ECE 175 Computer Programming for Engineering Applications

Fall 2017

Relevant Programming Concepts:

- **User-Defined Functions**

1 Approximating π

The value of π can be approximated using the Nilakantha series

$$\pi \approx 3 + \frac{4}{2 \cdot 3 \cdot 4} - \frac{4}{4 \cdot 5 \cdot 6} + \frac{4}{6 \cdot 7 \cdot 8} - \frac{4}{8 \cdot 9 \cdot 10} + \frac{4}{10 \cdot 11 \cdot 12} - \frac{4}{12 \cdot 13 \cdot 14} + \cdots$$

Write a C function that calculates the value of π with a variable level of accuracy. For instance, if the desired accuracy is 10^{-6}, the absolute difference between the true value of π (see below) and the approximation from your function is less than 10^{-6}. Use the function prototype

```
double Pi_value(int numaccuracy);
```

ASSERT your function by running unit tests (see sec 5.7 in your Zybook) for values 1, 2, 3, 4, 5, 6

Examples of testing your function are

```
const double pi = 3.14159265358979323846643383;
assert(fabs(Pi_value(2) - pi) < pow(10.0, -2));
assert(fabs(Pi_value(6) - pi) < pow(10.0, -6));
```

2 Approximating $\sin(x^\circ)$

Given an angle in degrees, we can approximate the sin function as follows

$$\sin(x^\circ) \approx \frac{4x^\circ(180 - x^\circ)}{40500 - x^\circ(180 - x^\circ)}$$

Write a C function that implements the above equation. Use the following function prototype:

```
double sin_approx(double x_deg);
```

The above approximation is only valid for a certain range of x°. We wish to determine the range of values of x° where the approximation is valid. Compare the output of the above function to the output of the function given below

```
//You must include math.h for this function to work
double sind(double x_deg) {
  double pi, y;
  pi = Pi_value(10);
  y = sin(x_deg * pi / 180.);
  return(y);
}
```

Note: Your program should call the function Pi_value from problem 1 for the calculation of π.

Your main code should use the following steps

- Loop across values of x from -360 to 360 in steps of 1 degree
- Calculate Y1 = sin_approx(x);
- Calculate Y2 = sind(x);

- Calculate the error between the two. $err = |Y1 - Y2|$

- If err is small (say less than 0.0022) then approximation of sin is valid

- Report the range of x such that the approximation is a valid approximation.

3 Cone Volume and Height

You are given the volume $\boldsymbol{V}$ and height $\boldsymbol{h}$ of a cone. Write a C program that finds the radius r and side length l of the cone. Your program should call the function Pi_value from problem 1 for the calculation of π.
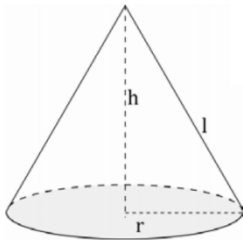
$$V = \frac{\pi r^2 h}{3}$$

$$l^2 = r^2 + h^2$$

Sample Code Execution: (Red entered by a user)

```
Enter the volume of the cone: 20.0
Enter the height of the cone: 0.0
No such cone exists
Do you want to continue (y/n) y
Enter the volume of the cone: 20.0
Enter the height of the cone: 3.3
The radius and side length of the cone are r = 2.406, l = 4.084
Do you want to continue (y/n) y
Enter the volume of the cone: 50.1
Enter the height of the cone: 5.3
The radius and side length of the cone are r = 3.004, l = 6.092
Do you want to continue (y/n) y
Enter the volume of the cone: 99.5
Enter the height of the cone: 4.22
The radius and side length of the cone are r = 4.745, l = 6.350
Do you want to continue (y/n) n
```