DFS ON DIRECTED GRAPHS

- Same idea as for undirected graphs
- Outer procedure is called DEPTH-FIRST-SEARCH
- Invokes inner procedure DFS on any still unvisited node
- Tree edges are still edges on which new vertices discovered
- There can be:
    - Back edges (from descendants to ancestors)
    - Forward edges (from ancestors to descendants)
    - Right-to-left cross edges
- But no left-to-right cross edges (why?)

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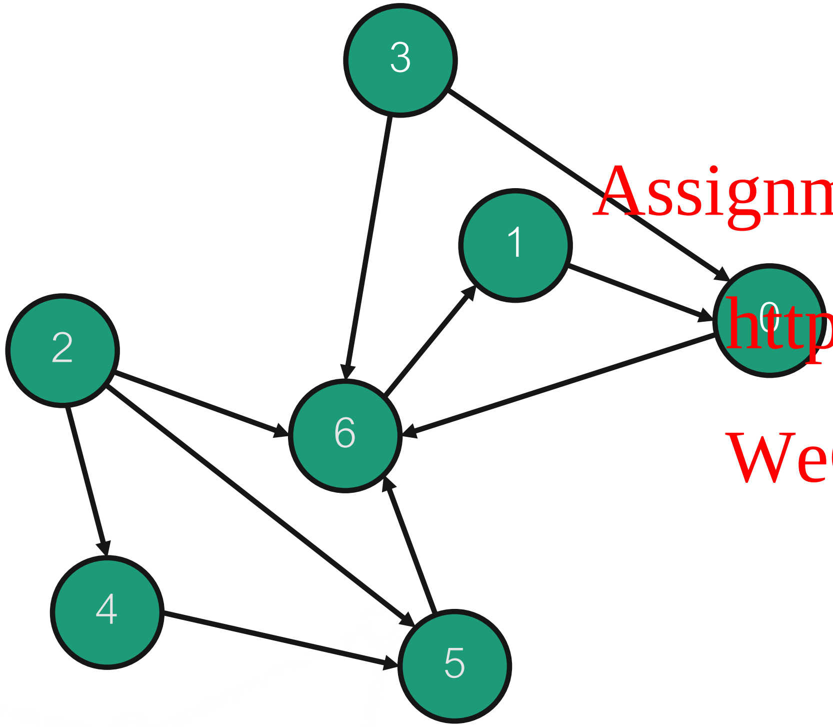
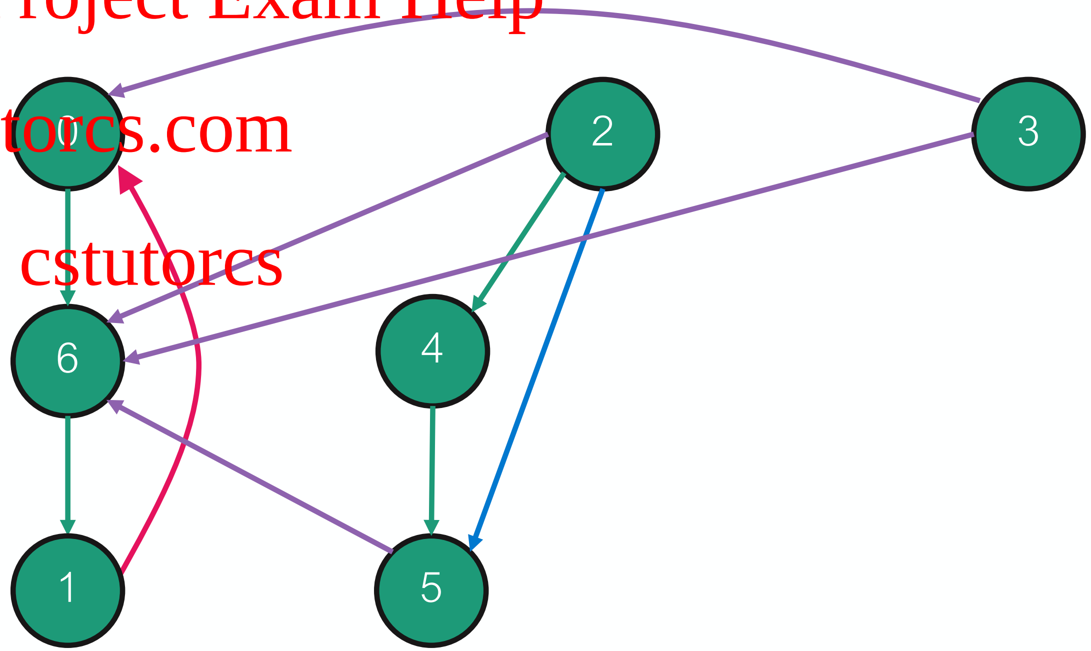
DFS ON DIRECTED GRAPHS

Example DFS traversal where ties between unseen vertices are broken by choosing the lower numbered vertex





TREE EDGE: GREEN CROSS EDGE: PURPLE

BACK EDGE: RED FORWARD EDGE: BLUE

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START AND FINISH TIMES

- ”Time” increments for each call to DFS and each end of DFS.
- In previous example:

Vertex	Start Time	Finish Time
0	1	6
1	3	4
2	7	12
3	13	14
4	8	11
5	9	10
6	2	5

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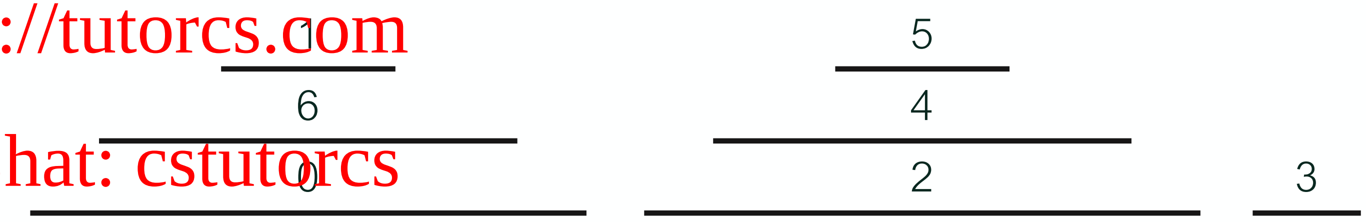

Schematic of intervals [$s(x)$, $f(x)$] for all vertices x

RUNNING TIME OF DFS

- Every edge examined once (twice for undirected graphs) $O(m)$
- Every vertex visited, undergoing two label changes

  Unseen to visited to finished $O(n)$
- Total running time $O(n+m)$
- For connected graphs: $m \geq n-1$ so it simplifies to $O(m)$

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