Engineering 14100
Flowcharting 1 ACT: Introduction to Flowcharting

Task 1 (of 5)

Objective: Analyze the given situation/problem, translate it into an algorithm, and create a flowchart representing the algorithm.
Initial Keyboard Operator: Person with the oldest parents

Remember:
1. You should be working as a team; ALL team members will be held responsible for all material.
2. You should all be working on this Task using one (1) computer, unless otherwise directed.

Background:
Flowcharts help to make complicated problems more doable by translating the problem into a multistep process. Flowcharts represent the algorithms that are used in programming, which makes them a helpful tool for planning and designing a program prior to its implementation.

Part A:
Engineering students in the new Third Street Suites residence hall are frustrated with the automated light system. They report that the lights seem to turn off immediately after being turned on. When the facility manager complained to the company that installed the lights, the company sent the following information in a report. The gist of the report was that the lights operate on a timer. When a student enters their room and turns on the light, a motion sensor checks for movement in the room once after 30 seconds and not again. If no movement is detected, the light turns back off and stays off until the student flips the switch again.

The facilities manager would like to distribute this information to the students in a concise manner rather than sharing the whole report. She's designing a flier with the information and she asks you to develop a flowchart depicting the process of a student turning on the light in the dorm room, beginning when the student flips the switch. The students have not had a similar problem in turning off the light. You may use any digital flowchart creation tool you choose, but the final product must be digital. If you use Lucidchart or VUE, save the chart as an image and copy it into a PowerPoint slide.

Save your flow chart in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part B:
The facilities manager has also invited the sophomores in the School of Electrical and Computer Engineering to observe the situation as part of ECE 20100 Linear Circuit Analysis. Prior to coming on-site, however, the professors of the course have requested that a basic description of the light system be provided to their class for discussion and analysis. Create a functional block diagram representing the lights in the new residence hall.

Save your functional block diagram in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part C:
As a TEAM, answer the following questions. Note that there are multiple acceptable solutions to each of these questions.

1. What is the difference between a functional block diagram and a flowchart? When would it be more appropriate to create a functional block diagram rather than a flowchart?
2. Describe the significance of the following shapes in a flowchart: rectangle, diamond, and parallelogram.

Save your answers in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Task 2 (of 5)

Objective: Analyze the given situation/problem, translate it into an algorithm, and create a flowchart representing the algorithm. Utilize conditional and repetitive structures in an algorithm.
Initial Keyboard Operator: Person with the most siblings

Background:

Many processes utilize steps that must be repeated until a certain condition is reached in order for a process to be executed correctly. One example is a light system that counts the number of people in the room as they enter and leave the room and turns off the lights when no one is present in the room. This would require the system to repeatedly evaluate the presence of people. Alternatively, timing a marathon runner by the second would be tedious for a person to do on their own, but the use of programming in a watch that repeatedly and accurately updates the time simplifies the process. These repetitive structures allow for simplification in programming and for the completion of monotonous tasks more efficiently and readily than if done by a human.

Part A:

When your parents visited this weekend, they gave you $20 to spend on a pizza for you and your closest friends. After successfully completing your first project as a team, you decide to share your pizza with your engineering team. You and your mates decide to order your pizza from Papa John's with onions on one half and olives on the other, despite the fact that you refuse to eat olives. Unfortunately, when the pizza arrives, there are olives on the entire pizza. Your team members each only want 1 piece of pizza, so they challenge you to eat as much as you can of the rest. In order to do so, you must remove all of the olives from each of the slices before you eat it.

In order to make sure you do not mistakenly eat any olives, you develop an algorithm for the process beginning from when the pizza is ordered to when you have stopped eating. Represent this algorithm in a flowchart.

Save your flowchart in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part B:

As a TEAM, answer the following questions. Note that there may be more than one correct answer.

1. Is there a different way to represent a repeated process other than the one you chose? If so, please describe the process. Otherwise, describe why the representation you chose is the best method.
2. Under what conditions, if any, would the algorithm "break" (i.e. no longer work successfully)?

Save your flowchart in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Task 3 (of 5)

Objective: To learn how to implement conditional loops to solve interdisciplinary problems.
Initial Keyboard Operator: Person with the most sisters

Background:

Mathematicians have been developing proofs to solve infinite series problems. Now we can write algorithms to solve them using a brute force method. However, certain conditions must be defined to avoid an infinite loop. Let's explore a couple of cases to help define these conditions.

The Basel Problem is a mathematical expression that determines the exact sum of the series

$$\sum_{n=1}^{\infty} \frac{1}{n^2} = \lim_{n \to +\infty} \left(\frac{1}{1^2} + \frac{1}{2^2} + \cdots + \frac{1}{n^2} \right)$$

Leonhard Euler defined a method to estimate this infinite series to prove the exact sum to be $\pi^2/6$ because the series converged on this single value. This was unlike the (divergent) harmonic series

$$\sum_{n=1}^{\infty} \frac{1}{n} = \lim_{n \to +\infty} \left(\frac{1}{1} + \frac{1}{2} + \cdots + \frac{1}{n} \right)$$

which continues to increase in value. If an algorithm was defined to estimate the value of an infinite series that has an unknown sum, then a useful strategy for the algorithm would be to specify a possible limiting value for a sum that diverges as well as a convergence criterion. The convergence criterion is a small positive number that represents a "radius" around the possible limiting value .

Suppose that λ is the possible limiting value and ε is the convergence criterion. If you can show that there is an integer K_{lim} such that for all $K > K_{lim}$

$$\left| \left(\sum_{n=1}^{K} \frac{1}{n^2} \right) - \lambda \right| < \varepsilon$$

It is <u>usually</u> safe to conclude that the series has converged. Be aware that this is not a mathematically rigorous convergence test.

Part A:

Construct a flowchart illustrating an algorithm that will take an input of the convergence criterion (a very small number, less than one) and the limiting value $\lambda = \pi^2/6$ and determine how many terms K of the Basel series need to be written in order to meet that criterion. The algorithm should output the number of terms needed to reach convergence.

Save your flowchart in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part B:
Remembering that your convergence criterion cannot be negative or zero, alter your flowchart to add a check to make sure that the convergence criterion is positive. If it is not, exit the algorithm. Additionally, augment the chart to output the sum of the series once convergence has occurred.

Save your flowchart in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part C:
Develop a trace table which shows values of each variable for each iteration of your algorithm. Hint: you might not want to pick too small of a value for the convergence criterion, as that could require a lot of iterations of your algorithm!

Save your table in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Task 4 (of 5)

Objective: To learn how to implement conditional loops to solve problems in an industrial setting.
Initial Keyboard Operator: Person with the grandparents living the closest to Purdue

Background:

The year is 1973. Oil prices soar and consumers look for any way possible to squeeze miles out of every tank of gas. The cruise control system was developed for mass automobile production in 1973 as a way to combat high gas prices.[1] The technology had existed for years, but full scale implementation occurred only in the 1970's. The feature became standard within a few years, and pretty soon virtually all production vehicles were equipped with cruise control capabilities.

Fast forward to today – you work at Ford Motor Company, and your boss needs a presentation for potential investors that explains how the cruise control system works. The flowchart from 1975 has gone missing, and you need something to graphically demonstrate the way the system works.

Having completed your master's thesis on cruise control systems, you understand that the process works by continuously checking the *change in speed* and adjusting the fuel to the engine accordingly. More specifically, when the driver engages the cruise control the current speed becomes the desired speed. A sensor regularly checks the current speed against the desired speed (e.g. every 0.05 seconds). If the speed is less than desired, then fuel is sent to the engine to increase the speed. The error between the current speed and desired speed determines how much fuel is sent to the engine. For safety reasons the maximum fuel delivered for each check of speed is constrained to a maximum value. If the speed is greater than desired, then less fuel is delivered but this amount is never less than zero.

Part A:

Create a flowchart which illustrates to the investors how a cruise control system works.
Save your answers in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Part B:

Pseudo-code is a generic form of logic-based flow or system charting which is loosely based on computer coding. For example, a conditional flow structure written in pseudo-code could look like:

```
if [some condition is true]
then [do a certain process]
otherwise [do a different process]
```

Basically, the idea is to be able to transform a flowchart into a typed document where each step is a new line. This does NOT need to be any official programming language, but does need to be typed as concisely as possible.

Generate a set of pseudo-code for a cruise control system. Paste your code into a PDF file:
`Flowcharting_1_ACT_`*`login`*`.pdf`

---

[1] *Ward's Auto World* (Vol. 10). (1974). Pennsylvania State University: Ward's Communications.

Task 5 (of 5)

Objective: Create FBD's and flowcharts that illustrate an industrial design change process
Initial Keyboard Operator: Person with the most cousins

Background:

When constructing new buildings, engineering firms often provide support to the field in order to clarify or change design specifications. In order to ensure the highest quality possible, several checks are made on any design changes that leave the firm and are sent to the field for implementation.

The design change process begins when the onsite construction crews have a question regarding a specific construction detail. These questions are submitted in the form of Requests for Information (RFI's). When the firm receives an RFI, they first determine if it is a simple clarification question or a request for a design change. If the RFI simply asks a question that does not result in a change order, a Response Author is chosen. When the author has finished answering the question, the document is forwarded to the Reviewer, who has the option to either reject the answer or approve it. If the document is rejected, it is sent back to the author for revision. If the reviewer approves the response, it is sent to the supervising manager. The manager can reject the response and send it back to the author, or he/she can approve it, in which case it is sent to the field for implementation.

If the RFI is asking for a specific change to be made, a different process is started. An author is still chosen, and he/she must determine if the change to be made should be applicable to all future projects or just to the current project. If the change is deemed applicable to all future projects, an Applicability Reviewer must first be contacted to ensure that the correct decision has been made. After the applicability review, or if the change is deemed only applicable to the current project, an engineer writes the appropriate change order. If the change requested is anticipated to affect the construction schedule or cost the company more than $250,000, the change is determined to be major and warrants a full upper management review. Upper management has the option to reject the change and send it back to the engineer for revision, or to approve it and issue the change order to the field. If the change is minor, the process mirrors that of a simple question response, with a reviewer and a manager both having the option to reject or approve the change. Once all approvals are met, the change order is issued to the site.

Part A:

Make a Functional Block Diagram of the algorithm for the design change process (this is sometimes called a systems chart). Also, make a flowchart for the detailed design change process, starting with an RFI being sent to the engineering firm and ending with a document being sent to the field.

Save your answers in a PDF file: `Flowcharting_1_ACT_`*`login`*`.pdf`

Bonus Activity Submissions

Instructions: Complete and submit **ALL** Task materials associated with this Activity (see 'Submit Files' below). You are allowed to combine the work you and your team completed during the Activity with materials you individually (or as a team) complete outside of class. The Bonus Activity Submission will not be graded and returned to you like a typical assignment. Instead, it will be reviewed, and the bonus point awarded, for its completeness, i.e., for completing ALL the Tasks associated with the Activity. Submitting an incomplete Bonus Activity (something less than all of the Tasks) will be considered an act of **Academic Dishonesty** for which the penalty will be forfeiture of the opportunity to earn future Bonus Activity Submission points.

There are two options for completing the materials for the Bonus Activity Submission:

As an Individual: Combine the work you and your team completed in class with materials you have individually completed outside of class. When submitting an individual Bonus Activity Submission you will append your electric signature (i.e., your typed name) at the top of the file that represents your individual work. Your electronic signature indicates that this is your individual work and you have not collaborated with other individuals (other than the teaching team) to obtain the final materials being submitted – working with other individuals/groups (e.g., discussing ideas and concepts, helping find errors, talking about potential solutions to errors) is permissible up to the point where the work represents a collaboration (i.e., working with another person or group to achieve an answer). Any work previously completed by your team should include each team member's electronic signature. The significance of an electronic signature by an individual for team work is stated below.

As a Team or Ad Hoc Group: Combine the work you and your team completed in class with materials your team (or ad hoc group) completed outside of class **(For the Bonus Activity Submission ONLY**: you are allowed to work with any other members of the class to complete the assignment. However, you should exercise care when appending your electronic signature to ensure you are in full compliance). When submitting a Bonus Activity that has been worked on as a team (or ad hoc group) each person will append his/her electronic signature (i.e., his/her typed name) at the top of the file that represents the collaborative work. The electronic signature of each individual implies he/she: was an active participant in the preparation of the materials; and has a general understanding of **ALL** the materials being submitted. Even for work submitted as a team, each individual who wishes to receive credit must submit the team's file (with all appropriate signatures) to their own individual assignment drop box.

Submit Files: Submit *all* files electronically via Blackboard to the appropriate box on time.

F1. `Flowcharting_1_ACT_`*`login`*`.pdf`