Numerical Methods for Engineers (5th Edition)

Step-by-step solution

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Relative error is given by the formula below:

$$\text{Relative error} = \left|\frac{\text{true value} - \text{approximate value}}{\text{true value}}\right|$$

Comment

Step 2 of 4

Consider the function:

$$f(x) = \frac{1}{\left(1-3x^2\right)^2}$$

Calculate the derivative of this function and get the equation:

$$f'(x) = \frac{6x}{\left(1-3x^2\right)^3}$$

Substitute $x = 0.577$ in the derivative:

$$\begin{aligned} f'(x) &= \frac{6\times 0.577}{\left(1-3\times 0.577^2\right)^3} \\ &= \frac{3.462}{\left(1-3\times 0.332929\right)^2} \quad \ldots\ldots (1) \\ &= \frac{3.462}{\left(1-0.998787\right)^2} \\ &= 2352911 \end{aligned}$$

There is no difficulty in to get the solution as the denominator does not come out to be zero in spite of being very close to it.

Comment

Step 3 of 4

Now, consider the 3-digit chopping case. Reduce the equation (1) into 3-digit arithmetic:

$$\begin{aligned} &= \frac{3.46}{\left(1-3\times 0.332\right)^2} \\ &= \frac{3.46}{\left(.004\right)^2} \\ &= \frac{3.46}{0.000004} \\ &= 216250 \end{aligned}$$

Hence, the solution in this case will come out as 216250. Now, the percentage of relative error can be calculated as:

$$\begin{aligned} \varepsilon_t &= \left|\frac{2352911-216250}{2352911}\right| \\ &= 90.8\% \end{aligned}$$

Comment

Step 4 of 4

Now, consider the 4-digit chopping case. Reduce the equation (1) into 4-digit arithmetic:

$$\begin{aligned} &= \frac{3.462}{\left(1-0.9987\right)^2} \\ &= \frac{3.462}{\left(.0013\right)^2} \\ &= \frac{3.462}{.00000169} \\ &= 2082521 \end{aligned}$$

Hence, the solution in this case will come out as 2048521. Now, the percentage of relative error can be calculated as:

$$\begin{aligned} \varepsilon_t &= \left|\frac{2352911-2048521}{2352911}\right| \\ &= 12.9\% \end{aligned}$$

Thus, the required error is $\boxed{12.9\%}$.

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$$K = \frac{c_c}{c_a^2 c_b}$$

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$$I = \int_a^b f(x)\,dx$$

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