

# Standard Model of Particle Physics

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# Standard Model of Particle Physics

	three generations of matter (fermions)			interactions / forces (bosons)	
	I	II	III		
mass charge spin	$\approx 2.2 \text{ MeV}$ $+2/3$ $1/2$	$\approx 1.3 \text{ GeV}$ $+2/3$ $1/2$	$\approx 173 \text{ GeV}$ $+2/3$ $1/2$	0 0 1	$\approx 125 \text{ GeV}$ 0 0
QUARKS	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b>g</b> gluon	<b>H</b> Higgs
	$\approx 4.7 \text{ MeV}$ $-1/3$ $1/2$	$\approx 96 \text{ MeV}$ $-1/3$ $1/2$	$\approx 4.2 \text{ GeV}$ $-1/3$ $1/2$	0 0 1	
	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom	$\gamma$ photon	
LEPTONS	$\approx 0.511 \text{ MeV}$ $-1$ $1/2$	$\approx 106 \text{ MeV}$ $-1$ $1/2$	$\approx 1.777 \text{ GeV}$ $-1$ $1/2$	$\approx 80.4 \text{ GeV}$ $\pm 1$ $-1$ 1	
	<b>e</b> electron	$\mu$ muon	$\tau$ tau	<b>W</b> W boson	
	$< 1.0 \text{ eV}$ 0 $1/2$	$< 0.17 \text{ eV}$ 0 $1/2$	$< 18.2 \text{ MeV}$ 0 $1/2$	$\approx 91.2 \text{ GeV}$ 0 0 1	
	$\nu_e$ electron neutrino	$\nu_\mu$ muon neutrino	$\nu_\tau$ tau neutrino	<b>Z</b> Z boson	
				GAUGE BOSONS VECTOR BOSONS	SCALAR BOSONS

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	mass $\approx 4.7$ MeV charge $-1/3$ spin $1/2$ <b>d</b> down	mass $\approx 96$ MeV charge $-1/3$ spin $1/2$ <b>s</b> strange	mass $\approx 4.2$ GeV charge $-1/3$ spin $1/2$ <b>b</b> bottom	0 0 1 <b><math>\gamma</math></b> photon	
	mass $\approx 0.511$ MeV charge $-1$ spin $1/2$ <b>e</b> electron	mass $\approx 106$ MeV charge $-1$ spin $1/2$ <b><math>\mu</math></b> muon	mass $\approx 1.777$ GeV charge $-1$ spin $1/2$ <b><math>\tau</math></b> tau	$\approx 80.4$ GeV $\pm 1$ 1 <b>W</b> W boson	
LEPTONS	mass $< 1.0$ eV charge 0 spin $1/2$ <b><math>\nu_e</math></b> electron neutrino	mass $< 0.17$ eV charge 0 spin $1/2$ <b><math>\nu_\mu</math></b> muon neutrino	mass $< 18.2$ MeV charge 0 spin $1/2$ <b><math>\nu_\tau</math></b> tau neutrino	$\approx 91.2$ GeV 0 1 <b>Z</b> Z boson	GAUGE BOSONS VECTOR BOSONS

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charge	$+2/3$	$+2/3$	$+2/3$	0	0
spin	$1/2$	$1/2$	$1/2$	1	0
QUARKS	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b>g</b> gluon	<b>H</b> Higgs
	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom	$\gamma$ photon	
	<b>e</b> electron	$\mu$ muon	$\tau$ tau	<b>W</b> W boson	
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GAUGE BOSONS  
VECTOR BOSONS  
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- ▶ **Fermions** of spin 1/2, which make up matter
  - ▶ Quarks
  - ▶ Leptons
  - ▶ Three generations
- ▶ **Gauge bosons** of spin 1, which mediate the fundamental interactions

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LEPTONS	$\approx 0.511 \text{ MeV}$ $-1$ $1/2$	$\approx 106 \text{ MeV}$ $-1$ $1/2$	$\approx 1.777 \text{ GeV}$ $-1$ $1/2$	$\approx 80.4 \text{ GeV}$ $\pm 1$ 1	
	<b>e</b> electron	<b><math>\mu</math></b> muon	<b><math>\tau</math></b> tau	<b>W</b> W boson	
	$< 1.0 \text{ eV}$ 0 $1/2$	$< 0.17 \text{ eV}$ $1/2$	$< 18.2 \text{ MeV}$ $1/2$	$\approx 91.2 \text{ GeV}$ 0 1	<b>Z</b> Z boson
	electron neutrino	muon neutrino	tau neutrino		
				<b>GAUGE BOSONS</b> <b>VECTOR BOSONS</b>	<b>SCALAR BOSONS</b>

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	mass $\approx 0.511$ MeV charge $-1$ spin $1/2$ <b>e</b> electron	mass $\approx 106$ MeV charge $-1$ spin $1/2$ <b><math>\mu</math></b> muon	mass $\approx 1.777$ GeV charge $-1$ spin $1/2$ <b><math>\tau</math></b> tau	$\approx 80.4$ GeV $\pm 1$ 1 <b>W</b> W boson	
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spin	$1/2$	$1/2$	$1/2$	1
	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b>g</b> gluon
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	$\approx 4.7 \text{ MeV}$	$\approx 96 \text{ MeV}$	$\approx 4.2 \text{ GeV}$	0
	$-1/3$	$-1/3$	$-1/3$	0
	$1/2$	$1/2$	$1/2$	1
	<b>e</b> electron	<b><math>\mu</math></b> muon	<b><math>\tau</math></b> tau	$\gamma$ photon
	$\approx 0.511 \text{ MeV}$	$\approx 106 \text{ MeV}$	$\approx 1.777 \text{ GeV}$	$\approx 80.4 \text{ GeV}$
	-1	-1	-1	$\pm 1$
	$1/2$	$1/2$	$1/2$	1
	<b><math>\nu_e</math></b> electron neutrino	<b><math>\nu_\mu</math></b> muon neutrino	<b><math>\nu_\tau</math></b> tau neutrino	<b>W</b> W boson
	$< 1.0 \text{ eV}$	$< 0.17 \text{ eV}$	$< 18.2 \text{ MeV}$	$\approx 91.2 \text{ GeV}$
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