0.1 Ch.0 Introduction

<u>Fig 1 - theory cube</u>

Dimension Analysis

- The physical constants
- Speed of light: $[c] = \frac{L}{T}$
- Gravitational constant: $[G] = \frac{L^3}{MT^2}$
- Planck's constant: $[\hbar] = \frac{ML^2}{T}$
- The quantities
  - Planck's Length: $\ell_P = \sqrt{\frac{G\hbar}{c^3}} \simeq 10^{-33}\,\mathrm{cm}$
  - Planck's Time: $t_P = \sqrt{\frac{G\hbar}{c^5}} \simeq 10^{-44}\,\mathrm{sec}$
  - Planck's Mass: $M_P = \sqrt{\frac{c\hbar}{G}} \simeq 10^{19}\,\mathrm{GeV/c^2}$

Fundamental forces

- *EM force* (matter & photon)
- *weak force* (nuclei decay): slow process
- *strong force* (binding quarks)
- *gravitational force* (massive particles)

<u>Fig 2 - theory tree</u>

unification of fundamental force

<u>Fig 3 - forces unification</u>

Equations

- Newton's laws : $\vec{F} = m\vec{a}$ (1 eqs)
- Masswell eqution (2x1+2x3 eqs)
- Schodinger equation (1 eqs)
- Einstein's equation $G_{\mu\nu} = \kappa T_{\mu\nu}$ (4x4 eqs)
- $G_{\mu\nu}$: Einstein tensor (Geometry of spacetime)
- $T_{\mu\nu}$: Energy-Momentum tensor

  John Wheeler (1911 2008)
  $\longrightarrow$ *Curved spacetime tells the matter how to move*
  $\longleftarrow$ *Matter tells the spacetime how to curved*

Notions

In our course, the Minkowski metric

$$\eta_{\mu\nu} = \mathrm{diag}([1, -1, -1, -1]) \tag{1}$$

in other (like Special Relativity) $\eta_{\mu\nu} = \mathrm{diag}([-1, 1, 1, 1])$