CS 158/159 Homework 5

This assignment is worth 15 points and will be **due Monday March 26, 2018 at 11:00pm**. All assignment deadlines are firm and the ability to submit your assignment will be disabled after the deadline elapses. No late work will be accepted. You are encouraged to start this assignment as soon as possible so that you have ample time to seek assistance should you experience difficulties completing or submitting this assignment.

This programming assignment does not have a single solution, and the assignment you submit must be your own original work. **Collaboration with other students is not permitted on homework assignments.** Any submission may be processed with comparison software and the results will be used to detect unacceptable collaboration between individuals. If you need assistance, you should only consult course staff regarding your program.

Your program must adhere to the course programming standards (available in the course packet and in Blackboard). Please review this document before submitting your assignment, because failure to adhere to it will result in a reduction in points. Your program must include the designated program header (~cs15x/student/hdrProg) at the top of the program (which can be inserted in `vi` using the `hp` shortcut while in command mode). The header must include an appropriate description of your program and must contain your official Purdue career account e-mail address. Also note that course standards prohibit the use of advanced programming concepts not yet introduced in the course, unless otherwise specified.

Each of the example executions provided below represents a single execution of the program. Your program must accept input and produce output **exactly** as demonstrated in the example executions. Your program will be tested with the data seen in the examples below and an unknown number of additional tests making use of reasonable data. Do not include any example outputs with your submission.

A single program file (with the `.c` extension) must be submitted electronically via the `guru` server. An example submission was conducted during the first week in lab00. Any attempts to submit via another method will be denied consideration. You may make multiple submissions before the deadline, but only the last attempt is retained and graded. All previous submissions will be over-written and cannot be recovered. The submission script will reject the submission of any file that does not compile. A program must compile to be considered for partial credit. You should always check the confirmation e-mail you receive after a submission to verify that you have submitted the correct file, to the correct assignment, and to the correct lab section. If you have a concern regarding how to submit work, please visit course staff prior to the assignment deadline.

Problem: Your task is to calculate the work done on a system given a polynomial function of the second degree for the net force on the system. The work (W) done on a system is the area under the curve on a graph of the force (F, vertical axis) versus position (x, horizontal axis). Given the coefficients (A, B, C) for the function you will calculate the work using a method that approximates this area (from lower bound to upper bound of `x`-axis) using a given number of trapezoids (steps); calculate the exact value using integration; and compare the results.

$F[x] = Ax^2 + Bx + C$	Force function
$F'[x] = \frac{A}{3}x^3 + \frac{B}{2}x^2 + Cx$	Integrated force function
$\Delta x = \frac{x_N - x_0}{N} \qquad x_{j+1} = x_j + \Delta x$	Step Size (x_N upper bound, x_0 lower bound)
$W \approx \sum_{j=0}^{N-1} \frac{F[x_j] + F[x_{j+1}]}{2} \Delta x$	Trapezoidal sum approximation of work • `N` – number of trapezoids (steps)
$W = \int_{x_0}^{x_N} F[x]\mathrm{d}x = F'[x_N] - F'[x_0]$	Exact equation for work

Example Execution #1:

```
Enter coefficient A -> 3
Enter coefficient B -> 5
Enter coefficient C -> 7
Enter lower bound -> 10
Enter upper bound -> 20
Enter number of steps for trapezoidal sum -> 6

Integral of: (3.000) x^2 + (5.000) x + (7.000)
From x: 10.000 to 20.000

Using trapezoidal sum with 6 steps: 7833.889
Using exact equation: 7820.000
Trapezoidal sum error: 0.18%
```

Example Execution #2:

```
Enter coefficient A -> 3
Enter coefficient B -> 5
Enter coefficient C -> 7
Enter lower bound -> 10
Enter upper bound -> 20
Enter number of steps for trapezoidal sum -> 18

Integral of: (3.000) x^2 + (5.000) x + (7.000)
From x: 10.000 to 20.000

Using trapezoidal sum with 18 steps: 7821.543
Using exact equation: 7820.000
Trapezoidal sum error: 0.02%
```

Example Execution #3:

```
Enter coefficient A -> 0
Enter coefficient B -> 0
Enter coefficient C -> 9
Enter lower bound -> 3
Enter upper bound -> 11
Enter number of steps for trapezoidal sum -> 4

Integral of: (0.000) x^2 + (0.000) x + (9.000)
From x: 3.000 to 11.000

Using trapezoidal sum with 4 steps: 72.000
Using exact equation: 72.000
Trapezoidal sum error: 0.00%
```

Example Execution #4:

```
Enter coefficient A -> 5
Enter coefficient B -> 0
Enter coefficient C -> -2
Enter lower bound -> 5
Enter upper bound -> 15
Enter number of steps for trapezoidal sum -> 3

Integral of: (5.000) x^2 + (0.000) x + (-2.000)
From x: 5.000 to 15.000

Using trapezoidal sum with 3 steps: 5489.259
Using exact equation: 5396.667
Trapezoidal sum error: 1.72%
```

Example Execution #5:

```
Enter coefficient A -> 0
Enter coefficient B -> 11
Enter coefficient C -> 2
Enter lower bound -> 30
Enter upper bound -> 50
Enter number of steps for trapezoidal sum -> 3

Integral of: (0.000) x^2 + (11.000) x + (2.000)
From x: 30.000 to 50.000

Using trapezoidal sum with 3 steps: 8840.000
Using exact equation: 8840.000
Trapezoidal sum error: 0.00%
```

Example Execution #6 (input validation expectations demonstrated):

```
Enter coefficient A -> -4
Enter coefficient B -> 10
Enter coefficient C -> 3
Enter lower bound -> -5
Enter upper bound -> -10

Error: upper bound must be greater than lower bound!

Enter upper bound -> -8

Error: upper bound must be greater than lower bound!

Enter upper bound -> -5

Error: upper bound must be greater than lower bound!

Enter upper bound -> 5
Enter number of steps for trapezoidal sum -> 10

Integral of: (-4.000) x^2 + (10.000) x + (3.000)
From x: -5.000 to 5.000

Using trapezoidal sum with 10 steps: -310.000
Using exact equation: -303.333
Trapezoidal sum error: 2.20%
```

Additional Notes:

- As seen in the sixth example your program must ensure that the upper bound is greater than the lower bound. This is the only input validation requirement for this assignment. See the lecture notes for sample input validation code.
- Course standards prohibit the use of programming concepts not yet introduced in lecture. For this assignment you can only consider material in the first 6 chapters of the book, notes, and lectures. Use of advanced programming constructs beyond this material would result in a loss of points.