Homework 2
Due date: 2019.04.08

Problem 1.
1) Assume that at the LHC the Higgs has a production cross section of 20 picobarn, how many Higgs per year can be produced with a luminosity of $10^{33}/\text{cm}^2/\text{s}$? Please round your result to two significant figures. [1 point]
2) At the LHC, assume that each proton beam consists of 2808 bunches, and each bunch contains 1.15×10^{11} protons, and each proton has an energy of 7 TeV. For one beam, if its total energy can be used to melt ice, how many kg of zero temperature ice can be melted to zero temperature water? The specific latent heat of fusion for water is 333.55 kJ/kg. Please round your result to two significant figures. [1 point]
3) What is the speed of a proton with a total energy of 7 TeV, in $c = 1$ units? Please give your result until the digit which is not 9. [1 point]

Problem 2. Please use $c = 1$ units, and round your results to two significant figures.
1) Find the maximum value of v such that the relativistic energy can be expressed by $E \approx m + \frac{1}{2}mv^2$ with an error of one percent, where m is the rest mass. [2 points]
2) Find the minimum value of v so that the relativistic energy can be expressed by $E \approx |\vec{p}|$ with an error of one percent, where $\vec{p}$ is the space component in the four-momentum $p^\mu = (E, \vec{p})$. [1 point]

Problem 3.
1) Find the analytic expression for the total three-body phase space for a final state containing one massive particle with mass m and two massless particles. That is, assume that the matrix element is a constant, then $d\Pi_3$ can be integrated to get an explicit expression for Π_3. Write your result in terms of m and s, where s is the square of the center-of-mass energy, $s = (p_1 + p_2 + p_3)^2 = E_{cm}^2$. You can directly use the formulae derived in class. [5 points]
2) Evaluate your expression for $s = (106\,\text{MeV})^2$ and $m = 0.511\,\text{MeV}$, in $c = \hbar = 1$ units. Please round your result to two significant figures. [1 point]

Problem 4.
1) Do the same as in problem 3, but this time assume that all three particles are massless. You can directly use the formulae derived in class. [2 points]
2) Evaluate your expression for $s = (106\,\text{MeV})^2$, in $c = \hbar = 1$ units. Please round your result to two significant figures. [1 point]