

ELEMENTARY PARTICLE CARDS



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} m

W^+ BOSON

DISCOVERED: 1983

W^+

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} m

W^- BOSON

DISCOVERED: 1983

W^-

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} 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

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} 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} 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} 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

 μ^-

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

 τ^-

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

 ν_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

 ν_μ

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

 ν_τ

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

PARTICLE
CARDS**ANTI-UP QUARK**

DISCOVERED: 1969



ANTIMATTER PARTICLE

Mass: $\sim 2 \frac{\text{MeV}}{c^2}$
 Electric Charge: $-\frac{2}{3}$
 Strong Charge: anti-blue \uparrow
 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 \rightarrow
 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 \nwarrow
 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 \uparrow
 Weak Charge: $-\frac{1}{2}$
 Lifetime: 10^{-12} 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 \rightarrow
 Weak Charge: $-\frac{1}{2}$
 Lifetime: 10^{-12} 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 \nwarrow
 Weak Charge: $-\frac{1}{2}$
 Lifetime: 10^{-12} 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 \uparrow
 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 \rightarrow 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 \nwarrow 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 \uparrow
 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 \rightarrow
 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 \nwarrow
 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 \uparrow
 Weak Charge: $+\frac{1}{2}$
 Lifetime: $5 \cdot 10^{-8} \text{ s}$

ANTI-STRANGE QUARK

DISCOVERED: 1969



ANTIMATTER PARTICLE

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

ANTI-STRANGE QUARK

DISCOVERED: 1969



ANTIMATTER PARTICLE

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

ANTI-BOTTOM QUARK

DISCOVERED: 1977



ANTIMATTER PARTICLE

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

ANTI-BOTTOM QUARK

DISCOVERED: 1977



ANTIMATTER PARTICLE

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

ANTI-BOTTOM QUARK

DISCOVERED: 1977



ANTIMATTER PARTICLE

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



MATTER PARTICLES: ANTI-LEPTONS

POSITRON

DISCOVERED: 1932



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



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



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



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



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



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


 PARTICLE
CARDS
GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: red \rightarrow + anti-green \leftarrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: red \rightarrow + anti-blue \uparrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: green \leftarrow + anti-red \rightarrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: green \leftarrow + anti-blue \uparrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: blue \uparrow + anti-red \rightarrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: blue \uparrow + anti-green \leftarrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: red \rightarrow + anti-red \rightarrow
or green \leftarrow + anti-green \leftarrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m

GLUON

DISCOVERED: 1979



EXCHANGE PARTICLE

Mass: $0 \frac{\text{MeV}}{c^2}$

Electric Charge: 0

Strong Charge: red \rightarrow + anti-red \rightarrow
or green \leftarrow + anti-green \leftarrow or blue \uparrow + anti-blue \uparrow

Weak Charge: 0

Lifetime: unlimited

Range: 10^{-15} m