

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:

$$\frac{dv}{dt} = g - \frac{c}{m} v \quad (6.1a)$$

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

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 n^{th} order equation includes an n^{th} derivative.

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

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

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

$$y_{i+1} = y_i + \phi h \quad (6.3)$$

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,

$$\phi = f(x_i, y_i) \quad (6.4)$$

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):

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

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

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Michael D. Greenberg



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