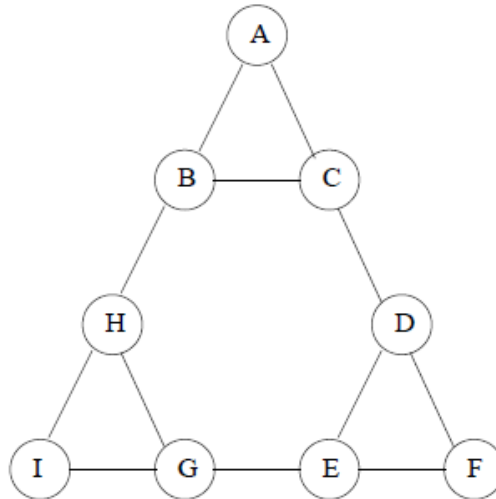


## Assignment 3 - Part 1

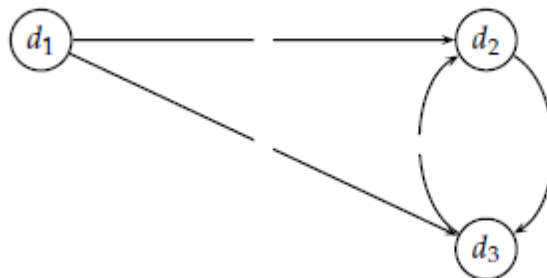
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**Question 1.** The figure below is an example of a social-network graph.



1. Use the Girvan-Newman approach to find the number of shortest paths from each of the following nodes that pass through each of the edges. (a) A (b) B.
2. Using symmetry, the calculations of part 1 are all you need to compute the betweenness of each edge. Do the calculation.
3. Using the betweenness values from part 2, determine reasonable candidates for the communities in Fig. 10.9 by removing all edges with a betweenness above some threshold.

**Question 2.** For the web graph in the figure below, compute PageRank, hub and authority scores for each of the three pages. Also give the relative ordering of the 3 nodes for each of these scores, indicating any ties.



**PageRank:** Assume that at each step of the PageRank random walk, we teleport to a random page with probability 0.1, with a uniform distribution over which particular page we teleport to.

**Hubs/Authorities:** Normalize the hub (authority) scores so that the maximum hub (authority) score is 1.

**Hint 1:** Using symmetries to simplify and solving with linear equations might be easier than using iterative methods.

**Hint 2:** Provide the relative ordering (indicating any ties) of the three nodes for each of the three scoring measures.