Abstract (should be about half a page):
1) Clear summary of the experiment (including how the air track works, how speed is measured, what types of collisions are studied, what is varied between different collisions).
2) Statement of how many different collisions were performed and, of these, how many agree/disagree, within exp. uncertainty, with momentum conservation. If you have some disagreement, give a one-line comment on what might be causing this.

Introduction:
1) Why are conservation laws important in physics?
2) Give some history of the idea of momentum conservation.
3) Discuss difficulties with this type of measurement (can we really achieve zero-friction?).
4) Must include reference(s) ... should avoid direct quotes from any source.

Theory:
1) Define momentum and give general equation for momentum conservation.
2) Give specific equations for the two-object elastic and inelastic collisions studied here.
3) Expression for uncertainty in P^{total} (with proper reference) and our simplified versions of this uncertainty equation. Explain under what conditions the simplified equations are valid.
4) Equations must be numbered and all variables must be defined.
5) Cannot have a list of equations ... each equation is considered part of a sentence.
6) NO direct copying or close paraphrasing from the theory section of the lab instructions.

Apparatus:
1) Diagram or annotated photograph of the set up, with a Figure caption. NO copying of figures from the lab instructions or the internet.
2) Begin with reference to your figure of the setup and explain of how the main parts work.
3) Discuss why the track must be level and why you place the photogates where you do.
4) Give your average glider length (with uncertainty) here and explain why it is needed.
5) Discuss why we use the glider speed loss to determine the uncertainty in our speed measurements. Give your average speed loss value here.
6) Brief explanation of how data is taken.
7) This section must include all experimental measurement uncertainties.
8) NO step-by-step description of the procedure, i.e., DO NOT include statements like: "we turned on the air blower and opened the Data Studio program named ...".

Results:
1) Must start with text describing in some detail what is included in the data table(s).
2) Well formatted data tables that include units (with column/row descriptor) and measurement uncertainty as appropriate (at head of column/row if same for all entries), and <u>proper number of significant digits</u> displayed. Number each collision so they can be referred to in the Discussion.
3) There must be text explaining how the data was used to compute the final results and final uncertainty, with reference to the appropriate equations from the Theory Section.
4) No discussion of how "good" the results are here ... this all must be in the next section.

Discussion:
1) Start by discussing which particular data sets agree/disagree, within uncertainty, with momentum conservation.
2) Discuss the magnitude of the uncertainties and identify the largest contributor(s) to the uncertainties.

3) Discuss any systematic trends observed in the data (e.g., was the final total momentum always larger/smaller than the initial total momentum?).
4) Discuss any assumptions made about the setup (e.g., the track is perfectly flat, the buoyancy force supporting the glider is the same everywhere along the track, the needle goes straight into the wax, etc.)
5) Suggest how this experiment might be improved to give a better test of momentum conservation.

References:
1) Should include a reference to the textbook for general theory.
2) Must include two separate entries for the lab manual ... one for the Lab 4 instructions and one for the Data Analysis section ... appropriate format for the latter is:

> "Some Notes on Data Analysis", in Physics 113/213 Laboratory Manual, Hiram College Physics Dept. (2017).

3) The references MUST be cited in the text in appropriate locations by including the reference number (i.e., [1], [2], [3-5], etc.).

For PHYS 213 only: For a more interesting lab paper you might also address the following two questions:
1) Are the elastic collisions really "elastic" (i.e., is the kinetic energy conserved).
2) What fraction of kinetic energy is "lost" in the inelastic collisions. (When glider 2 is initially at rest, we expect $\Delta K/K_i = m_2/(m_1+m_2)$).