This article covers the selection of policies for the timing of inspections or replacements, which are optimal according to some predefined criterion. The primary application of such policies is in problems of maintenance optimization. Mechanical devices, electrical components, and civil infrastructures are examples of items which generally need some form of maintenance. Inspections and replacements in various forms are actions that may be performed as part of a maintenance strategy. Repairs may be performed before an item has failed, in which case it is a preventive maintenance action, or it may be performed after an item has failed in which case it is a corrective maintenance action. Depending on the risk involved with the failure of an item, the decision maker will have a preference for one of these two types of maintenance actions.

The times at which failures occur are usually uncertain. For systems that depend on the availability of an item, for example, a conveyor belt in a production line, the failure of such an item results in unplanned and costly disruptions of production. It will therefore pay to perform inspections and repairs preventively. An optimal policy describes how often these inspections and repairs should be performed, such that the cost of these maintenance actions is well balanced against the cost of simply letting an item fail. The decision to preventively replace an item may be based on its condition, in which case the policy may also include the quality criteria by which an item will be deemed necessary to be replaced or not.

Optimal maintenance policies are obtained using mathematical models, which are almost always probabilistic in nature. Deterministic models are only applicable when the occurrence of failures is deterministic or when (probabilities of) the outcomes of an inspection are assumed to be known beforehand to the decision maker. Many models have been proposed for the purpose of optimizing maintenance actions of which Refs 1–10 all give an overview in some form or another. In the following section, many of the common assumptions that characterize these models are mentioned. The next section lists three cost-based criteria that can be used to compare different maintenance policies. This is followed by a section with the mathematical details of the two most common models: age-based and condition-based replacements.

### MODEL ASSUMPTIONS AND NOTATIONS

Maintenance models are built upon a number of assumptions that help to keep the calculations tractable. They also ensure that the resulting policies are easy to implement in practice.

Inspections are generally performed to determine the condition of an item. However, in some cases they may be required to ascertain if an item is still functional or not. This means that a failure of the item is not noticed until an inspection is performed. Inspections are almost always assumed to be instantaneous. This is generally a good approximation if the duration of an inspection is negligible compared to the lifetime of the item. The same assumption is often made for repairs, although there are many applications in which the duration of a repair is relevant. This is especially true for cases in which the availability of an item is an important operating characteristic of the maintenance policy. Inspections are either periodic or not, where in the latter case the times between inspections may differ. An example of an aperiodic inspection policy is one in which the frequency of inspections increases...