Forces and Exchange Particles

The Four Interactions

There are four forces in the universe, some you will have come across already and some will be new:
The electromagnetic interaction causes an attractive or repulsive force between charges.
The gravitational interaction causes an attractive force between masses.
The strong nuclear interaction causes an attractive (or repulsive) force between quarks (and so hadrons).
The weak nuclear interaction does not cause a physical force, it makes particles decay. 'Weak' means there is a low probability that it will happen.

Interaction/Force	Range	Relative Strength	
Strong Nuclear	$\sim 10^{-15}$m	1	(1)
Electromagnetic	∞	$\sim 10^{-2}$	(0.01)
Weak Nuclear	$\sim 10^{-18}$m	$\sim 10^{-7}$	(0.0000001)
Gravitational	∞	$\sim 10^{-36}$	(0.000000000000000000000000000000000001)

Exchange Particles

In 1935 Japanese physicist Hideki Yukawa put forward the idea that the interactions/forces between two particles were caused by 'virtual particles' being exchanged between the two particles.
He was working on the strong nuclear force which keeps protons and neutrons together and theorised that they were exchanging a particle back and forth that 'carried' the force and kept them together. This is true of all the fundamental interactions.
The general term for exchange particles is *bosons* and they are fundamental particles like quarks and leptons.

Ice skating analogy

Imagine two people on ice skates that will represent the two bodies experiencing a force.
If A throws a bowling ball to B, A slides back when they release it, and B moves back when they catch it.
Repeatedly throwing the ball back and forth moves A and B away from each other, the force causes repulsion.
The analogy falls a little short when thinking of attraction, but bear with it.
Now imagine that A and B are exchanging a boomerang (bear with it), throwing it behind them pushes A towards B, B catches it from behind and moves towards A. The force causes attraction.

Each force has its own exchange particles

Interaction/Force	Exchange Particle			What is acts upon
Strong Nuclear	Gluons between quarks	Pions between Baryons		Nucleons (Hadrons)
Electromagnetic	Virtual Photon			Charged particles
Weak Nuclear	W^+	W^-	Z^0	All particles
Gravitational	Graviton			Particles with masses