

1. Draw a PERT network for the construction of a highway grade separation bridge consisting of the 27 activities listed below (use as few dummy arcs as possible to more directly represent the precedences). Some explanation of precedences as you see them should be explained. You can check terms using a dictionary. You might google a picture of a paving train!

1. Set up traffic detour
2. Order and deliver piles
3. Excavate for Abutment A
4. Excavate for Abutment B
5. Drive piles for Abutment A
6. Move pile driver to Abutment B
7. Drive piles for Abutment B
8. Construct footings for Abutment A
9. Construct footings for Abutment B
10. Construct Abutment A
11. Place backfill for Abutment A
12. Place backfill for Abutment B
13. Construct Abutment B
14. Construct bridge deck
15. Fabricate structural steel
16. Erect structural steel
17. Place backfill for approaches
18. Order and deliver bridge railings
19. Order and deliver guard rail
20. Erect bridge railing
21. Erect guard rail
22. Construct concrete curb and gutter
23. Set up paving train
24. Pave approach roadways
25. Delay seeding of slopes until April 1
26. Seed and sod approach slopes
27. Final inspection

2. A small-scale entrepreneur buys produce from growers and sells it to some corner groceries. She has collected data from the previous four years and used it to estimate prices and demand for apples as follows:

Month	Grower's Price (\$/kg)	Selling Price (\$/kg)	Demand (1000kg)
August	.80	.90	10
September	.55	.65	15
October	.55	.65	15
November	.55	.85	15
December	.75	1.00	13
January	.85	1.00	10
February	.95	1.20	10
March	<i>N/A</i>	1.20	10
April	<i>N/A</i>	1.20	9
May	<i>N/A</i>	1.00	7
June	<i>N/A</i>	.80	5
July	<i>N/A</i>	.80	5

From September to January, unlimited supplies are available from the grower, but there are limits of 15,000 kg for purchases in August and in February, and no apples available March through July. The entrepreneur has cold storage areas which can store up to 50,000 kg, but at a cost of 2.5 cents per kg per month. She will start August with no inventory and would like to end July with no inventory.

- a) Formulate as a network flow problem. Solve using LINDO or using LINGO (using idea outlined in the LINGO file for network flows). You will be phrasing the network flow problem as a linear programming problem in order to solve. I expect variables corresponding to flows on arcs with labels corresponding to the tail node and the head node. I can't offer you special purpose network flow software. In preparing the formulation use the idea of the apples as flow on arcs moving forward in time. Most nodes will have conservation of flow but one imagines a source node for your apples and a sink node corresponding to your demand. You will be seeking a minimum cost flow (perhaps with lower bounds as well as upper bounds on certain arc flows). Appeal to the flow decomposition theorem to ensure that the minimal flow you get corresponds to a feasible flow of apples.
- b) How would you determine (from your output) what price should she be willing to pay for apples available in March?
- c) How would you introduce the possibility of unmet demand, but at a cost. Do this by adding to the network flow formulation. We can estimate a cost of 5 cents per kg of unmet demand. (Unmet demand costs lost profits as well as reputation). No need to solve, just describe the formulation.