

# Leptons

	Lepton	Symbol	Charge ( $e$ )	Weak isospin $T_z$	Mass ( $\text{MeV}/c^2$ )	Lifetime (s)	Spin ( $\hbar$ )
1st generation	electron	$e$	-1	-1/2	0.5110	stable	1/2
	electron neutrino	$\nu_e$	0	1/2	$\leq 2.2 \text{ eV}/c^2$	stable	1/2
2nd generation	muon	$\mu$	-1	-1/2	105.659	$2.197 \times 10^{-6}$	1/2
	muon neutrino	$\nu_\mu$	0	1/2	$\leq 3.5 \text{ eV}/c^2$	stable	1/2
3rd generation	tau	$\tau$	-1	-1/2	1,784	$3.3 \times 10^{-13}$	1/2
	tau neutrino	$\nu_\tau$	0	1/2	$\leq 8.4 \text{ eV}/c^2$	stable	1/2



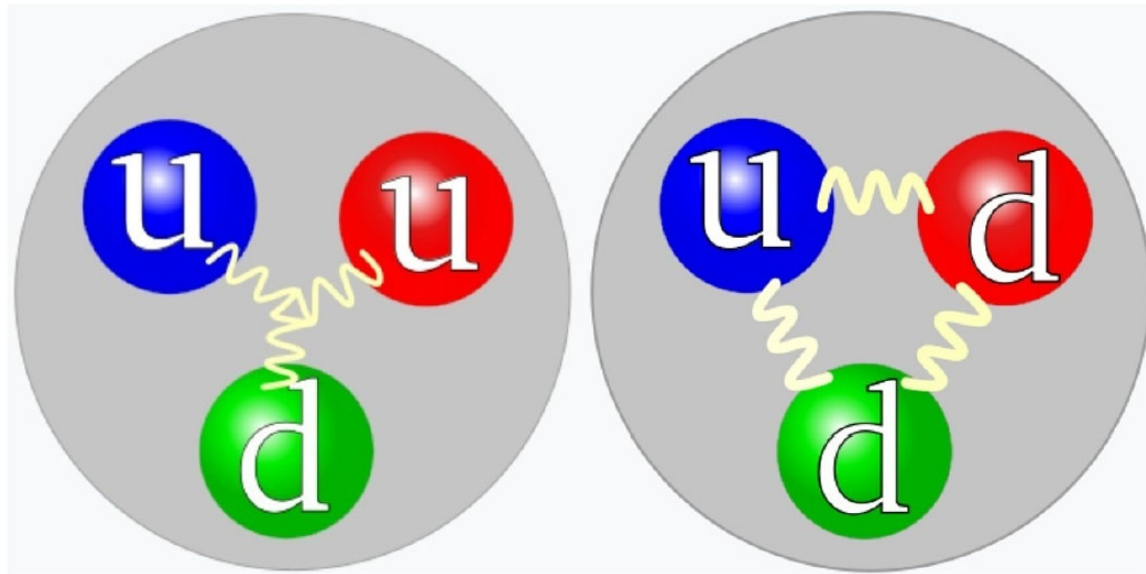
# Quarks

	Quark ( $q$ )	Symbol	Charge ( $e$ )	Weak isospin $T_z$	Mass (MeV/ $c^2$ )	Spin ( $\hbar$ )	Baryon number
1st generation	up	$u$	$2/3$	$1/2$	336	$1/2$	$1/3$
	down	$d$	$-1/3$	$-1/2$	338	$1/2$	$1/3$
2nd generation	charm	$c$	$2/3$	$1/2$	1,500	$1/2$	$1/3$
	strange	$s$	$-1/3$	$-1/2$	540	$1/2$	$1/3$
3rd generation	top	$t$	$2/3$	$1/2$	170,900	$1/2$	$1/3$
	bottom	$b$	$-1/3$	$-1/2$	5,000	$1/2$	$1/3$



# Proton and neutron

	Quark ( $q$ )	Symbol	Charge ( $e$ )	Weak isospin $T_z$	Mass (MeV/ $c^2$ )	Spin ( $\hbar$ )	Baryon number
1st generation	up	$u$	$2/3$	$1/2$	336	$1/2$	$1/3$
	down	$d$	$-1/3$	$-1/2$	338	$1/2$	$1/3$
2nd generation	charm	$c$	$2/3$	$1/2$	1,500	$1/2$	$1/3$
	strange	$s$	$-1/3$	$-1/2$	540	$1/2$	$1/3$
3rd generation	top	$t$	$2/3$	$1/2$	170,900	$1/2$	$1/3$
	bottom	$b$	$-1/3$	$-1/2$	5,000	$1/2$	$1/3$



Left: proton  $uud$ , charge  $+e$ . Right: neutron  $udd$ , charge  $0$



# Force carriers

Interaction	Force carrier	Mass (GeV/c <sup>2</sup> )	Spin ( $\hbar$ )	Source	Particles carrying charge	Range (m)	Interaction time (s)	Coupling constant
Strong	gluon	0	1	color charge	$q, g$	$10^{-15}$	$10^{-23}$	$\alpha_s \approx 1$
Electromagnetic	photon	0	1	electric charge	$q, e, \mu, \tau, W^\pm$	$\infty$	$10^{-18}$	$\alpha = 1/137$
Weak	$W^\pm, Z^0$	80, 91	1, 1	weak charge	$q, e, \mu, \tau, W^\pm, Z^0$	$10^{-18}$	$10^{-16}$ to $10^{-10}$	$\alpha_w \approx 10^{-5}$
Gravity	graviton	0	2	mass	$q, e, \mu, \tau, \nu, W^\pm, Z^0$	$\infty$	?	$\alpha_g \approx 10^{-38}$

