IE 400: Principles of Engineering Management
Study Set 4 Solutions

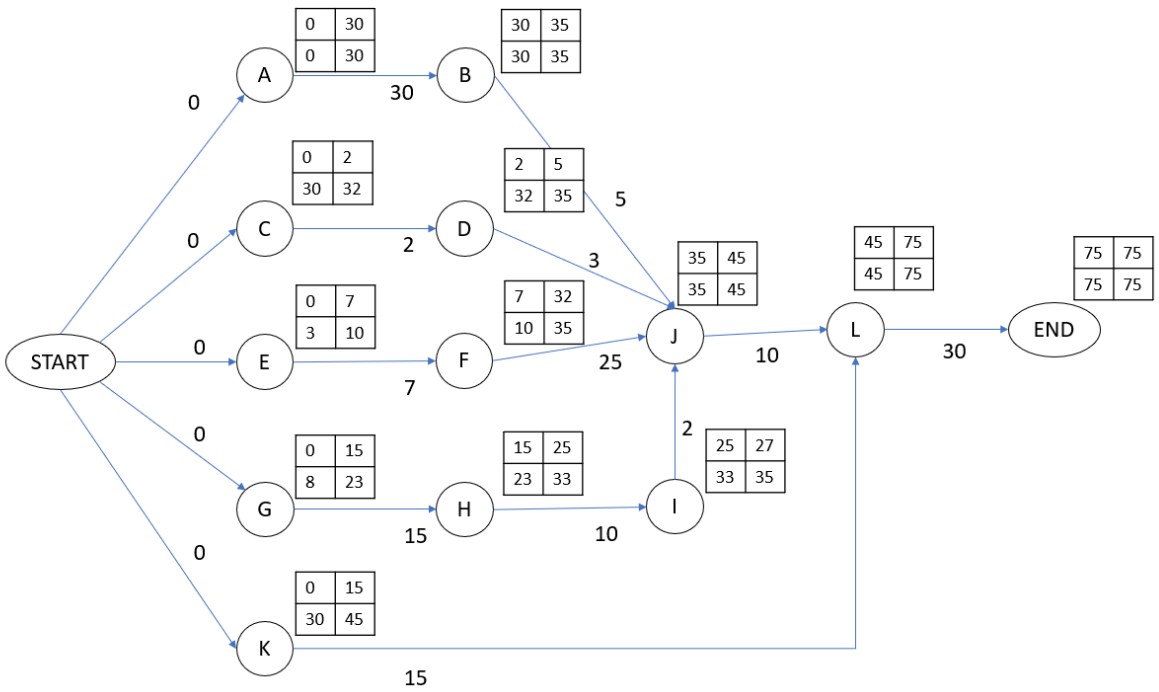
Summer 2020

Question 1.

ES: Earliest Start, EF: Earliest Finish, LS: Latest Start, LF: Latest Finish

ES	EF
LS	LF

(a)-(b)



Activity	Slack
A	0
B	0
C	30
D	30
E	3
F	3
G	8
H	8
I	8
J	0
K	30
L	0

(c) Since the slack for cutting the onions and mushrooms is 3, the dinner will be delayed 6-3=3 minutes.

If the cutting time is 2 minutes, slack is 10 (latest finish time) – 2 (task duration) = 8 minutes. Since the slack time is more than the delay time, it does not delay the dinner.

(d) Let N be the set of activities and A be the set of arc in the project network.

Parameters:

a_i : Duration of activity i, for all i $\in N$

d : Project duration (75)

Decision Variables:

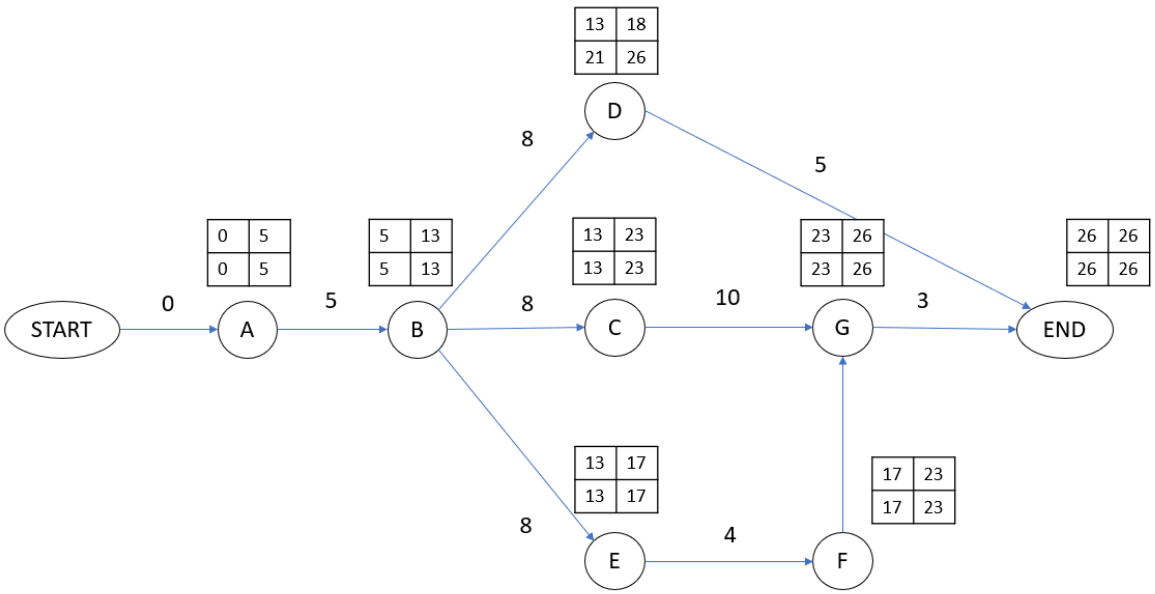
x_i : Start time of activity i, for all $i \in N$

Model:

$$
\begin{aligned}
\max \quad & \sum_{i \in N} x_i & \\
\text{s.t.} \quad & x_j \geq x_i + a_i & (i,j) \in A \\
& x_{end} \leq d & \\
& x_i \geq 0 & i \in N \\
& x_{start} = 0 &
\end{aligned}
$$

Question 2.

(a)



(b) D can be delayed for 8 days.

(c) Let N be the set of activities and A be the set of arc in the project network.

Parameters:

c_j : Cost of reducing the activity j

r_j : maximum reduction of the activity j

d_j : duration of the activity j

Decision Variables:

x_j : starting time of activity j $\in N$

y_j : Number of days that the duration of activity j is reduced

Model:

$$
\begin{aligned}
\min \quad & \sum_{j \in N} c_j x_j & \\
\text{s.t.} \quad & y_j \leq r_j & j \in N \\
& x_j \geq x_i + d_i - y_i & (i,j) \in A \\
& x_j \geq 0 & j \in N \\
& x_{start} = 0 & \\
& x_{end} \leq 20 & \\
& y_j \geq 0 & j \in N \\
& y_j \text{ integer} & j \in N
\end{aligned}
$$

By plugging in the parameters, we obtain the following model:

$$
\begin{aligned}
\min\ & 30y_A + 15y_B + 20y_C + 40y_D + 20y_E + 30y_F + 40y_B \\
\text{s.t.}\ & x_A \geq x_{start} \\
& x_B \geq x_A + 5 - y_A \\
& x_C \geq x_B + 8 - y_B \\
& x_D \geq x_B + 8 - y_B \\
& x_E \geq x_B + 8 - y_B \\
& x_G \geq x_C + 10 - y_C \\
& x_G \geq x_F + 6 - y_F \\
& x_{end} \geq x_G + 3 - y_G \\
& x_{end} \geq x_D + 5 - y_D \\
& x_{start} = 0 \\
& x_{end} \leq 20 \\
& y_A \leq 2 \\
& y_B \leq 3 \\
& y_C \leq 1 \\
& y_D \leq 2 \\
& y_E \leq 2 \\
& y_F \leq 3 \\
& y_G \leq 1 \\
& y_j \geq 0 \\
& y_j \text{ integer}
\end{aligned}
$$

Critical paths are A-B-C-F and A-B-E-F.

Question 3.

End of Year	Principal Repayment	Interest Repayment	Remaining Balance
0			\$10000
1	\$1671	\$900	\$8329
2	\$1821	\$750	\$6508
3	\$1985	\$586	\$4523
4	\$2164	\$407	\$2359
5	\$2359	\$212	\$0

Question 4.

Our aim is to obtain:

$$F = 2P$$

It is known that

$$F = P(1 + 0.15)^N$$

. Hence, we should find N that satisfies the following equality:

$$2P = P(1 + 0.15)^N$$

$$\log 2 = N \log(1.15)$$

$$N = 4.96 \text{ years}$$

Question 5.

$$\$25000 + \$30000 \underbrace{(P/F, 10\%, 6)}_{0.5645} = C \underbrace{(P/A, 10\%, 12)}_{6.814} + \$1000 \underbrace{(P/A, 10\%, 6)}_{4.355} \underbrace{(P/F, 10\%, 6)}_{0.5645}$$

$$39476.6025 = 6.814 \cdot C$$

$$C = 5793.4550$$

Question 6.

If we select the base period at $n = 0$:

$$\$100 \underbrace{(P/A, 13\%, 5)}_{3.517} + \$20 \underbrace{(P/A, 13\%, 3)}_{2.361} \underbrace{(P/F, 13\%, 2)}_{0.7831} = A \underbrace{(P/A, 13\%, 5)}_{3.517}$$

$$388.678 = A \cdot 3.517$$

$$A = 110.5141$$

Question 7. Selecting the base period at $n = 3$:

$$\$950(i+1)^3 + \$200 = \$250(i+1)^2 + \$350(i+1) + \$700$$

$$950i^3 + 2850i^2 + 2850i + 1150 = 250i^2 + 850i + 1300$$

$$950i^3 + 2600i^2 + 2000i - 150 = 0$$

$$i = 6.87\% \text{ (only positive real root)}$$