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## Assignment # 5

**Question # 1 :** A function is given by  $f(x) = 6e^{-3x}$ . Now Answer the following:

1. [1 Mark] Calculate  $f'(x)$  at  $x = 0.5$  with  $h = 0.32$  using the central difference formula.
2. [1 Mark] Calculate  $f'(x)$  at  $x = 0.5$  with  $h = 0.16$  using the central difference formula.
3. [3 Marks] Now compute  $D_{0.32}^{(1)}$  at  $x = 0.5$  using Richardson extrapolation method.
4. [2 Marks] If the exact value of the derivative,  $f'(0.5)$  is  $-4.01634$ , find the percentage error with extrapolated value found in the previous part.

**Question # 2 :** In the lecture note and also in the video lecture, we have shown the general expression for  $D_h^{(1)}$ , which is known as the Richardson Extrapolation method to find the numerical derivative of a function. Using the same method, answer the following:

1. [2 Marks] Starting from the expression for  $D_h^{(1)}$ , write the expression for  $D_{h/2}^{(1)}$  up to order of  $\mathcal{O}(h^8)$ .
2. [3 Marks] Define the 6-th order approximation as the following

$$D_h^{(2)} \equiv \frac{2^4 D_{h/2}^{(1)} - D_h^{(1)}}{2^4 - 1}.$$



Now find an algebraic expression for  $D_h^{(2)}$  up to terms of order  $\mathcal{O}(h^8)$ .

**Question # 3:** A function  $f(x) = 3x^3 + 12x - 20$  has a root in the interval  $[0, 2]$ . Now, answer the following:

1. [4 Marks] Find the approximate root using Interval Bisection Method up to three iterations.
2. [2 Marks] If the actual root is  $x_* = 1.2165$  calculate the percent error of the approximate result found in the previous part.
3. [2 Marks] If the machine epsilon of the system is  $1.6 \times 10^{-8}$ , how many iterations are needed to find the root.

Submission of the Assignment #5:

- Solve all problems above.
- Prepare a title page including

**Your Name, Your ID#, Theory Section #.**

- Prepare a single .pdf or .jpg file containing the title page and the solution pages.
- To submit your assignment solution, visit the Submission Link (**Click here**). This will take you to a Google Form link.
- Fill up the Google Form link with correct information and upload the file there. You are done.

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