MASTER OF COMPUTER SCIENCE/
MASTER OF SCIENCE IN COMPUTER SCIENCE

MCS4204 - Software Project Management

Topic 8: Project Resource Management

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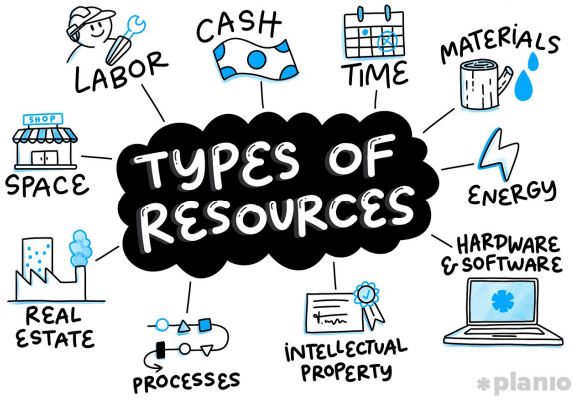
Categories of Resources

Assets required for the successful completion of a project

- Labour
- Equipment
- Materials
- Space
- Services
- Time
- Money



They can be budgeted, spent, lost, or saved

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Project Resources

- Human/Team resources: Personnel (PM &Team members) They may have varied skill sets, be assigned full- or part-time, and be added or removed from the team as the project progresses.
  - Should be aware of skill levels, job positions, and working conditions
- Physical resources: equipment, materials, facilities, and infrastructure that are needed for the successful completion of the project in an efficient and effective way.
  - Should be aware of resource demands, resource configurations that will be required to meet those demands, and the supply of resources.

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Resource Allocation and Management

- Use the Work-Break-Down Structure and allocate the resources required to complete each task.
- Include processes to identify, acquire, and manage the resources needed for the successful completion of the project.
- Ensure that the right resources will be available to the project manager and project team at the right time and place
  - Prepare/update the Activity Schedule, Resource Schedule and the Cost Schedule

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Why is Resource Management challenging?

- Allocation of extra resources will be a waste.
- Allocation of fewer resources will negatively impact the quality of the project activities.
- Failing to secure critical resources on time may result in delays
- Organizations have to conduct different kinds of projects using fewer resources.
- Ordering low-quality material may damage the quality of the final product
- Keeping too much inventory may result in high operations costs

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Project Resource Management Processes

1. Plan Resource Management > Prepare the resource management plan, Team charter, update project documents
2. Estimate Activity Resources > Identify the resource requirements, make basic estimates, and resource breakdown structure
3. Acquire Resources> Assign physical resources, and project team, and make resource calendars and change requests
4. Develop Team > Assess team performance, make change requests, update the project management plan
5. Manage Team > Make change requests, update project management plan and other documents
6. Control Resources > Obtain work performance information, make change requests and update management plan and other documents

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Resource Planning

- Project resources may include team members, supplies, materials, equipment, services and facilities.
- Determine and identify an approach to ensure that sufficient resources are available for the successful completion of the project.
- Effective resource planning should consider and plan for the availability of, or competition for, scarce resources.

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Plan Resource Management

Inputs	Tools & Techniques	Outputs
.1 Project charter .2 Project management plan • Quality management plan • Scope baseline .3 Project documents • Project schedule • Requirements documentation • Risk register • Stakeholder register .4 Enterprise environmental factors .5 Organizational process assets	.1 Expert judgment .2 Data representation • Hierarchical charts • Responsibility assignment matrix • Text-oriented formats .3 Organizational theory .4 Meetings	.1 Resource management plan .2 Team charter .3 Project documents updates • Assumption log • Risk register

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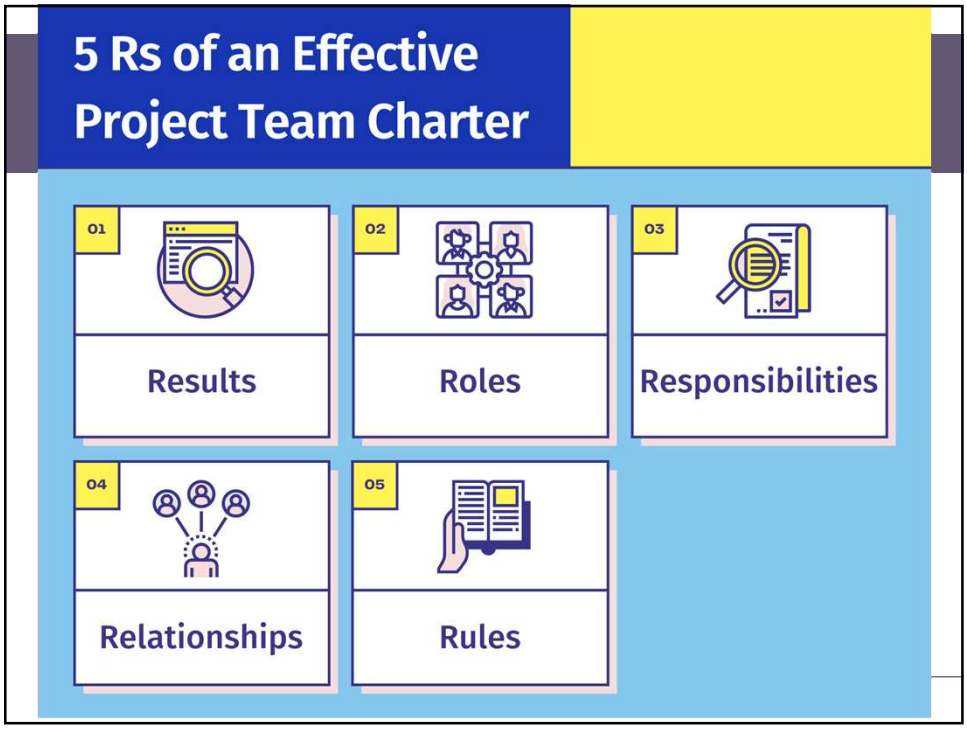

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Plan Resource Management: Tools and Techniques

- Expert judgement
- Data representation using Hierarchical charts
  - **Work breakdown structures (WBS):**
    - Break down project deliverables into work packages and shows the high-level areas of responsibility.
  - **Organizational breakdown structure (OBS):**
    - Organizational entities and the project activities or work packages listed under each department
  - **Resource breakdown structure (RBS):**
    - A hierarchical list of team and physical resources related by category and resource type that is used for planning, managing and controlling project work

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Plan Resource Management: Tools … Contd.

- **Assignment Matrix:**
  - illustrates the connections between work packages, or activities, and project team members
- **Text-oriented format:**
  - Team member responsibilities that require detailed descriptions can be specified in text-oriented formats
- **Organizational Theory:**
  - Provides information regarding the way in which people, teams, and organizational units behave.
- **Meetings**

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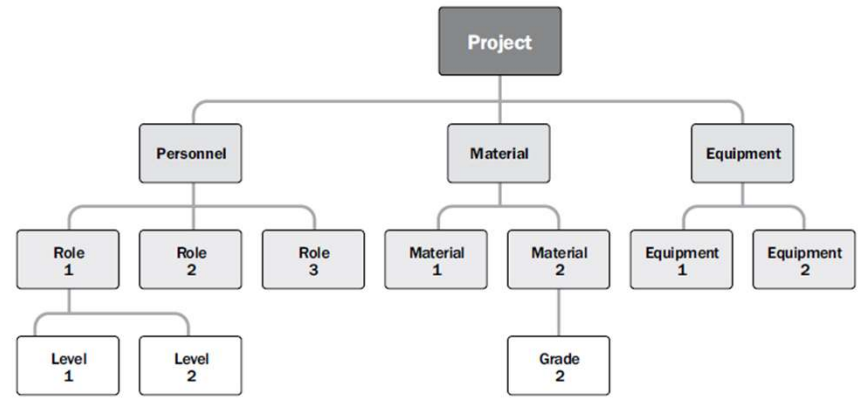
Resource Breakdown Structure



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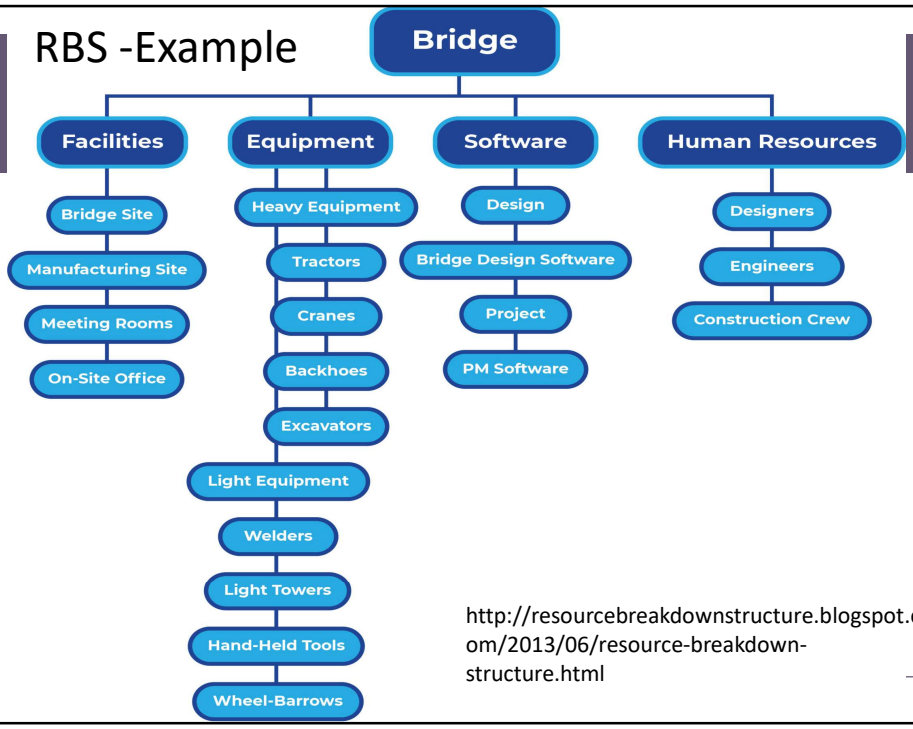
RBS -Example



http://resourcebreakdownstructure.blogspot.com/2013/06/resource-breakdown-structure.html

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Resource Assignment Matrix:

RACI (responsible, accountable, consult, and inform) chart

RACI Chart	Person				
Activity	Amara	Bandara	Chintha	Devaka	Erandi
Create charter	A	R	I	I	I
Collect requirements	I	A	R	C	C
Submit change request	I	A	R	R	C
Develop test plan	A	C	I	I	R

R = Responsible A = Accountable C = Consult I = Inform

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Example: RACI Chart/Matrix

R	Responsible
A	Accountable
C	Consulted
I	Informed

Project tasks	Product Owner	Business Analyst	Financial Lead	Design Director	Design Lead	CRM Lead	Head of CRM	Senior Stakeholders*	Senior Stakeholders**	AGENCY
1. Research										
Econometric model	C	C	A	I	I	C	I	C	I	R
Strategic framework	A	C	C	I	I	C	I	C	I	R
2. Define										
Product concept	A	C	I	C	I	C	C	C	I	R
User testing	A	C	I	I	I	C	I	I	I	R
User journey	A	C	I	I	I	C	I	C	I	R
Design framework	C	C	I	R	A	I	I	C	I	R
Technology recommendations	C	A	I	I	I	I	I	C	I	R
Measurement framework	R	C	A	I	I	C	I	C	I	R
Product backlog	A	R	I	C	I	C	I	C	I	C
Delivery roadmap	A	R	I	R	C	C	I	C	C	R

*Senior Stakeholder 1, Senior Stakeholder 2, Senior Stakeholder 3, Senior Stakeholder 4
** Senior Stakeholder 5, Senior Stakeholder 6, Senior Stakeholder 7, Senior Stakeholder 8

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QUIZ

What is meant by RACI?

A. Responsible, Accountable, Confirmed, Inquired

B. Requested, Accountable, Consulted, Informed

C. Responsible, Accountant, Consulted, Inquired

D. Responsible, Accountable, Consulted, Informed

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Estimate Activity Resources

Inputs	Tools & Techniques	Outputs
.1 Project management plan • Resource management plan • Scope baseline .2 Project documents • Activity attributes • Activity list • Assumption log • Cost estimates • Resource calendars • Risk register .3 Enterprise environmental factors .4 Organizational process assets	.1 Expert judgment .2 Bottom-up estimating .3 Analogous estimating .4 Parametric estimating .5 Data analysis • Alternatives analysis .6 Project management information system .7 Meetings	.1 Resource requirements .2 Basis of estimates .3 Resource breakdown structure .4 Project documents updates • Activity attributes • Assumption log • Lessons learned register

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Acquire Resources

Inputs	Tools & Techniques	Outputs
.1 Project management plan • Resource management plan • Procurement management plan • Cost baseline .2 Project documents • Project schedule • Resource calendars • Resource requirements • Stakeholder register .3 Enterprise environmental factors .4 Organizational process assets	.1 Decision making • Multicriteria decision analysis .2 Interpersonal and team skills • Negotiation .3 Pre-assignment .4 Virtual teams	.1 Physical resource assignments .2 Project team assignments .3 Resource calendars .4 Change requests .5 Project management plan updates • Resource management plan • Cost baseline .6 Project documents updates • Lessons learned register • Project schedule • Resource breakdown structure • Resource requirements • Risk register • Stakeholder register .7 Enterprise environmental factors updates .8 Organizational process assets updates

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Acquire Resources

- Acquire Resources is the process of obtaining team members, facilities, equipment, materials, supplies, and other resources necessary to complete project work.

Tools and Techniques:

- Pre-Assignment: The team members are selected in advance-promised in the proposal to have the expertise, or some members are defined within the project charter.
- Virtual teams: groups of people with shared goals who fulfil their roles with little or no time spent meeting face to face.

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Acquiring and Scheduling Resources

- Having produced the resource requirements list, the next stage is to map this onto the activity plan.
- This mapping is best done by representing the activity plan as a bar chart and using a Resource Histogram for each resource.
- Allocate resources on an activity-by-activity basis.
- Find the best allocation.
- Prioritize activities.

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Scheduling Resources

- In practice, resources are allocated activity-by-activity basis and finding the best allocation can be time-consuming and difficult.
- Allocating a resource to one activity limits the flexibility for resource allocation and scheduling of other activities.
- Therefore, it is better to prioritize activities so that resources can be allocated to activities in some rational order.

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Prioritizing Activities

1) **Total float priority**

i. Activities are ordered according to their total float.

ii. One with the smallest total float has the highest priority.

2) **Ordered list priority (Burman's priority list)**

i. Shortest critical activity

ii. Other Critical activities

iii. Shortest non-critical activities

iv. Non-critical activity with the least float

v. Other Non-critical activities

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Creating Critical Paths

- Scheduling resources can create new critical paths.
- Delaying the Start of an activity due to a lack of resources will cause that activity to become critical if this delay uses up its float.
- A delay in completing one activity can delay the availability of a resource required for a later activity.
- If the latter one is already critical then the earlier one might now have been made critical by linking their resources.

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Factors to be considered when Allocating individuals to Activities

- **Availability** –the particular individual will be available when required.
- **Criticality** - Allocate more experienced personnel to critical activities to shorten the duration and reduce the risk of overrun.
- **Risk -** Allocate experienced staff to activities with highest risks.
- **Training**- Allocate Junior Staff to non-critical activities
- **Team Building** – Consider the final shape of the project staff.

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Example: Estimate Activity Resources

Activity	Duration (Days)	Dependencies	Labour
A	2	-	3
B	4	A	2
C	6	A	4
D	9	A	3
E	5	B	4
F	7	B, C	2
G	3	D, E, F	4

Let's draw the AON network and find the project duration.

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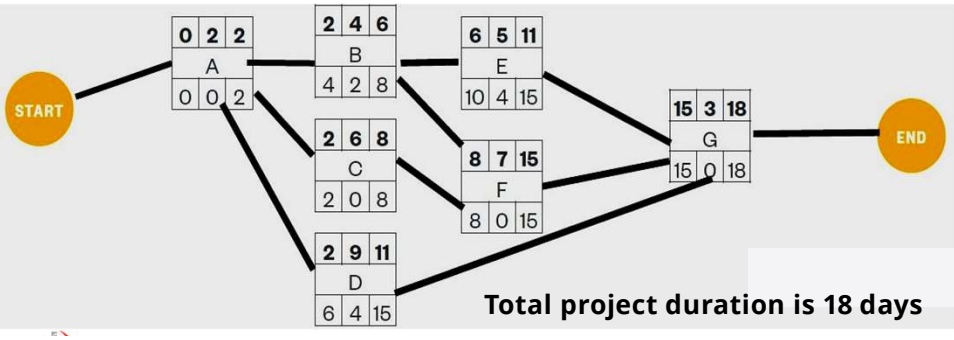
Activity	Duration (Days)	Dependencies	Labour
A	2	-	3
B	4	A	2
C	6	A	4
D	9	A	3
E	5	B	4
F	7	B, C	2
G	3	D, E, F	4



Next, draw the Gantt Chart.

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Activity	Duration (Days)	Dependencies	Labour
A	2	-	3
B	4	A	2
C	6	A	4
D	9	A	3
E	5	B	4
F	7	B, C	2
G	3	D, E, F	4

Duration (Days)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3	3																
B			2	2	2	2												
C			4	4	4	4	4	4										
D			3	3	3	3	3	3	3	3	3							
E							4	4	4	4	4							
F									2	2	2	2	2	2	2			
G																4	4	4
TOTAL	3	3	9	9	9	9	11	11	9	9	9	2	2	2	2	4	4	4

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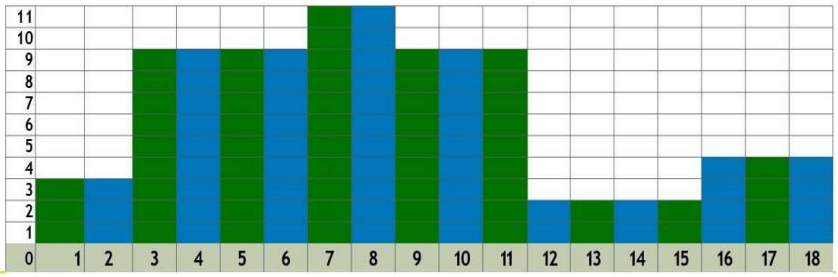
Gantt Chart (Activity Schedule)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3	3																
B			2	2	2	2												
C			4	4	4	4	4	4										
D			3	3	3	3	3	3	3	3	3							
E							4	4	4	4	4							
F									2	2	2	2	2	2	2			
G																4	4	4
Total	3	3	9	9	9	9	11	11	9	9	9	2	2	2	2	4	4	4



Resource Histogram (Resource Schedule)

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Resource Optimization Techniques

1. Resource Levelling
2. Resource Smoothing
3. Reverse Resource Allocation - Start with the last or most critical task and allocate resources to make sure that the deadline or critical tasks must happen as planned.

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Resource Levelling

- A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing the demand for resources with the available supply.
- Resource levelling can be used:-
  - When shared or critically required resources are available only at certain times or in limited quantities
  - When resources are overallocated, such as when a resource has been assigned to two or more activities during the same time period.
  - When there is a need to keep resource usage at a constant level.
- Resource levelling can **often cause the original critical path to change**. Available float is used for levelling resources.
  - Consequently, the critical path through the project schedule may change.

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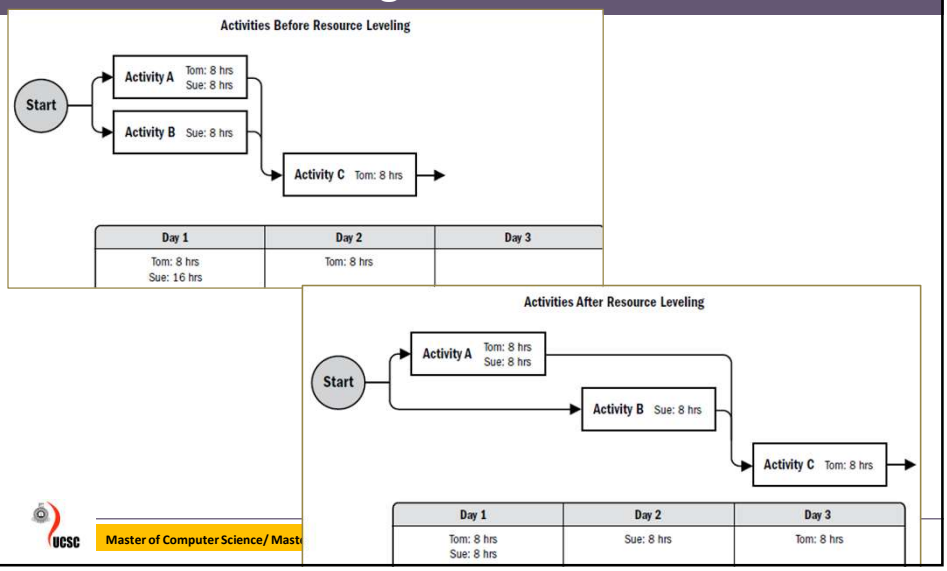
Resource Levelling



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Resource Smoothing

- A technique that adjusts the activities of a schedule model such that the requirements for resources on the project do not exceed certain predefined resource limits.
- The project's critical path is not changed and the completion date may not be delayed.
- Activities may only be delayed within their free and total float.
- Resource smoothing may not be able to optimize all resources.

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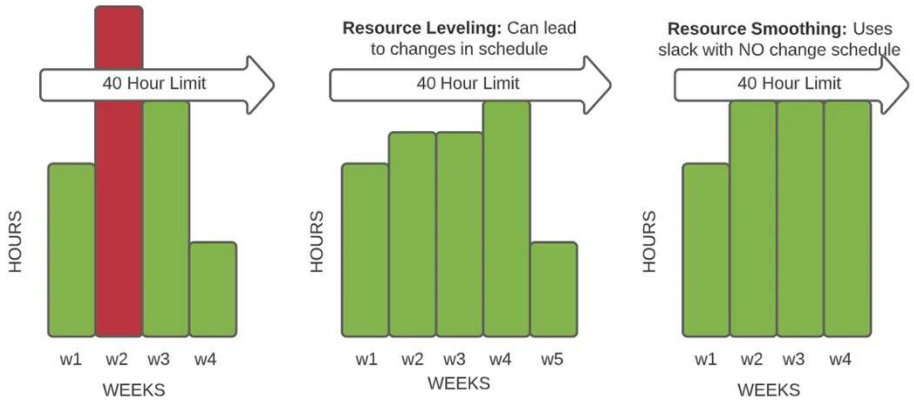
Duration (Days)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3	3																
B			2	2	2	2												
C			4	4	4	4	4	4										
D			3	3	3	3	3	3	3	3	3							
E							4	4	4	4	4							
F									2	2	2	2	2	2	2			
G																4	4	4
TOTAL	3	3	9	9	9	9	11	11	9	9	9	2	2	2	2	4	4	4

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	3	3																
B			2	2	2	2												
C			4	4	4	4	4	4										
D			3	3	3	3	3	3	3	3	3							
E									4	4	4	4	4					
F									2	2	2	2	2	2	2			
G																4	4	4
Total	3	3	9	9	9	9	7	7	9	9	9	6	6	2	2	4	4	4

Maximum 9 Labourers per day
Gantt Chart (Activity schedule) after applying the Resource Smoothing technique

Resource Leveling vs Resource Smoothing



Publishing Resource Schedule

- In allocating and scheduling resources, people used an activity plan, information on network diagrams, activity bar charts and resource histograms.
- These are not the best way of publishing and communicating project schedules.
- For this, we need some form of Work Plan.
- Work Plans are commonly published as lists or charts.

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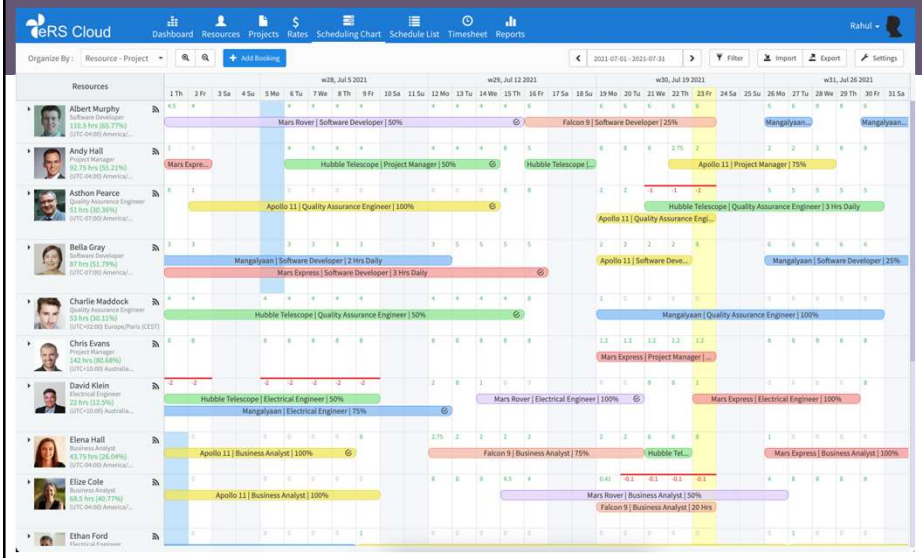
E.g. Work Plan



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Exercise 2: You are managing a website development project with the following tasks and dependencies

Resources Available: 1 BA, 2 Developers, 1 UI Designer and 1 Tester

Activity	Description	Est.Hrs	Duration (days)	Predecessor/s
A	Requirements Gathering	24	3	-
B	Design	32	4	A
C	Setup Development Env.	32	2	A
D	Backend Development	80	5	B, C
E	Frontend Development	24	3	B
F	Integration Testing	16	2	D, E
G	Final Review and fixes	32	2	F

1. Draw the network diagram with critical path highlighted
2. Complete the table showing resource estimation
3. Draw the Gantt chart and or the histogram
4. If only 1 developer was available instead of 2, what would happen to the project duration?

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Cost Schedules

- Combines **budgeting** and **timeline** to ensure projects are delivered on time and within budget.
- Shows weekly or monthly costs over the life of the project.
- Aligns **expenditures** with the project **schedule**
- Helps track when costs will be incurred and control spending
- Supports Resource Allocation
- Facilitates Stakeholder Communication
- Assists risk management and decision making

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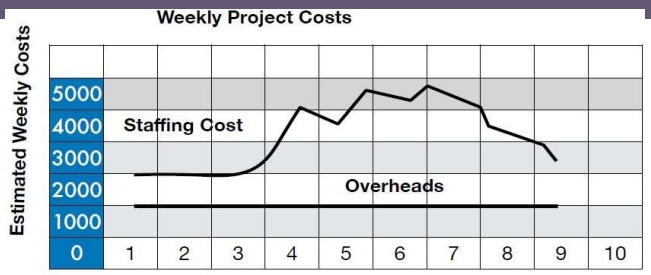
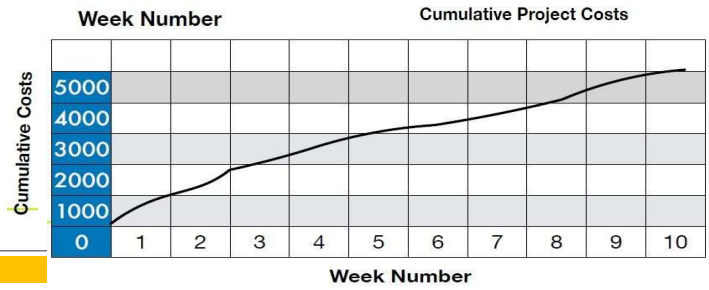
Cost Schedules Cont...





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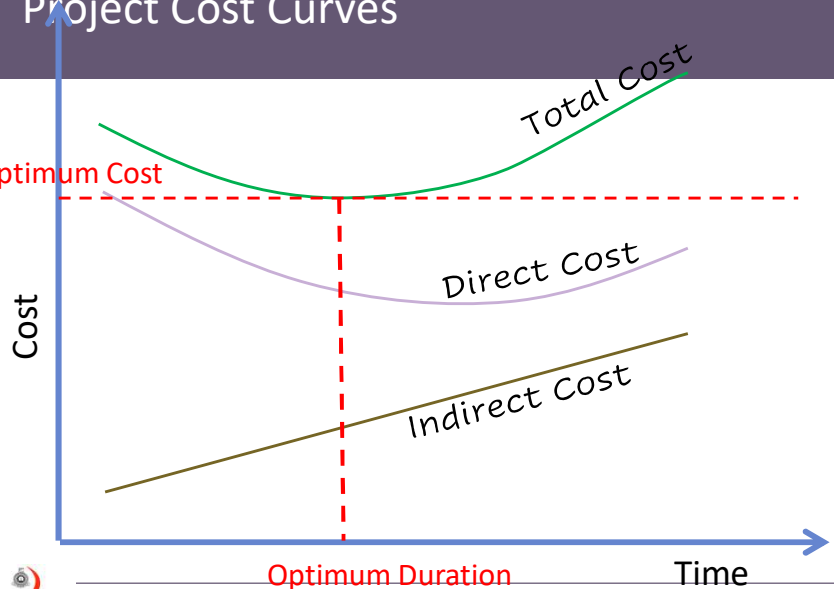
Project Cost Curves



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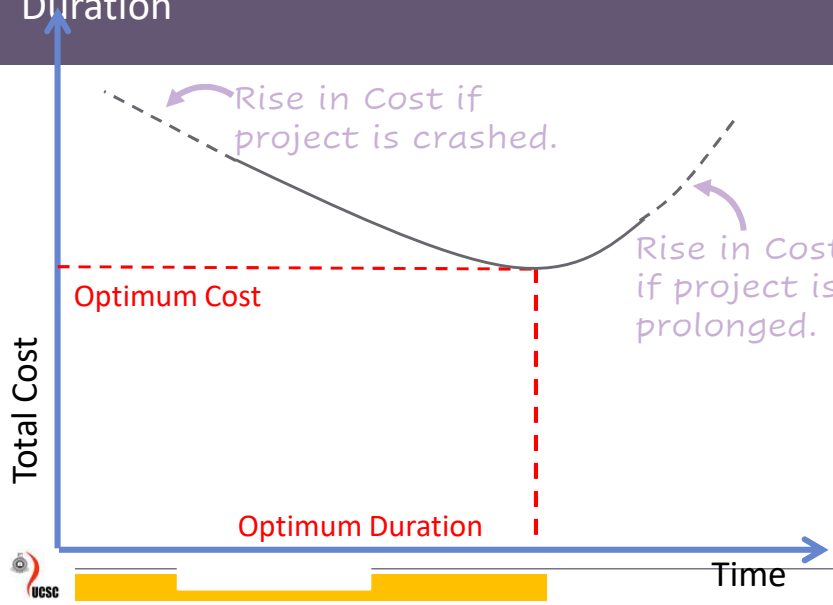
Variation in Total Project Cost Due to Change in Duration



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Shortening the Project Schedule

The strategies for shortening the project schedule are;

1. **Project Crashing** - Assigning additional resources by bearing the extra cost.
2. **Omit unnecessary requirements** from the project scope under the agreement of project sponsors.
3. **Motivate employees to complete the project as soon as possible**. There may be;
   - penalties for late delivery
   - bonuses for early delivery

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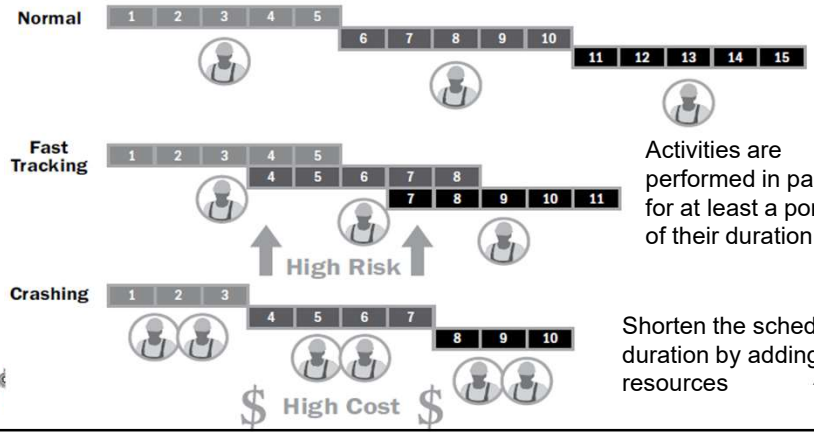
Schedule Compression

- Used to shorten or accelerate the schedule duration without reducing the project scope in order to meet schedule constraints, imposed dates, or other schedule objectives.



Activities are performed in parallel for at least a portion of their duration.

Shorten the schedule duration by adding resources

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Crashing a project

- Project crashing is the method for shortening the project duration by reducing the time of one or more critical activities to less than normal time.
- Crashing is achieved by devoting more resources. Thus the cost associated with the project is increased.
- In Crashing if cost increases then time decreases. Time and cost are thus inversely related.

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Effect of crashing

- Slope = cost/time
- To determine if crashing is effective, a cost/time slope is calculated for each activity that can be expedited (crashed).
- The formula to calculate Slope;

$$\text{Crash cost per period} = \frac{(\text{Crash cost} - \text{Normal cost})}{(\text{Normal time} - \text{Crash time})}$$

- Crash cost = Full cost with the alternative approach

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An Example of Crashing

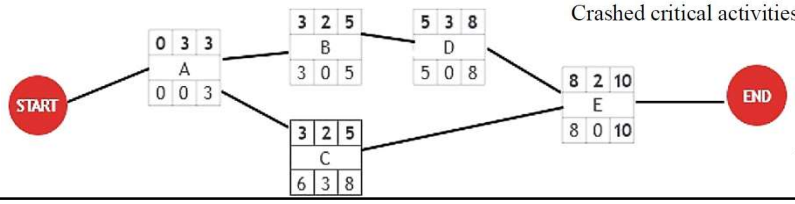
Activity	Precedence	Duration (wk)		Cost (Rs. Thousand)	
		Normal	Crashed	Normal	Crashed
A	-	3	2	40	80
B	a	2	1	20	80
C	a	2	2	20	20
D	b	3	1	30	120
E	C and d	2	1	10	80

Critical Path - A-> B-> D-> E

Non-Critical Activities - C

Critical Activities - A-> B-> D-> E

Crashed critical activities.



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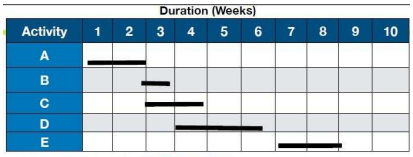
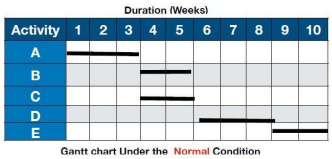
An Example of Crashing…contd.

Activity	Precedence	Duration (wk)		Cost (Rs. Thousand)	
		Normal	Crashed	Normal	Crashed
A	-	3	2	40	80
B	a	2	1	20	80
C	a	2	2	20	20
D	b	3	1	30	120
E	C and d	2	1	10	80



Gantt chart Under the A and B crashed

8,220



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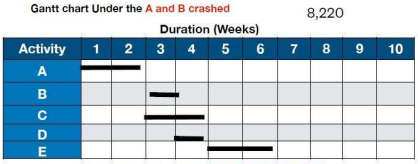
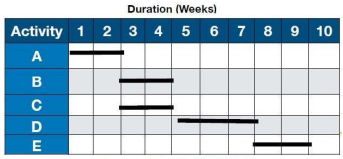
Gantt chart Under the Normal Condition



Gantt chart Under the A ,B and D crashed

6,310



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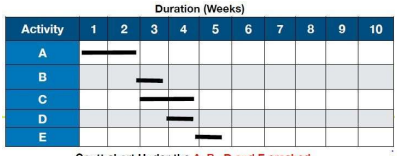
Gantt chart Under the A crashed



Gantt chart Under the A ,B , D and E crashed

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Crash Cost Vs Duration

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Calculating Slope

$$\text{Crash cost per period} = \frac{\text{(Crash cost – Normal cost)}}{\text{(Normal time – Crash time)}}$$

Crash cost per period for Activity D = $\frac{120 - 30}{3 - 1}$

= 45

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Exercise 1: Find the cost-slope

Activity	Precedence	Cost ($)	Time (Days)	Crash Cost	Crash Time
A	-	12000	120	14000	100
B	-	1800	20	2800	15
C	B	16000	40	22000	30
D	C	1400	30	2000	20
E	D,F	3600	50	4800	40
F	B	13500	60	18000	45

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e.g. Find optimum duration and cost

Activity	Normal		Crash	
	Time in days	Cost in Rs $	Time in days	Cost in Rs. $
1-2	3	300	2	400
2-3	6	480	4	520
2-4	7	2100	5	2500
2-5	8	400	6	600
3-4	4	320	3	360
4-5	5	500	4	520

Total normal cost = $. 4100 and Total crash cost = $. 4900.
Suppose indirect cost =$ 100 per day

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Activity	Cost-slope		
	ΔC	ΔT	$\frac{\Delta C}{\Delta T}$
1-2	100	1	100
2-3	40	2	20
2-4	400	2	200
2-5	200	2	100
3-4	40	1	40
4-5	20	1	20

Critical path activities 2-3 and 4-5 have least cost slopes. Therefore, these activities are first crashed, and network is drawn again .

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Exercise 2

Activity	Normal time (Days)	Cost per day (Rs)K	Crash time (Days)	Crash costs per day (Rs)K
1-2	18	30	14	40
1-3	23	10	22	11
2-3	8	50	6	70
2-4	10	35	6	80
3-4	3	40	2	80
4-5	8	25	6	50

1. Find the critical path, total cost of crashing, & total normal cost.
2. If there's an indirect cost of Rs20K per day, which activities should not be crashed? Find the optimum duration and cost of the project.

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Exercise 3

Activity	Predecessor	Normal Time	Normal Cost	Crash Time	Crash Cost
a	-	5	$50	3	$150
b	-	4	40	2	200
c	b	7	70	6	160
d	a, c	2	20	1	50
e	a, c	3	30	-	-
f	b	8	80	5	290
g	d	5	50	4	100
h	e, f	6	60	3	180

a) Calculate crash cost per day for each activity.
b) Find the optimum way of getting 18 days delivery time. What is the project cost?
c) Calculate the shortest delivery time for the project. What is the total project cost?

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Exercise 2

Activity	Normal time (Days)	Cost per day (Rs)K	Crash time (Days)	Crash costs per day (Rs)K
1-2	18	30	14	40
1-3	23	10	22	20
2-3	8	50	5	90
2-4	10	35	6	60
3-4	3	40	2	80
4-5	8	25	6	50

1. Find the critical path, total cost of crashing, & total normal cost.
2. If there's an indirect cost of Rs50 per day which activities should not be crashed. Find the optimum duration and cost of the project.

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Exercise 3

Activity	Predecessor	Normal Time	Normal Cost	Crash Time	Crash Cost
a	-	5	$50	3	$150
b	-	4	40	2	200
c	b	7	70	6	160
d	a, c	2	20	1	50
e	a, c	3	30	-	-
f	b	8	80	5	290
g	d	5	50	4	100
h	e, f	6	60	3	180

a) Calculate crash cost per day for each activity.
b) Find the optimum way of getting 18 days delivery time. What is the project cost?
c) Calculate the shortest delivery time for the project. What is the total project cost?

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Develop Team

Inputs	Tools & Techniques	Outputs
.1 Project management plan • Resource management plan .2 Project documents • Lessons learned register • Project schedule • Project team assignments • Resource calendars • Team charter .3 Enterprise environmental factors .4 Organizational process assets	.1 Colocation .2 Virtual teams .3 Communication technology .4 Interpersonal and team skills • Conflict management • Influencing • Motivation • Negotiation • Team building .5 Recognition and rewards .6 Training .7 Individual and team assessments .8 Meetings	1. Team performance assessments .2 Change requests .3 Project management plan updates • Resource management plan .4 Project documents updates • Lessons learned register • Project schedule • Project team assignments • Resource calendars • Team charter .5 Enterprise environmental factors updates .6 Organizational process assets updates

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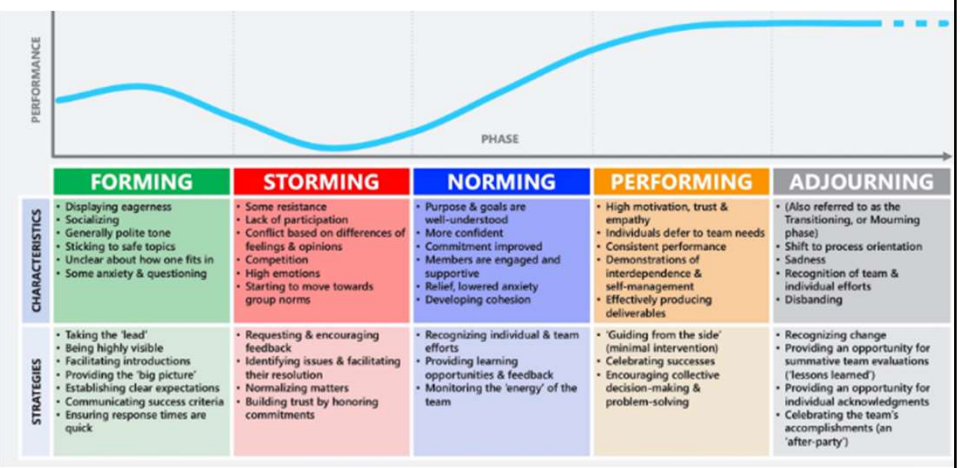
Phases of Team Development by Scott M. Graffius



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Manage Team

Inputs	Tools & Techniques	Outputs
.1 Project management plan • Resource management plan .2 Project documents • Issue log • Lessons learned register • Project team assignments • Team charter .3 Work performance reports .4 Team performance assessments .5 Enterprise environmental factors .6 Organizational process assets	.1 Interpersonal and team skills • Conflict management • Decision making • Emotional intelligence • Influencing • Leadership .2 Project management information system	.1 Change requests .2 Project management plan updates • Resource management plan • Schedule baseline • Cost baseline .3 Project documents updates • Issue log • Lessons learned register • Project team assignments .4 Enterprise environmental factors updates

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Control Resources

Inputs	Tools & Techniques	Outputs
.1 Project management plan • Resource management plan .2 Project documents • Issue log • Lessons learned register • Physical resource assignments • Project schedule • Resource breakdown structure • Resource requirements • Risk register .3 Work performance data .4 Agreements .5 Organizational process assets	.1 Data analysis • Alternatives analysis • Cost-benefit analysis • Performance reviews • Trend analysis .2 Problem solving .3 Interpersonal and team skills • Negotiation • Influencing .4 Project management information system	.1 Work performance information .2 Change requests .3 Project management plan updates • Resource management plan • Schedule baseline • Cost baseline .4 Project documents updates • Assumption log • Issue log • Lessons learned register • Physical resource assignments • Resource breakdown structure • Risk register

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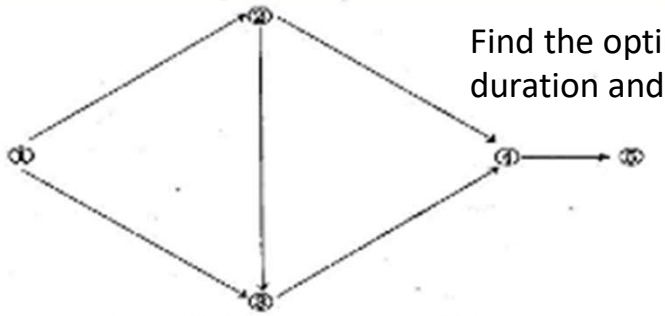
Exercise: Indirect Cost =Rs70 per day



Find the optimum duration and the cost

Activity	Normal Time (Days)	Crash Time (Days)	Crashing Cost (Rs./day)
1-2	18	14	40
1-3	23	22	20
2-3	8	5	60
2-4	10	6	40
3-4	3	2	80
4-5	8	6	50

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