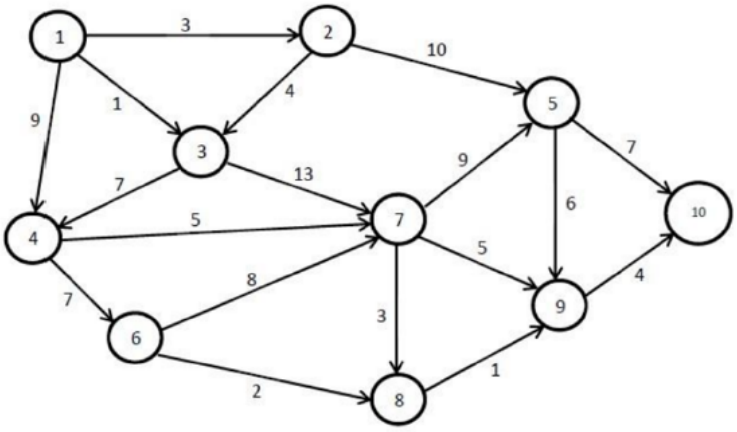
IE 400: Principles of Engineering Management
Study Set 5

Spring 2022

Question 1. Bob, Ed and Stu are in a car pool. They each live at the points 1, 2, and 7 respectively in the following network. They agree to meet at point 10 every morning at a certain time and proceed from there to their work in a single car. The numbers on the arcs represent the travel times in minutes.

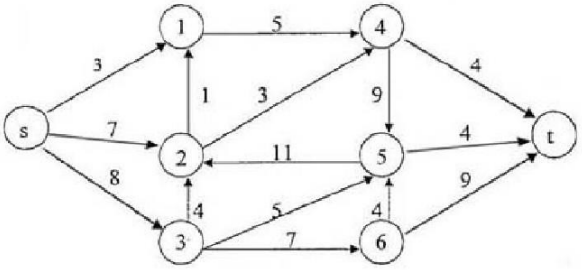


a) What is the fastest route for each man to the meeting point?

b) How early (continuing back from the meeting time) should each man leave?

c) Would anyone be agreeable to give another a ride to point 10?

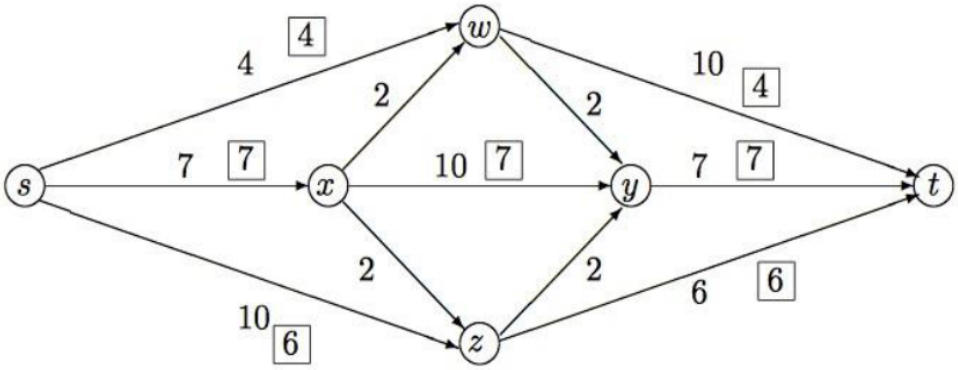
Question 2. Consider the following directed network. At node t, there is a large populated city and nodes 1, 2, 3, 4, 5, 6 are small populated areas. Experts predict that in a month the river at node s will flood and it will reach the city unless we block its way. The arc (i, j) on the network represents the route that a flood can use to reach node j from node i and the numbers on the arcs are the costs required to block that route.



Determine the minimal cost required to prevent the flood from reaching the city, node t. Show all your work and briefly explain your logic.

Question 3. The Hatfields, Montagues, McCoys, and Capulets are going on their annual family picnic. Four cars are available to transport the families to the picnic. The cars can carry the following number of people: car 1, four; car 2, three; car 3, three; and car 4, four. There are four people in each family, and no car can carry more than two people from any one family. Formulate the problem of transporting the maximum possible number of people to the picnic as a maximum-flow problem.

Question 4. The figure below shows a flow network on which an $s - t$ flow is shown. The capacity of each edge appears as a label next to the edge, and the numbers in boxes give the amount of flow sent on each edge. (Edges without boxed numbers have no flow being sent on them.)



(a) What is the value of this flow?

(b) Is this a maximum $s-t$ flow in this graph? If not, find a maximum $s-t$ flow.

(c) Find a minimum $s-t$ cut. (Specify which vertices belong to the sets of the cut.)

Question 5. A company is planning to manufacture a product that consists of three parts (A, B, and C). The company anticipates that it will take 5 weeks to design the three parts and to determine the way in which these parts must be assembled to make the final product. Then the company estimates that it will take 4 weeks to make part A, 5 weeks to make part B, and 3 weeks to make part C. The company must test part A after it is completed (this takes 2 weeks). The assembly line process will then proceed as follows: assemble parts A and B (2 weeks) and then attach part C (1 week). Then the final product must undergo 1 week of testing. Draw the project network, find the critical path and free float for each activity. Also set up an LP that could be used to find the critical path.

Question 6. You and several friends are about to prepare a lasagna dinner. The tasks to be performed, their immediate predecessors and their estimated durations are as follows:

Task	Description	Predecessor	Time (minutes)
A	Buy the mozzarella cheese	-	30
B	Slice the mozzarella	A	5
C	Beat two eggs	-	2
D	Mix eggs and ricotta cheese	C	3
E	Cut up onions and mushrooms	-	7
F	Cook the tomato sauce	E	25
G	Boil water	-	15
H	Boil the lasagna noodles	G	10
I	Drain the lasagna noodles	H	2
J	Assemble all ingredients	B,D,F,I	10
K	Preheat the oven	-	15
L	Bake the lasagna	J,K	30

(a) Construct the project network and find the critical path for preparing this dinner.

(b) Find the earliest start time, earliest finish time, latest start time, latest finish time and the slack for each activity.

(c) Because of a phone call, you were interrupted for 6 minutes when you should have been cutting the onions and mushrooms. By how much will the dinner be delayed? If you use your food processor, which reduces the cutting time from 7 to 2 minutes, will the dinner still be delayed?

(d) Formulate an LP model that would give the latest start time of activities without delaying the dinner.

Question 7. Consider the list of activities for an agricultural field:

Activity			Completion Time (Hours)		
	Description	Predecessor	Optimistic	Most Likely	Pessimistic
A	Excavation	-	5	6	7
B	Sprinkler installation	-	4	5	18
C	Planting	A	4	15	20
D	Irrigation	B,C	3	4	5
E	Fertilizer Utilization	A	5	16	18

(a) Determine the expected value and the variance of the completion time for each activity and find the critical path.

(b) Assuming that the normal distribution applies, determine the probability that the critical path will take between 18 and 26 days to complete.