Discontinuities arise in many different problems in mechanics. In some cases, a discontinuity is part of the exact solution, while in other cases a discontinuity is used to approximate a continuous field which has a very high gradient across a small length. This presentation will focus on computational methods for modelling discontinuities when the location of discontinuities is not known \textit{a priori}.

The failure of solids is usually characterised by the appearance of discontinuities. A crack in an elastic solid is the most obvious example. Another examples is a shear band. At one scale of observation, a shear band can be represented as a jump in the strain field across a finite width, while at another scale it can be considered as a displacement discontinuity across a surface. This is a case where a continuous field with high gradients across a small zone can be approximated as a discontinuity. Computationally, discontinuities can be captured by including discontinuous functions in the span of the basis used for interpolating a field. With the finite element method, including functions is the underlying basis allows discontinuities to propagate arbitrarily in a body, independent of the mesh structure. The key to including discontinuous functions in the underlying basis is treating finite element shape functions as \textit{partitions of unity}. This special property, which requires that a collection of continuous functions sum to unity everywhere in a body, allows the underlying basis to be locally enriched during a calculation by adding extra degrees of freedom to existing nodes. It will be shown that this method can be used to simulate discontinuities, completely independent of the finite element mesh structure and element size. The method is illustrated for mode-I (tension) and mode-II (shear) type failure problems under both quasi-static and dynamic loading.