

QUARK Cards

Purpose

To teach students of the existence of quarks, substructure of mesons and baryons, particle decay and the concept of colour change with links to Senior secondary science curriculum, Physics, Unit 4, ACSPH141, ACSPH142, ACSPH144.

Background knowledge

Mesons and Baryons

Mesons are composed of quark-antiquark pairs. Must have a colour charge – e.g. must be red / anti-red pair.

Baryons are composed of three quarks. Must have neutral colour charge (red, green and blue OR anti-red, anti-green and anti-blue).

Table 1 includes some common mesons and baryons quark combinations.

Annihilation

Annihilation refers to the event where a particle and its anti-particle collide, and release energy (equivalent to the mass that has disappeared, given by the mass-energy equivalence $E=mc^2$).

At high energies, new heavier particles can sometimes be created but for the purpose of this game when particles are annihilated, we will act as though they simply disappear and produce energy such that no new cards need to be played.

QUARK Cards

Quark Cards

On the back of the cards the words “Quark Cards” are written and contain no other information.

- On the front of the cards there are several pieces of information given including:
 - The flavour of quark (i.e. up, down, strange, charm, bottom, and top)
 - The colour charge (given by the colours e.g. two shades of red to denote red and anti-red)
 - The mass (given in units of eV/c^2) and the charge.

The games rely on the flavour and colour charge.

There are two reference cards in each deck which also briefly explain this information.

Table 1: Common mesons and baryons

Particle	Quark combination
P	uud
n	udd
Λ	uds
Σ^+	uus
Σ^0	uds
Σ^-	dds
Ω^-	sss
π^+	$u\bar{d}$
π^0	$u\bar{u}$
π^-	$d\bar{u}$
K^+	$u\bar{s}$
K^0	$d\bar{s}$
K^-	$s\bar{u}$

QUARK Card Games

Game 1

The goal of this game is to get rid of all your cards, as fast as possible.

Set up

- Players start with 10 cards
- The remaining cards are flavour-face down in a stack in the middle
- One card is flipped over from the middle stack of cards, flavour-face up and is the beginning of the discard pile

Turns

At each turn players can do one of the following:

- Play a meson into the discard pile
- Play a baryon into the discard pile
- Pick up a card from the middle stack of flavour-face down cards

Additionally, for each turn one annihilation can occur as follows:

- After a turn has been made from one of the three options above, the top upwards facing card in the discard pile can be annihilated
- This is when either the top quark card in the discard pile can be annihilated by the respective anti-particle / colour combination

QUARK Card Games

Game 2

The goal of this game is to have the highest number of points at the end of the game.

Set up

- Players start with 10 cards
- The remaining cards are face down in the middle

Turns

- To start the game, each player will place in front of them as many meson and baryon combinations as they can make with their hand of 10 cards
- After this at each turn players must:
 - Ask another player for a specific quark-card
 - If that player doesn't have the requested card, the person who asked must pick up another card from the middle stack
- As players create new baryons and mesons, they can place them in front of them as they go (they don't have to wait for their turn to place down their cards if they realise they have a new combination in their hand)
- If a player runs out of cards and there are still cards in the middle stack, they must pick up a new set of 5 cards
- This continues until a player runs out of cards and there are no cards to begin a new hand from the middle stack or there are no possible moves
- The game ends and the points are counted:
 - Baryons are worth 3 pts
 - Mesons are worth 2 pts

QUARK Cards

Can you think of more games?

Share them on our Facebook group @QUTSTEMis4me or email them through to stemschools@qut.edu.au

Want more resources like this?

Find more resources on the QUT STEM High School Engagement Learning Hub at <https://www.qut.edu.au/study/career-advisers-and-teachers/stem-for-schools/stem-learning-hub>

References

Annihilation. (2019). In *Britannica Online Academic Edition*. Retrieved from <http://academic.eb.com/levels/collegiate/article/7695>

Sproull, R. and Phillips, W. (1980). Modern Physics: The Quantum Physics of Atoms, Solids and Nuclei. 3rd ed. New York.