FLINN SCIENTIFIC

Name______________________________________

Name	Category	Description	Charge (e) & Spin	Symbol(s)
Standard Model	Model	The current dominant model of elementary particles and their interactions, showing that all matter, no matter how exotic, is formed of quarks and leptons.		
Matter	Grouping	The predominant building block of the universe, defined as anything with mass and form. It is composed of quarks and leptons.		
Antimatter	Grouping	Every particle has an opposite particle; it will be identical aside from having the opposite charge, or in the cases of neutral particles, an opposite magnetic moment. Obeys the same laws of physics as matter.		
Fundamental Particle	Grouping	Any particle that is not known to have any smaller substructure, and thus cannot be broken down into smaller pieces; examples are electrons and quarks.		
Composite Particle	Grouping	Any particle that is composed of smaller particles, such as atoms (composed of protons, neutrons, and electrons) and protons (composed of quarks).		
Quark	Grouping	Family of elementary particles; these are fundamental particles of matter. Combine to form hadrons; never found alone naturally. There are six possible flavors.	Charge: ±2/3 or ±1/3 Spin: ½	u, c, t, d, s, b
Lepton	Grouping	Family of elementary particles; these are fundamental particles of matter. Do not combine, and do not participate in strong force interactions. There are six flavors, three with charge, and each sharing a generation with a neutral neutrino—the electron and the electron neutrino, for example.	Charge: 0, ±1 Spin: ½	☒$_e$, ☒$_☒$, ☒$_☒$, e, ☒, ☒
Gauge boson	Grouping	Family of elementary particles responsible for the fundamental forces of nature. Examples are photons for electromagnetic force, and gluons for the strong force. Also called *force carrier particles*.	Charge: None Spin: 0, 1, 2	
Generation I	Grouping	Generation of quarks and leptons; contains the up and down quarks, and the electron and electron neutrino leptons.		
Generation II	Grouping	Generation of quarks and leptons; contains the charm and strange quarks, and the muon and muon neutrino leptons.		
Generation III	Grouping	Generation of quarks and leptons; contains the top and bottom quarks, and the tau and tau neutrino leptons.		
Fermion	Grouping	Family of particles that have half-integer values for spin and follow the Pauli exclusion principle, which states that only one particle can occupy a given state at a time. Includes protons, neutrons, and electrons.	Charge: Varies Spin: Any half-integer value (½, 3/2, 5/2, etc.)	
Boson	Grouping	Family of particles that have integer spin values and do not obey the Pauli exclusion principle. Includes photons and mesons.	Charge: Varies Spin: Any integer spin (0, 1, 2, etc.)	
Hadron	Grouping	Group of particles composed of quarks held together by the strong force; has two subset classifications, baryons and mesons.	Charge: Varies Spin: Varies	

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Baryon	Subgroup	Type of hadron (particles made of quarks) made of three quarks. Group includes protons and neutrons. Because of the odd number of fermions (in this case, quarks), the spin will be a half-integer value. All members of this subgroup are also fermions.	Charge: Varies Spin: Any half-integer value (½, 3/2, etc.)	
Meson	Subgroup	Type of hadron (particles made of quarks) made of one quark and one antiquark. Group includes pion and kaon. Because of the even number of quarks, the spin will be an integer value. All members of this subgroup are bosons.	Charge: Varies Spin: Integer spin (0, 1, etc.)	
Up quark	Quark	Combines with the down quark to form protons and neutrons. Belongs to Generation I with the down quark.	Charge: +2/3 Spin: ½	u
Antiup quark	Antiquark	Antiquark to the up quark. Paired with the antidown quark.	Charge: –2/3 Spin: ½	$\overline{u}$
Down quark	Quark	Combines with the up quark to form protons and neutrons. Belongs to Generation I with the up quark.	Charge: –1/3 Spin: ½	d
Antidown quark	Antiquark	Antiquark to the down quark. Paired with the antiup quark.	Charge: +1/3 Spin: ½	$\overline{d}$
Charm quark	Quark	Second generation quark. Paired with the strange quark.	Charge: +2/3 Spin: ½	c
Anticharm quark	Antiquark	Antiquark to the charm quark. Paired with the antistrange quark.	Charge: –2/3 Spin: ½	$\overline{c}$
Strange quark	Quark	Second generation quark. Paired with the charm quark.	Charge: –1/3 Spin: ½	s
Antistrange quark	Antiquark	Antiquark to the "strange" quark. Paired with the anticharm quark.	Charge: +1/3 Spin: ½	$\overline{s}$
Top quark	Quark	Third generation quark; proposed name was "Truth" quark. Paired with the bottom quark. Last of the quarks to be discovered (1995, at Fermilab).	Charge: +2/3 Spin: ½	t
Antitop quark	Antiquark	Antiquark to the top quark. Paired with the antibottom quark.	Charge: –2/3 Spin: ½	$\overline{t}$
Bottom quark	Quark	Third generation quark. Proposed name was "Beauty" quark. Paired with the top quark.	Charge: –1/3	b
Antibottom quark	Antiquark	Antiquark to the bottom quark. Paired with the antitop quark.	Charge: +1/3 Spin: ½	$\overline{b}$
Proton	Baryon	Particle that is a building block of atoms. Made of two up quarks and one down quark (written as uud).	Charge: +1 Spin: ½	p, uud
Antiproton	Antibaryon	Antiparticle to the proton. Made of two antiup quarks and one antidown quark (written as $\overline{u}\,\overline{u}\,\overline{d}$.	Charge: –1 Spin: ½	$\overline{p}$, $\overline{u}\,\overline{u}\,\overline{d}$

Neutron	Baryon	Particle that is a building block of atoms. Made of one up quark and two down quarks (written as uud).	Charge: 0 Spin: ½	n, udd
Name	**Category**	**Description**	**Charge (e) & Spin**	**Symbol(s)**
Antineutron	Antibaryon	Antiparticle to the neutron. Made of one anitup quark and two antidown quarks (written as $\bar{u}\,\bar{d}\,\bar{d}$).	Charge: 0 Spin: ½	$\bar{n}$, $\bar{u}\,\bar{d}\,\bar{d}$
Pion	Meson	Lightest of the mesons. Created by cosmic rays and made of up- and down-quark and antiquark combinations. First true meson to be discovered.	Charge: ±1 ($\pi^{\pm}$), 0 (π^0) Spin: 0	π^+, π^-, π^0
Kaon	Meson	Meson composed of either a strange or antistrange quark. Unusual in that its neutral state, K^0, has two distinct lifetimes, which is the amount of time before an individual particle may decay. Scientists denote these two K^0_{long} and K^0_{short}.	Charge: ±1 ($K^{\pm}$), 0 (K^0) Spin: 0	K^+, K^-, K^0_{long}, K^0_{short}
Electron	Lepton	Elementary particle that is a building block of atoms. Equal but opposite charge of a proton.	Charge: –1 Spin: ½	e^-
Positron	Antilepton	Antiparticle to the electron, also called an "antielectron." Easily created but short-lived, due to colliding with and annihilating matter.	Charge: +1 Spin: ½	e^+
Electron Neutrino	Lepton	Elementary particle in the lepton family; paired with the electron. Created whenever a proton turns to a neutron by capturing an electron, or when a neutron decays into a proton and an electron, such as during radioactive beta decay.	Charge: 0 Spin: ½	ν_e, $\bar{\nu}_e$ (anti)
Muon	Lepton	Elementary particle very similar to an electron but 200 times heavier and thus ironically passes more easily through matter. Originally thought to have been a meson, and was thus called the "Mu meson." Later experiments showed it was a fundamental particle, in the lepton family.	Charge: –1 Spin: ½	μ^-, μ^+ (anti)
Muon neutrino	Lepton	Elementary particle in the lepton family. Paired with the muon. Created only by high-energy impacts such as cosmic rays. Very little interaction with matter, but still detectable.	Charge: 0 Spin: ½	ν_μ, $\bar{\nu}_\mu$ (anti)
Tau	Lepton	Heavy elementary particle belonging to lepton family. Twice the mass of a proton and 3,500 times the mass of an electron! Shortest lifetime of the leptons.	Charge: –1 Spin: ½	τ^-, τ^+ (anti)
Tau neutrino	Lepton	Elementary particle in the lepton family. Paired with the tau. Created only by high-energy impacts such as cosmic rays. Very little interaction with matter, but still detectable.	Charge: 0 Spin: ½	ν_τ, $\bar{\nu}_\tau$ (anti)
Photon	Gauge boson	Elementary, massless particle that is the unit of light. Force-carrier responsible for carrying electromagnetic interactions.	Charge: 0 Spin: 1	γ, or hγ
Gluon	Gauge boson	Elementary particle responsible for the strong force, or "gluing" the nucleus together.	Charge: 0 Spin: 1	g
W^+ boson	Gauge boson	Gauge boson with mass. Associated with the weak force. Antiparticle is the W^- boson. Has a role in radioactive beta decay.	Charge: +1 Spin: 1	W^+
W^- boson	Gauge boson	Gauge boson with mass. Associated with the weak force. Antiparticle is the W^+ boson. Has a role in radioactive beta decay.	Charge: –1 Spin: 1	W^-
Z boson	Gauge boson	Gauge boson with mass. Associated with the weak force. Is its own antiparticle. Unlike the $W^{\pm}$ bosons, these cannot change electric charge of particles.	Charge: 0 Spin: 1	Z

Name	Category	Description	Charge (e) & Spin	Symbol(s)
Graviton	Hypothetical Gauge boson	Hypothesized gauge boson responsible for gravity; has never been observed. Not part of the Standard Model, it is predicted by string theory.	Charge: 0 Spin: 2 (hypothesized)	G*
Higgs Boson		Predicted but not yet observed "scalar fundamental particle." According to theory, this particle would help explain the origin of mass in the universe. The search for this fundamental particle is the main reason behind building the world's highest energy collider.	Charge: 0 Spin: 0	H
Cosmic rays	High-energy Particles	High speed natural-radiation particles coming from space and the Sun. Mostly composed of protons, but also includes helium nuclei (alpha particles) and electrons (beta particles). Responsible for creation events of many strange particles including pions(π) and kaons().		p, ,
Spin	Property	A quantum mechanical property of particles; a measure of intrinsic angular momentum.		s
Electric charge	Property	A property that dictates whether a particle will participate in electromagnetic interactions. For example, the positively charged proton does, but the neutral neutron does not.		q
Flavor	Property	The name used for different quark and lepton types.		
Mass	Property	A property of particles that is a measure of their inertia, or resistance to change in motion.		m
Color charge	Property	A property of quarks and gluons. Unrelated to visual perception, the whimsical name helps to explain the strong interactions of quarks and gluons with each other. The charge can be red, green, blue for quarks, along with antired, antigreen, and antiblue, typically represented by cyan, magenta, and yellow, respectively.		
Pauli exclusion principle	Principle	A rule governing fermions that does not allow two particles with identical properties to occupy the same quantum state at the same time.		

Particle Physics Chart