is closest to Galileo Galilei's birthday of February 15 goes first

On your turn, you will

- Draw a card or pick up the top card in the discard pile
- Play a new set of cards of 3 or more cards and/or play on sets already on the table
- Discard (either a card you want to get rid of or an Action card you want to play)

What can you play

- A set consists of 3 or more cards that be grouped together to describe a single scenario
- You may not play two identical cards (e.g. two "positive acceleration" cards) on the same set
- You may not play two of the same type of card (e.g. two position vs time graphs) on one set.
- Note that there are multiple motion diagram cards and free body diagram cards that could be matched to a certain set. However, once a card is played as part of a set, you cannot play any cards that conflict with any of the cards already in that set

Challenges

- After a player ends their turn, you can challenge that player if you think their set is invalid or their add-on card(s) does not match the set. If you are correct, the player who played incorrectly draws two cards. If you are wrong, you draw two cards. You must make your challenge within 15 seconds and must be before the next player plays any cards.
- A challenge can be decided by an expert (e.g. the instructor, if being played in a classroom); alternatively, the answer key can be consulted

Mutli-Player Review Activity

- Have groups of 2 to 4 students take the entire deck and sort them into scenarios
- This can be a useful warmup activity before standard game play.
- A game board made specifically for this review activity can be used to sort the cards on

Alternate game for 2 to 3 players

- Deal 5 cards to each player.
- Play according to the standard rules, but you do not play your cards until all four of your cards fit a single scenario, at which point you win!
- On your turn you will take the top card from the deck or the discard pile. If the card you place on the discard pile is an action card, complete that action according to the instructions on the card.
- Players will always have exactly 5 cards in their rack, except during their turn.
- When a player has a valid set, they declare it and reveal their cards, so the other players have a chance to find any possible mismatched cards in their set.
- If they do have a set, they win. If not, they skip their next turn.

ANOTHER Alternate game for 2 to 3 players

Getting started

- Remove Action cards from the deck
- All players should be on the same side of the table, so they can always view played cards upright.
- Lay out the Scenario Cards in a column, on the left side of the playing area.
- Place a coordinate system card on the table
- Distribute a help sheet to each player

Game Play

- Flip over the top card
- When a player thinks they know on which scenario that card can be played, they touch the card. The player who touches the card first has 15 seconds to place that card into one of the six scenarios.
- If the player correctly places the card, they earn 1 point.
- If the player incorrectly places the card or runs out of time, they lose two points and the card is put at the bottom of the deck
- Play continues by flipping the next card
- If no one is willing to try to place the card, the players can agree to put that card at the bottom of the deck.
- The first player to earn 10 points wins.
- Note: You may not play more than one of the same type of card in a scenario

Solitaire Rules

- Start a 15-minute timer.
- Draw 8 cards and lay them out on the table. Group them into sets (there is no minimum number of cards for a set in solo play.
- Draw another card and determine which set it goes with or create a new set
- Continue drawing cards and making sets until the timer goes off
- Check your sets against the answer keys.
- The goal is to get as many sets of 5 or more cards as you can within the time limit.

Game board for Alternate Game