CMS Office Hours
Quiz 1: *Relatively* Easy **2020-Jun-30**

Use natural units! $\hbar = c \equiv 1$

1. A particle is considered *relativistic* when its energy is at least twice its rest mass.
   (a) Calculate the Lorentz factor (γ) of such a particle. (**Toolkit Equation**)
   (b) Calculate β (the speed of the particle as a fraction of the speed of light).
   (c) In general, what are the minimum and maximum values for γ and β?
   (d) Plot $\gamma(\beta)$.

2. Consider a 60 GeV muon produced in a $\mathrm{H} \to \mu^+\mu^-$ decay in the middle of the CMS detector.
   (a) On average, how far does it travel before decaying in **its rest frame**?
   (b) On average, how far does it travel before decaying in **the lab frame**?
   (c) Should a physicist worry about this muon decaying *before* it reaches the Muon System in CMS?
   (d) CMS passes nearly 20,000 A across a solenoid to create a magnetic field of 3.8 T. This magnetic field points parallel to the beam pipe and is highly uniform within the volume of the solenoid. Calculate the *radius of curvature* of the muon as it travels perpendicular to the uniform magnetic field. (**Toolkit Equation**)
   (e) What particles does a μ^+ decay into?
   (f) What particles does a μ^- decay into?

3. In High-Energy Particle Physics, there are a couple very useful *Pythagorean equations* (an equation of the form: $a^2 + b^2 = c^2$).
   (a) Write the Pythagorean equation for a massive particle that relates its mass (m), 3-momentum ($\vec{p}$), and energy (E). (**Toolkit Equation**)
   (b) Derive the Pythagorean equation which relates γ and β. (I find this to be a useful identity when simplifying equations which contain factors like: $\gamma\beta$, $\gamma^2\beta^2$, $1/\gamma^2$, etc.). (**Toolkit Equation**)