



**Definition**

The *skeleton* of the directed graph  $(V, E)$  is the undirected graph  $(V, F)$  where

$$F = \{\{v, w\} \subset V \mid (v, w) \in E \text{ or } (w, v) \in E\}.$$

In other words, the skeleton is an undirected graph whose vertex set is  $V$  and whose edges are all (unordered) pairs which appear as an ordered pair in the directed graph.

In the case that  $(V, E)$  is a directed graph and  $E$  is a symmetric relation, the skeleton of  $(V, E)$  is a natural undirected graph to associate with  $(V, E)$ . An *orientation* of an undirected graph  $G$  is a directed graph whose skeleton is  $G$ .

An *oriented graph* is a directed graph without self-loops satisfying the property for any two vertices  $x$  and  $y$ , either  $(x, y)$  or  $(y, x)$  is an edge, but not both. An oriented graph can be obtained from an undirected graph by selecting an “orientation” of the undirected edges.



