MASSEY UNIVERSITY
UNIVERSITY OF NEW ZEALAND
MASSEY BUSINESS SCHOOL

Week 8

Project Scheduling

THE ENGINE OF THE NEW NEW ZEALAND

Project Scheduling

Project scheduling requires us to follow some carefully laid-out steps, in order, for the schedule to take shape.

Project planning as it relates to the scheduling process, has been defined by the PMBoK as:

The identification of the project objectives and the ordered activity necessary to complete the project including the identification of resource types and quantities required to carry out each activity or task.

Project Scheduling

Project scheduling techniques lie at the heart of project planning and subsequent monitoring and control

Project scheduling represents the conversion of project goals into an achievable methodology for their completion; a timetable and the network logic that relates project activities to each other in a coherent fashion

Project scheduling defines network logic for all activities: tasks that must either precede or follow other tasks from the beginning of the project to completion

Project Scheduling

Project scheduling can take a lot of time and effort, but when done well…

- ✓ Clearly illustrates the interdependence of all tasks and work packages
- ✓ Facilitates communication flow
- ✓ Helps with master scheduling of organisational resources
- ✓ Identified critical activities & distinguishes them from the less critical
- ✓ Provides expectation for when the project will be completed & dates on which various project activities must start and end
- ✓ Helps with coordination of activities that are dependent on each other

Example

Project = research project (paper and presentation)

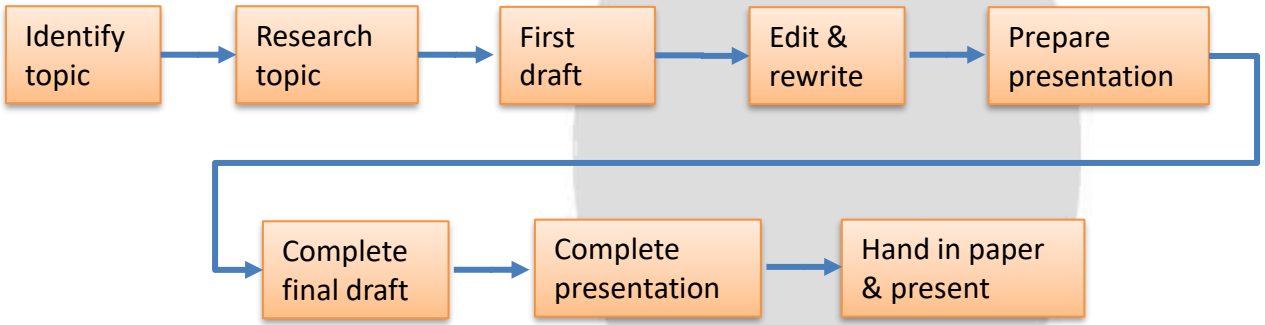
What steps do we need to complete?
What order do they need to be completed in?

Identify the topic
Research the topic
Write the first draft of the paper
Edit and rewrite the paper
Prepare a class presentation
Complete the final draft of the paper
Complete the presentation
Hand in the paper and present the topic in class

Network diagram – serial sequential logic

- Identify the topic
- Research the topic
- Write the first draft of the paper
- Edit and rewrite the paper
- Prepare a class presentation
- Complete the final draft of the paper
- Complete the presentation
- Hand in the paper and present the topic in class

***Project Network Diagram**: Any schematic display of the logical relationships of project activities.*

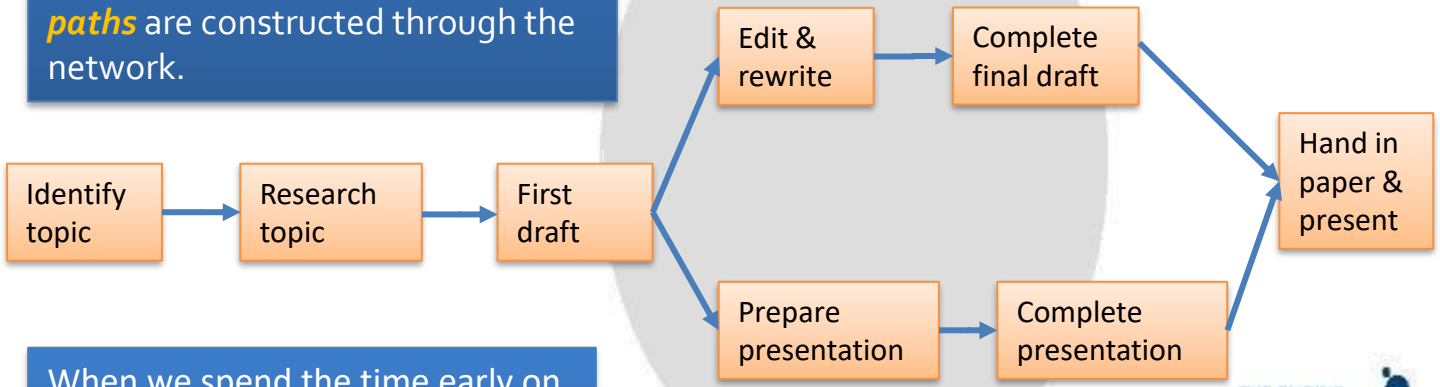


Serial activities are those that flow from one to the next, in sequence.

Network diagram – nonserial sequential logic

- Identify the topic
- Research the topic
- Write the first draft of the paper
- Edit and rewrite the paper
- Prepare a class presentation
- Complete the final draft of the paper
- Complete the presentation
- Hand in the paper and present the topic in class

When the nature of the work allows for more than one activity to be accomplished at the same time, these activities are called ***concurrent***, and ***parallel project paths*** are constructed through the network.



When we spend the time early on (planning) we can set ourselves up for success using network logic

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Project Scheduling

Terminology

Project network – a visual flow diagram developed from the WBS

Activity – an element in the project that consumes time

Parallel activities – can take place at the same time

Serial activities – those that flow from one to the next, in sequence

Merge activity – has more than one activity immediately preceding it

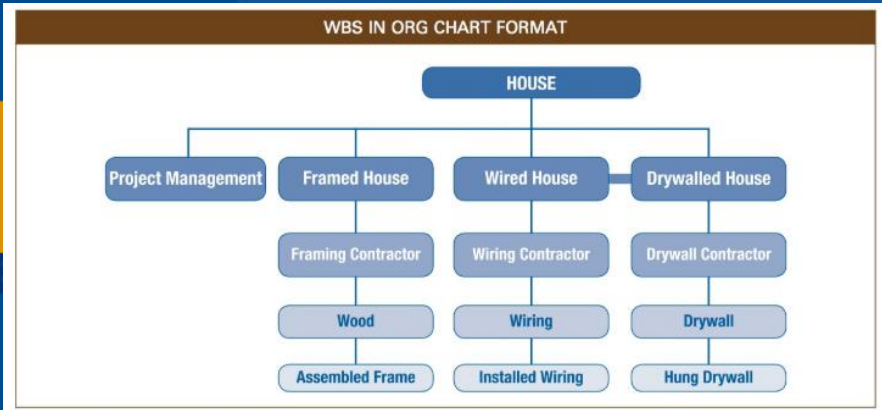
Burst activity – has more than one activity immediately following it

Event – term used to represent a point in time when an activity starts or ends. It does not consume time

Path – a sequence of connected, dependent activities

Critical path – the path with the longest duration, which determines the shortest project length

Recall: WBS



- Organization chart for the project
- Creates logic for tracking costs, schedule, and performance specifications
- Communicates project status
- Improves project communication
- Demonstrates control structure

HOUSE

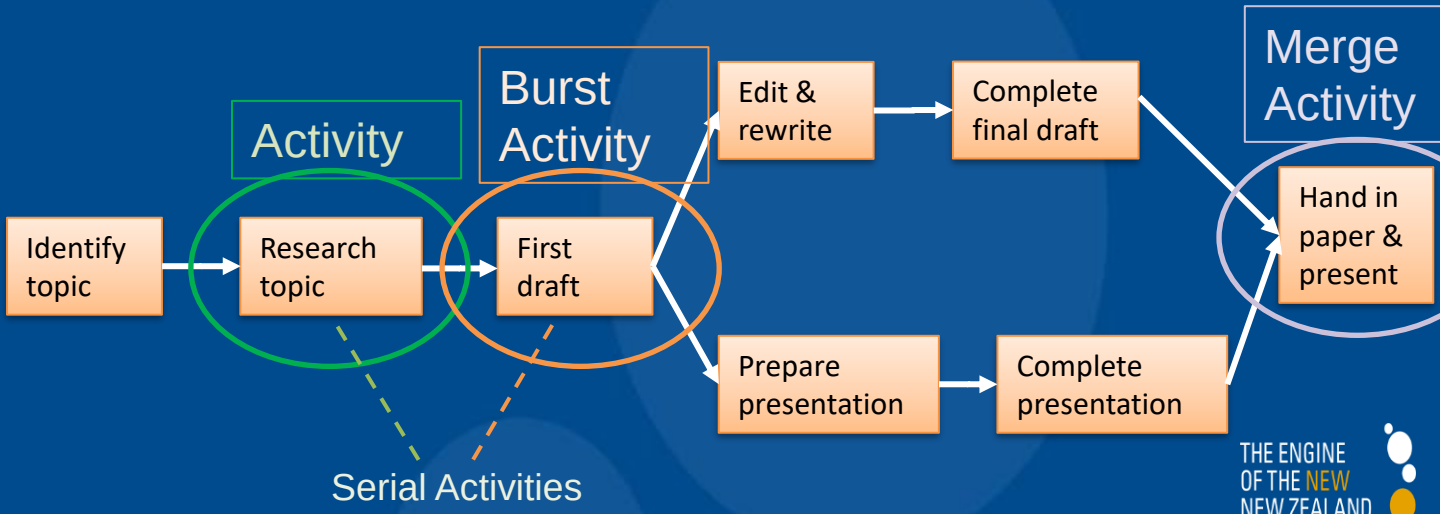
- Project Management
- Framed House
  - Framing Contractor
  - Wood
  - Assembled Frame
- Wired House
  - Wiring Contractor
  - Wiring
  - Installed Wiring
- Drywalled House
  - Drywall Contractor
  - Drywall
  - Hung Drywall

A ***deliverable-oriented*** grouping of project elements which organizes and defines the total scope of the project. Each descending level represents an increasingly detailed definition of a project component.

Project Scheduling

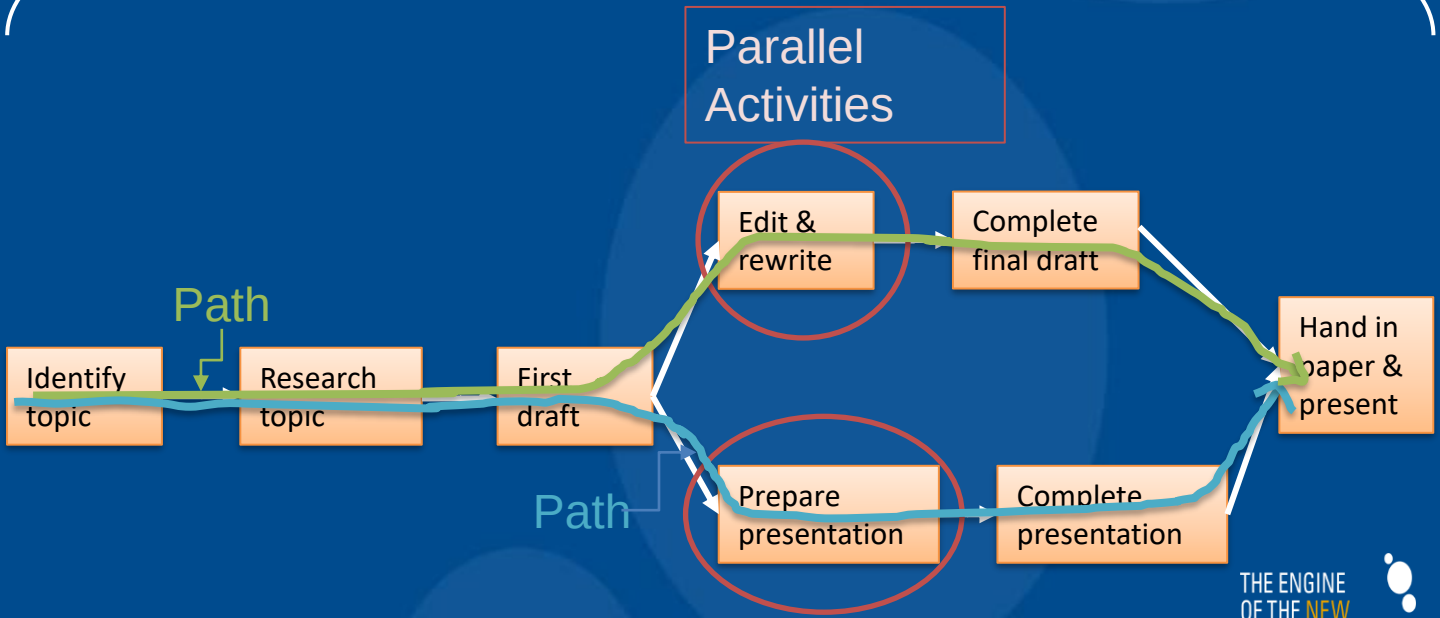
***Merge activity**: An activity with two or more immediate predecessors.*

***Burst activity**: An activity with two or more immediate successors.*



Project Scheduling

Project network

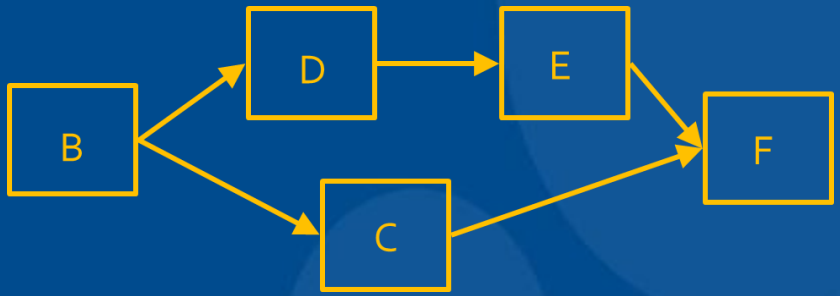


AOA & AON

Two common approaches: AOA and AON

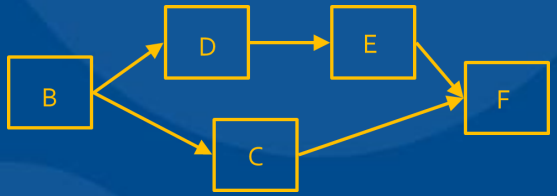
- Both use the arrow and the node as building blocks
- Activities represented by letters

AOA – arrows depict the activities



AON – nodes depict the activities

AON



In practice, AON has come to dominate

- ✓ ***Activities*** represented by ***nodes***
- ✓ ***Arrows*** are merely ***connection devices*** – simplified network labeling
- ✓ ***Easy to read & comprehend***, even for novice project managers
- ✓ Primary drawback – as the project becomes more ***complex*** the ***sheer number of arrows or nodes*** can become "messy"

AON

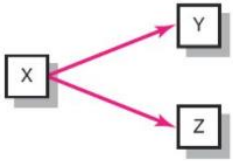
Predecessors: *Those activities that must be completed prior to initiation of a later activity in the network.*

Successors: *Activities that cannot be started until previous activities have been completed. These activities follow predecessor tasks.*

Activity-on-Node fundamentals

A is preceded by nothing
B is preceded by A
C is preceded by B

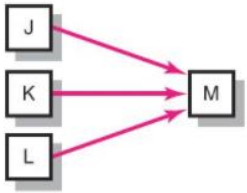
(A)



Y and Z are preceded by X

Y and Z can begin at the same time, if you wish

(B)

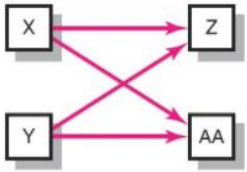


J, K, & L can all begin at the same time, if you wish (they need not occur simultaneously)

but

All (J, K, L) must be completed before M can begin

(C)

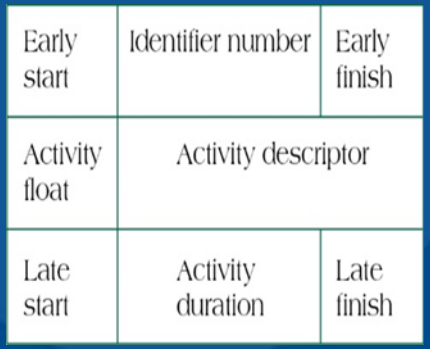


Z is preceded by X and Y

AA is preceded by X and Y

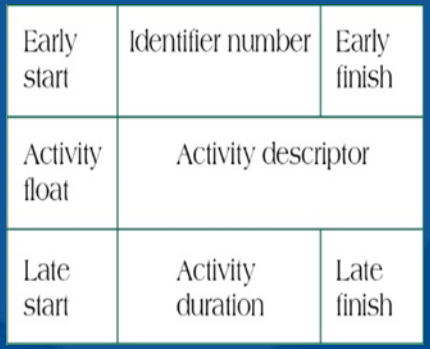
(D)

AON - Guidelines



- CPM networking techniques
- Some determination of ***activity precedence ordering*** must be done prior to creating the network (i.e., logically linking, successor, etc.)
- Flow: ***left to right***
- An activity ***cannot begin*** until all preceding connected activities have been completed
- ***Arrows*** on networks indicate ***precedence*** and ***logical flow***. Arrows can cross over each other (but not recommended – for clarity)
- ***Unique identifier*** needed for each activity
- ***Looping*** (or recycling) through activities is ***not permitted***
- Good to ***start and end with a single node***

AON - Nodes



***Early start (ES)**: The earliest an activity can start.*
It is the largest early finish of all immediate predecessors.

***Late start (LS)**: The latest an activity can start and not delay the following activity/activities.*

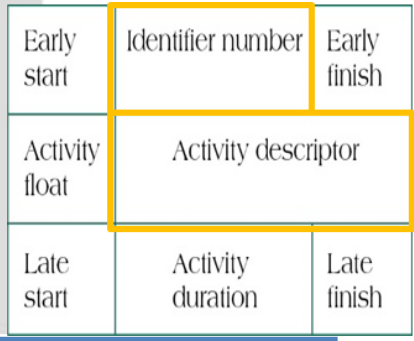
***Early finish (EF)**: The earliest an activity can finish if all its preceding activities are finished by their early finish times.*

***Late finish (LF)**: The latest an activity can finish and not delay the following activity/activities.*

***Activity float:** The amount of time an activity may be delayed from its early start without delaying the finish of the project.*

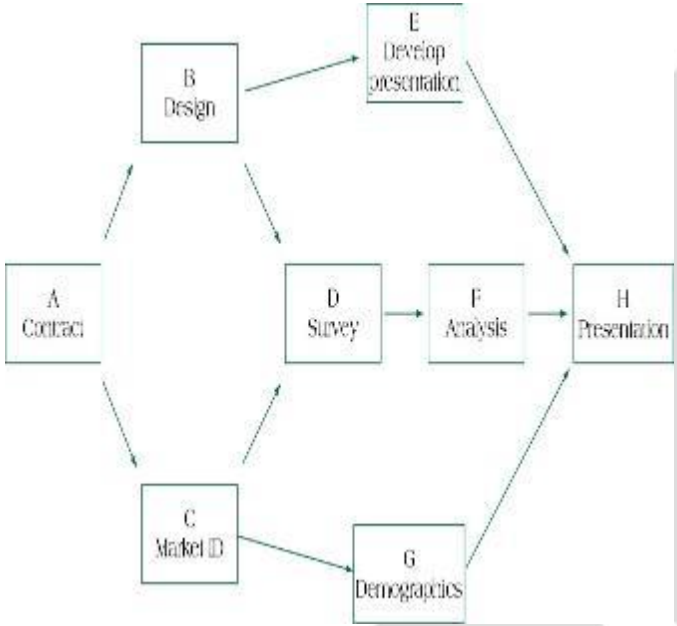
***Identifier number:** The unique identifier for the activity (can be a letter)*

Activity – Draw the AON Diagram



Activity	Description	Predecessor
A	Contract signing	None
B	Questionnaire design	A
C	Target market ID	A
D	Survey sample	B, C
E	Develop presentation	B
F	Analyse results	D
G	Demographic analysis	C
H	Presentation to client	E, F, G

Activity – Draw the AON Diagram



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A	Contract signing	None
B	Questionnaire design	A
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D	Survey sample	B, C
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F	Analyse results	D
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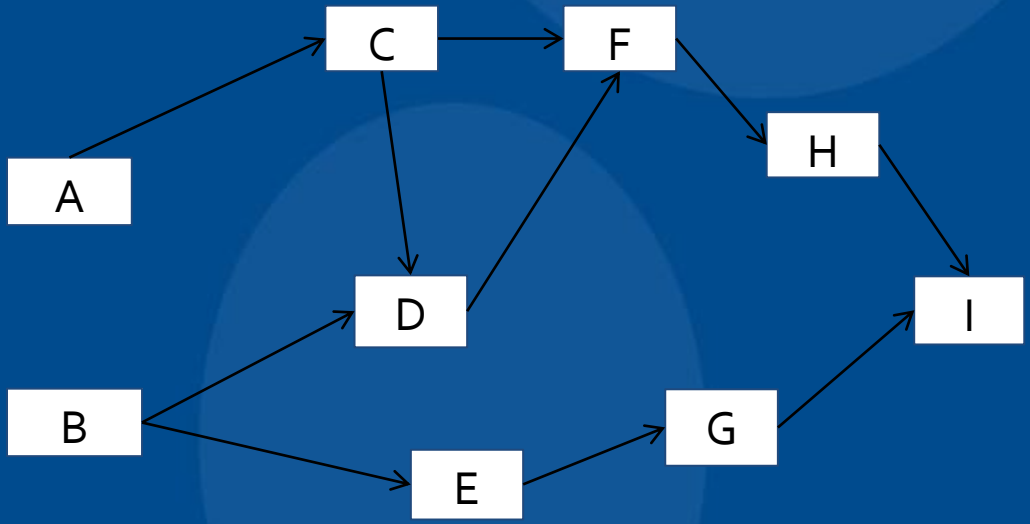
H	Presentation to client	E, F, G

Activity: draw a project network diagram

Activity	Preceding activities
A	-
B	-
C	A
D	B, C
E	B
F	C, D
G	E
H	F
I	G, H

Solution:

Activity	Preceding activities
A	-
B	-
C	A
D	B, C
E	B
F	C, D
G	E
H	F
I	G, H



Keep in Mind

- So far, we have only considered the tasks (activities) and their order
- But we have not considered:
  - How long each activity will take, or
  - Who is in charge for each activity

- NEXT,
- We will include the duration (how long each activity will take to be completed) for each activity

Activity Duration Estimates

How might we figure out how long an activity could take?

- Experience *(we use past examples of similar projects and use them as a baseline)*
- Expert opinion
- Mathematical derivation *(developing duration probability)*

$$Activity\ Duration = \mathrm{TE} = \frac{a + 4m + b}{6}$$

TE = estimated time of activity

a = most optimistic time to complete the activity

m = most likely time to complete the activity

b = most pessimistic time to complete the activity

Activity – Calculate Activity Durations

$$Activity\ Duration = \mathrm{TE} = \frac{a + 4m + b}{6}$$

TE = estimated time of activity
a = most optimistic time to complete the activity
m = most likely time to complete the activity
b = most pessimistic time to complete the activity

Activity	Description	Most optimistic (a)	Most likely (m)	Most pessimistic (b)	Activity Duration (TE)
A	Contract signing	3	4	11	
B	Questionnaire design	2	5	8	
C	Target market ID	3	6	9	
D	Survey sample	8	12	20	
E	Develop presentation	3	5	12	
F	Analyse results	2	4	7	
G	Demographic analysis	6	9	14	
H	Presentation to client	1	2	4	

Activity – Calculate Activity Durations

$$Activity\ Duration = \mathrm{TE} = \frac{a + 4m + b}{6}$$

TE = estimated time of activity
a = most optimistic time to complete the activity
m = most likely time to complete the activity
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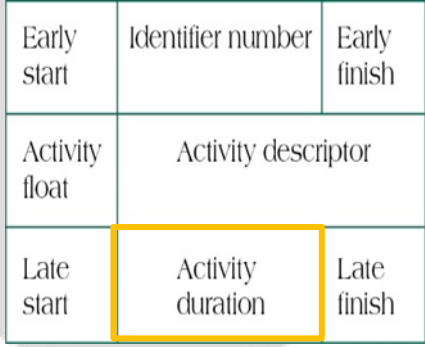
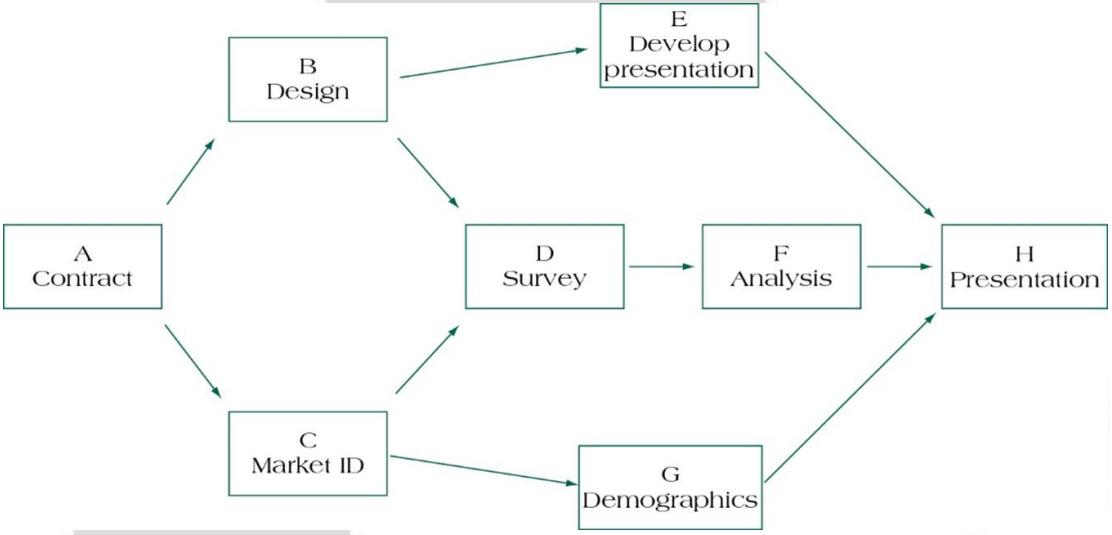
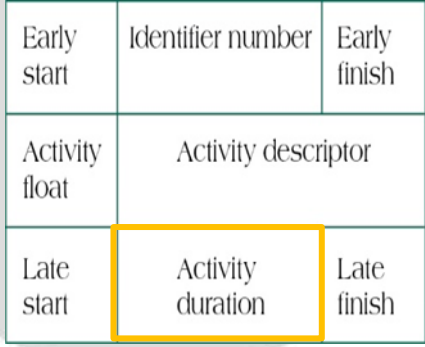
Activity	Description	Most optimistic (a)	Most likely (m)	Most pessimistic (b)	Activity Duration (TE)
A	Contract signing	3	4	11	5
B	Questionnaire design	2	5	8	5
C	Target market ID	3	6	9	6
D	Survey sample	8	12	20	12.7 (13)
E	Develop presentation	3	5	12	5.8 (6)
F	Analyse results	2	4	7	4.2 (4)
G	Demographic analysis	6	9	14	9.3 (9)
H	Presentation to client	1	2	4	2.2 (2)

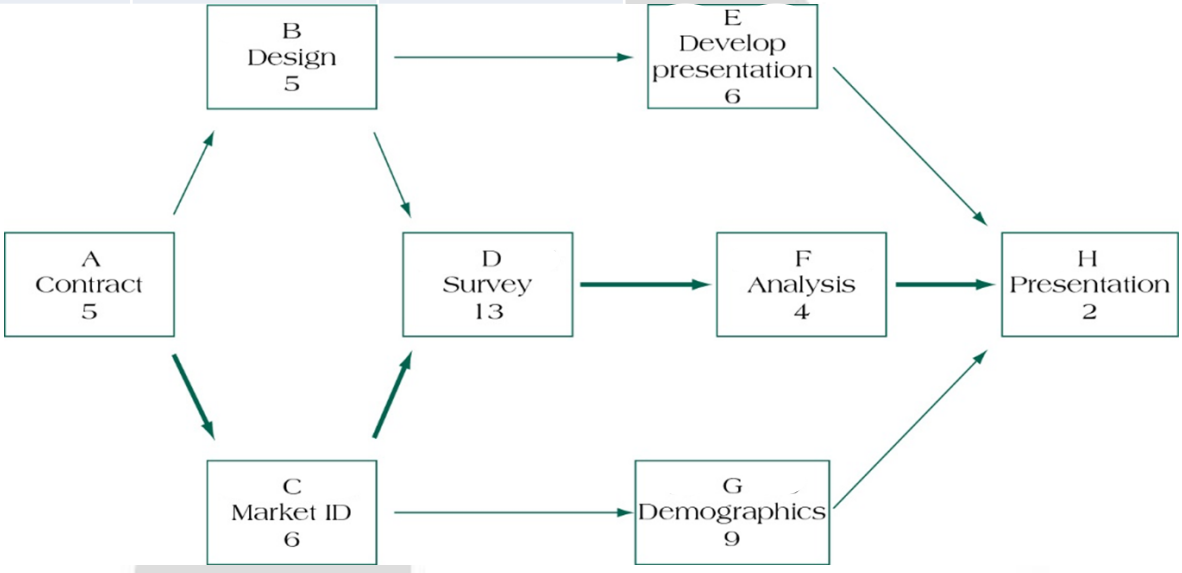
	Description	Predecessor	Activity Duration
A	Contract signing	None	5
B	Questionnaire design	A	5
C	Target market ID	A	6
D	Survey sample	B, C	13
E	Develop presentation	B	6
F	Analyse results	D	4
G	Demographic analysis	C	9
H	Presentation to client	E, F, G	2





	Description	Predecessor	Activity Duration
A	Contract signing	None	5
B	Questionnaire design	A	5
C	Target market ID	A	6
D	Survey sample	B, C	13
E	Develop presentation	B	6
F	Analyse results	D	4
G	Demographic analysis	C	9
H	Presentation to client	E, F, G	2





Constructing the Critical Path

- How soon can our activities start? (ES)
- How soon can each activity end? (EF)
- How soon can the project be finished? (TE)

Forward Pass

- How late can the activity start? (LS)
- How late can the activity finish? (LF)
- Which activities represent the critical path? (CP) [the longest path which, when delayed, will delay the project]
- How long can each activity be delayed? (float)

Backward Pass

Constructing the Critical Path

Forward pass – an ***additive move*** through the network from ***start to finish***

Backward pass – a ***subtractive move*** through the network from ***finish to start***

Critical path – the ***longest path*** from end to end which determines the ***shortest project length***

Forward Pass (ES, EF, & project TE)

***Forward pass**: Network calculations to determine earliest start/earliest finish for an activity through working forward through each activity in network.*

RULES WHEN USING THE FORWARD PASS

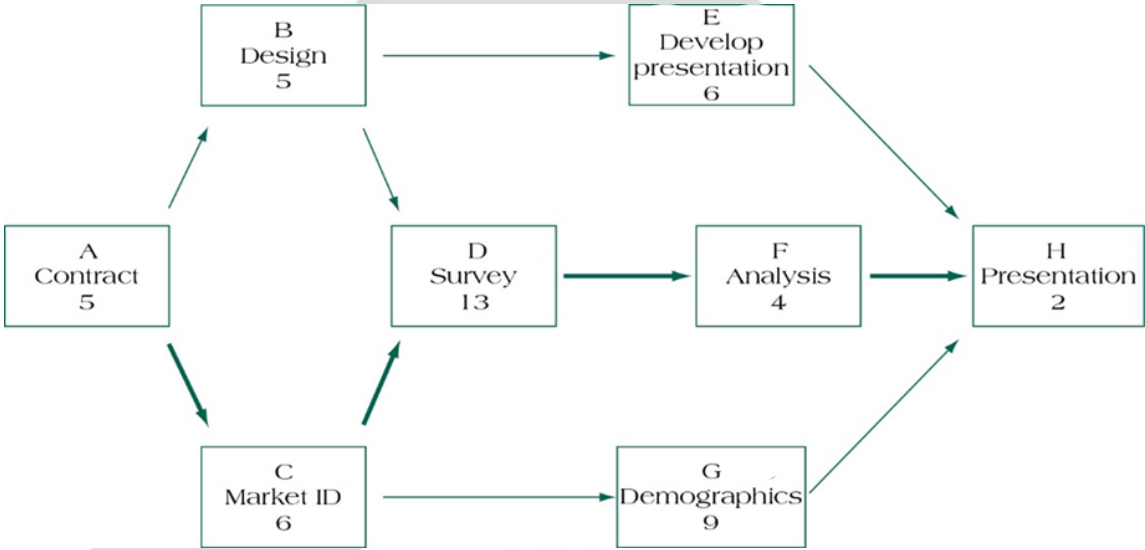
1. Add all activity times along each path as we move through the network (**ES + Dur = EF**).
2. Carry the EF time to the activity nodes immediately succeeding the recently completed node. That EF becomes the ES of the next node, unless the succeeding node is a merge point.
3. At a merge point, the largest preceding EF becomes the ES for that node.

When we complete the forward pass we can calculate all ES, EF, and project TE

Activity – Forward Pass

Early start	Identifier number	Early finish
Activity float	Activity descriptor	
Late start	Activity duration	Late finish

1. ES + Dur = EF
2. EF becomes ES, unless at a merge – then
3. The largest EF becomes the merge activity ES



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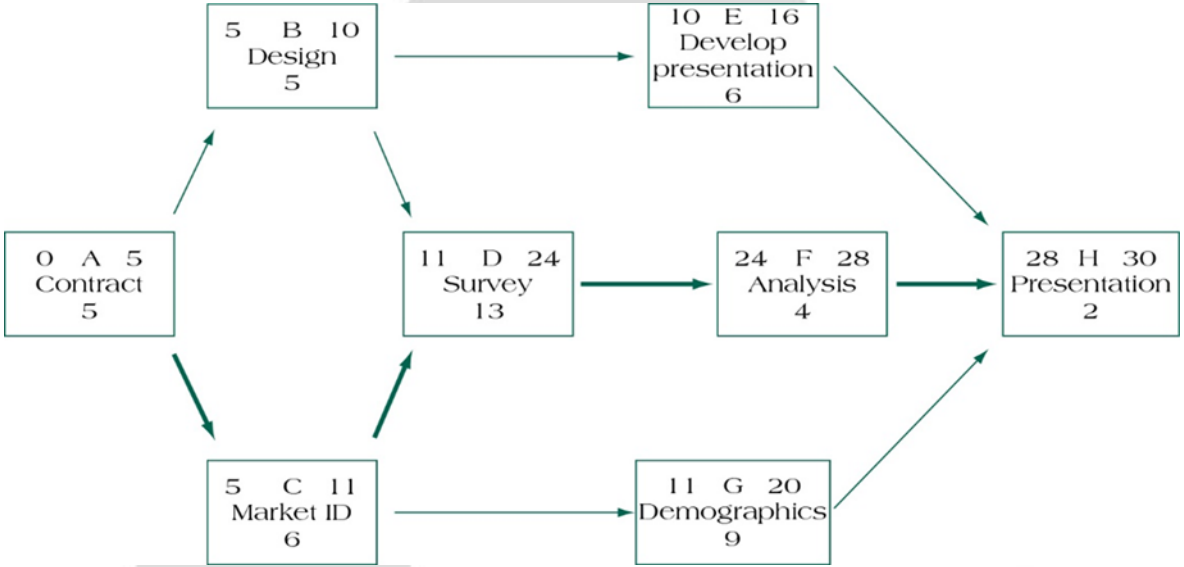


Backward Pass (LS, LF, & Float)

Backward pass: *Network calculations to determine late start/late finish for uncompleted tasks through working backward through each activity*

RULES FOR USING THE BACKWARD PASS

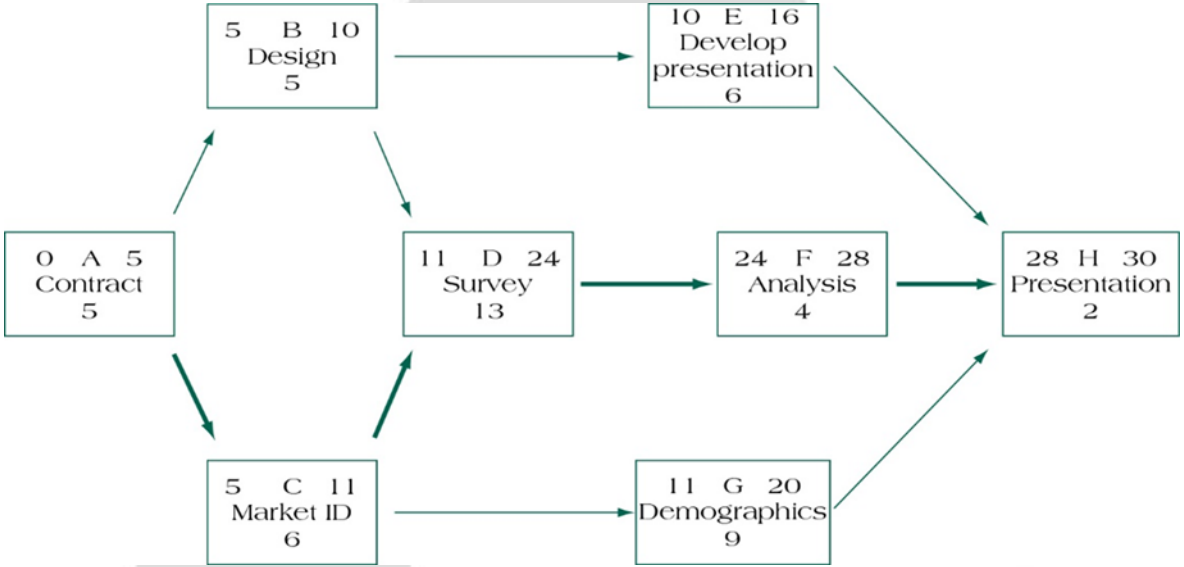
1. Subtract activity times along each path as you move through the network (**LF – Dur = LS**).
2. Carry back the LS time to the activity nodes immediately preceding the successor node. That LS becomes the LF of the next node, unless the preceding node is a burst point.
3. In the case of a burst point, the smallest succeeding LS becomes the LF for that node.

When we complete the backward pass we can calculate all LS, LF, and float

Activity – Backward Pass

Early start	Identifier number	Early finish
Activity float	Activity descriptor	
Late start	Activity duration	Late finish

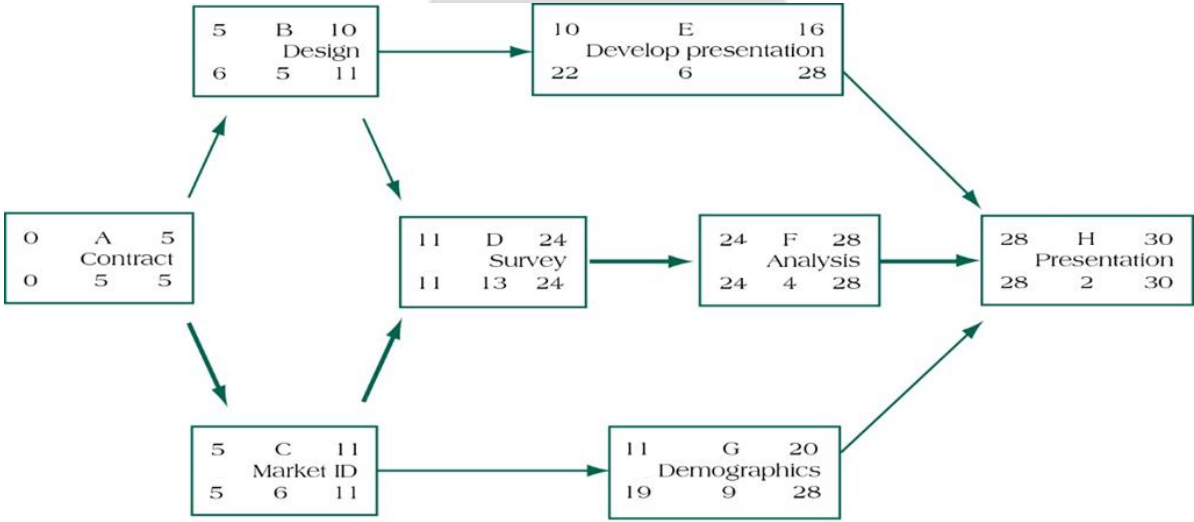
1. LF – Dur = LS
2. LS becomes LF, unless at a burst – then
3. The largest LS becomes the burst activity LF



Activity – Backward Pass

Early start	Identifier number	Early finish
Activity float	Activity descriptor	
Late start	Activity duration	Late finish

1. LF – Dur = LS
2. LS becomes LF, unless at a burst – then
3. The smalles LS becomes the burst activity LF

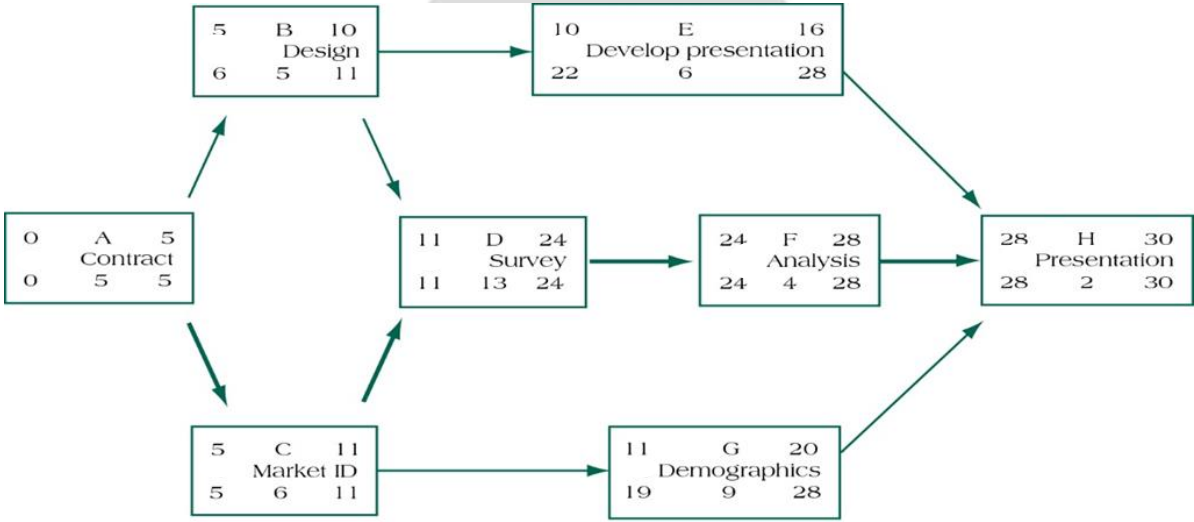


Activity – Backward Pass

LF – EF = Float
LS – ES = Float

Early start	Identifier number	Early finish
Activity float	Activity descriptor	
Late start	Activity duration	Late finish

Activity Float: *The amount of time that a schedule activity can be delayed without delaying the early start date of any immediately following schedule activities.*



Activity – Backward Pass

LF – EF = Float
LS – ES = Float

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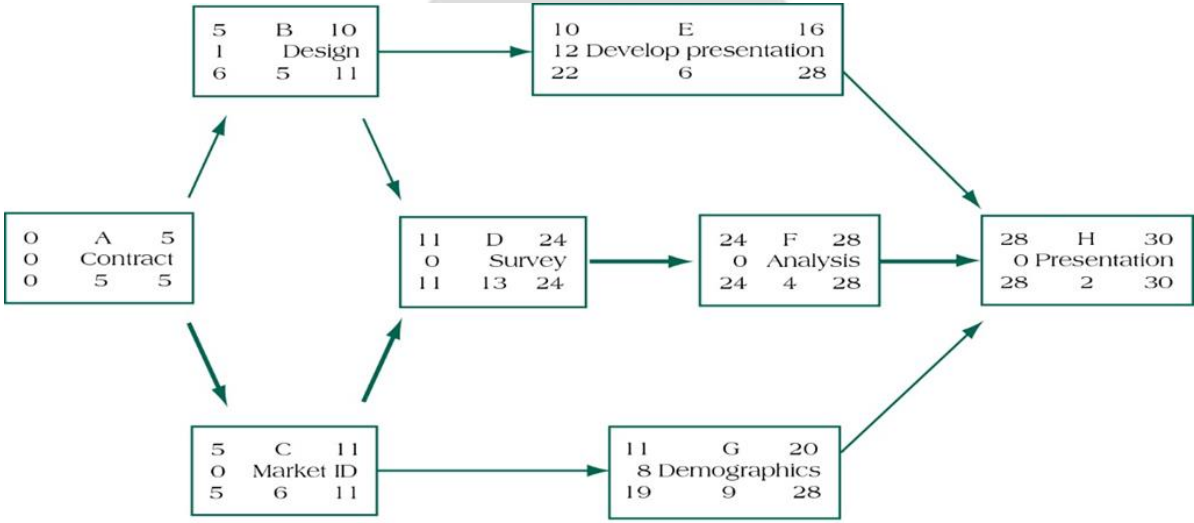
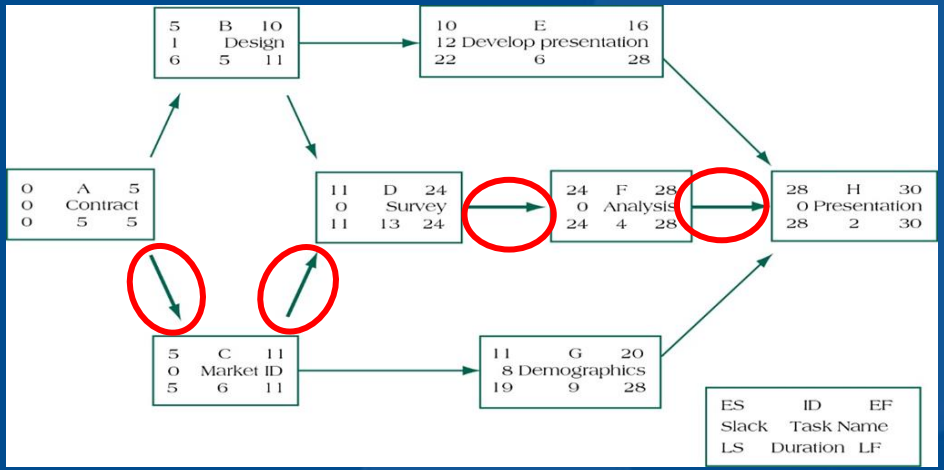


Critical Path

What are our different paths?
How long are they?
Which is our critical path?

***Critical path**: The path through project network with the longest duration.*
***Critical Path Method**: A network analysis technique used to determine the amount of schedule flexibility on logical network paths in project schedule network and to determine minimum project duration.*



A-B-E-H
18 weeks

A-B-D-F-H
29 weeks

A-C-D-F-H
30 weeks

A-C-G-H
22 weeks

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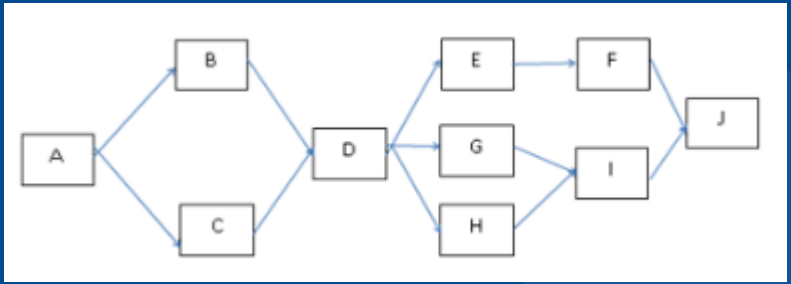
AON Practice

a. Identify all burst activities and merge activities.
b. Calculate the forward and backward pass on the network diagram. What is the estimated total duration for the project?
c. Which is the critical path for the project?
d. Which activities have slack time?

Activity	Predecessors	Duration (Days)
A	_	1
B	A	2
C	A	5
D	B, C	1
E	D	4
F	E	5
G	D	2
H	D	1
I	G, H	3
J	F, I	1

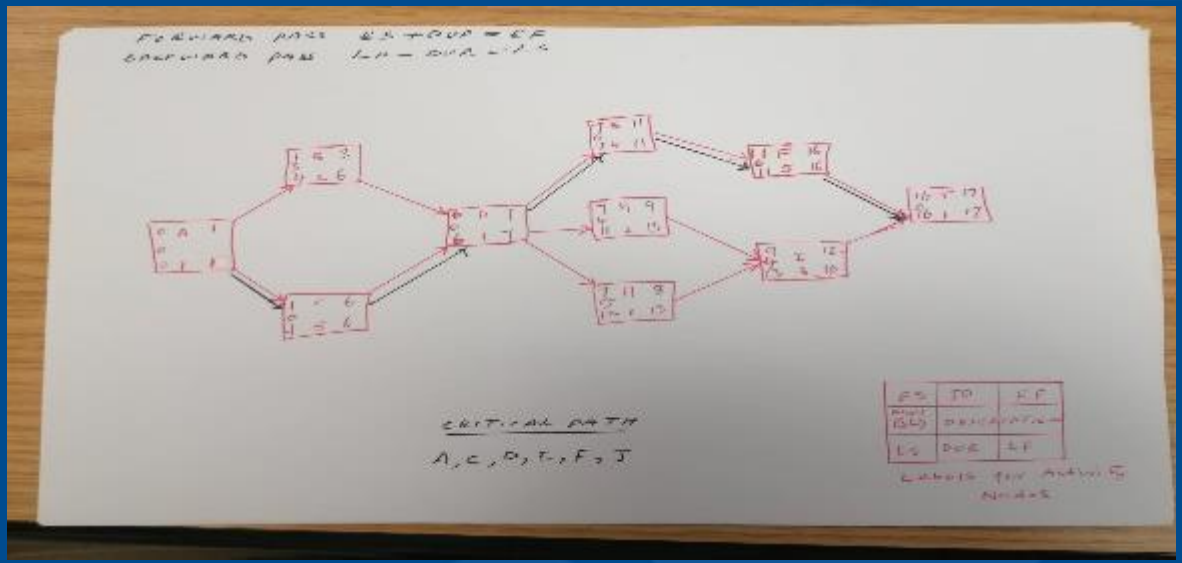
a. Identify all burst activities and merge activities.
    a. Burst = A, D
    b. Merge = D, I, J



***Burst activity**: An activity with two or more immediate successors.*

***Merge activity**: An activity with two or more immediate predecessors.*

a. Calculate the forward and backward pass on the network diagram. What is the estimated total duration for the project?
    a. Project duration = 17 days
b. Which is the critical path for the project?
    a. The critical path for the project is A, C, D, E, F, J
c. Which activities have float/slack time?
    a. Float is identified in tasks B, G, H, I



Critical path – the path with the longest duration, which determines the shortest project length

Activity Float: *The amount of time that a schedule activity can be delayed without delaying the early start date o any immediately following schedule activities.*