

# Physics 110B, Problem Set 9

Not for grading

**This homework it is not for grading and it includes problems on relativistic kinematics that should be a refresher from what you have seen in past courses. It is likely that one problem on relativistic kinematics will be included in the final exam.**

Problems from Griffiths 5th edition. Same numbering in 4th edition as well.

**1 Griffiths 5th edition Problem 11.14**

**2 Griffiths 5th edition Problem 12.7**

**3 Griffiths 5th edition Problem 12.33**

**4 Griffiths 5th edition Problem 12.34**

**5 Problem 5**

Consider the collision of a high energy proton of mass  $m$  and momentum  $p$  with

- Another proton (say a hydrogen nucleus) at rest.
- Another proton of equal and opposite momentum.

Take the proton beam(s) to be ultrarelativistic  $p \gg mc$ . Consider the reaction  $pp \rightarrow A + \text{other stuff}$  where  $A$  is some new heavy particle. Find the maximum possible mass  $M$  of the  $A$  particle that could emerge from such a collision. You should find that  $M$  is much greater in the second case (“colliding beam experiment”) than in the first case (“fixed target experiment”). And this is why we do colliding beam experiments....

Hint: in order to “make” a new particle with the highest possible mass, the “other stuff” in the reaction must be “nothing else”. This is because otherwise some of the available energy is be “wasted” in the mass and kinetic energy of “other stuff”.