**Eulerian Path**

- Every edge once
- \( O(1V + (1E)) \) - DFS
- Give you path

**Hamiltonian Path**

- Every vertex once
- No poly time alg.
- Cost Inst $10^{-6}$
- Give path

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**Problems in P**

- **MST**
- **SAT**
- **Sorting**
- **3-SAT**

- All problems where solution can be verified in poly time.

**Computers and Intractability**

C. H. Papadimitriou

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**NP Complete Problems**

- **3-SAT**
- **NAND**
- **NP**
- **co-NP**
- **NP**
- **co-NP**

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**Graphs**

- \( x, y, z \)
- \( n \) variables
- \( x^2 = t \)
- \( y = t \)
- \( z = t \)
SAT is hardest problem in NP

Input: a language in NP

HP is hardest problem in NP

\[ 3\text{CNF} \]

\[ (v \lor v \lor v) \land (v \lor v \lor v) \land (v \lor v \lor v) \land \ldots \land (v \lor v) \]

variable

implies the variable

\( p \) is NP-hard if it is at least as hard as any problem in NP

\( p \) is NP-complete if it is NP-hard and \( p \in \text{NP} \)

Graph coloring - verification \( O((|V| + |E|)\) 

\( 3\text{-SAT} \) \( \rightarrow \) \( 3\text{-COLOR} \)