

# ELEMENTARY PARTICLE CARDS

- ▶ This document contains 61 elementary particle cards. 24 matter and antimatter particles, 12 exchange particles, and the Higgs boson.
- ▶ They should be printed out in color on thick paper, cut out, and laminated.
- ▶ Use the cards to stimulate ideas as well as questions and answers for learning about elementary particles.

## EXCHANGE PARTICLES AND HIGGS-BOSON

**Z BOSON**  
DISCOVERED: 1983

**Z**

EXCHANGE PARTICLE

Mass:  $\sim 91200 \frac{\text{MeV}}{c^2}$   
 Electric Charge: **0**  
 Strong Charge: **color neutral  $\vec{0}$**   
 Weak Charge: **0**

Lifetime:  $3 \cdot 10^{-25} \text{ s}$   
 Range:  $10^{-18} \text{ m}$

**W<sup>+</sup> BOSON**  
DISCOVERED: 1983

**W<sup>+</sup>**

EXCHANGE PARTICLE

Mass:  $\sim 80400 \frac{\text{MeV}}{c^2}$   
 Electric Charge: **+1**  
 Strong Charge: **color neutral  $\vec{0}$**   
 Weak Charge: **+1**

Lifetime:  $3 \cdot 10^{-25} \text{ s}$   
 Range:  $10^{-18} \text{ m}$

**W<sup>-</sup> BOSON**  
DISCOVERED: 1983

**W<sup>-</sup>**

EXCHANGE PARTICLE

Mass:  $\sim 80400 \frac{\text{MeV}}{c^2}$   
 Electric Charge: **-1**  
 Strong Charge: **color neutral  $\vec{0}$**   
 Weak Charge: **-1**

Lifetime:  $3 \cdot 10^{-25} \text{ s}$   
 Range:  $10^{-18} \text{ m}$

**PHOTON**  
DISCOVERED: 1905

**γ**

EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: **0**  
 Strong Charge: **color neutral  $\vec{0}$**   
 Weak Charge: **0**

Lifetime: **unlimited**  
 Range: **unlimited**

**HIGGS BOSON**  
DISCOVERED: 2012

**H**

EXCHANGE PARTICLE

Mass:  $\sim 125000 \frac{\text{MeV}}{c^2}$   
 Electric Charge: **0**  
 Strong Charge: **color neutral  $\vec{0}$**   
 Weak Charge:  **$-\frac{1}{2}$**

Lifetime:  $2 \cdot 10^{-22} \text{ s}$

PARTICLE  
CARDS**UP-QUARK**

DISCOVERED: 1969

**u**

MATTER PARTICLE

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: **unlimited**

**UP-QUARK**

DISCOVERED: 1969

**u**

MATTER PARTICLE

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: **unlimited**

**UP-QUARK**

DISCOVERED: 1969

**u**

MATTER PARTICLE

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: **unlimited**

**DOWN-QUARK**

DISCOVERED: 1969

**d**

MATTER PARTICLE

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **880 s**

**DOWN-QUARK**

DISCOVERED: 1969

**d**

MATTER PARTICLE

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **880 s**

**DOWN-QUARK**

DISCOVERED: 1969

**d**

MATTER PARTICLE

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **880 s**

**CHARM-QUARK**

DISCOVERED: 1974

**c**

MATTER PARTICLE

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$

**CHARM-QUARK**

DISCOVERED: 1974

**c**

MATTER PARTICLE

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$

**CHARM-QUARK**

DISCOVERED: 1974

**c**

MATTER PARTICLE

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$



PARTICLE CARDS

**STRANGE-QUARK**  
DISCOVERED: 1969

**S**

MATTER PARTICLE

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8} \text{s}$

**STRANGE-QUARK**  
DISCOVERED: 1969

**S**

MATTER PARTICLE

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8} \text{s}$

**STRANGE-QUARK**  
DISCOVERED: 1969

**S**

MATTER PARTICLE

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8} \text{s}$

**TOP-QUARK**  
DISCOVERED: 1995

**t**

MATTER PARTICLE

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{s}$

**TOP-QUARK**  
DISCOVERED: 1995

**t**

MATTER PARTICLE

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{s}$

**TOP-QUARK**  
DISCOVERED: 1995

**t**

MATTER PARTICLE

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{2}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{s}$

**BOTTOM-QUARK**  
DISCOVERED: 1977

**b**

MATTER PARTICLE

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **blue** ↓  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12} \text{s}$

**BOTTOM-QUARK**  
DISCOVERED: 1977

**b**

MATTER PARTICLE

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **red** ↗  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12} \text{s}$

**BOTTOM-QUARK**  
DISCOVERED: 1977

**b**

MATTER PARTICLE

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{1}{3}$   
 Strong Charge: **green** ↘  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12} \text{s}$



## MATTER PARTICLES: LEPTONS

**ELECTRON**

DISCOVERED: 1897

 $e^-$ 

MATTER PARTICLE

Mass:  $0,511 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: unlimited

**MUON**

DISCOVERED: 1937

 $\mu^-$ 

MATTER PARTICLE

Mass:  $106 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $2,2 \cdot 10^{-6} \text{ s}$

**TAU**

DISCOVERED: 1975

 $\tau^-$ 

MATTER PARTICLE

Mass:  $1777 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $2,9 \cdot 10^{-13} \text{ s}$

**ELECTRON-NEUTRINO**

DISCOVERED: 1956

 $\nu_e$ 

MATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: undefined

**MUON-NEUTRINO**

DISCOVERED: 1962

 $\nu_\mu$ 

MATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: undefined

**TAU-NEUTRINO**

DISCOVERED: 2000

 $\nu_\tau$ 

MATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: undefined



**ANTI-UP QUARK**  
DISCOVERED: 1969

**ANTIMATTER PARTICLE**

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **unlimited**

**ANTI-UP QUARK**  
DISCOVERED: 1969

**ANTIMATTER PARTICLE**

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-red** ↗  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **unlimited**

**ANTI-UP QUARK**  
DISCOVERED: 1969

**ANTIMATTER PARTICLE**

Mass:  $\sim 2 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-green** ↘  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: **unlimited**

**ANTI-CHARM QUARK**  
DISCOVERED: 1974

**ANTIMATTER PARTICLE**

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$

**ANTI-CHARM QUARK**  
DISCOVERED: 1974

**ANTIMATTER PARTICLE**

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-red** ↗  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$

**ANTI-CHARM QUARK**  
DISCOVERED: 1974

**ANTIMATTER PARTICLE**

Mass:  $\sim 1300 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-green** ↘  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $10^{-12} \text{ s}$

**ANTI-TOP QUARK**  
DISCOVERED: 1995

**ANTIMATTER PARTICLE**

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{ s}$

**ANTI-TOP QUARK**  
DISCOVERED: 1995

**ANTIMATTER PARTICLE**

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-red** ↗ Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{ s}$

**ANTI-TOP QUARK**  
DISCOVERED: 1995


**ANTIMATTER PARTICLE**

Mass:  $\sim 173000 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $-\frac{2}{3}$   
 Strong Charge: **anti-green** ↘ Weak Charge:  $-\frac{1}{2}$   
 Lifetime:  $6 \cdot 10^{-25} \text{ s}$



PARTICLE CARDS


**ANTI-DOWN QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: 880 s


**ANTI-DOWN QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-red** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: 880 s


**ANTI-DOWN QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 5 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-green** ↙  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: 880 s


**ANTI-STRANGE QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8}$  s


**ANTI-STRANGE QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-red** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8}$  s


**ANTI-STRANGE QUARK**  
DISCOVERED: 1969



**ANTIMATTER PARTICLE**

Mass:  $\sim 100 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-green** ↙  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $5 \cdot 10^{-8}$  s


**ANTI-BOTTOM QUARK**  
DISCOVERED: 1977



**ANTIMATTER PARTICLE**

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-blue** ↑  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12}$  s


**ANTI-BOTTOM QUARK**  
DISCOVERED: 1977



**ANTIMATTER PARTICLE**

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-red** ↘  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12}$  s

**ANTI-BOTTOM QUARK**  
DISCOVERED: 1977



**ANTIMATTER PARTICLE**

Mass:  $\sim 4200 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+\frac{1}{3}$   
 Strong Charge: **anti-green** ↙  
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $2 \cdot 10^{-12}$  s



## MATTER PARTICLES: ANTI-LEPTONS

**POSITRON**

DISCOVERED: 1932

 $e^+$ 

ANTIMATTER PARTICLE

Mass:  $0,511 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime: unlimited

**ANTI-MUON**

DISCOVERED: 1937

 $\mu^+$ 

ANTIMATTER PARTICLE

Mass:  $106 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $2,2 \cdot 10^{-6} \text{ s}$

**ANTI-TAU**

DISCOVERED: 1975

 $\tau^+$ 

ANTIMATTER PARTICLE

Mass:  $1777 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $+1$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $+\frac{1}{2}$   
 Lifetime:  $2,9 \cdot 10^{-13} \text{ s}$

**ANTI-ELECTRON-NEUTRINO**

DISCOVERED: 1956

 $\bar{\nu}_e$ 

ANTIMATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: undefined

**ANTI-MUON-NEUTRINO**

DISCOVERED: 1962

 $\bar{\nu}_\mu$ 

ANTIMATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: undefined

**ANTI-TAU-NEUTRINO**

DISCOVERED: 2000

 $\bar{\nu}_\tau$ 


ANTIMATTER PARTICLE

Mass:  $< 0,0000001 \frac{\text{MeV}}{c^2}$   
 Electric Charge:  $0$   
 Strong Charge: color neutral  $\vec{0}$   
 Weak Charge:  $-\frac{1}{2}$   
 Lifetime: undefined



# EXCHANGE PARTICLES: GLUONS

**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: red ↗ + anti-green ↘  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$


**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: red ↗ + anti-blue ↑  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$

**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: green ↘ + anti-red ↗  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$

**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: green ↘ + anti-blue ↑  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$

**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: blue ↑ + anti-red ↗  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$


**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: blue ↑ + anti-green ↘  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$


**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: red ↗ + anti-red ↗ or green ↘ + anti-green ↘  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$

**GLUON**  
DISCOVERED: 1979



EXCHANGE PARTICLE

Mass:  $0 \frac{\text{MeV}}{c^2}$   
 Electric Charge: 0  
 Strong Charge: red ↗ + anti-red ↗ or blue ↑ + anti-blue ↑  
 Weak Charge: 0  
 Lifetime: unlimited  
 Range:  $10^{-15} \text{ m}$