

# Particle Physics & Cosmology

Physics 457 at [University of Michigan](#)

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Winter Semester 2022

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**Lecture 1. (Jan 5) *First Day***

eV is energy required to move 1  $e^-$  through 1 V

We can set  $c, \hbar, k_B = 1$  A result of that is being able to describe all quantities in terms of energies or inverse energies.

**Lecture 2. (Jan 7) *Second Day***

eV are a thng

Natural units are thing

Dimension	SI	Planck	Natural
Energy	$1.602 \times 10^{-10}$ J	1 GeV	1 GeV
Mass	$1.783 \times 10^{-27}$ kg	1 GeV/ $c^2$	1 GeV
Momentum	$5.33 \times 10^{-19}$ kg*m/s	1 GeV/c	1 GeV
Distance	$1.973 \times 10^{-16}$ m	$\hbar c$ GeV	1 GeV $^{-1}$
Time	$5.33 \times 10^{-19}$ kg*m/s	1 GeV/c	1 GeV $^{-1}$
Mass Density	$2.322 \times 10^{20}$ kg/ $m^3$		1 GeV $^4$

Table 1: Units

Proper time is  $\Delta t_0$  with the clock at rest in that frame

Time dilation is  $\Delta t = \gamma \Delta t_0$  in the frame

Proper length is  $\Delta x_0$  with the clock at rest in that frame

Length Contraction is  $\Delta x = \Delta x_0 / \gamma$  in the frame

**Lecture 3. (Jan 12) *Finishing Special Relativity***

Invariant vs constant and how they are different.

Different relationships for beta and gamma

Lorentz transform in matrix form as boost.

E from beam at target and from two beams: pros and cons of cost and statistics and max energy.

**Lecture 4. (Jan 14) *Matter particles***

Stable particles! Proton is only quark combo that's stable! Possibly make baryon template for Tikz? Baryon has odd number of valence (?) quarks

**Lecture 5. (Jan 19) *Quark Confinement***

Quark model 1960s

Gluons predicted in late 1970s

hadrons are made of quarks, either baryons or mesons

Baryons are 3 quark bound states, baryon #  $\pm 1$ , proton is lightest

Mesons have quark antiquark bound states, B=0

protons have mass from energy stored in gluon fields, higgs is mass for small mass like  $e^-$  (< 2%)

words