**Question 1**

Let be the amount of materials delivered by mode j in week i, where

Constraints:

Objective: Minimize

**Question 2**

Let be the amount of products deliver from plant i to center j,

Objective: Minimize 45

Constraints:

**Question 3**

Let be the binary variable being 1 if project i is selected, being 0 if project i is not selected, where

Let be the amount of funds carried out in year j,

Objective: Maximize

Constraints:

**Question 4**

Average time a customer spends in the customer service area is W (expected total time in system)

**Question 5**

Average number of customers in the customer service area is L (expected number in system)

**Question 6**

1. M-M-1
2. 66.67%
3. ~~2~~ 1.333 average # customers waiting for a haircut = Lq
4. 0.1667 hour
5. 0.25 hour

**Question 7**

1. CMP network

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Activity** | **Duration** | **ES** | **EF** | **LS** | **LF** | **Slack** | **Critical** |
| A | 5 | 0 | 5 | 0 | 5 | 0 | yes |
| B | 3 | 5 | 8 | 10 | 13 | 5 | no |
| C | 4 | 5 | 9 | 5 | 9 | 0 | yes |
| D | 7 | 9 | 16 | 13 | 20 | 4 | no |
| E | 6 | 9 | 15 | 9 | 15 | 0 | yes |
| F | 5 | 15 | 20 | 15 | 20 | 0 | yes |
| G | 4 | 20 | 24 | 20 | 24 | 0 | yes |

It should take 24 days to complete. The critical path is ACEFG.

1. Paths

|  |  |
| --- | --- |
| **Path** | **Duration** |
| ABDG | 19 |
| ACDG | 20 |
| ACEFG | 24 |

**Question 8**

The critical path is ADH and the time required is 17 to complete the project.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Path** | **Normal** | **H\*2** | **D&G** | **A&G** | **A&B** |
| ADH | 17 | 15 | 14 | 13 | 12 |
| ADF | 13 | 13 | 13 | 12 | 11 |
| BH | 15 | 13 | 13 | 13 | 12 |
| BF | 11 | 11 | 11 | 11 | 10 |
| BG | 15 | 15 | 14 | 13 | 12 |
| BE | 12 | 12 | 12 | 12 | 11 |
| CE | 9 | 9 | 9 | 9 | 9 |
| **Crashing cost** | | 400 | 550 | 600 | 800 |

By crashing, the project duration can be reduced to 12. This crashing policy is 2H, 1D, 2G, 2A, 1B. It will cost 2350 for crashing. The 3 critical paths obtained are ADH, BH, BG.

0

**Question 9**

0

+100

-100

30

40

50

80

50

Let be the amount of crude oil flow from node i to node j, where

Objective: Minimize

*Constraints:*

**Question 11**

Let and be the amount of overachieve and underachieve the goal I,

Let be the amount of door style j produced, which

Objective: minimize

Constraints:

**Question 12**

Let Q be the minMax dummy variable

Let be the amount of door style j produced, which

Objective: Minimize Q

Constraints: