0. The standard model

3 kinds of elementary particles: leptons, quarks, mediators (bosons)
six leptons: classified based on charge, electron num (L_e) muon number L_μ and tau number (L_τ)

	ℓ	Q	L_e	L_μ	L_τ
first gen	e	-1	1	0	0
	ν_e	0	1	0	0
second generation	μ	-1	0	1	0
	ν_μ	0	0	1	0
third generation	τ	-1	0	0	1
	ν_τ	0	0	0	1

+ 6 anti leptons with all signs reversed:
positron: $Q = +1$ $L_e = -1$

$\Downarrow$

12 leptons

6 flavours of quarks

classified by charge, strangness S, charm: C, beauty B, truth T
"upness" U, 'downness' D - not used often $\rightarrow$ redundant terms

also 3 generations:

	q	Q	D	U	S	C	B	T
1st	d	$-1/3$	-1	0	0	0	0	0
	u	$2/3$	0	1	0	0	0	0
2nd	s	$-1/3$	0	0	-1	0	0	0
	c	$2/3$	0	0	0	1	0	0
3rd	b	$-1/3$	0	0	0	0	-1	0
	t	$2/3$	0	0	0	0	0	1

+ antiquarks with all signs reversed

+ 3 colour options

$\Downarrow$

36 quarks

3 generations represent increasing mass

+ 12 mediators: γ + 8 gluons + $W^\pm$ + Z^0 + Higgs

1) Particle physics

Book: David Griffiths: Introduction to Elementary Particles

Elementary particle dynamics

⇓ how do particles interact with each other
⇓
quantum + relativity
⇓
quantum field theory

The four forces:

	Strength	Theory	Mediator
Strong	10	chromo-dynamics	Gluon
Electromagnetic	10^{-2}	electrodyn.	Photon
Weak	10^{-13}	flavour dyn.	W and Z
Gravitational	10^{-42}	geometrodynamics → general relativity	graviton

Weak force: β decay, decay of the π, μ and many of the strange particles

↳ the theory is sometimes called flavour-dynamics or Glashow - Weinberg - Salam (GWS) theory

⇓

treats weak and electromagnetic interactions as a form of a single electroweak force ⇒ instead of 4 → 3 forces

Strong force: chromo dynamics

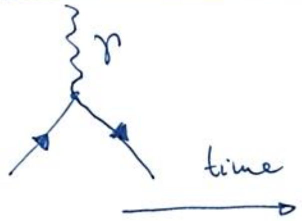
→ mediated by particle exchange

→ strong nuclear force between two protons is in reality a complicated interaction between 6 quarks

Summary - Particle Physics - Elementary particle dynamics

Quantum electro dynamics : QED

- → interaction trough photons γ 〰
- → only charged particles
- → primitive vertex:



(not a real physical phenomena)

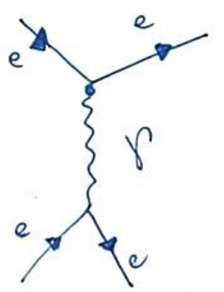
⇓

combine 2 or more vertices to represent physical phenomena

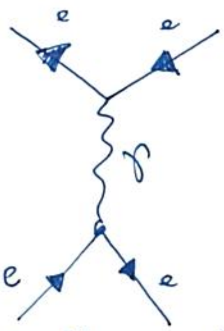
⇓

Feyman diagrams

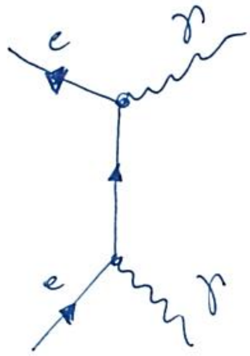
Examples:



Møller scattering (same charges)



Bhabha scattering (opposite charge)



pair annihilation
$e^- + e^+ \to \gamma + \gamma$

crossing symmetry: rotating or twisting the diagrams
- internal lines: virtual particles, describe the mechanism of the interaction
- external lines: real particles, describe what physical process is occuring
- Feyman diagrams are symbolic: they represent interactions

To analyse a particular proces:
- draw all possible diagrams
- evalute the contribution of each and sum them
  ↳ each vertex introduces a factor of $\alpha = \frac{e^2}{\hbar c} = \frac{1}{137}$ finestructure constant
- the sum total of the Feyman diagrams represents the process

→ Energy and momentum conservation