# IE 400: Principles of Engineering Management
# Study Set 5

Fall 2020

**Question 1.** 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 2.** 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.

**Question 3.** Solve the following linear programming problem using DP. Define stages, states and recursive function clearly.

$$\begin{aligned} \max\ & 2x_1 + 5x_2 \\ \text{s.t. } & 2x_1 + x_2 \leq 430 \\ & x_2 \leq 230 \\ & x_1, x_2 \geq 0 \end{aligned}$$

**Question 4.** An electric power utility forecasts that $r_t$ kilowatt-hours (kwh) of generating capacity will be needed during year t (the current year is year 1). At the beginning of each year, the utility must decide by how much generating capacity should be expanded. It costs $c_t(x)$ dollars to change generating capacity by x kwh during year t (x can be both positive and negative). During each year, 10% of the old generating capacity becomes obsolete and unusable (capacity does not become obsolete during its first year of operation). It costs the utility $m_t(i)$ dollars to maintain i units of capacity during year t. At the beginning of year 1, 100,000 kwh of generating capacity are available. Formulate a dynamic programming recursion that will enable the utility to minimize the total cost of meeting power requirements for the next T years.

**Question 5.** A company needs 15, 30, 10, 30 and 20 workers during each of the next five years. At present, the company has 20 workers. Each worker is paid \$30,000 per year. At

the beginning of each year, workers may be hired or fired. It costs $10,000 to hire a worker and $20,000 to fire a worker. A newly hired worker can be used to meet the current years worker requirement. During each year, 10% of all workers quit (workers who quit do not incur any firing cost). With dynamic programming, formulate a recursion that can be used to minimize the total cost incurred in meeting the worker requirements of the next five years.