Review

1 JIT AND LEAN PRODUCTION: PRECEDENCE NETWORK

Problem 1

The following list contains information related to the major activities of a research project. Use the information given to do the following:

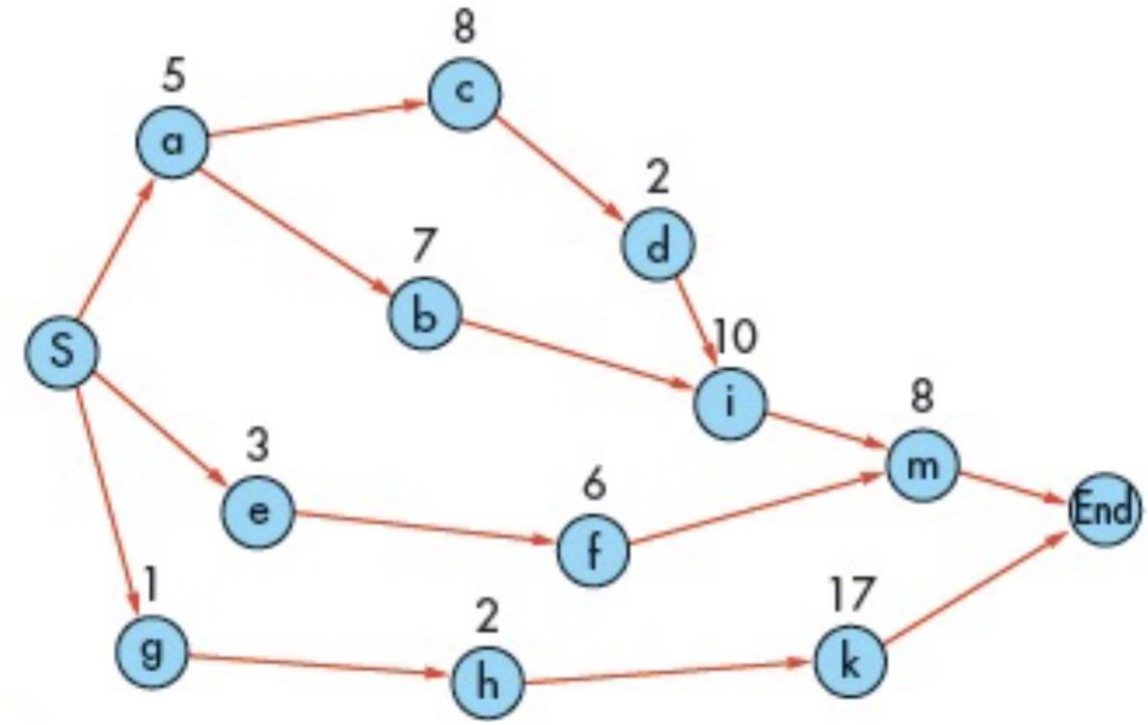
a. Draw the precedence network.

b. Find the critical path by identifying all the start-to-end paths and calculating their lengths.

c. What is the expected duration of the project?

Activity	Immediately Precedes	Expected Duration (days)
a	c, b	5
c	d	8
d	i	2
b	i	7
e	f	3
f	m	6
i	m	10
m	End	8
g	h	1
h	k	2
k	End	17

a. Precedence network:



Review

b. Critical path:

Path	Length (days)
$S - a - c - d - i - m - End$	$5 + 8 + 2 + 10 + 8 = 33$
$S - a - b - i - m - End$	$5 + 7 + 10 + 8 = 30$
$S - e - f - m - End$	$3 + 6 + 8 = 17$
$S - g - h - k - End$	$1 + 2 + 17 = 20$

Critical path: $S - a - c - d - i - m - End$.

c. Expected duration:

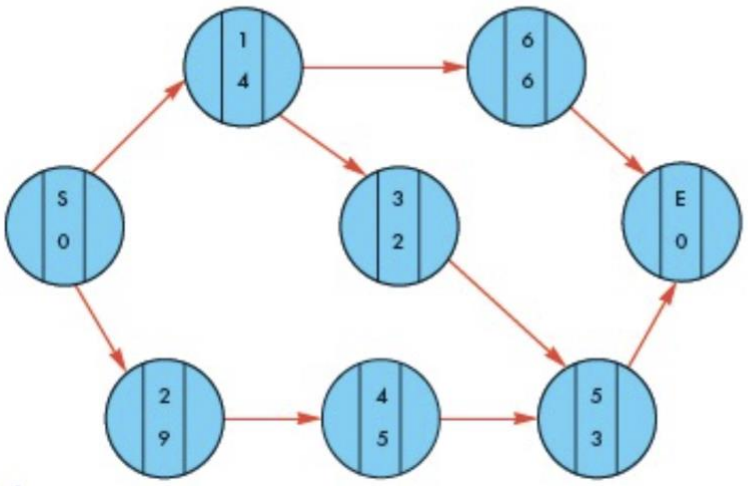
Expected project duration $= 33$ days.

Review

2 JIT AND LEAN PRODUCTION: PERT/CPM, SLACK TIMES

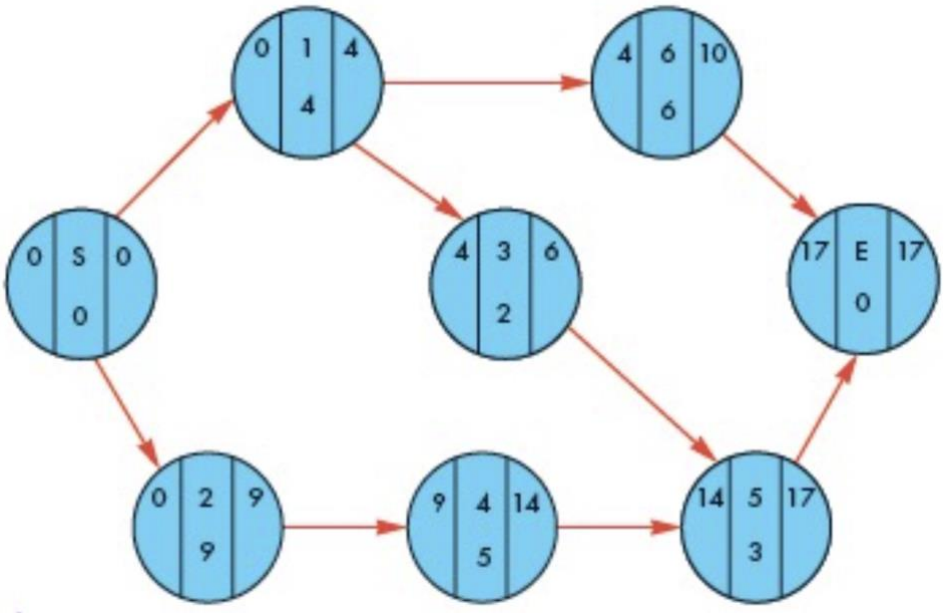
Problem 2

Using the PERT/CPM solution technique, determine the ES, EF, LF, LS, and slack times for each activity in the following precedence network (durations are in days). Identify the activities that are on the critical path.



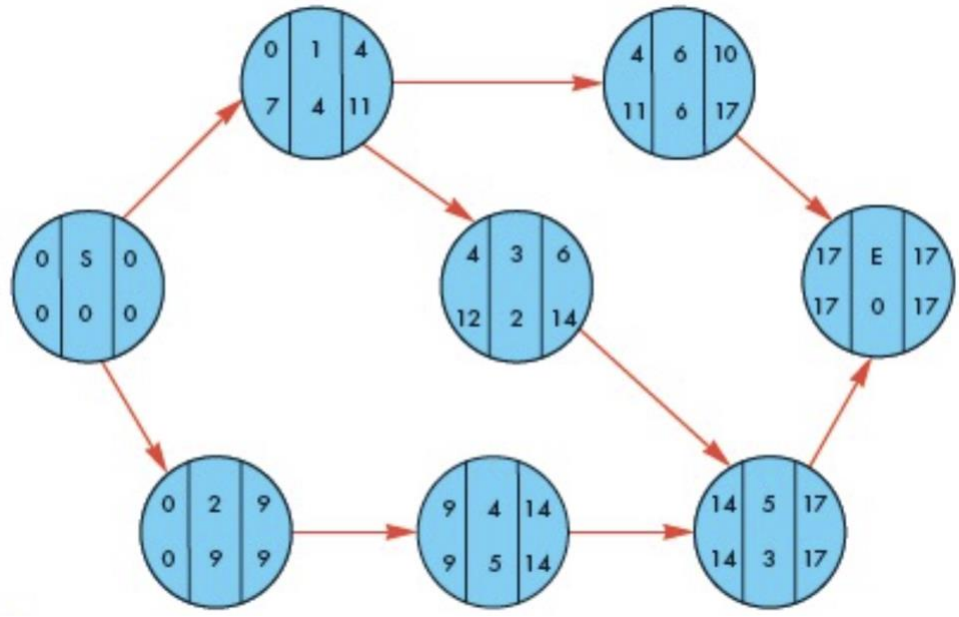
Determine and place the ES, EF, LS, and LF times for each activity in its circle as follows:

Forward pass to get ES and EF:



Review

Backward pass to get LS and LF:



The slack time for an activity is the difference between either LF and EF or LS and ES. Thus,

Activity	**LS**	**ES**	**Slack**	**or**	**LF**	**EF**	**Slack**
S	0	0	0		0	0	0
1	7	0	7		11	4	7
6	11	4	7		17	10	7
3	12	4	8		14	6	8
2	0	0	0		9	9	0
4	9	9	0		14	14	0
5	14	14	0		17	17	0
E	0	0	0		0	0	0

Critical path: $S - 2 - 4 - 5 - E$

Review

3 JIT AND LEAN PRODUCTION: KANBAN 1

A manager wants to determine the number of *kanbans* to use in a new process for a part. The process will have a usage rate of 80 pieces of the part per hour. Because the process is new, the manager has assigned a safety factor of 1.0. Each container holds 45 pieces and a *kanban* will take an average of 75 minutes to complete a cycle. How many *kanbans* should be used? As the system improves, will more or fewer *kanbans* be required? Why? LO6

$D = 80$ pieces per hour

$X = 1.0$

$C = 45$ pieces

$T = 75$ minutes $= 1.25$ hours

$N = ?$

$$N = \frac{DT(1+X)}{C} = \frac{80(1.25)(1+1.0)}{45} = 4.4\ [use\ 4\ of\ 5\ containers]$$

As the system improves, fewer containers will be required because wait times, set up times, and process variability will decrease.

Review

4 JIT AND LEAN PRODUCTION: KANBAN 2

A JIT/lean system uses *kanban* cards to authorize production and movement of materials. In one portion of the system, a work centre uses an average of 100 pieces of a part per hour. The manager has assigned a safety factor of .50. Standard containers are designed to hold six dozen pieces each. The cycle time for a kanban is 105 minutes. How many *kanbans* are needed? LO6

$D = 100$ pieces per hour

$X = 0.50$

$C = 6 \times 12 = 72$ pieces

$T = 105$ minutes $= 1.75$ hours

$N = ?$

$$N = \frac{DT(1+X)}{C} = \frac{100(1.75)(1+0.50)}{72} = 3.65\ [round\ to\ 4\ containers]$$

Review

5 AGGREGATE OPERATIONS PLANNING: FORECASTS, TOTAL COST

Given the following forecasts and steady regular output of 550 every month, what total cost would result if overtime is limited to a maximum of 40 units a month, and subcontracting is limited to a maximum of 10 units a month? Unit costs are: LO2

Regular output = $20

Overtime = $30

Subcontract = $25

Inventory per month = $10

Backorder per month = $18

Month	1	2	3	4	5	6
Forecast	540	540	570	590	600	580

Step 1: Check for backorders.

Month	1	2	3	4	5	6	Total
Forecast	540	540	570	590	600	580	3,420
Output							
Regular	550	550	550	550	550	550	3,300
Part Time							0
Overtime							0
Subcontract							0
Output – Forecast	10	10	−20	−40	−50	−30	−120
Inventory							
Beginning	0	10	20	0	0	0	
Ending	10	20	0	0	0	0	
Average	5	15	10	0	0	0	30
Backorder	0	0	0	40	90	120	250

There are backorders in months 4, 5, and 6: $40 + 50 + 30 = 120$ units, so account for them.

Step 2: Calculate total cost.

Review

Month		1	2	3	4	5	6	Total
Forecast		540	540	570	590	600	580	3,420
Output								
Regular		550	550	550	550	550	550	3,300
Part Time								0
Overtime					30	40	20	90
Subcontract					10	10	10	30
Output – Forecast		10	10	−20	0	0	0	0
Inventory								
Beginning		0	10	20	0	0	0	
Ending		10	20	0	0	0	0	
Average		5	15	10	0	0	0	30
Backorder		0	0	0	0	0	0	0
Costs								
Regular	$20	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$66,000
Part Time								$0
Overtime	$30	$0	$0	$0	$900	$1,200	$600	$2,700
Subcontract	$25				$250	$250	$250	$750
Hire/Layoff								$0
Inventory	$10	$50	$150	$100				$300
Backorders	$18	$0	$0	$0	$0	$0	$0	$0
		$11,050	$11,150	$11,100	$12,150	$12,450	$11,850	$69,750

Total cost = $69,750.

Review

6 SUPPLY CHAIN MANAGEMENT: LOGISTICS, CHEAPEST TOTAL COST

Pratt & Whitney, a major aircraft engine manufacturer, wants to re-evaluate the transportation mode it uses to send unfinished parts to its joint-venture facility in Chengdu, China.[4] Annual demand is 2,900 units. At present the company uses air freight. It takes approximately six days from Los Angeles to Chengdu (including pickup and delivery and customs delays). There are 20 parts in a lot, each weighing 30 kilograms. The air freight cost per part is $90. The pickup and delivery charges at origin and destination add up to $15 per part. The alternative is to use an ocean liner to ship the parts to Shanghai and from there to either use a truck or a train (a 2,000 km distance). The ocean freight for this lot size will cost $30 per part and will take 15 days. The truck from Shanghai to Chengdu will cost $20 per part and will take six days (including pickup and delivery and customs delays). Transportation by rail will cost $15 per part and will take 14 days (including pickup and delivery, customs, and transfer delays). In addition, for rail there is a $10 per part charge for pickup and delivery. The company's inventory holding cost rate is 12 percent per year, and the value of each part is $1,000. Assume 365 days per year. LO2

Due to variability of lead times, at the destination, safety stocks of 60, 210, and 290 units will be kept if air, ship and truck, and ship and train are used, respectively. Determine the cheapest (total freight, delivery, and in-transit and safety holding cost) mode of transportation for these parts. *Hint:* The value of a part in Chengdu for calculating the safety-stock holding cost should include the freight cost.

Mode	Duration (days)	Cost ($) Per Part
Air	6	$90 + 15 = 105$
Ocean, Truck	$15 + 6 = 21$	$30 + 20 = 50$
Ocean, Train	$15 + 14 = 29$	$30 + 15 + 10 = 55$

Annual freight and delivery cost = cost per part × annual demand.

Mode	Annual Freight and Delivery Costs
Air	$\$105 \times 2{,}900 = \$304{,}500$
Ocean, Truck	$\$50 \times 2{,}900 = \$145{,}000$
Ocean, Train	$\$55 \times 2{,}900 = \$159{,}500$

Review

Annual in-transit holding cost = value per part × holding rate × $\frac{duration}{365}$ × annual demand.

Mode	Annual In-Transit Holding Costs
Air	$\$1{,}000 \times 0.12 \times \frac{6}{365} \times 2{,}900 = \$5{,}720.55$
Ocean, Truck	$\$1{,}000 \times 0.12 \times \frac{21}{365} \times 2{,}900 = \$26{,}460$
Ocean, Train	$\$1{,}000 \times 0.12 \times \frac{29}{365} \times 2{,}900 = \$36{,}714$

Annual safety stock holding cost = safety stock × (value per part + cost per part) × holding rate.

Mode	Annual Safety Stock Holding Costs
Air	$60 \times (\$1{,}000 + \$105) \times 0.12 = \$7{,}956$
Ocean, Truck	$210 \times (\$1{,}000 + \$50) \times 0.12 = \$26{,}460$
Ocean, Train	$290 \times (\$1{,}000 + \$55) \times 0.12 = \$36{,}714$

Total cost = Freight and delivery cost + In-transit holding cost + Safety stock holding cost.

Mode	Annual Total Cost
Air	$\$304{,}500 + \$5{,}720.55 + \$7{,}956 = \$318{,}176.55$
Ocean, Truck	$\$145{,}000 + \$20{,}021.92 + \$26{,}460 = \$191{,}481.92$
Ocean, Train	$\$159{,}500 + \$27{,}649.32 + \$36{,}714 = \$223{,}863.32$

The cheapest mode of transportation for these parts is by ocean and truck.