# Notes on Causality, Prediction and Search by Peter Spirtes

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## Notation and Basic Definitions:

### Graphs:

Notation for Edges:

**undirected edge** :

**directed edge** :

**non-directed edge** :

**partially directed edge** :

Note on Inducing Path Graph: contains both directed edges (e.g., ) , bi-directed edges (e.g., ), non-directed edges (e.g., ), and partially directed edges (e.g., ).

**Graph** (*traditional definition*): ordered pair where is a set of vertices and is a set of edges. The members of are pairs of vertices (an ordered pair in a directed graph and an unordered pair in an undirected graph). For example, the edge is represented by the ordered pair . We need to specify variables and **marks** at each end. In general, we will allow that the end of an edge can be unmarked, can be marked with an arrowhead , or can be marked with an . For example, the left end of can be represented as ordered pair , while the right end can be represented as the ordered pair . The entire edge is a set of ordered pairs representing the endpoints . The edge is the same as .

Note that a directed edge such as has no mark at the endpoint; we consider the mark at the A endpoint to be empty, but when we write out the ordered pair, we will use the notation to stand for the empty mark e.g.,

**Graph** (our definition): an ordered triple where is a non-empty set of vertices, is a non-empty set of marks, and is a set of sets of ordered pairs of the form , where and are in , , and and are in . Except in our discussion of systems with feedback we will always assume that in any graph, any pair of vertices and occur in at most one set in , or, in other words, that there is at most one edge between any two vertices. If we say that is over .

Figure 1: Example of directed graph

For example, the directed graph on Figure 1 can be represented as:

**edge**: any member of .

**edge-end**: each ordered pair

**endpoint**: each vertex in an edge

**adjacent endpoints:** vertices are adjacent iff there is an edge with endpoints

**undirected graph**: a graph in which the set of marks .

**directed graph**: a graph in which the set of marks .

**directed edge** from to : an edge

**edge into** : any edge

**edge out** of **:** any edge

**parent/child**: is parent of which is child of if there is a directed edge from to

**indegree** of vertex : the number of the parents of

**outdegree** of vertex : the number of children of

**undirected path** between and in graph : a sequence of vertices beginning with and ending with such that for every pair of vertices and that are adjacent in the sequence there is an edge in .

**edge is in path**: is in the path iff and are adjacent to each other (in either order) in .

vertices **adjacent on path**: if an edge between and is in the path we say that and are adjacent on .

**path is out of vertex**: if the edge containing in **an undirected** **path** between and **is** **out of** then we say that **path is out** of .

path is into vertex: if the edge containing X in a path between X and Y is into X we say that **the path is into** X.

## Introductory Notes

# Bibliography

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# Downloadable Links for the Bibliography

(Eells, 1991): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/eells_probabilistic_causality_1991.pdf)

(Reichenbach, 1956): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/the-direction-of-time-hans-reichenbach-ucal-press-1971.pdf)

(Spirtes, Glymour, & Sheines, 1993): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/CausationPredictionandSearch_Spirtes_CMU_2000.pdf)

(Otte, 1982): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/Probability_and_Causality_PhD_Thesis_Otte_1982.pdf)

(G.E. Hughes, 1996): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/ModelChecking/huges_cresswell_modal_logic.pdf)

(Salmon, Causality and Explanation, 1998): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/Causality_and_Explanation_Wesley_Salmon_1997.pdf)

(Salmon, Probabilistic Causality, 1980): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/Probabilistic_Causality_Salmon_1980.pdf)

(Good, 1961): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/CausalCalculus_part_I_and_II_Good_1960.pdf)

(Mackie, 1980): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/cement-of-the-universe-a-study-of-causation-JL-Mackie-1980.pdf)

(Lewis, Counterfactuals, 1973): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/books/Counterfactuals-lewis-1973.pdf)

(Lewis, Causation, 1974): [here](https://github.com/dimitarpg13/root_cause_analysis_and_model_checking/blob/main/literature/Lewis-Causation_1974.pdf)