Roller Coaster Design Project
Table of Contents

Table of Contents
1) Introduction
   Document Structure
   Lab Rules and Guidelines
2) Project Background
   2.1) Curriculum Objectives
3) Project Management
   Project Planning
   Project Scheduling
4) Project Parameters
   Project Timeline
   Proposal Process
   Budget
   Supplies
   Coaster Requirements
   Coaster Evaluation
   Coaster Contest Rules & Scoring
5) Project Documents
6) Project Records
1) Introduction

Welcome to the 1182 project document. Everything that you need to know during the course of your 1182 design project should be captured within this document. Please take the time to read through the entire document as soon as you can. The effort has been made to keep this document concise and information dense. If you have any comments, corrections, additions, etc, please inform your instructor via email.

Document Structure

The remainder of this document is organized into the following high-level sections:

1. High-Level Project Goals: This summarizes the high-level goals of the 1182 project. These are predominantly learning objectives and you should try to keep them in mind as you work on your project throughout the semester.

2. Project Management: This section covers the project planning and scheduling requirements of the design project.

3. Project Parameters: These are the rules that your project lives and dies by. This includes the project timeline, the proposal process details, budgeting, required reports, building supplies, and coaster contest rules and grading.

4. Documents and Forms: This section has copies of all the various documents you may find yourself needing throughout the semester.

5. Labs: This section contains high-level descriptions of the labs used during class. Full lab procedures will be made available on the EEIC website.

Lab Rules and Guidelines

The guidelines that must be followed at all times in the lab are as follows:

1. Get circuits and programs verified by instructional staff prior to plugging in the power if you are at all unsure about their operation

2. DO NOT STAND on lab furniture (stools, tables, etc)

3. Do not move or use any of the ECE lab equipment, or open or use any of the ECE equipment boxes.

4. No dangling jewelry or loose clothes

5. No ‘open’ shoes. Close-toed shoes or boots only.

6. Be aware of sharp corners and edges which may exist on tables or on apparatus and tools.

7. Always know the location of the first-aid kit

8. Report to the instructor ALL injuries occurring during lab

Failure to follow these rules and guidelines may result in losing lab privilege with a loss in lab participation grade for the course.
2) Project Background

In the competitive amusement park industry, engineers are responsible for continually innovating and developing exciting new roller coaster rides while still being constrained by the laws of physics and by safety requirements. As part of Engineering 1182, your team will design, build, document and test a model roller coaster. In addition, your team will brainstorm, design, and propose a compelling electronic add-on to the coaster.

The design/build project consists of several different kinds of labs:
1. An introductory lab, where you will inspect structural components and brainstorm as a group in order to respond to a presented RFP.
2. A pair of roller coaster physics labs, where you will gather information about energy conversion and losses that will aid you in the design of your coaster.
3. This is followed by a series of Arduino-focused labs where you will learn to program the Arduino microcontroller and how to interface it with other electronic devices.

2.1) Curriculum Objectives

The RC design project has five main curriculum objectives:

1. Project Management and Teamwork - which includes, but is not limited to: time management and task scheduling, team communications and meetings, fair division of labor and team member responsibilities.

2. Proposal and Design Process - which consists of identifying the requirements found in a Request For Proposal (RFP), gathering background information, brainstorming, identification of management of materials, preliminary analysis and initial design, production of a written proposal, and the build/test/document cycle.

3. System Modeling - which focuses primarily on the modeling of a simple physics system, specifically with regard to energy conversion and energy losses.

4. Microcontroller Design and Programming - using the Arduino microcontroller platform and a variety of sensors, motors, and actuators.

5. Project Documentation - which includes three parts:
   a. Project notebook - complete documentation of the project, and which was reviewed on a weekly basis
   b. Final oral presentation - overview of design experience
   c. Midterm and final written report - complete summary of all aspects of the design
3) Project Management

Project Planning
An important part of any project is proper planning early in the process. This involves identifying and analyzing the requirements, translating them into tasks, and then mapping the tasks to the available resources and timeframe. For the roller coaster project, each team should carefully examine this document to understand all of the deliverables required for this project.

It is often tempting to skip planning in favor of starting work on deliverables right away. Sometimes, this is even unavoidable, as some work will need to be completed before a finalized solution can be developed. Design teams should do their best to avoid this pitfall, as in almost all cases it leads to longer project completion times and increases the amount of wasted effort and resources.

Project Scheduling
After a period of initial planning, teams should create a project schedule as quickly as possible. A good schedule will include not just a list of tasks with deadlines, but also start times, work assignments (who is responsible for which tasks), and task dependencies (what things need to be done before others can begin). Once developed, a team's project schedule becomes an important tool for measuring the progress of the project overall.

The project schedule should be reviewed and updated reviewed at least weekly to identify tasks completed and the status of uncompleted tasks. Additionally, it should be updated as needed when major milestones have been reached. If initial tasks fall behind or overlooked tasks are identified, a re-plan effort needs to be done to establish a revised plan to meet the project deadline. This project schedule will be evaluated as often as weekly by the instructional staff.

Prior to the start of coaster construction, each team will be required to submit a project schedule for their design. At the last lab, the initial, revised and final versions of the project schedule should be included in the project notebook for grading. Below is a list of tasks that will probably be included in your schedule (some changes may occur due to the nature of your add-on project). You are expected to add other tasks as you feel appropriate to allow you to manage your project. You should assign team members to them and identify a planned start and finish time for each task along with any dependencies between tasks.

Tasks for the Roller Coaster Project
- Read project description document and syllabus
- Read the released RFP
- Team design brainstorming session(s)
- Develop initial project plan
- Writing and submitting of proposal
- Notebook updates
• Lab 1 memo
• Lab 2 memo (etc)
• Team design meetings
• Initial design paper
• Revisions incorporated into final design paper
• Initial construction begins
• Instructor Meeting #1
• All features built
• Ball rolls through entire roller coaster
• Instructor Meeting #2
• Mounting of speed sensors
• Building of capture bin
• Initial testing of completed design
• Preliminary Test
• Final Test
• Prepare final paper design
• Performance analysis using speed measurements
• Final Written report – outline, draft, final
• Oral Presentation – outline, draft, final, actual presentation

The project schedule will need to be included as a graded part of the proposal, the initial and final design papers, all lab reports, as well as the final notebook. Teams should strive to keep it detailed, well organized, and up-to-date
4) Project Parameters

The following section is most germane to the project work for this course. If design teams have any questions about how some aspect of the project works, this document should be the first point of reference. Please take the time to read and understand all of it, as you will be expected to know and operate by everything within it.

Project Timeline

The 1182 roller coaster design project takes place over the entirety of the semester. Work on the project starts immediately with the beginning of the semester, and your final act for this class at the end of the semester (in place of a final exam) is your oral presentation, the roller coaster contest, and the final project notebook. Below is a schedule of key events and when they occur.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFP Released</td>
<td>Aug. 26</td>
</tr>
<tr>
<td>Proposal Review</td>
<td>Sept. 2</td>
</tr>
<tr>
<td>Final Proposals Due</td>
<td>Sept. 9</td>
</tr>
<tr>
<td>Design Document - 1st Draft</td>
<td>Sept. 30</td>
</tr>
<tr>
<td>R&amp;D Parts Order Deadline</td>
<td>Sept. 30</td>
</tr>
<tr>
<td>Design Document - 2nd Draft</td>
<td>Oct 21</td>
</tr>
<tr>
<td>Project Review 1</td>
<td>Nov. 4</td>
</tr>
<tr>
<td>Parts Order Deadline</td>
<td>Nov 9</td>
</tr>
<tr>
<td>Project Review 2</td>
<td>Nov 18</td>
</tr>
<tr>
<td>Coaster Contest</td>
<td>Dec 9</td>
</tr>
<tr>
<td>Notebook/Final Report Due</td>
<td>Dec 9</td>
</tr>
</tbody>
</table>

Proposal Process

When a company, government agency, or another group has need of engineering services of some sort, that entity may release publicly a “Request For Proposals” or RFP. Engineering firms review RFPs, and, when appropriate, will respond to these entities with corresponding proposals.

What is an RFP and what does it include?

An RFP is a document publicly released by an entity seeking professional services. In this class, we will limit that scope to engineering services. There is no set form for an RFP and it may include any possible range of information. In short, an RFP is a document that encapsulates everything about a particular project that the issuing entity deems important. All relevant dates, requirements, budgets, limitations, etc, are included, and anything not included is left in the hands of the responding parties.
What is a Proposal and what does it include?

A proposal is a corresponding document to the RFP. They are produced by engineering firms wishing to compete for clients business. Primarily, proposals address the need put forth in the RFP. This includes a plan to solve the problem at hand, or design for the requested product, a timeline for completion of the project, a detailed budget estimate, and a comprehensive list of resources and requirements to execute the proposed plan.

Additionally, proposals will contain information about the submitting agency. In many ways, this information acts as a sales pitch to whoever released the RFP. It should include areas of expertise, special resources not generally available to other groups, and examples of past performance related to the area of the RFP.

The process for 1182

In this class, your instructor will produce and issue an RFP early in the semester. You should, as a group, read the RFP and produce a proposal based on the contents of the RFP. This proposal will be returned to the instructor by the deadline given in the RFP. Proposals will be reviewed and accepted or rejected. Proposals may be rejected for quality as well as for being too ambitious/not ambitious enough. Reasons for rejection will be clearly indicated. Rejected proposals must be revised and resubmitted until they are accepted.

Please take this process seriously! You are more likely to enjoy the project and class if you come up with a design and plan that everyone in the group can get excited about, and is challenging enough to stretch your capabilities. Don’t be afraid to fail in the end! A failed project in NO WAY means a failing grade in the class!

Writing your proposal

Writing of your proposal is a group activity. It is suggested that you begin as soon as possible, in order to avoid delays on your project before you even begin! There is no specific format or required length or content for your proposal other than:

- It must address the issue at hand, as put forward by the RFP
- It must answer any questions put forward by the RFP
- It must include an estimated budget
- It must include an initial project timeline

Other considerations about your proposal

Binding Proposal

You should consider your proposal to be binding. The design you initially propose will be the project you are required to implement. The details of the implementation may well change as you move forward with your work, but the core idea you present must remain the same.
Gantt Charts
When creating your timeline, use a Gantt chart format. Gantt charts use a number of horizontal bars to represent tasks. Leading and trailing edges of the bars indicate start and end times for the task. Included within the bars are an indication of percent completion of the task and task assignment. Arrows between bars indicate task dependencies. You can find a number of tools to create Gantt charts online.

Timeline Updates
Throughout the project, your group's timeline will inevitably change. Deadlines will be missed, tasks will become obsolete, and new tasks will emerge. Whenever such things happen, your timeline should be updated to reflect these things. You are expected to keep your timeline up-to-date with your actual progress on the project. Your team should be meeting weekly (outside of class), and one of the agenda items in these meetings should be these updates.

Proposal Grading
Proposals are graded pass/fail. Once a proposal has been accepted, it is counted as a passing grade.

Budget
There are two considerations for budgeting that your team needs to track. First, the project budget, second the classroom budget.

Project Budget
Specifics about the size of your budget as well as what parts are provided/included within that budget are specified in the RFP. This section primarily covers how to tell what things should be included in your budgetary calculations. When considering particular items for your budgeting calculations all of the followings should be taken into account:

- Is the item actually being used in the design, or has it been left out? Only items actually used in the final design are included in your budget calculations.
- Is the item “free”? Often, questions arise about using “free” materials, such as empty cans, jars, etc. In these cases, the cost of the purchased item that was contained with these containers must be included in your budget.
- How much of the item is being used in your design? If you purchase 100’ of paracord, and only 5’ are used in your final design, prices should be adjusted accordingly.

Classroom Budget
All items paid for by the university are counted against your classroom budget, regardless of whether or not they are used in your final design. Every group has a $30 classroom budget that includes all items ordered and printed (but not reclaimed items). Exceeding this amount is done at the discretion of the instructor.
Supplies
This section covers various aspects of the project related to when, where, and how you may acquire the parts to build your coasters. There are five main supplies of parts:

1. The supplies provided to every group as part of the standard roller coaster kit load-out.
2. Parts reclaimed from previous semesters and classroom stock
3. The required Arduino kit purchased by each student as part of the class.
4. Parts purchased by or provided by students
5. The ordering of specific parts, as needed. Each of these is covered in brief below.

Provided Supplies
Every group is given their own roller coaster kit. All kits are identical. All parts included in the kit are not counted against the team's proposal budget. The full kit includes:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Extras Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snap-Fits</td>
<td>90</td>
<td>$0.25</td>
</tr>
<tr>
<td>¼” OD poly tubing - 25’ lengths</td>
<td>2</td>
<td>$0.25 / ft</td>
</tr>
<tr>
<td>10-24x1/2” steel shoulder thumb screw</td>
<td>35</td>
<td>$0.10</td>
</tr>
<tr>
<td>10-24 square nut</td>
<td>35</td>
<td>$0.10</td>
</tr>
<tr>
<td>Nylon loop strap, .63” ID</td>
<td>35</td>
<td>$0.05</td>
</tr>
<tr>
<td>½” CPVC 90° drop ear elbow</td>
<td>16</td>
<td>$1</td>
</tr>
<tr>
<td>½” CPVC tee</td>
<td>50</td>
<td>$1</td>
</tr>
<tr>
<td>½” CPVC coupler</td>
<td>24</td>
<td>$1</td>
</tr>
<tr>
<td>18” CPVC pipe</td>
<td>12</td>
<td>$1.50</td>
</tr>
<tr>
<td>12” CPVC pipe</td>
<td>16</td>
<td>$1</td>
</tr>
<tr>
<td>6” CPVC pipe</td>
<td>30</td>
<td>$0.5</td>
</tr>
<tr>
<td>4” CPVC pipe</td>
<td>30</td>
<td>$0.35</td>
</tr>
<tr>
<td>3” CPVC pipe</td>
<td>20</td>
<td>$0.25</td>
</tr>
<tr>
<td>2” CPVC pipe</td>
<td>20</td>
<td>$0.15</td>
</tr>
<tr>
<td>Speed Sensor Kit</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Speed Sensors</td>
<td>8</td>
<td>$3.00</td>
</tr>
<tr>
<td>RJ-11 Cables</td>
<td>8</td>
<td>$1.00</td>
</tr>
<tr>
<td>Nylon Marble</td>
<td>1</td>
<td>$1.00</td>
</tr>
</tbody>
</table>

Additional Parts may be purchased against the project budget for the prices listed in the table above. In addition to these parts, the lab includes a speed sensor reader. This is a required component that must be attached to your final coaster, but does not count against your budget, and may not be used for anything other than reading the speed sensors. Provided parts may not be modified in any permanent way. **Damaged or destroyed parts will be replaced at the student's expense.**
Additionally, the lab also has two 3d printers. Students are encouraged to make as much use of these printers as they can. Designed parts can be submitted to the instructor for printing via email. The instructor will confirm the part cost with the group prior to printing. Parts may be rejected by the instructor for poor quality or excessive size/cost. Printing costs depend on the printer, material, and other factors. Part costs count against both project and classroom budget, as appropriate. Ask the instructor for further details.

The lab also has a number of tools available for use by the students including basic hand tools and a rotary tool. These are free to use with permission of the instructor and with proper safety equipment, when necessary. In addition, lab power supplies may be used for free, with permission.

Finally, the lab also has a number of consumables available for groups to use (duct tape, masking tape, various glues, etc). Limited use of these supplies is permitted without expense to the project. The instructor may, at their discretion, require the removal of any tape from a coaster at any time, for any reason.

**Reclaimed Supplies**

The classroom parts bin includes all the parts and reclaimed pieces of value from previous years roller coasters. It is a first-come, first, serve resource. Parts from the bin are STILL COUNTED against your budget. Part prices are at the discretion of the instructor.

**Arduino Kit**

All groups are required to purchase at least 2 Arduino development kits of their own choosing. The kits must each include an actual Arduino (any form factor/type), at least one motor, one other optical element, and at least two different sensor types. Minimum kit cost is $30 for a new kit. Any approved kit may be resold to students in following semesters for whatever price is agreed upon by both parties, so long as the kit is still largely (approx. 95%) complete and functional. Components from the kit count against the project budget unless otherwise stated in the RFP.

**Parts Orders**

Should additional parts be required outside of the sources listed above, they may be ordered through the instructor at times specified on the class schedule of events above. Parts may be ordered from digikey.com and amazon.com, or other approved vendors at the time. Ordered parts count against both project and classroom budget.

**Student Provided Parts**

Additionally, students are free to purchase whatever parts they wish, from whatever sources they wish, with their own funds. Such purchases still count against the project budget, but parts purchased in this manner will be returned to the student at the end of the term if they wish.
Coaster Requirements

The physical form of your team's coaster must meet the following set of requirements unless specifically modified by the RFP:

- The coaster must fit on the lab table/your half of the lab table (depending on enrollment).
- Must have a feature set worth between 50 and 75 points (see feature definitions below for feature values).
- The coaster must include at a minimum 1 vertical loop, 1 horizontal loop, 1 bump and 1 horizontal straight (all defined below). Failure to include each of these will result in a 25% reduction in overall coaster feature score.
- The coaster must use all 25’ of provided track
- The coaster must use the provided starting tower
- No portion of the coaster may extend more than 3” over the side of the table
- The coaster may not be more than 18” taller than the start tower. Additionally, it must be loadable by the group without having to have anyone stand on anything other than the lab room floor.
- If the coaster ends abruptly (track runs out) the ball must land in a catch bin which:
  - has a base of no more than 9” square
  - has sides no more than 2” high
  - is located with at least 3” of vertical space between the end of the track and the top of the bin
  - is not attached to the tabletop

Coaster-Features and Scoring

The following is a list of feature definitions that may be built as part of your coaster. Following that is a table of feature values.

- Vertical loop – a loop with mostly horizontal axis around which the track traverses 360°
- Double vertical loop – a loop with horizontal axis around which the track traverses 720°
- Horizontal loop – a loop with a mostly vertical axis around which the track traverses 360°
- Double horizontal loop – a loop with vertical axis around which the track traverses 720°
- Upward horizontal loop - a loop with mostly vertical axis around which the track traverses 360° and which trends upward during the loop
- Double upward horizontal loop - a loop with vertical axis around which the track traverses 720° and which trends upward during the loop
- Figure 8 - Connected horizontal loops with clockwise and counter-clockwise turns. Viewed from the top, the track should look like the number 8.
- Bump – the bump is required to have a minimum height of 1” with a maximum length of 4 times the height.
- Rise – a section of track with an upward slope of at least 25°
- Straight horizontal run – a section of straight horizontal track, of at least 12” in length.
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Points</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vertical Loops:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>+12</td>
<td>in addition to scoring for the single loop</td>
</tr>
<tr>
<td>Triple</td>
<td>+14</td>
<td>in addition to scoring for the double loop</td>
</tr>
<tr>
<td><strong>Horizontal Loops:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Downward</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Double Downward</td>
<td>+6/+8</td>
<td>in addition to scoring for single, greater score if the second loop is at least 1” smaller radius</td>
</tr>
<tr>
<td>Single Upward</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Double Upward</td>
<td>+8/+10</td>
<td>in addition to scoring for single, greater score if the second loop is at least 1” larger radius</td>
</tr>
<tr>
<td>Figure 8</td>
<td>+4</td>
<td>in addition to scoring of two single horizontal loops</td>
</tr>
<tr>
<td>Straight</td>
<td>1 per 4”</td>
<td>minimum 12”</td>
</tr>
<tr>
<td>Bump</td>
<td>1 per 1”</td>
<td>minimum 2”</td>
</tr>
<tr>
<td>Rise</td>
<td>1 per 2”</td>
<td>minimum 6”</td>
</tr>
</tbody>
</table>

**Speed Sensor Requirements**

Your coaster kit contains 8-speed sensors with which your group must instrument your coaster. Your group will position these sensors to divide your coaster into nine regions with each region being dedicated to a specific feature of the coaster. The first sensor will be at the beginning of the very first scoring feature (vertical loop, etc). The second sensor will be at the boundary between this feature and the next, and so on, until either there are no more sensors or no more features. Should there be extra sensors, the team must place them at other key points along the coaster (the tops of loops, etc). These sensors will provide the group with data to compare to their modeling calculations that are developed during labs.

**Coaster Evaluation**

All coasters will be tested and given a preliminary score that is included as part of the team notebook assignment score. The testing takes the form of three trial runs. Prior to the initial trial run, teams are required to give a short oral presentation describing their coaster, how the add-on is intended to function, and any interesting statistics about the design. Between system test trial runs, teams are permitted to make tuning adjustments to their coaster and add-on. Trial runs will rotate around the room, with volunteer groups going first.

During each trial runs up to 75 points can be earned [25 for the add-on project, and 50 for coaster performance].
During each trial run, points for performance are calculated according to the following, with a maximum of 50 performance points possible:

- The ball travels correctly through a feature + feature value points
- ‘Skipping’ -1 point
- The ball leaving the track -5 points
- The ball leaves the catch bin -5 points
- The ball fails to correctly interact with the add-on -5 points

Note that extra features can provide a buffer for deductions. For instance, a coaster with 60 points worth has a ball travel through all features but fails to stay in the bin. Thus, 60 points are awarded for features, and a 5 point deduction is taken for the ball leaving the bin, resulting in a total of 55 points, which is then lowered to the maximum of 50 points.

Values for both feature points and add-on points are recorded for all three runs on the Final Performance Test record sheet, and the highest total out of 75 will be used as part of your final notebook grade. The record sheet must be included in the notebook to be awarded these points.

**Coaster Contest Rules & Scoring**

A final competition among all the teams in all sections of 1182 at OSU Marion takes place at the end of the semester. Participation in the competition is optional, but any team or partial team may participate. In order to receive any benefit from the contest, they student must be present.

The contest plays out in much the same way as the final system test. Dress is business casual (those not dressed appropriately will not be permitted into the contest). The contest takes the form of three trial runs. Groups should have their documentation on-hand for the judges to consider. Teams are encouraged to make additional visual aids and appearance-only additions to their coaster prior to the contest.

After all test runs are complete, the judges will retire briefly and choose a first, second, and third place coaster. During deliberation, students should remain in the room, ready to answer any questions that may arise from the judges. Judges will be a mix of technical and lay volunteers. They will focus primarily on the following attributes of the coasters:

- Solid structure
- Reproducible design
- Reliability
- Creativity
- Documentation

Contest winners are awarded bonus points. First place is awarded 150 points, second place 125 points and third place 100 points. Bonus points will be added to the project’s grade.
5) Project Documents

The following table is a summary of all written deliverables that make up the 1182 coaster project. Following the table are explanations of the role of each document along with guidelines for developing them, along with grading rubrics.

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Purpose</th>
<th>Max. Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeline</td>
<td>Gantt Chart of tasks, keep the team on track. Included with all other documents.</td>
<td>N/A</td>
</tr>
<tr>
<td>Lab 1 - Proposal</td>
<td>Define the add-on project specifics, as well as coaster design. Sets broad goals that define success of project</td>
<td>10</td>
</tr>
<tr>
<td>Lab 2 &amp; 3 Report</td>
<td>Show understanding coaster physics and using motors with the Arduino</td>
<td>10</td>
</tr>
<tr>
<td>Lab 4 &amp; 5 Report</td>
<td>Show understanding of basic and advanced techniques with the Arduino</td>
<td>10</td>
</tr>
<tr>
<td>Initial Design Doc</td>
<td>First pass at defining the design details of the coaster as well as the add-on project</td>
<td>50</td>
</tr>
<tr>
<td>Final Design Doc</td>
<td>Final pass at defining specific goals that define the success or failure of the project as a whole</td>
<td>100</td>
</tr>
<tr>
<td>Oral Presentation</td>
<td>Communicate specifics of your design and work with others</td>
<td>20</td>
</tr>
<tr>
<td>Project Notebook</td>
<td>Overall documentation of the entire project design. Includes everything</td>
<td>200</td>
</tr>
</tbody>
</table>

**Timeline**

The project timeline is not graded, in and of itself, but rather is an important part of nearly every other document. Your group should create and maintain an up-to-date and detailed Gantt chart. This chart should include a variety of R&D tasks, design tasks, coaster building tasks, add-on design and build tasks, coding tasks, and testing tasks. The timeline should at the very least show which team members worked on past tasks, and which team members are working on current
tasks. Completed, in progress and upcoming tasks should be distinguishable from each other and task dependencies should be clear.

**Grading:** The timeline is graded as part of other documents. So long as it is up to date and sufficiently detailed, and included, it should not be a source for lost points. The specific value of the timeline in the document is detailed in the relevant documents.

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**Lab 1 - Proposal**

**Goal:** This is the first document you will produce as a group in 1182. It is in response to the RFP issued by the instructor. For nearly every section of the RFP, there should be a corresponding section in your proposal. Make sure to answer any and all question in the RFP, explicit as well as any that you feel are implied by the RFP.

**Document Requirements:** Requirements for this document will vary from semester to semester, depending on the RFP issued. In general, make sure to propose a sufficiently complex, interesting idea related to the RFP, and make sure to answer all questions posed by the document. Additionally, the proposal should include an initial budget estimate and an initial, less detailed form of the timeline.

**Grading:** The proposal is a completion grade assignment. The document is considered complete when it is accepted by the instructor (not collected, ACCEPTED).

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**Lab 2&3 and 4&5 Reports**

**Goal:** These 4 reports will be completed after completing the relevant lab(s). You should produce a report summarizing the lab activities, discussing results the implications of those results, and give some insight on how the issues discussed in the labs will impact your coaster design and build.

**Document Requirements:** The lab should follow the standard format from the EEIC Tech Comm guide for a Lab Memo.

**Grading:** See the project document and lab rubrics for more details. Include rubrics with your lab reports.

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**Design Document Drafts**

**Goal:** To develop and document a roller coaster design based on the requirements listed in this document supported by solid physics principles and detailed speed calculations. Additionally, to document your teams design for fulfilling the proposal submitted.

**Document Requirements:**
The document must cover all aspects of the coaster and project design. In addition to an introduction discussing the motivation of your design, and a detailed description of the design and its operation, the document must include each of the following, organized neatly and cohesively:
Technical Drawings
The drawing must contain neat, three-dimensional representation (isometric and 3 orthographic views) of the roller coaster. It may be hand drawn or done in SolidWorks. It must include:

- The general shape of the track
- An approximate representation of the CPVC parts required to support it along with an initial parts count estimate.
- Location of the speed sensors.
- Location of any and all additional parts required for fulfillment of the proposed add-on
- Dimensions for each major feature

Calculations
Velocity must be calculated for the entry and exit of all segments/features of the design including the start and end of the track. Additionally, velocities must be calculated for the tops of loops and hills, and for all banks of greater than 90°. These calculations must include frictional losses and can be done using Excel or MATLAB. Only the resulting calculated speeds should be included in the main body of the document in either a table or graphical format (preferred). The excel sheet or MATLAB code, along with equations should be provided in the appendix. There should be labeling on the drawing corresponding to points of calculation.

Initial design Feature list
Create an ordered table listing the roller coaster features of the initial design and the associated feature score. Included in this list should be any features that the ball interacts with that are part of your add-on project.

Grading: See the rubric in the “Rubrics” section for details. Include a print-off of it as a cover page for your document.

Caution:
Each team must select a safe mechanism to launch roller coaster nylon ball. The unsafe method will not be permitted in the laboratory.
6) **Project Records**

- Project Records
- Print Requests
- Parts Requests
- Proposal Modifications
- Budget Timeline
- Progress Checks
- Final Performance Test Record
- Contest Record
### 7) Rubrics

**Initial Design Paper Rubric**

**Team Name:** ____________________________ **Number:** ______

<table>
<thead>
<tr>
<th>Item</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content:</strong></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>• Drawing (Include: 1. The shape of the track, 2. A parts list, 3. The location of speed sensors, 4. Dimensions)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>• Calculations (Include: 1. Entry/Exit velocities for all features, 2. Velocity at the top of vertical loops and comparison to ((gr)^{1/2}), 3. Banking calculations for horizontal curves and loops, 4. Velocity at the top of bumps and comparison to ((gr)^{1/2})</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>• Feature List</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>• Design Motivation</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>• Coaster Description</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>• Add-On Description</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td>50’</td>
<td></td>
</tr>
</tbody>
</table>

* 5 point deduction if this rubric not attached as cover page

Comments:
## Notebook Rubric

**Team Name:** ____________________________  **Number:** ________  

<table>
<thead>
<tr>
<th>Content</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introduction - A formal written memo that introduces the coaster concept and it’s motivation describes any add-on projects in detail and gives a working description of the coaster. The next three section after this should be referenced here.</td>
<td>35</td>
</tr>
<tr>
<td>• Final Drawing (Include: 1. The shape of the track, 2. A parts list, 3. The location of speed sensors, 4. Dimensions). Should be done as much in SolidWorks as possible.</td>
<td>35</td>
</tr>
<tr>
<td>• Calculations (Include: 1. Entry/Exit velocities for all features, 2. Velocity at the top of vertical loops and comparison to ((gr)^{1/2}), 3. Banking calculations for horizontal curves and loops, 4. Velocity at the top of bumps and comparison to ((gr)^{1/2}). Should clearly indicate all included, relevant parameters.</td>
<td>30</td>
</tr>
<tr>
<td>• Feature List - In the order the ball will travel through them. For non-linear coasters, a flow chart is acceptable.</td>
<td>10</td>
</tr>
<tr>
<td>• Lab Documentation - All previous lab reports, memos, etc, along with any relevant notes, sketches, or other material. Preference should be given to graded materials.</td>
<td>5</td>
</tr>
<tr>
<td>• Design Documentation - final accepted proposal, Initial and final drafts of the design paper. Preference should be given to graded materials.</td>
<td>5</td>
</tr>
<tr>
<td>• Group Notes - Any and all notebooks, scrap paper, or other notes were taken by the group throughout the semester. May be included as physical notes or as a PDF file on some form of media, attached to the notebook.</td>
<td>70</td>
</tr>
<tr>
<td>• Oral Presentation Slides</td>
<td>5</td>
</tr>
<tr>
<td>• Final System Test (if not in contest) or Contest Score Sheet</td>
<td>5</td>
</tr>
</tbody>
</table>

**Total Points** 200
Rubrics continued.

**Final Design Paper Rubric**

Team Name: ___________________________ Number: ______

<table>
<thead>
<tr>
<th>Item</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Drawing (Include: 1. The shape of the track, 2. A parts list, 3. The location of speed sensors, 4. Dimensions)</td>
<td>25</td>
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</tr>
<tr>
<td>● Calculations (Include: 1. Entry/Exit velocities for all features, 2. Velocity at top of vertical loops and comparison to (gr)(^{1/2}), 3. Banking calculations for horizontal curves and loops, 4. Velocity at the top of bumps and comparison to (gr)(^{1/2}))</td>
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<td></td>
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<tr>
<td>● Feature List</td>
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<td>● Design Motivation</td>
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<tr>
<td>● Add-On Description</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td>100*</td>
<td></td>
</tr>
</tbody>
</table>

* 5 point deduction if this rubric not attached as cover page

Comments:
All PVC parts, the start tower, and add-on components should at an absolute minimum be rendered in SolidWorks. The track, snap-fits, speed sensors, etc, should be as well if possible, however, consideration will be given to overall complexity.

Notes from labs may be included in the group notes section if they have been recorded in such a way that makes separating lab notes from design notes impossible.

* 5 point deduction if this rubric not attached as cover page