SOEN 6011

SOFTWARE PROCESSES

Deliverable 1 Problems 1 to 3 Function $sinh(x)$

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1 Function Description

It is a basic hyperbolic function which is better expressed in terms of exponential function sinh, denoted by $sinh(x) = \frac{e^x - e^{-x}}{2}$ This function represents a hyperbola, it could be seen like the trigonometric sin but sinh does not deal with triangles but hyperbolas, these hyperbolic function has an extended reputation on the physics filed, for example when "describing the shape of the curve formed by a high-voltage line suspended between two towers".

1.1 Domain

All the real numbers from -infinite to +infinite. This function is an odd function, because for all and each value of $x : sinh(-x) = -sinh(x)$ This function is a continuous function because its derivate is greater than 0. Where the set (0,0) is the inflection point.**??**

1.2 Co-Domain

All the real numbers from $- \propto to + \propto$

1.3 Characteristic of the function:

As per this formula $sinh(x) = \frac{e^x - e^{-x}}{2}$ we can infer for the resulting graph certain characteristics, for example, when x =0, e^x=1 and e^{-x}=1, so sinh 0 = 0 We can observe in the below graph 1 that when x gets larger, e^x increases quickly and decreases quickly. When x is negative, e^{-x} becomes large and negative very quickly, but decreases very quickly.

1.4 Graph

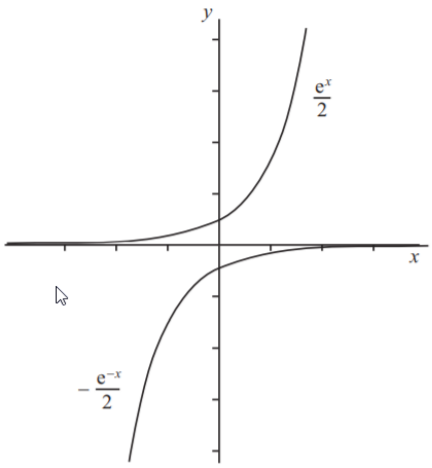

Figure 1: source. $http://www.mathcentre.ac.uk/resources/workbooks/mathcentre/hyperbolicfun$

2 Function Express Requirements

This report aims to describe the $y = sinh(x)$ function requirements and assumptions for a calculator application according to the ISO/IEC/IEEE 29148 standards. This function is expressed by the formula: $sinh(x) = \frac{e^x - e^{-x}}{2}$ where e is constant value.

2.1 Functional Assumptions

- Assumption 1
  - ID: FUNA1
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: Floating-point values are returned for floating-point arguments.
  - Rationale:when $x = 2.8$ $y = 8.19$
- Assumption 2
  - ID: FUNA2
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: $y = sinh(x) = 0$ when x =0, this is due to the nature of the formula $sinh(x) = \frac{e^x - e^{-x}}{2} = \frac{1-1}{2} = 0$ exact for finite x.
  - Rationale:$x = 0$

- Assumption 3
  - ID: FUNA4
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: The sinh(x) curve is positive where e^x is large, and negative where e^{-x} is large.
  - Rationale: e^x and e^{-x}

2.2 Requirements

- Requirement 1
  - ID: FUNR1
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: The arguments passed to the function sinh(x) shall be real numbers from $-\propto to+\propto$ and they can be expressed in radians.
  - Rationale:when $x = 2.2$, $y = 4.45$ where x expressed in radians.
- Requirement 2
  - ID: FUNR2
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: Euler's Number (e) is an irrational number which is a constant that has an approximate value of 2.71828, this value will be provided
  - Rationale: $(1 + 1/n)n$ where $n > 0$ and $n <= 1000$

- Requirement 3
  - ID: FUNR3
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: Power function, this function will be calculated
  - Rationale:for an even number $a^b = (a^2)^b/2$ odd $a^b = a * (a^2)^b/2$ for negative number $a^{-n} = 1/a^n$
- Requirement 4
  - ID: FUNR4
  - Version: 1.0
  - Type: functional
  - Owner: Jesus
  - PRIORITY: 1
  - Difficulty: Easy
  - DESC: Absolute value function, this function will be calculated
  - Rationale:for any real number $|-n| = n$ and for $|0| = 0$

3 Function $Sinh(x)$ Algorithms

The hyperbolic function Sinh of a given number x is denoted by the expression $sinh(x) = \frac{e^x - e^{-x}}{2}$ where e often called Euler's number is an irrational number which is usually calculated using the expression $e = (\frac{1+1}{n})^n$ where n is any natural number, the greater the n number is the closer to most commonly used value by this constant which is 2.71827.

3.1 Algorithms Description

The algorithm for calculating the $sinh(x)$ involves the implementation of different procedures such as the calculation of the e value which can be calculated using different approaches, the power of a number n^n, the power of a number n^{-n} and the calculation of the absolute value of a number $\mid n \mid$ where $n \in R$.
The procedure for calculating e was implemented using two different approaches, the first one is by resolving the expression $e = (\frac{1+1}{n})^n$. The second approached used for calculating the e value is by resolving the equation $e = (\frac{1}{0!} + \frac{1}{1!} + ... \frac{1}{n!})$ where ! is the factorial of n and n is any natural number.

The procedure for calculating the positive power of n was implemented using a recursive function and an iterative function.
The procedure for calculating the negative power of n was implemented using the expression $a^{-n} = \frac{1}{a^n}$.
The procedure for calculating the absolute value of $-n$ was implemented using the expression $abs(-n) = -n * -1$.

3.2 Algorithm 1 Advantages

The algorithm 1 uses a simple implementation of its involved functions which allows a better usage of the resources such as memory and processor, plus this algorithm applies the principle of Modularity which helps in the Maintainability of the system and in the Readability of the program.

3.3 Algorithm 1 Disadvantages

Some operations are set to a finite number of operations and some results could vary slightly when numbers are extreme large.

3.4 Algorithm 2 Advantages

The algorithm 2 is implemented applying the principle of separation of concerns, all the sub modules in the function are highly cohesive and low coupled, this allows the program being maintainable and change prone.

3.5 Algorithm 2 Disadvantages

The use of some recursive and iterative methods could demand more resources and make the application to have low performance when dealing with a great load of operations.

Algorithm 1 Calculate $sinh(x)$ Function

Require: value: $x from - \propto to + \propto$ ▷ where $x \in R$
Ensure: $result = \frac{e^x - e^{-x}}{2}$

procedure CalculatePower($base$, $exponent$)
  $power \leftarrow 1$
  for $i \leftarrow 1, exponent$ **do**
    $power \leftarrow power * base$
  end for
  return $power$ ▷ returns the power of a positive exponent
end procedure

procedure CalculateNegativePower(x)
  $power \leftarrow 0$
  $power \leftarrow \frac{1}{x}$
  return $power$ ▷ returns the power of a negative exponent
end procedure

procedure AbsoluteValue(x)
  $a \leftarrow x * -1$
  return a ▷ returns the absolute value of x
end procedure

procedure CalculateEuler( )
  $value \leftarrow 5000$ ▷ value is a set number
  $e \leftarrow 0$
  $calcule_e \leftarrow 0$
  $e \leftarrow \frac{1+1}{value}$
  $calcule_e \leftarrow$ CalculatePower($e, value$)
  return $calcule_e$ ▷ returns euler value
end procedure

procedure CalculateSinhX(x)
  $aux1 \leftarrow 0$ ▷ receives the value of positive power
  $aux2 \leftarrow 0$ ▷ receives the value of negative power
  $aux1 \leftarrow$ CalculatePower($CalculateEuler, x$)
  $aux2 \leftarrow$ CalculateNegativePower($aux1$)
  return $(aux1 - aux2) * 0.5$ ▷ returns sinh of x
end procedure

$result \leftarrow$ CalculateSinhX(x) ▷ Final result of $sinhx$

Algorithm 2 Calculate $sinh(x)$ Function, second approach for e and power

Require: value: $x from - \propto to + \propto$ ▷ where $x \in R$
Ensure: $result = \frac{e^x - e^{-x}}{2}$

procedure CalculatePower($base$, $exponent$)
  if $exponent \leftarrow 0$ **then**
    return 1 ▷ case base of the recursive function
  end if
  return $base *$ CalculatePower($n, exponent - 1$) ▷ recursive execution
end procedure

procedure CalculateNegativePower(n, x)
  $aux \leftarrow n$
  $x \leftarrow$ AbsoluteValue(x)
  for $i \leftarrow 2, x$ **do**
    $aux \leftarrow aux * n$
  end for
  return $response$ ▷ returns the power of a negative exponent
end procedure

procedure AbsoluteValue(x)
  $a \leftarrow x * -1$
  return a ▷ returns the absolute value of x
end procedure

procedure CalculateEulerFactorial(n)
  $aux \leftarrow 1$ ▷ auxiliar variable
  for $i \leftarrow 1, n$ **do**
    $aux \leftarrow aux * i$
  end for
  return aux ▷ returns euler factorial
end procedure

procedure CalculateEuler( )
  $aux \leftarrow 1$ ▷ auxiliar variable
  for $i \leftarrow 1, 10$ **do**
    $aux \leftarrow aux + (\frac{1}{\text{CalculateEulerFactorial}(x)})$
  end for
  return aux ▷ returns euler value
end procedure

procedure CalculateSinhX(x)
  $euler1 \leftarrow$ CalculatePower($CalculateEuler, x$)
  $euler2 \leftarrow$ CalculateNegativePower($euler1, x$)
  return $(euler1 - euler2) * 0.5$ ▷ returns sinh of x
end procedure

$result \leftarrow$ CalculateSinhX(x) ▷ Final result of $sinhx$

4 Acknowledgments

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Bibliography

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