

# AP Physics

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## The Standard Model

### Fundamental Forces, Particles and Interactions

#### Standard Model of Elementary Particles + Gravity

	three generations of matter (fermions)			interactions / force carriers (bosons)		
	I	II	III			
mass	$\approx 2.4 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 172.44 \text{ GeV}/c^2$	0	$\approx 125.09 \text{ GeV}/c^2$	0
charge	$2/3$	$2/3$	$2/3$	0	0	0
spin	$1/2$	$1/2$	$1/2$	1	0	2
	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b>g</b> gluon	<b>H</b> higgs	<b>G</b> graviton
	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom	<b><math>\gamma</math></b> photon		
	<b>e</b> electron	<b><math>\mu</math></b> muon	<b><math>\tau</math></b> tau	<b>Z</b> Z boson		
	<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		

**QUARKS** (purple text)

**LEPTONS** (green text)

**GAUGE BOSONS VECTOR BOSONS** (red text)

**SCALAR BOSONS** (yellow text)

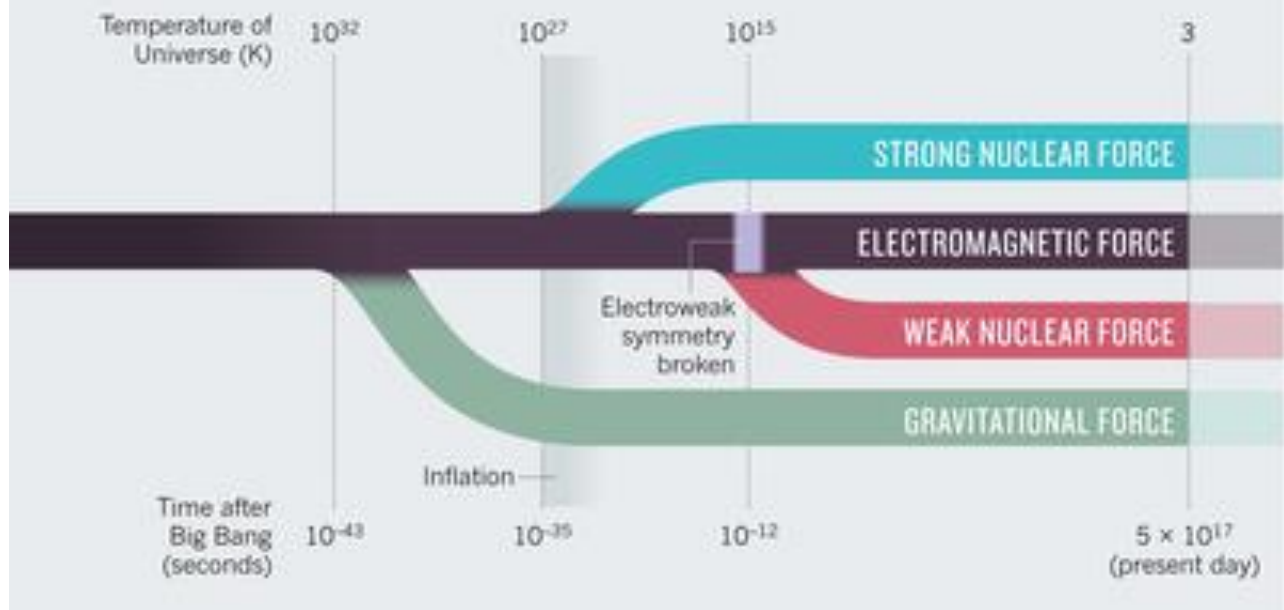
**HYPOTHETICAL TENSOR BOSONS** (blue text)

## Fundamental Forces

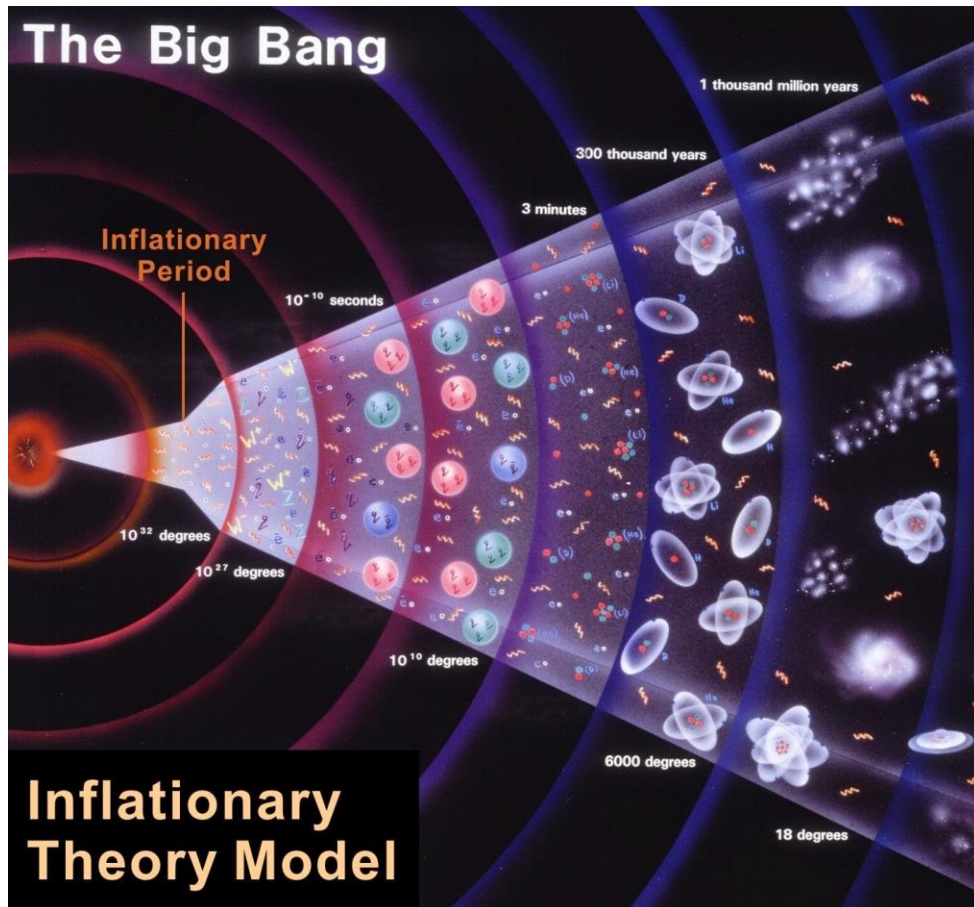
<b>Strong</b>		Force which holds nucleus together	Strength <b>1</b>	Range (m) $10^{-15}$ (diameter of a medium sized nucleus)	Particle gluons, $\pi$ (nucleons)
<b>Electro-magnetic</b>			Strength $\frac{1}{137}$	Range (m) Infinite	Particle photon mass = 0 spin = 1
<b>Weak</b>		neutrino interaction induces beta decay	Strength $10^{-6}$	Range (m) $10^{-18}$ (0.1% of the diameter of a proton)	Particle Intermediate vector bosons $W^+$ , $W^-$ , $Z_0$ , mass > 80 GeV spin = 1
<b>Gravity</b>			Strength $6 \times 10^{-39}$	Range (m) Infinite	Particle graviton ? mass = 0 spin = 2

# FUNDAMENTAL FORCES

After the Big Bang, the four forces divided as the cooling Universe underwent phase transitions. The Higgs boson broke the symmetry between the electromagnetic and weak nuclear forces.



# The Big Bang



**Inflationary Theory Model**