

# Mission Briefing: Fugitive Particles

**Purpose:** To discover patterns of various kinds to find a set of rules that govern the mysterious and elusive quarks.

**Discussion:** It has been trusted to you to discover the rules that the quarks obey. Unfortunately even though the particles make up everything all around you, they are so small there is no way that you are able to see them individually. Luckily, we have obtained a model of puzzle pieces, which obey the same rules as actual quarks.

Your mission ~~should you choose to accept~~ is to use these puzzle pieces to discover the laws that dictate how these particles form groups. You must present your findings as a series of rules that someone else could use to determine possible and impossible combinations of quarks.

For a hint to get started, see guidelines below.

## Guide to Quark Puzzle Pieces

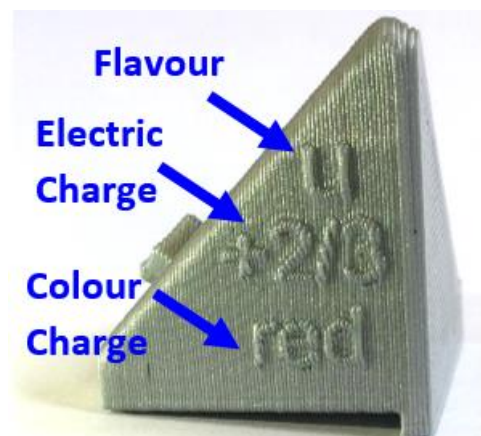
Each piece is a model that represents a “quark”. Every quark has a flavour, an electric charge and a colour charge. You can find these properties printed on the side of the quark.

**Flavours** include up (u), down (d), anti-up ( $\bar{u}$ ) or anti-down ( $\bar{d}$ ).

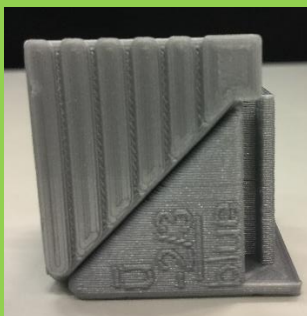
$+2/3$  is an example of **electric charge**.

Examples of **colour charge** are red and anti-blue ( $\bar{\text{blue}}$ ).

Some combinations fit together nicely, others ones do not. See diagrams below.

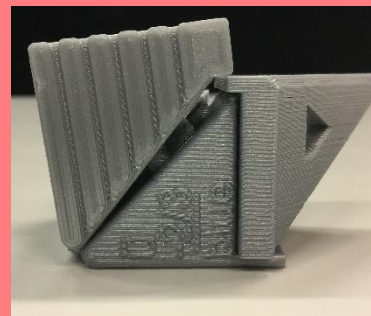


**Good Joint**



Here the pieces fit together nicely.

**Bad Joint**



Here the pieces do not fit together nicely.

Using groups that fit together nicely to discover the laws and complete the mission.

**Hint:** *If it is difficult to build a group, try sorting the quarks by colour charge first and try one from each pile.*

## Debrief - Comparing the Puzzle to Real Quarks (Research Task)

The puzzle provided is only a model and it does not show what real quarks look like. Do some research and in the table below write down the differences and similarities between the puzzle and real quarks. One row has been completed for you as an example:

Category	Quark Puzzle	Real Particles
Shape	In this puzzle, a proton has a cube shape. Pions have a double pyramid shape.	Real protons and pions have no well-defined shape that humans can see or even imagine.
Size		
Empty Space		
Colour Charge		
Electric Charge		
Anti-particles		