Lab Projects for Ma114

Lab projects are generally stated as a topic of investigation rather then as a specific exercise. You are required to perform a detailed analysis of the problem. This will include: setting up the problem, making a labeled diagram of the problem with information acquired, performing the necessary calculations and visually displaying the results (usually as graphs of functions). You must then organize this information into a full written report.

Lab projects are done by collaborative groups of three or four students who are expected to organize themselves, do the work, and prepare the report as a group. Each person in the group must sign the final report and be aware that in doing so he or she is guaranteeing that everyone who signed has done his or her fair share of the work. This does not mean that everyone did exactly the same number of tasks, spent the same amount of time, etc. It may well be the case that one member of the group provides the majority of the ideas, another provides the organization and direction, and another actually prepares the "write-up". It does mean that each person who signs the final report is personally satisfied that every author contributed in fair measure *and fully understands the report.*

The reports will be graded with each student in the group receiving the group grade. The grade may be determined either by the written report alone or in equal measure by an oral presentation by a randomly selected member of the group. Report grading will be on correctness, completeness, correct English, demonstration of understanding of the problem and solution, and style. Bonus points may be given for originality.

The following are general guidelines and expectations:

The Lab Session:

- Get started immediately. You will not be able to complete the project all in the last minute. Do not waste this valuable time.
- Read over the laboratory material carefully before you begin discussing or completing any part of it. This should be done before the lab sessions designated for this activity. Give some advanced thought to what you are going to do and the anticipated form of the report you are going to prepare.
- Initially you may have some trouble getting started. Don't panic, a discussion with your group partners will usually generate some ideas. Your TA can also give you a 'push' in the right direction. There will likely be a general discussion on the problem in lecture. Your TA may also be able to make suggestions as to how to organize your efforts.

- The generality of projects like these tend to make them quite different from the standard "exercises" of the homework. You will need to make assumptions to simplify the problem. Be sure to discuss such assumptions in detail in your final write-up.

- Plan on spending some time outside of lab on the report. In particular, plan on writing the final report outside of class.
- Your TA will be happy to go over complete drafts of your final report with you if they are ready at least two days before the submission deadline. He or she will then be able to point out areas of concern and make suggestions on improving the final submission.

The Lab Report: The report should be readable by anyone who can understand the mathematics with no reference to any other source It must at least have the following identifiable features:

1. **A Cover Page** signed by each member of the team which produced the report. A signature on a report means that each person signing attests to the fact that each contributed approximately equally to the work. Each member of the team is responsible for any errors; each member of the team may be asked to explain any detail of a report.
2. A **complete statement of the problem**
3. An **analysis** of the problem, complete with carefully drawn sketch which contains a complete explanation of the solution, derives and explains all equations and sets up all calculations that need to be done. This may be done as part of a Maple worksheet and should contain carefully annotated graphs of the pertinent functions. This is the most important part of the report.
4. **Details of the calculations** (this can be an annotated Maple worksheet. It must be clear to the reader what each calculation is intended to do. This can be done with comments.

   The report should be free of any extraneous calculations. Do not include any intermediate calculations unless you need to refer to them or you feel that their presence makes the report easier to read.

   Most of the graphs will be in this section. It should be clear to the reader why one doing a certain graph before it is actually done. This can be done with a comment. Features of importance on a graph should be labeled and interpreted either on the graph itself or immediately following it. For instance the axes of all graphs should be labeled and a caption provided for each graph which explains its purpose. This labeling can be done by hand on computer-generated drawings. The function(s) being graphed should be in the caption or penciled on the graph.
5. **Conclusions and interpretations** . At the very least this should briefly explain how what has been done answers the original question or solves the original problem. If appropriate, it should refer back to graphs and relate features of the graphs to numerical calculations. Finally, there should be a summary paragraph or sentence describing what has been accomplished and (possibly) suggesting directions for further study. problem(s).

A good report will not be very long - probably three to five typed pages, excluding graphs.

The report should be free of any extraneous calculations (e.g. material that should have been cut out of a worksheet.)

Finally, there should be a summary paragraph or sentence describing what has been accomplished and (possibly) suggesting directions for further study. problem(s).

The Tilted Bottle

Date: ________________

Team Members:

____

____

____

____

____

____

Investigate the following question:

> A cylindrical container 6 inches high and 2.5 inches in diameter is 80% full of water and sits on a level table. The cylinder is tilted so that the plane of its base makes an acute angle of θ radians with the table.
>
> At which value of theta will water just begin to flow out of the container?

NOTE: This problem was originally suggested by Professor Peter Russell of McGill University. During a drive from the Montreal airport he was behind a beer delivery truck on whose sides cases of bottled beer sat in racks at an angle which made it easy for the delivery man to remove them. Dr. Russell noted that the fluid in the necks of the bottles didn't touch the lids even though the angle of the cases was actually rather steep and wondered exactly what angle would cause that to happen.

The Hot Water Tank Problem

Date: ____________________

Team Members:

____

____

____

____

____

____

Newpark Shipyards manufactures and repairs large barges. Many of the barges brought in for repair are tankers with substantial amounts of fuel vapor in the tanks. In the past this explosive gas was vented to the atmosphere but clean air standards now require that it be burned cleanly. The shipyard had to choose between a \$250,000 flare system or a \$500,000 hot water system which would use the fuel vapor to produce hot water which would then be used to clean the barge. The decision on which alternative to use boiled down to whether the hot water produced would on one day would be hot enough to use the next. This was because the vapor had to be removed but the tanks would not be safe for workers to enter for up to eight hours more.

Here is a modified version of one the problems that was solved to help with the decision.

> At six a.m. a tank contains 20,000 gallons of water at 90 degrees Fahrenheit. One hour earlier the water in the tank had been at At six a.m. fuel vapor from a barge is burned and the heat transferred to the water in the tank via a heat exchanger at a rate of 80,000 BTU per minute for four hours. Assuming that the ambient air temperature remains at a constant 80 degrees and that only Newton's Law of Cooling applies (ignore radiant heat loss) what will be the temperature at the end of the four hours and how long (if at all) will the water in the tank remain above 170 degrees Fahrenheit.

Investigate the problem above, answering the question posed. Then investigate the sensitivity of the answer to the "constant ambient temperature" assumption by assuming that the temperature is a constant during each clock hour, starting with 40 degrees from 6:00 to 7:00 and that it increases two degrees per hour until 6:00 p.m and then decreases two degrees per hour until it gets back to 40 degrees at 6:00 a.m. at which time the cycle repeats.