CHAPTER-VI

Numerical Solution of Ordinary Differential Equations

6.1 Introduction

Differential equations are equations composed of an unknown function and its derivatives. The following are examples of differential equations:

$$\frac{dv}{dt} = g - \frac{c}{m} v \tag{6.1a}$$

$$m \frac{d^2 x}{dt^2} + c \frac{dx}{dt} + kx = 0 \tag{6.1b}$$

Differential equations can be classified as *ordinary differential equations* (ODE) or partial *differential equations* (PDE). ODEs are equations in which the function involves *one* independent variable. PDE's involve functions two or more variables. Both Eq.(6.1a) and Eq.(6.1b) are ordinary differential equations. Differential equations are also classified as to their order. For Eq.(6.1a) is a first-order equation because the highest derivative is a first derivative. A second order equation includes a second derivative, as in Eq. (6.1b) above. Similarly, an nth order equation includes an nth derivative.

This chapter is devoted to solving ordinary differential equations of the form

$$\frac{dy}{dx} = f(x, y) \tag{6.2}$$

One-step Runge-Kutta (RK) methods can be generally expressed as

$$y_{i+1} = y_i + \phi h \tag{6.3}$$

According to this equation, the slope estimate of ϕ is used to extrapolate from an old value y_i to new value y_{i+1} over a distance h. This formula can be applied step by step to compute values of y. The simplest approach is to use the differential equation to estimate the slope in the form of first derivative at x_i.

6.2 Euler's Method

The first derivative provides a direct estimate of the slope at x_i. That is,

$$\phi = f(x_i, y_i) \tag{6.4}$$

where $f(x_i, y_i)$ is the differential equation evaluated at x_i and y_i. This estimate can be substituted into Eq. (6.3):

$$y_{i+1} = y_i + f(x_i, y_i)h \tag{6.5}$$

This formula is referred to as *Euler's method*.

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John A Banks

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