Math 9 Sec A&C Project Guidelines

Fall 2019

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In addition to your regular 8 homework assignments, you have to complete one group course project as mentioned in syllabus in which you will get the chance to apply some of the concepts, techniques, and skills from your previous calculus courses to solve or analyze a challenging real-life problem. Please study **"§7.6: Integration with Tables and Computer Algebra Systems & §7.7: Approximate Integration"** in your Calculus textbook ("Calculus: Early transcendentals, UCI Custom Edition", James Stewart, 8th Edition) first before you start working on this project. Specific instructions are provided below, but please do not hesitate to ask if you have any additional questions.

Instructions: *Violations to any of the below guidelines may result in your report being returned.*

(i) Work out all answers and solutions to the different parts of the problem.

(ii) Write and submit a report that summarizes your findings and answers:

- Begin with an introduction to the problem (similar to what's in the project description).
- In the main part, do not formally distinguish answers to the different problem parts whose purpose is merely to help you structure your thoughts and work. Rather, present your findings, answers, or solutions in coherent a form and a successive, logical manner.
- Give sufficient reason and show supporting math whenever applicable; however, assume mathematical maturity of the reader and do not include each and every little minor step.
- Conclude your report with a brief summary or with a brief summarizing statement.

(iii) Your project report must be

- typed with LaTeX without any handwritten edits;
- between 5 and 10 pages of length, including a cover page that shows names, project title, dates, and the relevant course information;
- written in first person plural ("we") using correct English and mathematical notations;
- spell-checked and free of (major) grammatical errors;
- contribution of each participants (additional 1 page).

(iv) You are allowed to work on the project with 3 partner, i.e., at most 4 students in your group. Your group should turn in only one report, with all your names on the title page in alphabetical order of your last names.

(v) Projects will be graded for organization, mathematical correctness, and overall presentation, and will count for 20 points of your course project grade (20 = excellent, . . . , 1 = poor, 0 = missing).

(vi) Reports are due on 11:59PM December 8, 2019, **electrical copy only!** Late submission will not be accepted. Finally, your group should present your project results on December 9, 2019.

Project Topic: The Happy Holiday Candy Factory

Themes: Building a definite integral, numerical integration with MATLAB/Mathematica on computer.

Project description: As mathematical consultant to the Happy Holiday Candy Factory, you must design the production schedule for their wildly popular chocolate-covered-asparagus Holiday candies. It is now 81 days before New Year, and the factory must have 2 million candies produced by New Year. Past research shows that to produce candies at a rate of R candies per day costs the factory $50 + \frac{R}{1000}$ cents per candy. To store A candies costs $\frac{A}{2}$ cents per day (to rent storage space, power the refrigerators, hire security guards, etc.) This project investigates what production schedule should be used in order to make the total production cost as small as possible.

(a) Let t be the time (in days) from today, and let $C(t)$ be the number of candies produced by time t (thus, the total output from today to time t). Find a definite integral over t for the total production cost from now until New Year in terms of $C(t)$. Slice the time interval $[0,81]$ into pieces; figure out the cost to the factory from time t to time $t+dt$.

(b) Consider a uniform production schedule (produce candies at a constant rate so that you just produce 2 million candies by New Year). Determine the total production cost for this schedule.

(c) Design a production schedule that has a smaller cost than the uniform schedule in (b). Try to minimize the total production cost as best you can. You will need to experiment a bit; please report the results for several of your experiments, and some intuitive reasoning for why your schedules cost less than the uniform schedule. Make sure you produce exactly 2 million candies by New Year in each case.

With the current model for storage, the cost of storing A candies for one day is a linear function $\frac{A}{2}$. A more realistic model for storage costs would be that the cost is an increasing but concave down function $f(A)$.

(d) Why might such a function f be a more realistic model of storage costs?

(e) Find a function $f(A)$ that is increasing and concave down for $A > 0$, which is approximately equal to $\frac{A}{2}$ for A small, but starts to deviate somewhat from $\frac{A}{2}$ when A is around 1 million. Make a plot of $f(A)$ and $\frac{A}{2}$ together.

(f) Repeat (a)–(c) for the model with $f(A)$ replacing $\frac{A}{2}$ as the storage cost. Depending on your function $f(A)$, you may need to compute integrals numerically. Discuss differences in results for this new storage cost model.

(g) Discuss another way in which this model is unrealistic. Adapt the model to respond to your objection, and repeat (a)–(c) for your new model.