Chapter 4
Planning Projects

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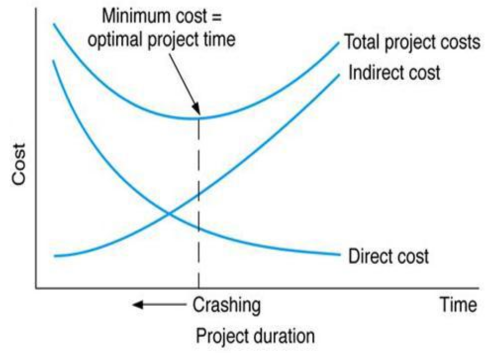
Crashing of the project

- Project crashing is the method for shortening the project duration by reducing the time of one or more critical activities to less than their normal time.
- Crashing is achieved by devoting more resources. Thus the cost associated with the project is increased.
- Objective:

i. To reduce project duration

ii. While minimizing cost of crashing.

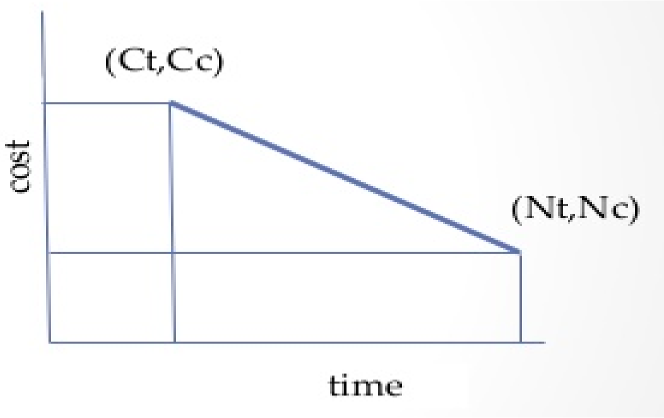


- In Crashing, if cost increases then time decreases. Time and cost are thus inversely related.

Cost Slope

- Cost Slope = $\frac{\boldsymbol{C_c - N_c}}{\boldsymbol{N_t - C_t}}$

where N_t: Normal time, N_c: Crashing time, C_t: Cost of activity in N_t and C_c: Cost of activity in N_c



Algorithm for Crashing

Step 1: Determine the normal Critical path and identify the critical activities.

Step 2: Calculate cost slope or increment cost per unit time for different activities.

Step 3: Rank activities in ascending order as per their cost slopes.

Step 4:

1. Crash activities of critical path as per lowest cost slope first.
2. Calculate the new direct cost by adding cost of crashing to the normal cost.

Step 5: Since Critical path duration is reduced so other path also become critical. Project duration can be reduced by simultaneously crashing activities in the parallel critical path.

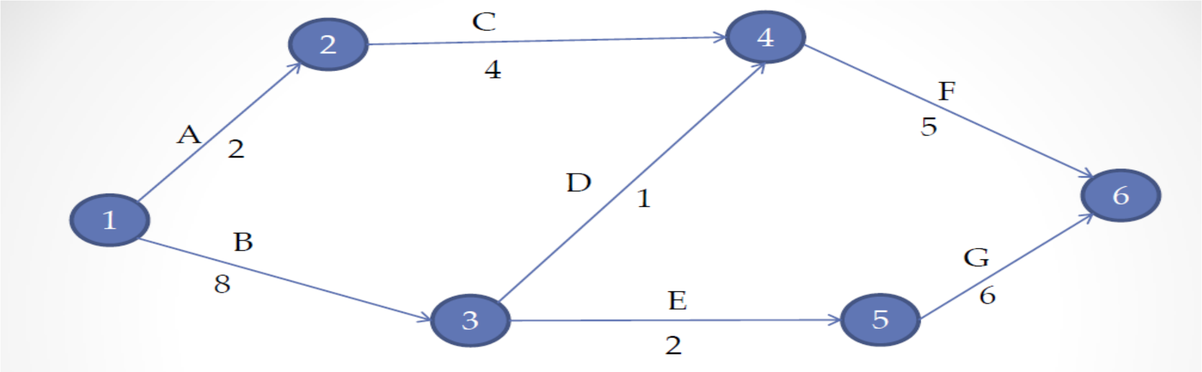
Step 6: By crashing as per step4 and 5, a point is reached when either no crashing is possible or crashing does not result in the reduction of project duration.

Example 1: Following are the time and cost details of the project.
Find the minimum possible time of the project and the minimum cost associated with it.

Activity	Predecessor	Normal Time	Crash Time	Normal Cost	Crash Cost
A	--	2	1	10000	15000
B	--	8	5	15000	21000
C	A	4	3	20000	24000
D	B	1	1	7000	7000
E	B	2	1	8000	15000
F	C,D	5	3	10000	16000
G	E	6	2	12000	36000

Solution:

As the problem involves direct cost, we expect that the project duration can be reduced with an increase in total cost. First we draw the network as below.



Paths:

A-C-F ➔ 11 weeks

B-D-F ➔ 14 weeks

B-E-G ➔ 16 weeks --------------→ Critical Path

Total Cost = ∑ Normal Costs = Rs. 82,000

Activity	Predecessor	Normal Time	Crash Time	Normal Cost	Crash Cost	Cost Slope	Rank
A	--	2	1	10000	15000	5000	4
B	--	8	5	15000	21000	2000	1
C	A	4	3	20000	24000	4000	3
D	B	1	1	7000	7000	0	
E	B	2	1	8000	15000	7000	6
F	C,D	5	3	10000	16000	3000	2
G	E	6	2	12000	36000	6000	5

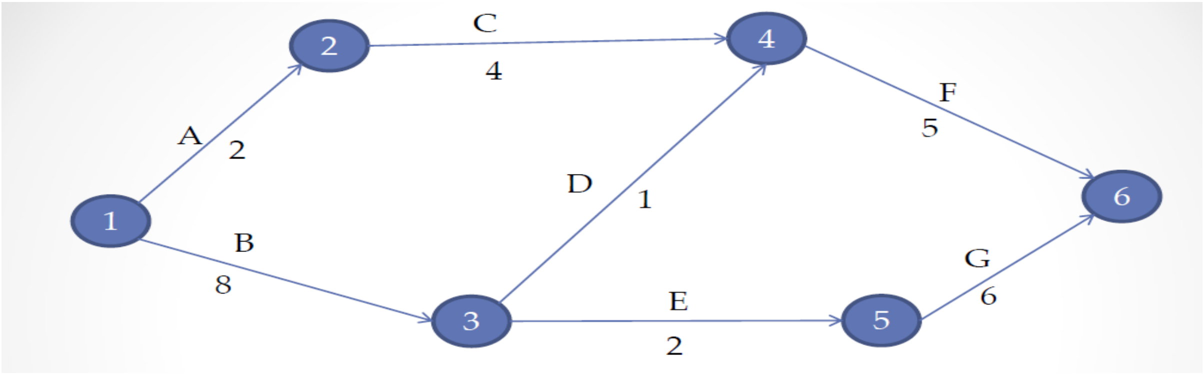
First Crashing:

We crash the activity B, as it is critical activity with minimum slope. We crash it for (8 - 5)=3 weeks at the rate of Rs. 2000 per week.

Project duration reduced to 16 - 3 = 13 weeks

Total cost = 82000 + 3 x 2000 = Rs. 88000.

- **Second Crashing:**



Now Paths are:

A-C-F ➔ 11 weeks

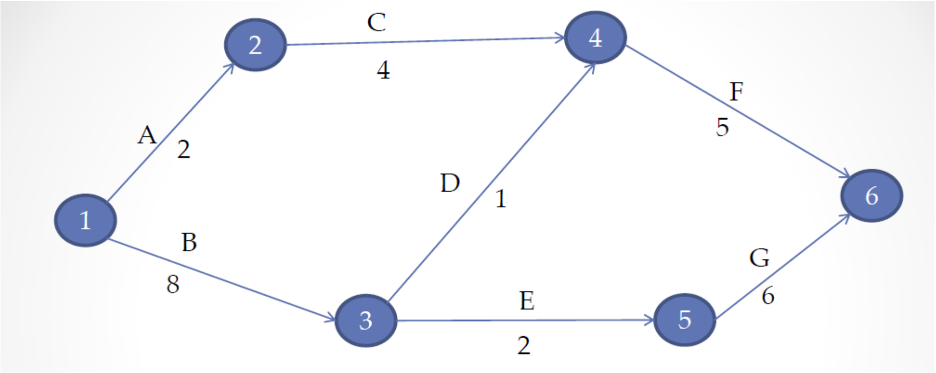
B-D-F ➔ 11 weeks

B-E-G ➔ 13 weeks --------------→ Critical Path

- We now crash the activity G, as it is critical activity with minimum slope next. Crashing G completely result in reducing duration below 11 weeks. So to attain 11 weeks, we crash G for 2 weeks only at the rate of Rs. 6000 per week.
- Project duration reduced to 13 - 2 = 11 weeks
- Total cost = 88000 + 2 x 6000 = Rs. 100000.

- **Third Crashing**:

After 11 days, we get all the paths that are critical.



- Now Paths are:

A-C-F ➔ 11 weeks --------------→ Critical Path

B-D-F ➔ 11 weeks --------------→ Critical Path

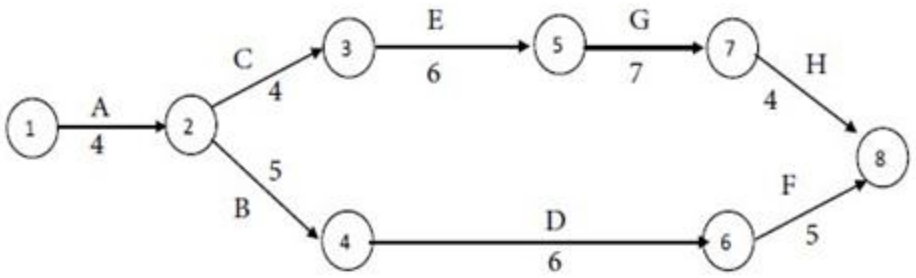
B-E-G ➔ 11 weeks --------------→ Critical Path

- Activity F is the activity with the next minimum cost slope. So crash F for 2 weeks. Again crashing F alone will leave path B-E-G with duration 11 weeks. So project will not be benefited by this crashing. So, we crash the activity G for 2 weeks in the path B-E-G and activity F for 2 weeks as it is common to the path A-C-F and B-D-F.
- Project duration reduced to 11 - 2 = 9 weeks
- Total cost = 100000 + 2 x 6000 + 2 x 3000 = Rs. 118000.

Example 2: A project has activities with the following normal and crash times and cost:

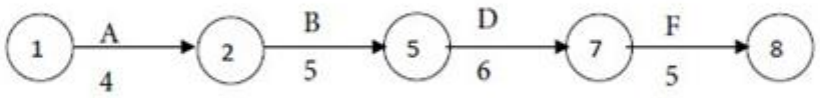
Activity	Predecessor Activity	Normal Time (Weeks)	Crash Time (Weeks)	Normal Cost (Rs.)	Crash Cost (Rs.)
A	-	4	3	8,000	9,000
B	A	5	3	16,000	20,000
C	A	4	3	12,000	13,000
D	B	6	5	34,000	35,000
E	C	6	4	42,000	44,000
F	D	5	4	16,000	16,500
G	E	7	4	66,000	72,000
H	G	4	3	2,000	5,000

Determine a crashing scheme for the above project so that the total project time is reduced by 3 weeks.



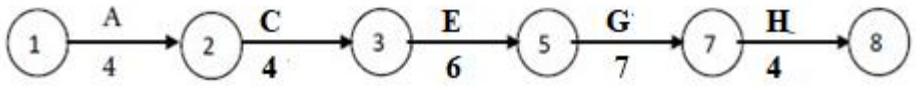
Beginning from the Start Node and terminating with the End Node, there are two paths for the network as detailed below:

Path I



The time for the path = 4 + 5 + 6 + 5 = 20 weeks.

Path II



The time for the path = 4 + 4 + 6 + 7 + 4 = 25 weeks.
Maximum of {20, 25} = 25.

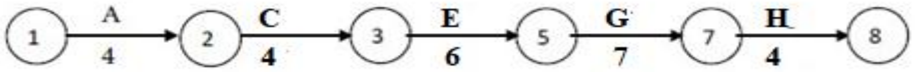
Therefore Path II is the critical path and the critical activities are A, C, E, G and H. The non-critical activities are B, D and F.

Cost Slope

Activity	Normal Time	Crash Time	Normal Cost	Crash Cost	Crash cost - Normal Cost	Normal Time - Crash Time	Crash Cost per unit time
A	4	3	8,000	9,000	1,000	1	1,000
B	5	3	16,000	20,000	4,000	2	2,000
C	4	3	12,000	13,000	1,000	1	1,000
D	6	5	34,000	35,000	1,000	1	1,000
E	6	4	42,000	44,000	2,000	2	1,000
F	5	4	16,000	16,500	500	1	500
G	7	4	66,000	72,000	6,000	1	6,000
H	4	3	2,000	5,000	3,000	1	3,000

A non-critical activity can be delayed without delaying the execution of the whole project. But, if a critical activity is delayed, it will delay the whole project. Because of this reason, we have to select a critical activity for crashing.

Path II

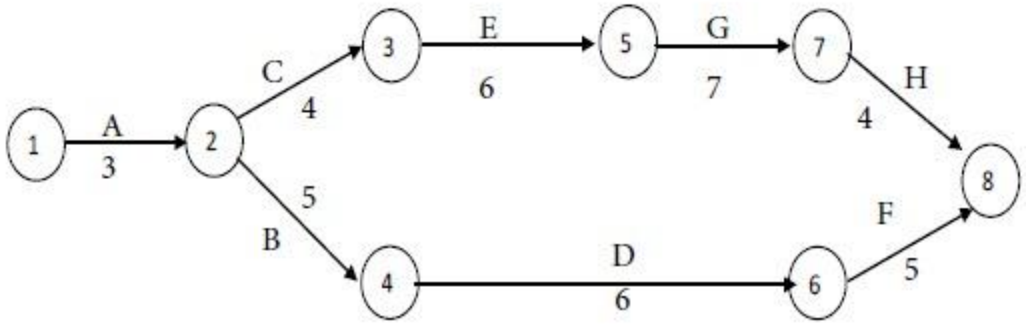


The time for the path = 4 + 4 + 6 + 7 + 4 = 25 weeks.

Here we have to choose one of the activities A, C, E, G and H. The crash cost per unit time (cost slope) works out as follows: Rs. 1,000 for A; Rs. 1,000 for C; Rs. 1,000 for E; Rs. 6,000 for G; Rs. 3,000 for H.

The minimum among them is Rs. 1,000. So we have to choose an activity with Rs.1,000 as the crash cost per unit time. However, there is a tie among A, C and E. The tie can be resolved arbitrarily. Let us select A for crashing. We reduce the time of A by one week by spending an extra amount of Rs. 1,000.

- After this step, we have the following network with the revised times for the activities:



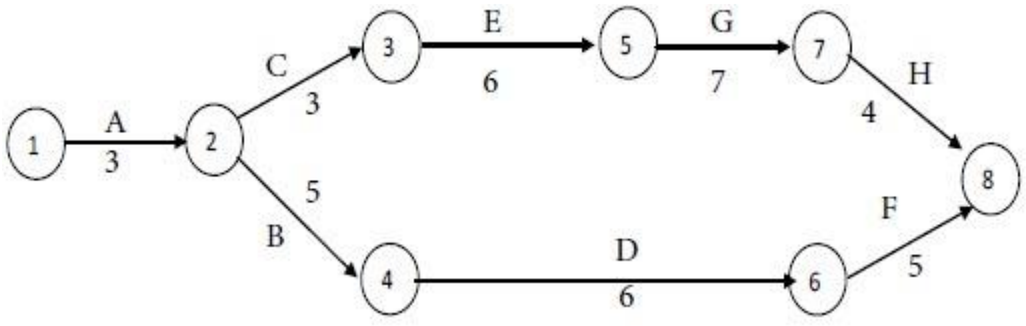
The revised time for Path I (ABDF) = 3 + 5 + 6 + 5 = 19 weeks.

The time for Path II (ACEGH) = 3 + 4 + 6 + 7 + 4 = 24 weeks.

Maximum of {19, 24} = 24.

Therefore Path II is the critical path and the critical activities are A, C, E, G and H. However, the time for A cannot be reduced further. Therefore, we have to consider C, E, G and H for crashing. Among them, C and E have the least crash cost per unit time. The tie between C and E can be resolved arbitrarily. Suppose we reduce the time of C by one week with an extra cost of Rs. 1,000.

After this step, we have the following network with the revised times for the activities:



The time for Path I (ABDF) = 3 + 5 + 6 + 5 = 19 weeks.

The time for Path II (ACEGH) = 3 + 3 + 6 + 7 + 4 = 23 weeks.

Maximum of {19, 23} = 23.

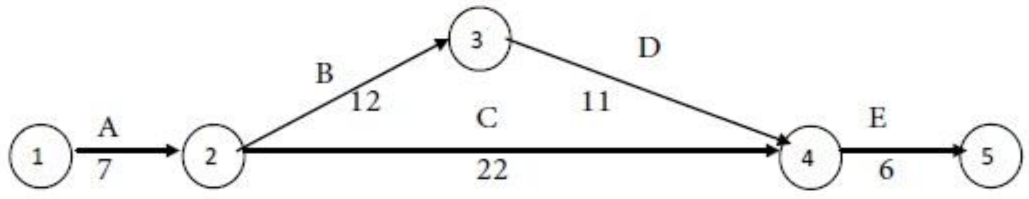
- Therefore Path II is the critical path and the critical activities are A, C, E, G and H. Now the time for A or C cannot be reduced further. Therefore, we have to consider E, G and H for crashing. Among them, E has the least crash cost per unit time. Hence we reduce the time of E by one week with an extra cost of Rs. 1,000.
- By the given condition, we have to reduce the project time by 3 weeks. Since this has been accomplished, we stop with this step.
- ***Result:*** We have arrived at the following crashing scheme for the given project:
- Reduce the time of A, C and E by one week each.
- Project time after crashing is 22 weeks.
- Extra amount required = 1,000 + 1,000 + 1,000 = Rs. 3,000.

Example 3. The management of a company is interested in crashing of the following project by spending an additional amount not exceeding Rs. 2,000. Suggest how this can be accomplished.

Activity	Predecessor Activity	Normal Time (Weeks)	Crash Time (Weeks)	Normal Cost (Rs.)	Crash Cost (Rs.)
A	-	7	6	15,000	18,000
B	A	12	9	11,000	14,000
C	A	22	21	18,500	19,000
D	B	11	10	8,000	9,000
E	C, D	6	5	4,000	4,500

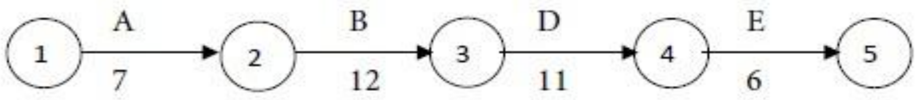
Solution:

We have the following network diagram for the given project with normal costs:



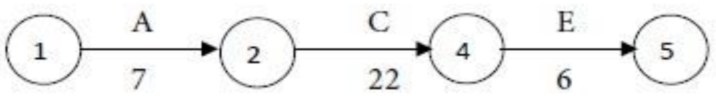
There are two paths for this project as detailed below:

Path I



The time for the path = 7 + 12 + 11 + 6 = 36 weeks.

Path II



The time for the path = 7 + 22 + 6 = 35 weeks.

Maximum of {36, 35} = 36.

Therefore Path I is the critical path and the critical activities are A, B, D and E. The non-critical activity is C.

The crash cost per unit time for the activities in the project are provided in the following table.

Activity	Normal	Crash Time	Normal Cost	Crash Cost	Crash cost - Normal Cost	Normal Time - Crash Time	Crash Cost per unit time
A	7	6	15,000	18,000	3,000	1	3,000
B	12	9	11,000	14,000	3,000	3	1,000
C	22	21	18,500	19,000	500	1	500
D	11	10	8,000	9,000	1,000	1	1,000
E	6	5	4,000	4,500	500	1	500

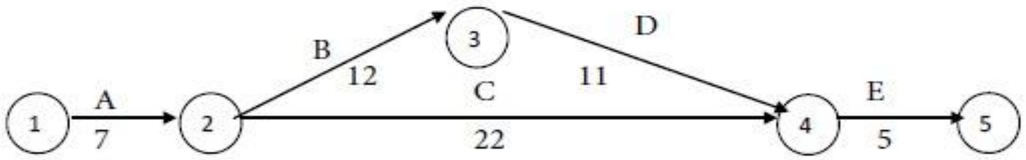
Cost Slope

We have to choose one of the activities A, B, D and E for crashing. The crash cost per unit time is as follows:

Rs. 3,000 for A; Rs. 1,000 for B; Rs. 1,000 for D; Rs. 500 for E.

The least among them is Rs. 500. So we have to choose the activity E for crashing. We reduce the time of E by one week by spending an extra amount of Rs. 500.

After this step, we have the following network with the revised times for the activities:



The revised time for Path I = 7 + 12 + 11 + 5 = 35 weeks.

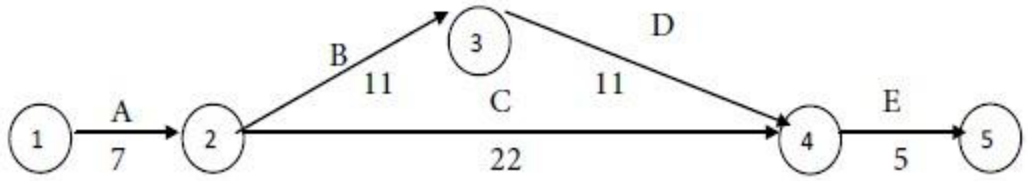
The time for Path II = 7 + 22 + 5 = 34 weeks.

Maximum of {35, 34} = 35.

Therefore Path I is the critical path and the critical activities are A, B, D and E. The non-critical activity is C.

The time of E cannot be reduced further. So we cannot select it for crashing. Next B and D have the smallest crash cost per unit time. Let us select B for crashing. Let us reduce the time of B by one week at an extra cost of Rs. 1,000.

After this step, we have the following network with the revised times for the activities:



The revised time for Path I = 7 + 11 + 11 + 5 = 34 weeks.

The time for Path II = 7 + 22 + 5 = 34 weeks.

Maximum of {34, 34} = 34.

Since both paths have equal times, both are critical paths. So, we can choose an activity for crashing from either of them depending on the least crash cost per unit time. In path I, the activities are A, B, D and E. In path II, the activities are A, C and E.

The crash cost per unit time is the least for activity C. So we select C for crashing. Reduce the time of C by one week at an extra cost of Rs. 500.

By the given condition, the extra amount cannot exceed Rs. 2,000.

Since this state has been met, we stop with this step.

Result: The following crashing scheme is suggested for the given project:

Reduce the time of E, B and C by one week each.

Project time after crashing is 33 weeks.

Extra amount required = 500 + 1,000 + 500 = Rs. 2,000.

Resource Loading & Resource Levelling

- ***Resource loading*** refers to the amount of a resource necessary to conduct a project.
- Because this amount depends on the requirements of the individual activities, the resource loading will change throughout a project as different activities are started and completed. This results in variable loading for a certain resource over time.
- The usual resource loading pattern in a project is a steady buildup, then a peak, then a gradual decline.
- Most projects require relatively few resources during the early and late stages compared to the many resources needed in the middle.
- The process of scheduling activities so that the amount of a certain required resource is somewhat balanced or “smoothed” throughout the project is called ***resource leveling***.
- The goal of resource leveling is to alter the schedule of individual project activities such that the resultant resource requirements for the overall project are maintained at a fairly constant level.

- Example:

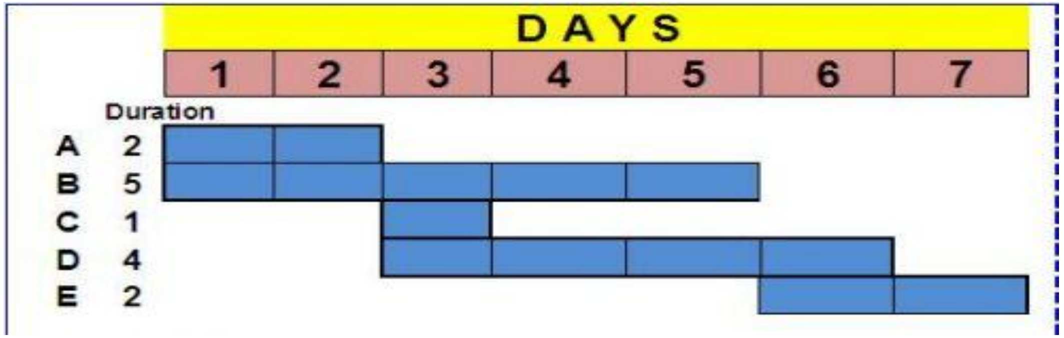
A company has taken a contract for landscaping of a plot of land. The job would require workers, supervisors, excavators, tractors and a variety of trees, bushes, shrubs beside stones in various color and shape. In order to simplify the matter, we presume that only labour would be required.

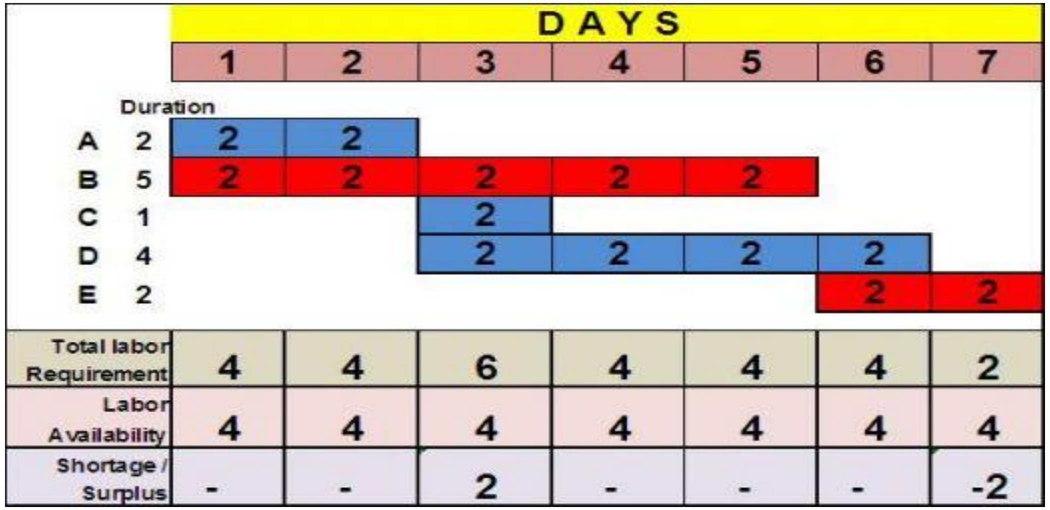
Given below are necessary details of activities, their duration and labour requirements.

Activity	Days	Workers	Precedent
A	2	2	
B	5	2	
C	1	2	A
D	4	2	A
E	2	2	B,C

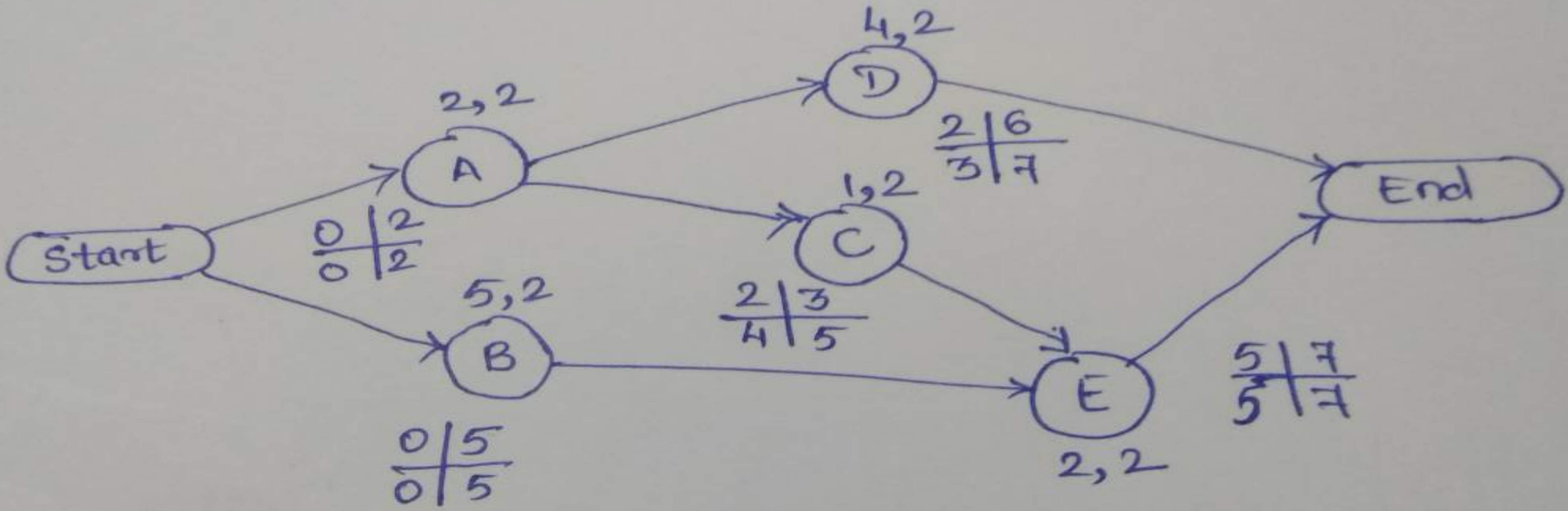
A total of 4 workers are available. Can we complete the job with only 4 workers?

- Just a cursory glance on the question would reveal that activity B has five days and needs two workers each day. Before B finishes, C & D would also start and labor requirements would exceed the availability. So we need some re-scheduling. Before, we can attempt it, we need to find out which activities are critical and which are not. For this purpose, we would draw a Gantt Chart as follows:





- We observe that B & E activities are on the critical path. Moving them would increase the total duration beyond seven days. We mark them red. We can now insert labor and get the following picture:



Activity	Duration	Predecessor	ES	EF	LS	LF	Total float
A	2	–	0	2	0	2	0
B	5	-	0	5	0	5	0
C	1	A	2	3	4	5	2
D	4	A	2	6	3	7	1
E	2	B, C	5	7	5	7	0

- It is evident that on third day, we would experience shortage of two workers while on the last day, two workers would be surplus. If we can make necessary adjustment, we would level or smooth out the excesses and shortages.
- Obviously, activities B & E cannot be moved. Moving A would not solve the problem as its shift would affect start of linked activities C & D. Even if there was no such linkage, moving A would not make any difference. This leaves C & D. We can move C for two days as there is free float for the same period. But it would result in increase of labor requirement for the subsequent period. So moving D for one day is cure-all. The revised Gantt Chart would appear as follows:

		DAYS						
		1	2	3	4	5	6	7
	Duration							
A	2	2	2					
B	5	2	2	2	2	2		
C	1			2				
D	4			2	2	2	2	
E	2						2	2
Total labor Requirement		4	4	6	4	4	4	2
Labor Availability		4	4	4	4	4	4	4
Shortage / Surplus		-	-	2	-	-	-	-2

		DAYS						
		1	2	3	4	5	6	7
	Duration							
A	2	2	2					
B	5	2	2	2	2	2		
C	1			2				
D	4				2	2	2	2
E	2						2	2
RESOURCE LOADING		4	4	4	4	4	4	4
LABOR AVAILABLE		4	4	4	4	4	4	4
LEVELING		-	-	-	-	-	-	-

Critical Chain Project Management(CCPM)

- Critical Chain Project Management was developed and publicized by Dr. Eliyahu M. Goldratt in 1997.
- The Critical Chain Method has its roots in another one of Dr. Goldratt's inventions: the Theory of Constraints (TOC).
- This project management method comes into force after the initial project schedule is prepared, which includes establishing task dependencies.
- The evolved critical path is reworked based on the Critical Chain Method. To do so, the methodology assumes constraints related to each task.

A Few of These Constraints Include

- There is a certain amount of uncertainty in each task.
- Task durations are often overestimated by team members or task owners. This is typically done to add a safety margin to the task so as to be certain of its completion in the decided duration.
- In most cases, the tasks should not take the time estimated, which includes the safety margin, and should be completed earlier.
- If the safety margin assumed is not needed, it is actually wasted. If the task is finished sooner, it may not necessarily mean that the successor task can start earlier as the resources required for the successor task may not be available until their scheduled time. In other words, the saved time cannot be passed on to finish the project early. On the other hand, if there are delays over and above the estimated schedules, these delays will most definitely get passed on, and, in most cases, will exponentially increase the project schedule.

- With the above assumptions, the Critical Path Methodology of project management recommends pooling of the task buffers and adding them at the end of the critical path:

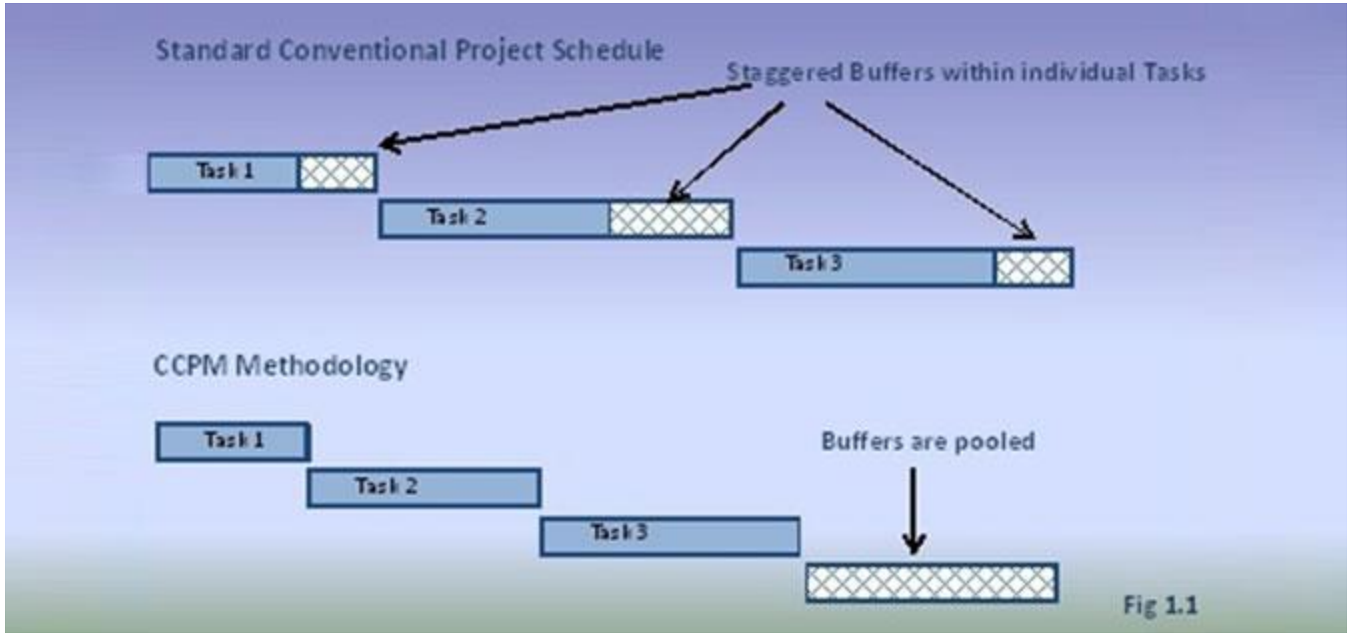
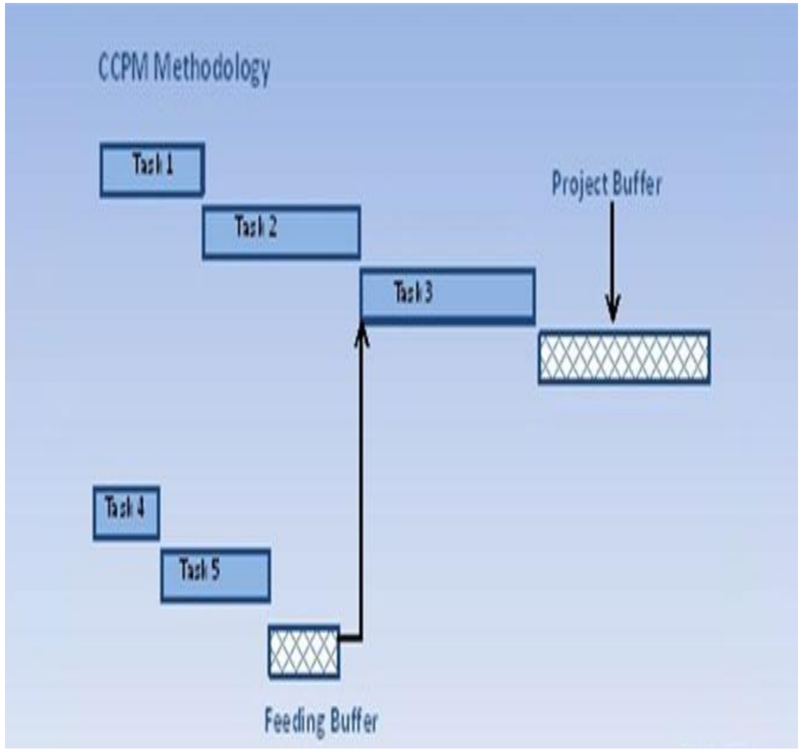


Fig 1.1

Critical Path Project Management Defines Three Types of Buffers

- Project Buffer: The total pooled buffer depicted in the image above is referred to as the project buffer.
- Feeding Buffer: In a project network, there are path/s which feed into the critical path. The pooled buffer on each such path represents the feeding buffer to the critical path (depicted in the image below), resulting in providing some slack to the critical path.
- Resource Buffer: This is a virtual task inserted just before critical chain tasks that require critical resources. This acts as a trigger point for the resource, indicating when the critical path is about to begin.



Advantages of CCPM

- Improve project delivery date reliability
- Shorten overall project duration
- Provide “early warning” of threats to project delivery
- Enable earlier, less drastic responses
- Reduce costs
- Reduce overtime
- Reduce rework

Project Stakeholder Communication Plan

- Project manager need to communicate the project's progress to the project stakeholders.
- This requires developing a communication plan which can help the stakeholders make well-informed decisions.
- Identify communication technology that can make sure that required communication reaches the stakeholders on time.
- Methods like written reports, fax, emails, project websites and verbal conversations can be used for communicating information.

Project Stakeholder Communication Plan (contd..)

- Various questions need to be answered while selecting communication methods:

1. Is the requirement of new technology or are the existing systems adequate to work?
2. Do the stakeholders need training to use the technology to be employed in the project?
3. Will the chosen technology be used throughout the project or will it need to be updated?
4. Where do the project people live?

Project Stakeholder Communication Plan (contd..)

- After answering these questions, the project manager needs to design a stakeholder communication plan, which includes:

1. Name of the stakeholders
2. Expectations of the stakeholders
3. Type of communication required to inform stakeholder
4. Frequency of communication messages
5. Ways to communicate messages
6. Individuals responsible for communicating information
7. Other document items

Communication Plan Template

Project Communication Plan

PROJECT MANAGEMENT COMMUNICATION PLAN

Project Name: Website and Mobile App Development	**Project Manager:** William Mathew
Beginning Date: July 25, 2024	**Completion Date:** October 25, 2024

PROJECT OBJECTIVES:
Create a well-optimized website and mobile app for the client's business. Integrate all the necessary plugins on the website.
Optimize both website and mobile app, in regard to the latest SEO guidelines. Add effective call-to-action.
Make a user-friendly website so that potential leads can be converted to customers easily.

COMMUNICATION GOAL	COMMUNICATION TOOL	AUDIENCE	FREQUENCY
Review the website and mobile app development plan.	In-person meeting	Project Team Sponsors Project Managers	Weekly
Team standup	In-person meeting	Project Team Sponsors Project Managers	Daily
Project review	Email/call	Project Team Project Managers Stakeholders & Clients	Monthly
Project completion	In-person team meeting	Project Team Project Managers Stakeholders & Clients	Monthly

Risk Management Planning

- The PMBOK® Guide describes risk as, ”An uncertain event or condition, that if it occurs, has a positive or negative effect on a project's objective”.
- The key element of this definition is that the effect of the uncertainty, if it occurs, may be positive or negative on the objectives of the planned endeavour.
- Uncertainty can have negative (threats) or positive (opportunities) outcomes.
- Risk impacts scope, schedule, cost, quality or the business objectives.
- Risk management involves identifying, assessing, monitoring and controlling, responding to the risk events.
- Objective is to reduce the chances and losses that can occur from threats, and enhance the chances and profits that can occur from opportunities.

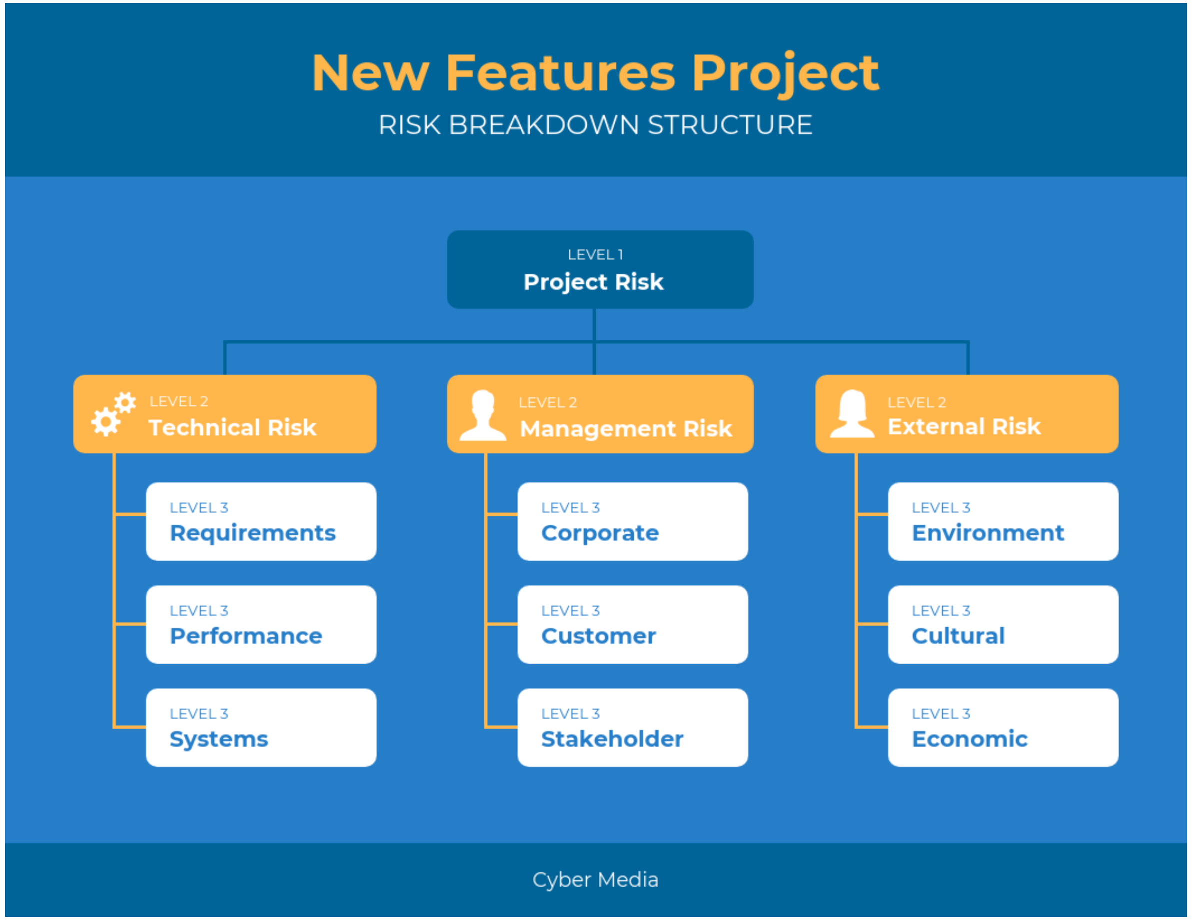
Risk Management Planning

- Risk Management Planning can be defined as a process of making decision regarding the way to approach and plan risk management activities.
- Planning is necessary to identify and mitigate risks associated with the timely completion of project.
- Information can be taken from following:

1. Project charter
2. Risk management policies used earlier in the organisation
3. Pre-defined roles, authority and responsibilities
4. Risk tolerance level
5. Work Breakdown Structure

Risk Breakdown Structure

Risk Breakdown Structure (RBS) identifies and categorizes the various sources of risk.



Risk Categories

Risk Rating						
Standard Risk Matrix for any Business						
Impact	5	Medium / High	Medium / High	High	High	High
	4	Low / Medium	Medium / High	Medium / High	High	High
	3	Low / Medium	Low / Medium	Medium / High	Medium / High	High
	2	Low	Low	Low / Medium	Low / Medium	Medium / High
	1	Low	Low	Low	Low / Medium	Low / Medium
		1	2	3	4	5
Likelihood						

Probability and Impact Matrix

Risk	**Probability**	**Impact**	**P x I**
Training gap	0.1	0.7	**0.07**
Missing the coding milestone due to scope change	0.5	0.5	**0.25**
Extending test coverage due to quality issues requiring more resources	0.3	0.9	**0.27**
Schedule impact due to year end holidays	0.3	0.5	**0.15**
Procurement delays	0.5	0.7	**0.35**

		Threats					Opportunities				
Probability	0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
	0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
	0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
	0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
	0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
		0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05
		Impact									

Risk Identification

- Risk identification is the process of identifying the potential risks which may affect the entire project.
- Must be identified from different sources.
- Document these risks in risk register.
- Various techniques and documents to identify the risks are:

1. Risk Repository
2. Checklist Analysis
3. Expert Judgement
4. Project Documents

Risk Register

- Also known as a Risk Log, the Risk Register is a tool for documenting risks, and actions to manage each risk.
- The Risk Register is essential to the successful management of risk.
- As risks are identified they are logged on the register and actions are taken to respond to the risk.

ID	Date raised	Risk description	Likelihood	Impact	Severity	Owner	Mitigating action	Contingent action	Progress on actions	Status
1	12/12/15	There is a risk that assets may not be completed in time to meet production schedules.	Low	High	Amber	S Scott	Agree writing days in advance, reallocate writer's other work. Agree to stagger delivery of chapters so that editing can start earlier.	Increase duration of Printing schedules & move from 4 col to 2 col.	Update 13/12/2015 mitigation actions implemented	Open

Risk Register (contd..)

- Risk ID - a unique identifier for the risk
- Date raised - the date the risk was identified
- Risk description - best written as 'There is a risk that xxxxx, because of xxxx if this occurs it will xxxx'
- Likelihood - How likely is that the risk will occur. Can be 1- 5 or High / Medium / Low
- Impact - What will the impact be if the risk occurs.
- Severity - Likelihood x Impact
- Owner - The person who will be responsible for managing the risk.
- Mitigating action - Actions that can be taken to reduce the likelihood of the risk occuring. May also be acceptance of the risk or transferance of the risk e.g. insurance. Risk Mitigation techniques.
- Contingent action - What will be done if this risk does occur. Usually actions to reduce the impact on the project
- Progress on actions - A regular update on progress of the mitigating actions
- Status - For example Open, Waiting, Closed, in Progress etc.

Functions of Risk Register

- To identify risks
- To perform qualitative risk analysis
- To perform quantitative risk analysis
- To plan risk response
- To monitor and control risk

Qualitative and Quantitative Risk Assessment

Qualitative Risk Assessment

- Brainstorming
- Questionnaires and Interviews
- Delphi Technique

Quantitative Risk Assessment

- Three point estimate
- Sensitivity analysis
- Monte Carlo Simulation

Q. The table shows estimation of probability and likely impact of certain risks in a project of “Restoring and refurbishing a heritage building housing a museum” by project engineer of a city municipal corporation. Total project cost is Rs. 100 Million and duration is 1 year.

Code	Risk	Probability	Impact (Mn Rs.)
A	Damage to structural artwork of building	20%	15
B	Theft of or damage to antique items	60%	80
C	Structural deterioration more than expected	80%	30
D	Loss of revenue due to delay in project	40%	5
E	Architect fees exorbitant due to likely increase in scope during execution	60%	2

Device a suitable impact scale and make a probability impact matrix and comment on the severity of each risk based on the same. (June 2018)

Solution:

Given: Total Project Cost 100 Mn

Total Project Duration 1 Year

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The impact of various risks is given in Rs. Terms. Following impact scale can be deviced.

Cost Impact on Project	Impact Level	Impact Scale
Less than 2% of project cost: Rs. 2 Mn and below	Very Low	0.05
Between 2% to 10% of project cost: Rs. 2 Mn to Rs. 10 Mn	Low	0.1
Between 10% to 20% of project cost: Rs. 10 Mn to Rs. 20 Mn	Moderate	0.2
Between 20% to 40% of project cost: Rs. 20 Mn to Rs. 40 Mn	High	0.4
More than 40% of project cost: Rs. 40 Mn and above	Very High	0.8

Based on given probability scale and the proposed impact scale following matrix can be developed as a template for assessing risk priority, based on probability and impact scale, based on product of P (probability) and I (Impact).

	Impact ➔	**0.05**	**0.1**	**0.2**	**0.4**	**0.8**
Probability ↓	**0.2**	0.01	0.02	0.04	0.08	0.16
	0.4	0.02	0.04	0.08	0.16	0.32
	0.6	0.03	0.06	0.12	0.24	0.48
	0.8	0.04	0.08	0.16	0.32	0.64
	1	0.05	0.1	0.2	0.4	0.8

The Green zone (Top left corner PxI < 0.04) is low priority risk zone and Red zone (Bottom right corner PxI > 0.16) is Top priority risk zone. Remaining area has moderate priority risks.

Now for the given case

Code	Risk	Probability	Impact Level	Impact Scale
A	Damage to structural artwork of building	0.2	Moderate	0.2
B	Theft of or damage to antique items	0.6	Very High	0.8
C	Structural deterioration more than expected	0.8	High	0.4
D	Loss of revenue due to delay in project	0.4	Low	0.1
E	Architect fees exorbitant due to likely increase in scope during execution	0.6	Very Low	0.05

Placing each risk in the Probability Impact Matrix

	Impact ➔	**0.05**	**0.1**	**0.2**	**0.4**	**0.8**
Probability	**0.2**	0.01	0.02	0.04 **(A)**	0.08	0.16
	0.4	0.02	0.04 **(D)**	0.08	0.16	0.32
	0.6	0.03 **(E)**	0.06	0.12	0.24	0.48 **(B)**
	0.8	0.04	0.08	0.16	0.32 **(C)**	0.64
	1	0.05	0.1	0.2	0.4	0.8

Based on the placement of various risks in the P & I matrix
The Low priority risks are A, D and E (Less severe risks)
There are no moderate priority risks The high priority risks are C and B (Very Severe risks).

Delphi Technique

- The Delphi Technique is a method used to estimate the likelihood and outcome of future events. A group of experts exchange views, and each independently gives estimates and assumptions to a facilitator who reviews the data and issues a summary report.
- The group members discuss and review the summary report, and give updated forecasts to the facilitator, who again reviews the material and issues a second report. This process continues until all participants reach a consensus.
- The experts at each round have a full record of what forecasts other experts have made, but they do not know who made which forecast. Anonymity allows the experts to express their opinions freely, encourages openness and avoids admitting errors by revising earlier forecasts.

Risk Response Strategies

- The risk can have both positive as well as negative impacts on the project.
- In case the risk is negative, one would try to avoid or reduce its impact.
- If the impact of risk is positive, one would try to increase the likelihood of its occurrence.
- Risk Response Strategies for Negative Risks: Escalate, Avoid, Mitigate, Transfer, Accept
- Risk Response Strategies for Positive Risks: Escalate, Exploit, Enhance, Share, Accept

Risk Response Strategies for Negative Risks

- **Escalate:** You use the escalate risk response strategy when you cannot manage risk on your own because you lack the authority, resources, or knowledge required for a response.
- **Mitigate:** This risk response strategy helps you lessen the impact or probability of the risk. Put simply, this strategy decreases the severity of the risk.
- **Transfer:** You use this strategy when you lack skills or resources to manage the risk, or you are too busy to manage it.
- **Avoid:** Here, you try to eliminate the risk or its impact. You do this by changing your project management plan, changing the project scope, or by changing the schedule.
- **Accept**: You can use this risk response strategy with positive and negative risks. Here you take no action to manage the risk other than acknowledging it.

Risk Response Strategies for Positive Risks

- **Escalate:** You use this strategy when you cannot realize an opportunity, as you lack the authority to take the necessary steps to make it happen.
- **Enhance:** In the enhance risk response strategy, you try to increase the chance of a risk happening so you can realize the risk. In this case, you try to realize the opportunity. The enhance risk response strategy is the opposite of the mitigate strategy.
- **Exploit:** In the exploit risk response strategy, you ensure that the opportunity is realized. Here, you do not try to realize the opportunity, you ensure you realize it.
- **Share:** You use the share risk response strategy when you cannot realize the opportunity on your own. So, you team up with another company and work together to realize it.
- **Accept:** In the accept risk response strategy, you take no action to realize the opportunity. You leave the opportunity as is, and if it happens on its own, you will benefit from it.