Final Exam

CSCI 4443 & 6616

April 14, 2021 to May 14, 2021

Final

Disclaimer

- As I have stated all term I am looking for effort not necessarily results in the form of completely correct assembly code (although that would be nice!)
- With this in mind please work this problem to the best of your ability
- Write a professional design document
    - 60% will design (Documented Design)
    - 30% will be based on submitted code
    - 10% will be test & verification
- Do your best to code this up and if it doesn't quite work that's ok
- Ask questions on April 14, 21, 28 and May 5
- More importantly have fun!

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Design Document Layout

- Your document should have the following sections
  - Problem Statement & Objective
  - Design Trades - A description of your thought process or rationalization of your design choices
  - Design Layout
    - Top Level Functions (description, arguments, returns)
      - Help Functions (description, arguments, returns)
    - Data Flow
  - Assembly Code Listing
  - Test Case Cases & Descriptions
  - Open Issues
  - Overall Results

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Problem Statement

- You have been hired by Stark Industries to work on their new Jarvis Mark I Targeting Computer
- The Jarvis Mark I will be used on all Allied Battleships and will allow the engagement of up to six targets simultaneously
- A successful engagement will be considered placing a round within a 30 m radius of the target
- The interface to the Jarvis Mark I will be via an RS-232 link that will allow ASC II Data to be set to & from the Jarvis Mark I
- Your job will be to write the code to implement the targeting function assuming the targeting data is available in a buffer

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Targeting Data Input

- Assume that input data will be placed into a specified buffer by another Stark Product
- Data will be ASC II String Data as follows;
  - TAR N RNG XXXXX.XX BR YYY.YY SP SS.SS DIR ZZZ.ZZ NULL
  - TAR N will designate the target 1 to 6
  - RNG will be the range to the target in meters
  - BR will be the bearing to the target in degrees from True North (0 degrees)
  - Sp will be the speed of the target in meters per second
  - DIR will be the direction of the target in degrees from True North (0 degrees)
  - NULL is an ASC II Null or “0”
  - All data is ASC II encoded

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Equations of Motion

- The charge used will provide 200×10^6 N/Kg of force. Refer to this constant as K_{Charge}
- The length of the battleship barrel (L_{barrel}) is 10 m
- The Force causing the projectile to accelerate is only applied while the projectile is in the barrel
- The mass of the projectile ($m_{projectile}$) is 100 Kg
- The acceleration applied to the projectile ($a_{projectile}$)within the barrel is given via F=ma or (m_{Charge} x $1/K_{Charge}$)/$m_{projectile}$ in Newtons (N)
  - $L_{barrel}=.5*a_{projectile}*\ t_{barrel}{}^2$
- Use t_{barrel} = 100 mS or 0.1 S
- Solve for $a_{projectile}$ and then solve for initial velocity

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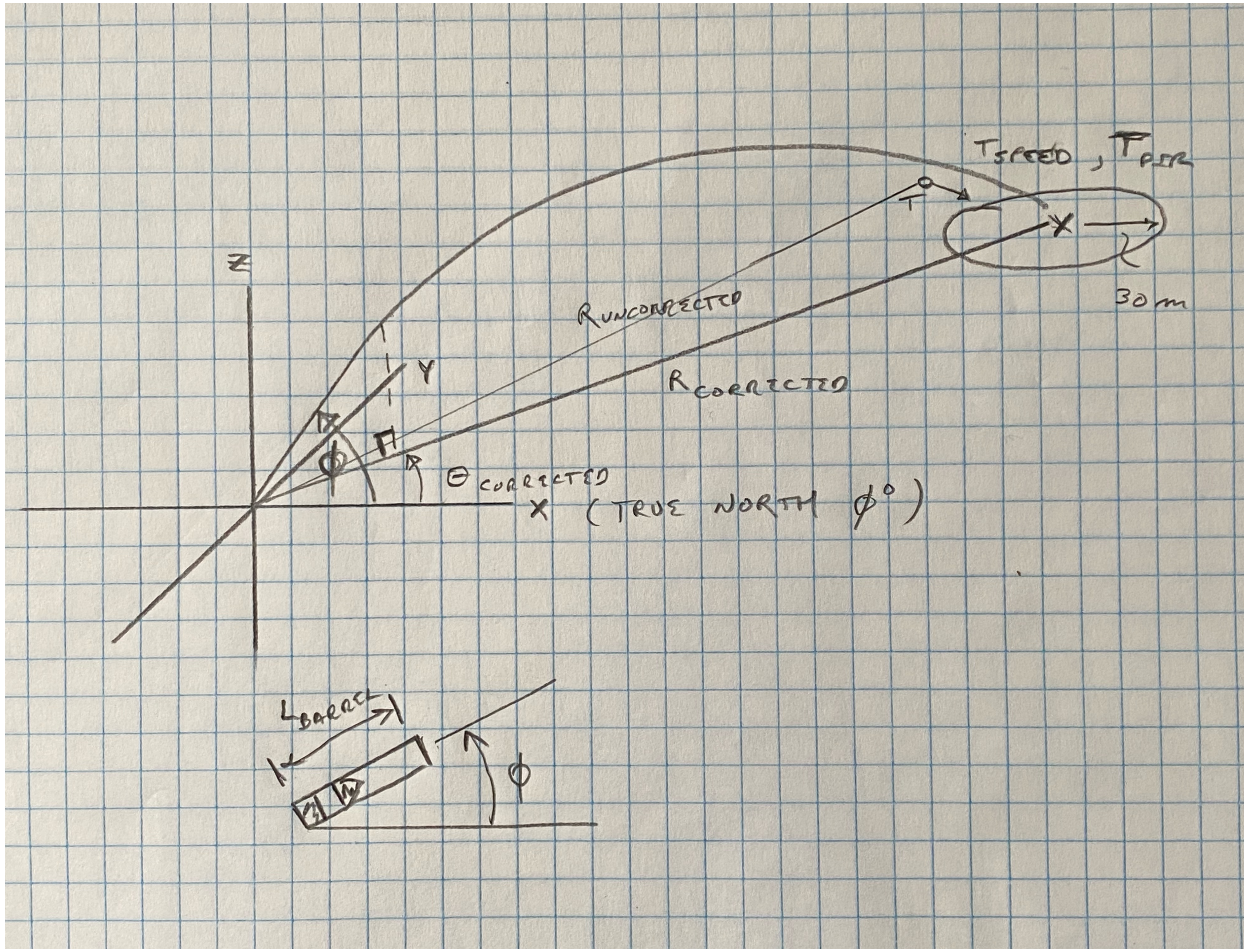
Geometric Representation



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Equations of Motion (Continued)

- Assume when the projectile exits the barrel that no additional force is applied from the charge to the projectile
- The velocity of the projectile at barrel exit is $v_{projectile\_init}=a_{projectile} \times t_{barrel}$
- The velocity of the projectile has an xy plane and z component given by the following;
  - $v_{proj\_init\_xyplane}=v_{projectile\_init} * \cos(phi)$
  - $v_{proj\_init\_z}= v_{projectile\_init} * \sin(phi)$
  - Where phi is the angle from the x axis to the z axis for elevation

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Equations of Motion (Continued)

- The time the projectile is in the air is governed by the amount of time the projective is above 0 elevation ($z > 0$) or $t_{flight\_uncorrected=}$ $(2 * v_{proj\_init\_z})/9.8$
- The range covered by the projective is given by
  - $R_{projectile\_uncorrected} = v_{proj\_init\_xyplane} * t_{flight\_uncorrected}$
  - This is referred to as uncorrected because we are initially shooting at where the target is now. The target will move while the projectile is in flight so we need to correct for this
  - We want ultimately the Corrected Range to the target to match the actual range and bearing to the target in order to score a hit at where the target will be
  - The correction required will be the additional time required to cover the addition distance the target will cover while the projectile is in transit

Final

Equations of Motion (Continued)

- The range to the target can be decomposed into x and y components
  - R_x = R * Cos(theta)
  - Ry = R * Sin(theta)
  - Theta is the bearing to the target from true North or 0 degrees & R is the range
  - Cos(x) and Sin(x) can be obtained via a Taylor Series
- The target change in position during the projectile flight time can also be decomposed into x and y components
  - D = V_{target} * $t_{flight\_uncorrected}$
  - D_x = D * cos(theta)
  - D_y = D * sin(theta)
  - Where theta is the target heading relative to 0 degrees (True North) **- NOTE THIS IS THE TARGET HEADING**

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Equations of Motion (Continued)

- The Aim Point Range, Bearing and Barrel Elevation can be determined from the vector sum of the initial range and range change
  - R_{Aim}=SQRT($(R_x + D_x)^2 + (R_y + D_y)^2$)
  - $Bearing_{Aim}$= $Tan^{-1}((R_y + D_y)/(R_x + D_x)$
  - $t_{flight\_corrected}$=$D/v_{projectile\_init}$+ $t_{flight\_uncorrected}$
  - $Elev_{Aim}$= $Cos^{-1}(R_{AIM}/(v_{projectile\_xy}*t_{flight\_corrected)})$
    - Tan^{-1} can be obtained via a Taylor Series
  - We can now calculate the mass of the actual charge required as $2*L_{barrel}*m_{projectile}/(K_{Charge} * t_{flight\_corrected}^2)$

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Program Output

- The output of the Jarvis Mark I will be a buffer loaded with ASC II String data as given below;
  - TAR N BR XXX.XX EV YY.YY CRG QQQ.QQ NULL
  - TAR N is the target number
  - BR is the corrected bearing to the target in degrees from true North
  - EV is the barrel elevation in degrees from the x axis
  - CRG is the charge required in kilograms
  - NULL is a Null Character
  - All data is ASC II encoded

Final

Project Output

- Please submit a word document detailing your design
- This document should include;
  - A description of how you have partitioned the design to accomplish the task
  - Detailed descriptions of your design modules (functions)
  - Detailed descriptions of your test cases and results
  - Proof of correct function
    - Hand calculations proving the output of your program is correct
  - The results of your program run against your hand calculated test cases

Final

Extra Credit +25 Points

- Provide an analysis showing how you can guarantee the requirement +/- 30 m accuracy requirement
  - This should focus on the Taylor Series Expansions and Data Types used along with th order of operations used

Final

Extra Credit +25 Points

- You may earn an additional +25 points if you implement the Jarvis Mark I using SIMD via the NEON Coprocessor
- This will allow the 6 targets solutions to be calculated in parallel for simultaneous engagement
- Please note this method of implementation will impact your entire design and test process
- It will also earn Stark Industries a additional $2 Billion in profit!
- Good Luck & Enjoy Your Summer Break!