1 INTRODUCTION

Many issues of structural integrity can be cast as problems of linear elastic fracture mechanics (LEFM). These can include fatigue crack propagation and life prediction, other types of sub-critical crack growth, residual strength estimation, and brittle fracture. In these and other related problems, it is essential to be able to predict the onset of crack growth, and its rate, shape, and stability. The finite element method, as performed within modern high-performance and low-cost computing environments, is a natural tool for attacking such LEFM problems. Therefore, this chapter has two purposes. The first is to show how the finite element method (FEM) can be formulated and used to calculate the parameters needed by LEFM. The chapter describes:

- Representation of the elastic crack front singularity, Section 2
- Calculation of stress intensity factors (SIF) and energy release rates for two dimensional (2D), three dimensional (3D), and plate and shell idealizations, Section 3
- Prediction of crack trajectory and its stability, Section 4
- Calculation of rates of energy release rates and growth instability of 2D crack systems, Section 5
- Calculation of rates of energy release rates for 3D planar cracks, Section 6

The second purpose is to demonstrate how the FEM can be used to simulate the process of crack growth under LEFM conditions on example problems of practical scope, Section 7. All of the necessary background theory for LEFM can be found in Volume 2, Chapter

3. This chapter concentrates on developing the mathematical formulations of that theory that are in the context of the FEM and readily accessible by modern FEM codes.