This document contains 30 elementary particle cards. 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.
MATTER PARTICLES: LEPTONS

**ELECTRON NEUTRINO**  
**DISCOVERED: 1956**

- Mass: $< 2 \times 10^{-6}$ MeV/c²
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $+1/2$
- Lifetime: undefined

**MUON NEUTRINO**  
**DISCOVERED: 1962**

- Mass: $< 2 \times 10^{-6}$ MeV/c²
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $+1/2$
- Lifetime: undefined

**TAU NEUTRINO**  
**DISCOVERED: 2000**

- Mass: $< 2 \times 10^{-6}$ MeV/c²
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $+1/2$
- Lifetime: undefined

**ELECTRON**  
**DISCOVERED: 1897**

- Mass: 0.511 MeV/c²
- Electric Charge: -1
- Strong Charges: –
- Weak Charge: $-1/2$
- Lifetime: unlimited

**MUON**  
**DISCOVERED: 1937**

- Mass: 106 MeV/c²
- Electric Charge: -1
- Strong Charges: –
- Weak Charge: $-1/2$
- Lifetime: $2.2 \times 10^{-6}$ s

**TAU**  
**DISCOVERED: 1975**

- Mass: 1777 MeV/c²
- Electric Charge: -1
- Strong Charges: –
- Weak Charge: $-1/2$
- Lifetime: $2.9 \times 10^{-13}$ s
ANTIMATTER PARTICLES: ANTIQUARKS

**ANTI-UP QUARK**
- DISCOVERED: 1969
- Mass: 2 MeV/c²
- Electric Charge: -2/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: -1/2
- Lifetime: unlimited

**ANTI-DOWN QUARK**
- DISCOVERED: 1969
- Mass: 5 MeV/c²
- Electric Charge: +1/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: +1/2
- Lifetime: 900 s

**ANTI-CHARM QUARK**
- DISCOVERED: 1974
- Mass: 1300 MeV/c²
- Electric Charge: -2/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: -1/2
- Lifetime: 10⁻¹² s

**ANTI-STRANGE QUARK**
- DISCOVERED: 1969
- Mass: 100 MeV/c²
- Electric Charge: +1/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: +1/2
- Lifetime: 5 · 10⁻⁸ s

**ANTI-TOP QUARK**
- DISCOVERED: 1995
- Mass: 173 · 10³ MeV/c²
- Electric Charge: -2/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: -1/2
- Lifetime: 6 · 10⁻²⁵ s

**ANTI-BOTTOM QUARK**
- DISCOVERED: 1977
- Mass: 4200 MeV/c²
- Electric Charge: +1/3
- Strong Charges: antiblue, antired, antigreen
- Weak Charge: +1/2
- Lifetime: 2 · 10⁻¹⁵ s
ELECTRON ANTI-NEUTRINO
DISCOVERED: 1956

- Mass: $< 2 \cdot 10^{-6}$ MeV/c$^2$
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $-\frac{1}{2}$
- Lifetime: undefined

MUON ANTI-NEUTRINO
DISCOVERED: 1962

- Mass: $< 2 \cdot 10^{-6}$ MeV/c$^2$
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $-\frac{1}{2}$
- Lifetime: undefined

TAU ANTI-NEUTRINO
DISCOVERED: 2000

- Mass: $< 2 \cdot 10^{-6}$ MeV/c$^2$
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $-\frac{1}{2}$
- Lifetime: undefined

POSITRON
DISCOVERED: 1932

- Mass: 0.511 MeV/c$^2$
- Electric Charge: +1
- Strong Charges: –
- Weak Charge: $+\frac{1}{2}$
- Lifetime: unlimited

ANTI-MUON
DISCOVERED: 1937

- Mass: 106 MeV/c$^2$
- Electric Charge: +1
- Strong Charges: –
- Weak Charge: $+\frac{1}{2}$
- Lifetime: $2.2 \cdot 10^{-6}$ s

ANTI-TAU
DISCOVERED: 1975

- Mass: 1777 MeV/c$^2$
- Electric Charge: +1
- Strong Charges: –
- Weak Charge: $+\frac{1}{2}$
- Lifetime: $2.9 \cdot 10^{-13}$ s
EXCHANGE PARTICLES AND HIGGS BOSON

**W^+ BOSON**
DISCOVERED: 1983

- Mass: $8.04 \times 10^3$ MeV/c$^2$
- Electric Charge: +1
- Strong Charges: –
- Weak Charge: +1
- Lifetime: $3 \times 10^{-25}$ s
- Range: $10^{18}$ m

**W^- BOSON**
DISCOVERED: 1983

- Mass: $8.04 \times 10^3$ MeV/c$^2$
- Electric Charge: -1
- Strong Charges: –
- Weak Charge: -1
- Lifetime: $3 \times 10^{-25}$ s
- Range: $10^{18}$ m

**Z BOSON**
DISCOVERED: 1983

- Mass: $91.2 \times 10^3$ MeV/c$^2$
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: 0
- Lifetime: $3 \times 10^{-25}$ s
- Range: $10^{18}$ m

**PHOTON**
DISCOVERED: 1905

- Mass: 0
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: 0
- Lifetime: unlimited
- Range: unlimited

**GLUON**
DISCOVERED: 1979

- Mass: 0
- Electric Charge: 0
- Strong Charges: red, blue, green + antired, antiblue, antigreen
- Weak Charge: 0
- Lifetime: unlimited
- Range: $10^{-5}$ m

**HIGGS BOSON**
DISCOVERED: 2012

- Mass: $125 \times 10^3$ MeV/c$^2$
- Electric Charge: 0
- Strong Charges: –
- Weak Charge: $-\frac{1}{2}$
- Lifetime: $2 \times 10^{-22}$ s