## الجدولة باستخدام اوقات الفعاليه :

الهدف من ، لجدولة ( scheduling ) لاي مشروع هو اعطاء متخذ القرار ( Decision Maker ) مختلف المعلومات منها ماهو متعلق بالمشروع ككل ومنها ماهو متعلق بالفعاليات المكونه للمشروع وللحصول على المعلومات هناك العديد من العمليات الحسابيه التي يجب تطبيقها على المخطط بعد انشائه

① على صعيد المشروع

ا- متى سينتهي المشروع كاملاً

ب- ماهي النشاطات الحرجة ( Critical Activities ) ، اي التي تؤثر على نهاية المشروع في حالة تأخرها ، وبالتالي يجب الحرص على زمن بداية ونهاية هذه الفعاليات

ج- الفعاليات ( النشاطات ) غير الحرجة ، اي التي لاتؤثر في نهاية المشروع مهما لو تأخرت بمقدار زمني معين يتم تحديده

د - في تاريخ زمني محدد هل ينتهي المشروع حسب المدة المحددة ، وفي حالة تأخر المشروع ، ماهي قيمة هذه الفترة الزمنية .

② على صعيد الفعاليات

ا - اعطاء الزمن لبدء اي فعاليه وزمن الانتهاء

ب - بيان التواريخ التي يمكن ان يسمح لغايتها تأجيل بداية اي فعاليه من خلال حساب قيم المرونه ( Float ) لتلك الفعالية

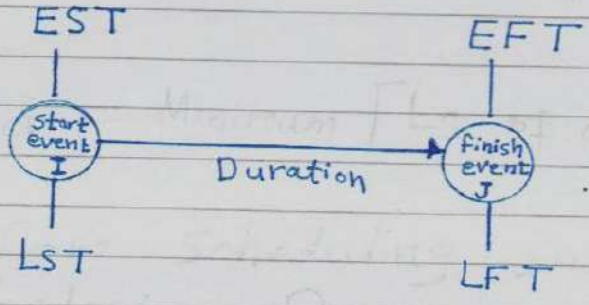
### الاوقات الاربعه للفعاليات

( EST ) Earliest start time وقت البداية المبكر : وهو المبكر وقت لابتداء فعاليه ما بدون مخالفة الفعاليات التي تسبقه . لايمكن للفعاليه ان تبدأ قبل هذا الوقت .

( EFT ) Earliest Finish Time وقت النهاية المبكر : هو المبكر وقت يمكن ان ينتهي عنده الفعاليه اذا بدأت في وقت البداية المبكر . لايمكن ان تنتهي الفعاليه قبل هذا الوقت

( LFT ) Latest Finish Time وقت النهاية المتأخر : هو آخر وقت يمكن ان تنتهي عنده الفعاليه دون ان يؤدي الى تأخير المشروع ككل

وقت البداية المتأخر (LST) Latest Start Time : هو آخر وقت يمكن لاي فعالية ان تبدأ دون تأخير المشروع ككل




$$EF = ES + Duration$$
$$LS = LF - Duration$$

المرور الامامي (Forward Pass) : الهدف من المرور الامامي تحديد الزمن الكلي للمشروع ووقت البداية المبكر (ES) والنهاية المبكر (Ef) للفعاليات المختلفة بدءاً من اول حدث وهو حدث البداية للمشروع وحتى آخر حدث وهو حدث النهاية للمشروع

في حالة وجود اكثر من فعالية سابقة تنتهي في حدث بداية فعالية ما وعليه يكون وقت البداية المبكر

$$ES_{(An\ activity)} = Maximum\ [EF\ of\ all\ Previous\ Activities]$$

$$EF_{The\ Project} = Maximum\ [EF\ of\ all\ terminal\ Activites]$$

المرور الخلفي (Backward Pass) : على العكس من المرور الامامي الذي يزودنا باوقات البداية والنهاية المبكرة فان المرور الخلفي يزودنا باوقات البداية والنهاية المتأخرة (LS) (LF)

$$L_S = L_F - \text{Duration}$$

$$L_{S\ \text{An activity}} = \text{Minimum}\ [L_S \text{ of all Succeeding Activites}]$$

الفعاليات اللاحقة

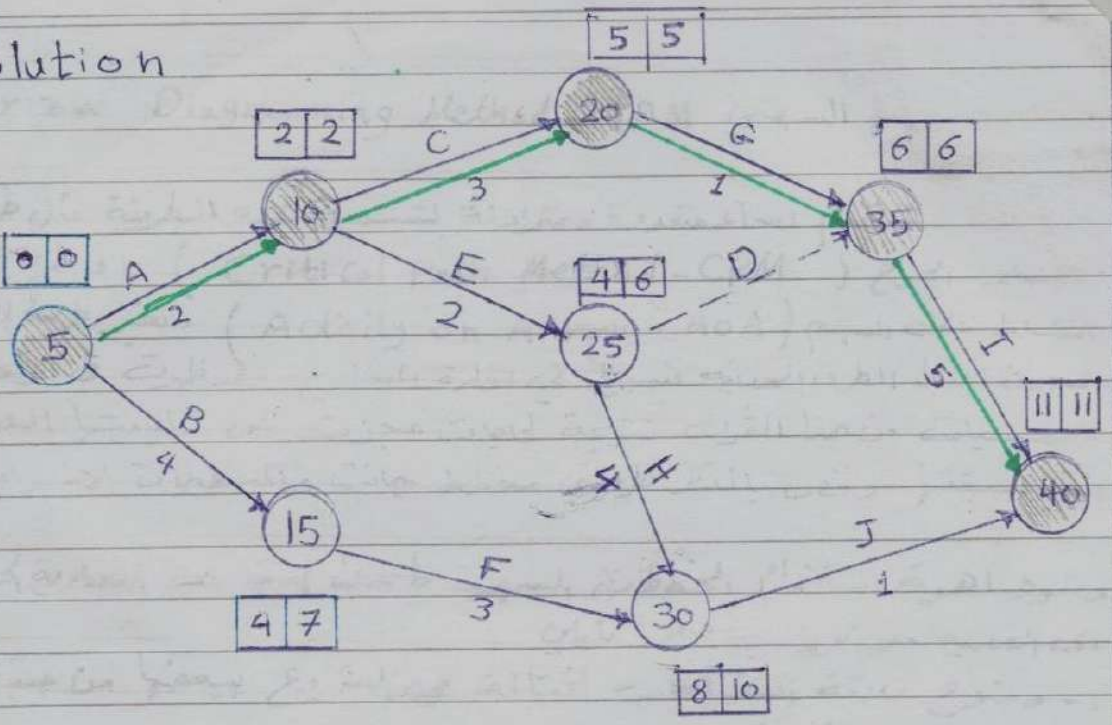
$$L_{S\ \text{the Project}} = \text{Minimum}\ [L_S \text{ of all Initial Activites}]$$

Ex. data For Scheduling Small Project are given below , Draw an arrow network & Determine the Following

1- Early & Late event time
2- list by atable the Four dates of each activity
3- Indicate the critical Path on the network and List the critical Path

| Activity | A | B | F | J | .I | H. | C | E | G | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Time Week | 2 | 4 | 3 | 1 | 5 | 4 | 3 | 2 | 1 | |
| Preceded by | — | — | B | F,H | G.E.C | E | A | A | C | |

Solution




| Activity | Duration | Preceded by | Early start | Early Finish | Latest start | Latest Finish | C.P |
|---|---|---|---|---|---|---|---|
| A | 2 | — | 0 | 2 | 0 | 2 | * |
| B | 4 | — | 0 | 4 | 3 | 7 | |
| F | 3 | B | 4 | 7 | 7 | 10 | |
| J | 1 | F,H | 8 | 9 | 10 | 11 | |
| I | 5 | G E C | 6 | 11 | 6 | 11 | * |
| H | 4 | E | 4 | 8 | 6 | 10 | |
| C | 3 | A | 2 | 5 | 2 | 5 | * |
| E | 2 | A | 2 | 4 | 4 | 6 | |
| G | 1 | C | 5 | 6 | 5 | 6 | * |
| D | | | 4 | 4. | 6 | 6 | |

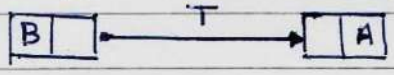
المرونه Float : هي مقدار الاحتياط الزمني (السماحيه) للفعاليات ، والتي تتكون من نوعين من ناحية وجود او عدم وجود قيمة للمرونه ، حيث ان الفعاليات التي لاتوجد لها اي مرونه تسمى الفعاليات الحرجة وهي تلك الفعاليات التي تؤدي اي تاخير بالمشروع فيما لو تأخرت ، اما الفعاليات غير الحرجة فهي تلك الفعاليات التي توجد لها مرونه والتي تنقسم الى

① المرونه الكلية Total Float ( T.F )

وهي تمثل السماحية الكلية للفعاليه او مجموعة من الفعاليات التي يمكن لها تأخير الفعاليات او زيادة زمن التنفيذ دون ان تؤثر على الزمن الكلي للمشروع

$$T.F_{\text{An Activity}} = LST_{\text{Same Activity}} - EST_{\text{Same Activity}}$$

OR



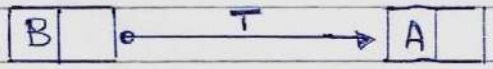

$$T.F = A - B - T$$

② المرونه الحرة Free Float ( F.F )

وهي عبارة عن السماحية التي تمتلكها الفعاليه دون ان تؤثر على المباشرة المبكرة للفعاليه اللاحقه حسب ايجادها

$$F.F_{\text{An Activity}} = \text{Minimum}\left[EST_{\text{of Succeeding Activities}} - EFT_{\text{An Activity}}\right]$$

كما ويمكن ايجادها من الخطوط من حاصل طرح الرقم الاسير للحدث عند رأس السهم وطرحاً منه الرقم الاسير للحدث عند بداية السهم وطرحاً منه زمن الفعالية.




$$F.F = A - B - T$$

③ المرونه المتداخلة Interfering Float ( INTF )

وهي الفترة الزمنية التي يمكن تأخير البدء بالفعالية دون التأخير في موعد انهاء المشروع ، علماً انها ستؤدي الى

تأخير لبدء في بعض النشاطات التي تليها ويتم ايجادها

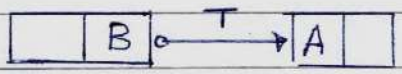
$$INTF_{An\ Activity} = TF_{Same\ Activity} - F.F_{same\ Activity}$$

④ المرونة المستقلة INDF Independent Float

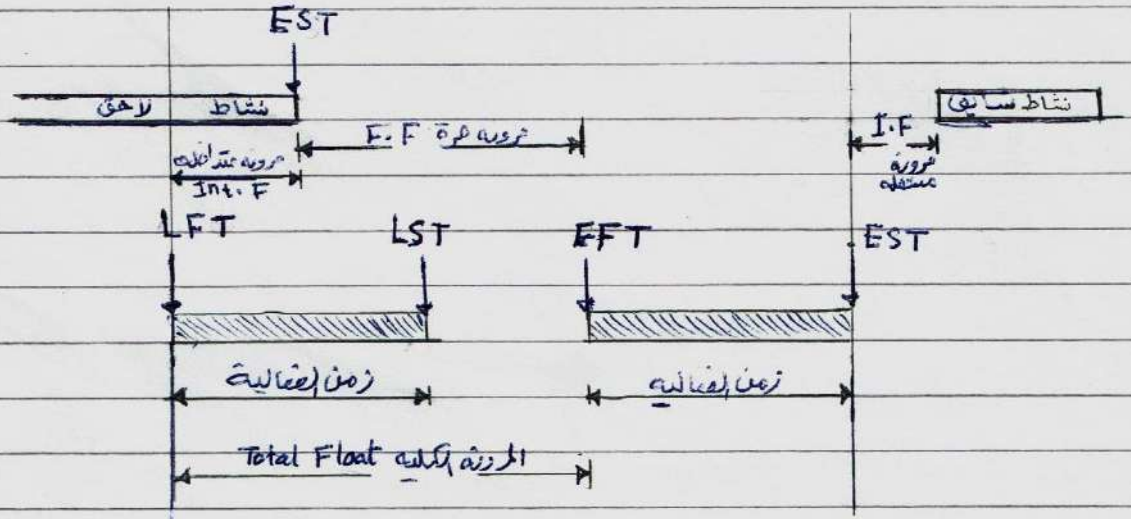
هي الفترة التي يمكن تأخير البدء في الفعالية بمقدارها، دون التأخير في موعد انتهاء المشروع او موعد بداية اي نشاط لاحق او دون ان تتأثر الفعالية المعنية نتيجة اي تأخير في اي فعالية سابقة.

$$I.F = E.S.T_{\text{الاحقة}} - L.F.T_{\text{سابقة}} - Time$$

كما يمكن ايجادها من خلال طرح الرقم الاسر للحدث عند رأس السهم مطروحاً منه الرقم الايمن عند بداية السهم مطروحاً منه زمن الفعالية المعنية.




$$I.F = A - B - T$$

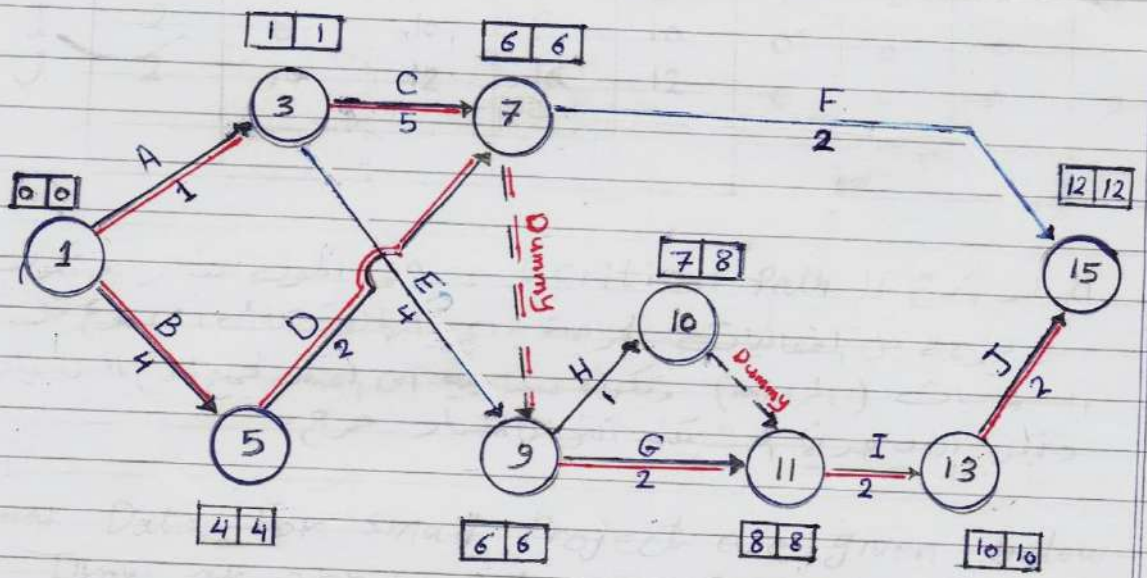



العلاقة بين اوقات الفعاليات الاربعة وانواع المرونة Float الاربعة

مثال : الفعاليات جزء من مشروع تنفيذ طريق المطلوب

١- رسم المخطط السهمي للمشروع وترقيمه
٢- حساب اوقات الفعاليات (EST, EFT, LST, LFT)
٣- حساب المرونة بانواعها الاربعة (T.F, F.F, INT F, I.F)
٤- تحديد مسار الحرج للمشروع

| Activity | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Duration (month) | 1 | 4 | 5 | 2 | 4 | 2 | 2 | 1 | 2 | 2 |
| Preceded by | – | – | A | B | A | C, D | C, D, E | C, D, E | G H | I |




⑧ بالاستعانة بالجدول الخاص بحساب اوقات الفعاليات والمرونة نجد ان هنالك مسارات حرجة عدد 2

first Critical Path : 1 – 3 – 7 – 9 – 11 – 13 – 15

Second Critical Path : 1 – 5 – 7 – 9 – 11 – 13 – 15

| Activity | Time | Earliest | | Latest | | Float | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Start | Finish | Start | Finish | Total | Free | Interfer. | Indep. |
| A | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| B | 4 | 0 | 4 | 0 | 4 | 0 | 0 | 0 | 0 |
| C | 5 | 1 | 6 | 1 | 6 | 0 | 0 | 0 | 0 |
| D | 2 | 4 | 6 | 4 | 6 | 0 | 0 | 0 | 0 |
| E | 4 | 1 | 5 | 2 | 6 | 1 | 1 | 0 | 1 |
| F | 2 | 6 | 8 | 10 | 12 | 4 | 4 | 0 | 4 |
| G | 2 | 6 | 8 | 6 | 8 | 0 | 0 | 0 | 0 |
| H | 1 | 6 | 7 | 7 | 8 | 1 | 0 | 1 | 0 |
| I | 2 | 8 | 10 | 8 | 10 | 0 | 0 | 0 | 0 |
| J | 2 | 10 | 12 | 10 | 12 | 0 | 0 | 0 | 0 |

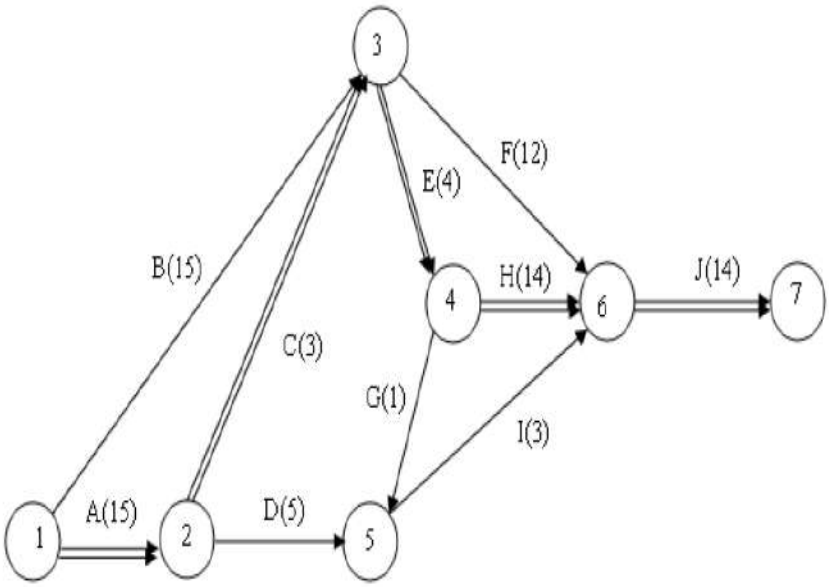
المسار الحرج ( Critical Path ) : هو اطول مسار ويتكون من مجموعة من الفعاليات الحرجة ، اي انها لا تمتلك اي نوع من السماحيات ( المرونة ) ويكون مساوية الى الصفر لجميع انواع السماحيات ويمكن ان يوجد في الشبكة اكثر من مسار حرج .

Ex: Data For small Project are given below Draw an arrow network Compute the early & Late dates , Indicate the Critical Path on the network & determine the Four Float for each activity & List there values in atable

| Activity | 1-2 | 1-3 | 2-4 | 3-5 | 4-9 | 5-6 | 5-7 | 6-8 | 7-8 | 8-10 | 9-10 | 10-11 | 4-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| duration Mon. | 9 | 4 | 8 | 7 | 3 | 6 | 8 | 2 | 3 | 3 | 3 | 3 | 0 |

**EXAMPLE :**Consider the network shown in Fig. which consists of the following activities as shown in the Table determine 1- the early &late event 2- list the four dates of each activity.

| Activities | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Immediate - Predecessor | — | — | A | A | B,C | B,C | E | E | D | F,H,I |
| Duration(weeks) | 15 | 15 | 3 | 5 | 8 | 12 | 1 | 14 | 3 | 14 |




| Activity | Duration | Start time | | Finish time | | Total float |
|---|---|---|---|---|---|---|
| | | Earliest | Latest | Earliest | Latest | (weeks) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| A(1-2) | 15 | 0 | 0 | 15 | 15 | 0 |
| B(1-3) | 15 | 0 | 3 | 15 | 18 | 3 |
| C(2-3) | 3 | 15 | 15 | 18 | 18 | 0 |
| D(2-5) | 5 | 15 | 32 | 20 | 37 | 17 |
| E(3-4) | 8 | 18 | 18 | 26 | 26 | 0 |
| F(3-6) | 12 | 18 | 28 | 30 | 40 | 10 |
| G(4-5) | 1 | 26 | 36 | 27 | 37 | 10 |
| H(4-6) | 14 | 26 | 26 | 40 | 40 | 0 |
| I(5-6) | 3 | 27 | 37 | 30 | 40 | 10 |
| J(6-7) | 14 | 40 | 40 | 54 | 54 | 0 |

**EXAMPLE :**

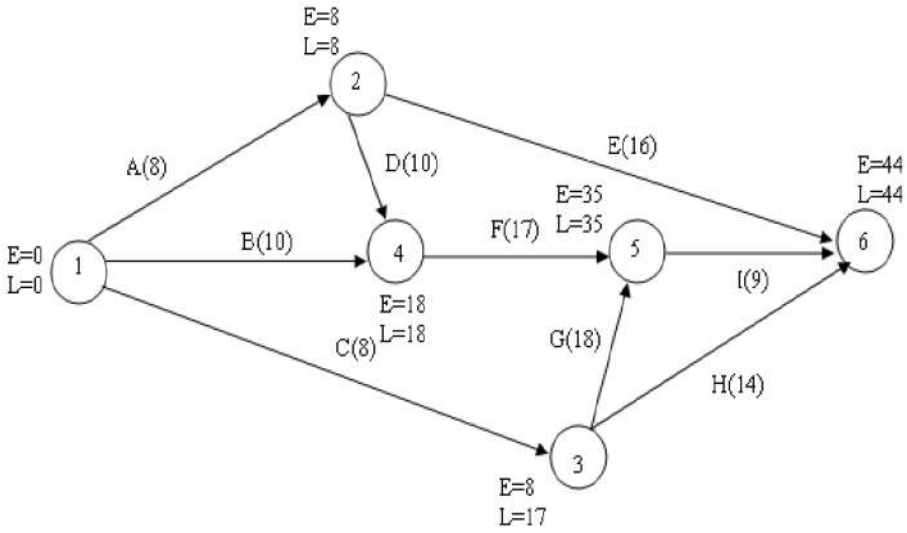
*Tasks A, B, C, H, I constitute a project. The precedence relationships are A < D; A<E, B < F; D < F, C < G, C < H; F < I, G < I*

*Draw a network to represent the project and find the minimum time of completion of the project when time, in days, of each task is as follows:*

| Task | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| Time | 8 | 10 | 8 | 10 | 16 | 17 | 18 | 14 | 9 |

*Also identify the critical path.*

**SOLUTION**




Fig( a)

The earliest occurrence time (E) and the latest occurrence time (L) of each event is then computed.

El = 0,

E2 = El + t12 =0 + 8 = 8,

E3 = El + t13 = 0 + 8 = 8,

E4 = Max. [0 + 10, 8 + 10] = 18,

E5 = Max. [18 + 17, 8 + 18] = 35,

E6 = Max. [8 + 16, 35 + 9, 8+14]=44.

Similarly,

L6 = E6 = 44,

L5 = L6 — t56 = 44 – 9 = 35,

L4 = L5 — t45 = 35 – 17 = 18,

L3 = Min. [44 – 14, 35 – 18 = 17,

L2 = Min. [44 –. 16, 18 – 10] = 8,

L1 =Min. [8-8, 17-8, 18– 10] =0

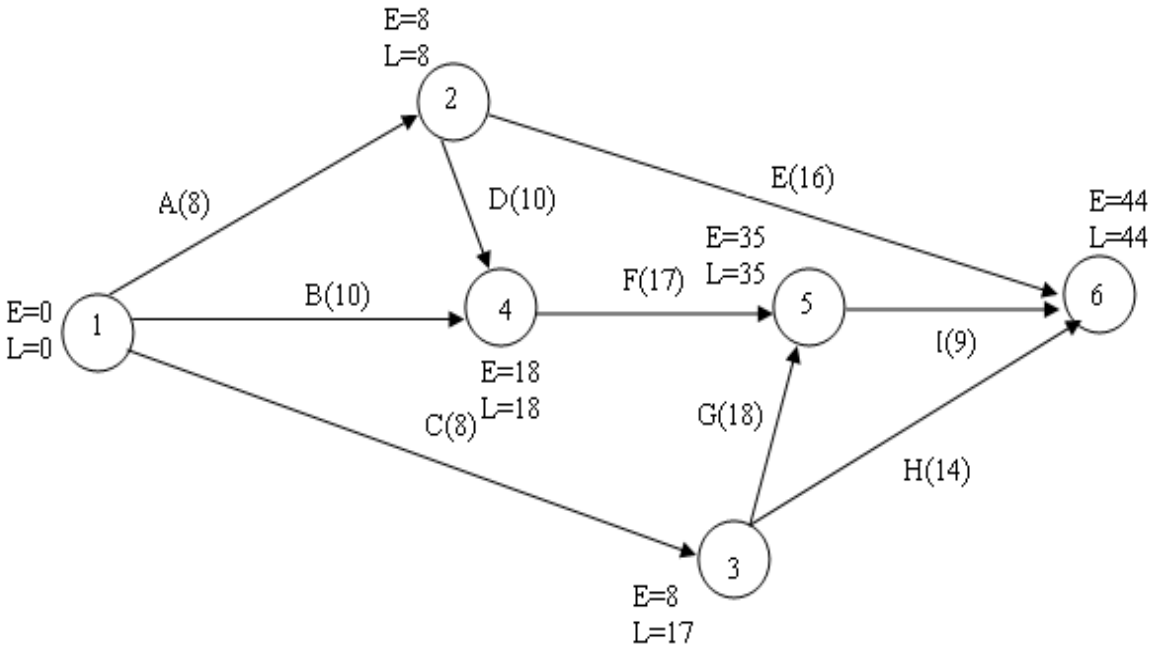



Fig (b)

The critical path is now determined by any of the following methods:

**Method 1.** The network analysis table is compiled as shown in the Table

| *Activity* | *Duration* | Start time | | Finish time | | Total float (weeks) |
|---|---|---|---|---|---|---|
| | | Earliest | Latest | Earliest | Latest | |
| 1-2 | 8 | 0 | 0 | 8 | 8 | 0 |
| 1-3 | 8 | 0 | 9 | 8 | 17 | 9 |
| 1-4 | 10 | 0 | 8 | 10 | 18 | 8 |
| 2-4 | 10 | 8 | 8 | 18 | 18 | 0 |
| 2-6 | 16 | 8 | 28 | 24 | 44 | 20 |
| 3-5 | 18 | 8 | 17 | 26 | 35 | 9 |
| 3-6 | 14 | 8 | 30 | 22 | 44 | 22 |
| 4-5 | 17 | 18 | 18 | 35 | 35 | 0 |
| 5-6 | 9 | 35 | 35 | 44 | 44 | 0 |

Activities 1-2, 2-4, 4-5 and 5-6 having zero float are the critical activities and 1-2-4-5-6 is the critical path.

**Method 2.** For identifying the critical path, the following conditions are checked. If an activity satisfies
all the three conditions, it is critical.
(i). E = L for the tail event.
(ii). E = L for the head event.
(iii). Ej - Ei = Lj - Li = t*ij*.
Activities 1-2, 2-4, 4-5 and 5-6 satisfy these conditions. Other activities do not fulfill all the three conditions. The critical path is, therefore, 1-2-4-5-6.

**Method 3**. The various paths and their duration are:
*Path Duration (days)*
1-2-6 24
1-2-4-5-6 44
1-4-5-6 36
1-3-5-6 35
1-3-6 22
Path 1-2-4-5-6, the longest in time involving 44 days, is the critical path. It represented by double bold lines in Fig b.

**EXAMPLE 9.5**
A project consists of a series of tasks labeled *A, B. H, I* with the following constraints A< D,E; B, D<F: C<G; B<H; F, G<I. (W<X, Y means X, and Y can't start until W is completed.) You are required to construct a network using this notation. Also find the minimum time of completion of the project when the time of completion of each task is given as follows.

| Task | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| Time(days) | 23 | 8 | 20 | 16 | 24 | 18 | 19 | 4 | 10 |

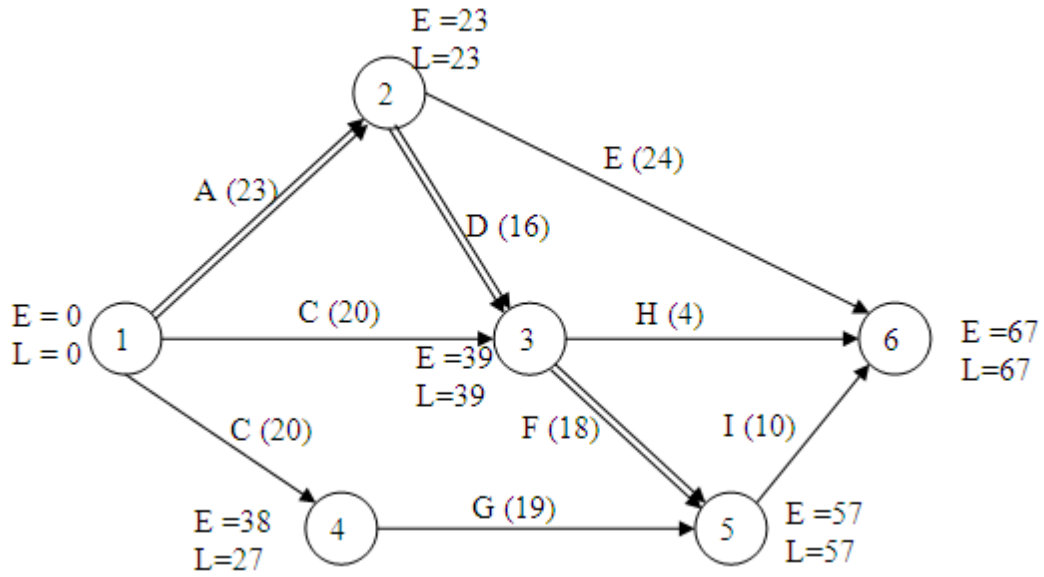
**SOLUTION** The given constraints can be given in the follow table.

| Activity | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| Proceeding Activity | -- | -- | -- | A | A | B,D | C | B | G,F |

To determine the minimum time of completion of the project, we compute ES*i* and LF*j* for each of the tasks (*i*, *j*) of the project. The critical path calculations are as shown in the Table. Critical path 1-2-3-5-6

| Actvity | Normal time | Earliest | | Latest | | Total floats |
|---|---|---|---|---|---|---|
| | | Start | Finish | Start | Finish | |
| A (1-2) | 23 | 0 | 23 | 0 | 23 | 0 |
| B (1-3) | 8 | 0 | 8 | 31 | 39 | 8 |
| C (1-4) | 20 | 0 | 20 | 18 | 38 | 18 |
| D (2-3) | 16 | 23 | 39 | 23 | 39 | 0 |
| E(2-6) | 24 | 23 | 47 | 43 | 67 | 20 |
| F( 3-5) | 18 | 39 | 57 | 39 | 57 | 0 |
| H( 3-6) | 4 | 39 | 43 | 63 | 67 | 24 |
| G( 4-5) | 19 | 20 | 39 | 38 | 57 | 18 |
| I(5-6) | 10 | 57 | 67 | 57 | 67 | 0 |

The above table shows that the critical activities are 1-2, 2-3, 3-5, 5-7 as their total float is zero. Hence, we have the critical path, 1-2-3-5-7 with the total project duration (the least possible time to complete the entire project as 67 days.




**EXAMPLE**

*A project schedule has the following characteristics*

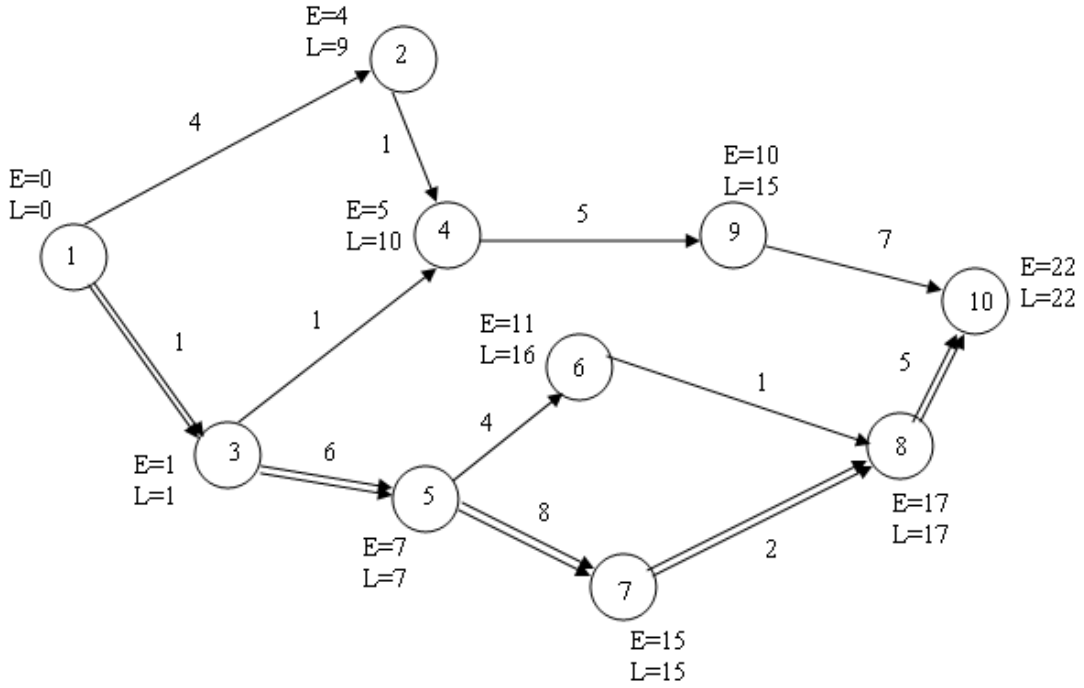
| *Activity* | *Time (weeks)* | *Activity* | *Times (weeks)* |
|---|---|---|---|
| 1-2 | 4 | 5-6 | 4 |
| 1-3 | 1 | 5-7 | 8 |
| 2-4 | 1 | 6-8 | 1 |
| 3-4 | 1 | 7-8 | 2 |
| 3-5 | 6 | 8-10 | 5 |
| 4-9 | 5 | 9-10 | 7 |

(i) *Construct the network.*
(ii) *Compute E and L for each event, and*
(iii) *Find the critical path.*

**SOLUTION**

The given data results in a network shown in Fig.. The figures along the arrows represent the activity times

The earliest occurrence time (E) and the latest occurrence time (L) of each event are now computed by employing forward and backward pass calculations.
In forward pass computations, E values are represented in Fig and in backward pass computations, L values are also represented in Fig..




Network analysis table is given Table

| Activity | Duration | Start time Earliest | Latest | Finish time Earliest | Latest | Total float (weeks) |
|---|---|---|---|---|---|---|
| 1-2 | 4 | 0 | 5 | 4 | 9 | 5 |
| 1-3 | 1 | 0 | 0 | 1 | 1 | 0 |
| 2-4 | 1 | 4 | 9 | 5 | 10 | 5 |
| 3-4 | 1 | 1 | 9 | 2 | 10 | 8 |
| 3-5 | 6 | 1 | 1 | 7 | 7 | 0 |
| 4-9 | 5 | 5 | 10 | 10 | 15 | 5 |
| 5-6 | 4 | 7 | 12 | 11 | 16 | 5 |
| 5-7 | 8 | 7 | 7 | 15 | 15 | 0 |
| 6-8 | 1 | 11 | 16 | 12 | 17 | 5 |
| 7-8 | 2 | 15 | 15 | 17 | 17 | 0 |
| 8-10 | 5 | 17 | 17 | 22 | 22 | 0 |
| 9-10 | 7 | 10 | 15 | 17 | 22 | 5 |

Path 1-3-5-7-8-10 with project duration of 22 weeks is the critical pat

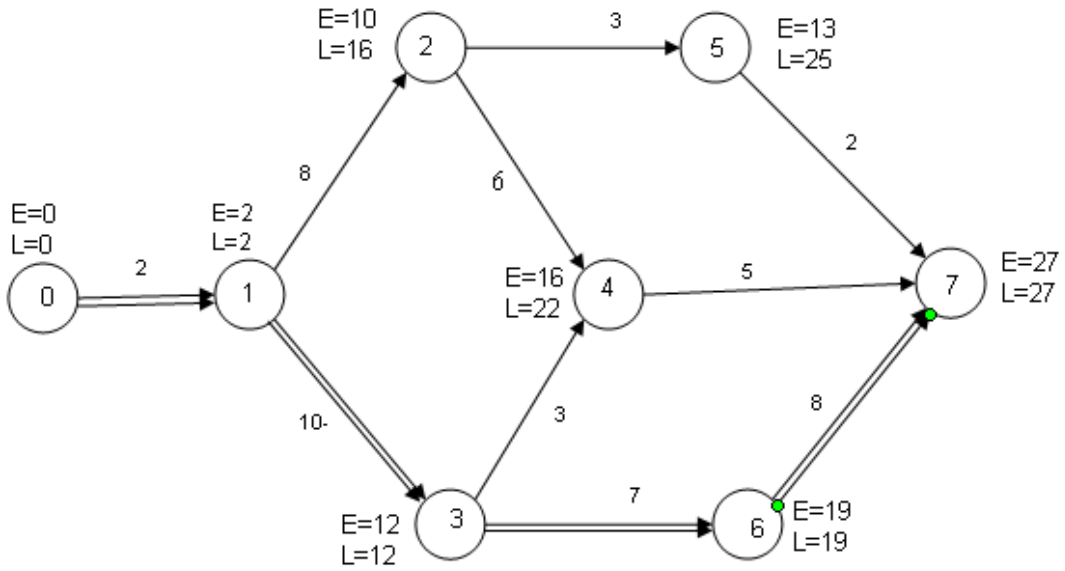
## EXAMPLE

*The utility data for a network are given below. Determine the total, free, and independent floats and identify the critical path.*

| Activity | 0-1 | 1-2 | 1-3 | 2-4 | 2-5 | 3-4 | 3-6 | 4-7 | 5-7 | 6-7 |
|---|---|---|---|---|---|---|---|---|---|---|
| Duration | 2 | 8 | 10 | 6 | 3 | 3 | 7 | 5 | 2 | 8 |

**SOLUTION**

The network diagram for the given project data is shown in Fig.. Activity durations are written along the activity arrows. The earliest start and latest finish times of the activities are computed by employing the forward pass and backward pass calculations, as explained in example 2. These times are represented in the network around the respective nodes. The network analysis table is now constructed in Table.



| Activity | Duration | Start time | | Finish time | | Float | | |
|---|---|---|---|---|---|---|---|---|
| | | Earliest | Latest | Earliest | Latest | Total | Free | Independent |
| 0-1 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| 1-2 | 8 | 2 | 8 | 10 | 16 | 6 | 0 | 0 |
| 1-3 | 10 | 2 | 2 | 12 | 12 | 0 | 0 | 0 |
| 2-4 | 6 | 10 | 16 | 16 | 22 | 6 | 0 | $-6 \approx 0$ |
| 2-5 | 3 | 10 | 22 | 13 | 25 | 12 | 0 | $-6 \approx 0$ |
| 3-4 | 3 | 12 | 19 | 15 | 22 | 7 | 1 | 1 |
| 3-6 | 7 | 12 | 12 | 19 | 19 | 0 | 0 | 0 |
| 4-7 | 5 | 16 | 22 | 21 | 27 | 6 | 6 | 0 |
| 5-7 | 2 | 13 | 25 | 15 | 27 | 12 | 12 | 0 |
| 6-7 | 8 | 19 | 19 | 27 | 27 | 0 | 0 | 0 |

*Total float* is the positive difference between latest and earliest finish times or latest and earliest start times. For activity 1-2,

Total float (T.F.) = 16 – 10 = 8 – 2 = 6.

Similarly, for activity, say 2-5,

Total float = 25-13 = 22 -10 = 12 and so on.

Total float calculations are depicted in column 7 of table 4.

*Free float of activity i - j* = Total float – head event slack

= Total float – (L – E) of event j. Thus free float of activity 0 – 1 =0–(L–E) of event 1, = 0–(2-2)=0, free float of activity 1 -2 =6–(16– 10)=6-6=0etc.

Free floats of various activities are calculated in column 8 of the network analysis table. Independent float of activity i - j = Free float – tail event slack = Free float – (L – E) of event *i*.

Thus independent float of activity 0 - 1 = 0 – (0 – 0) = 0,

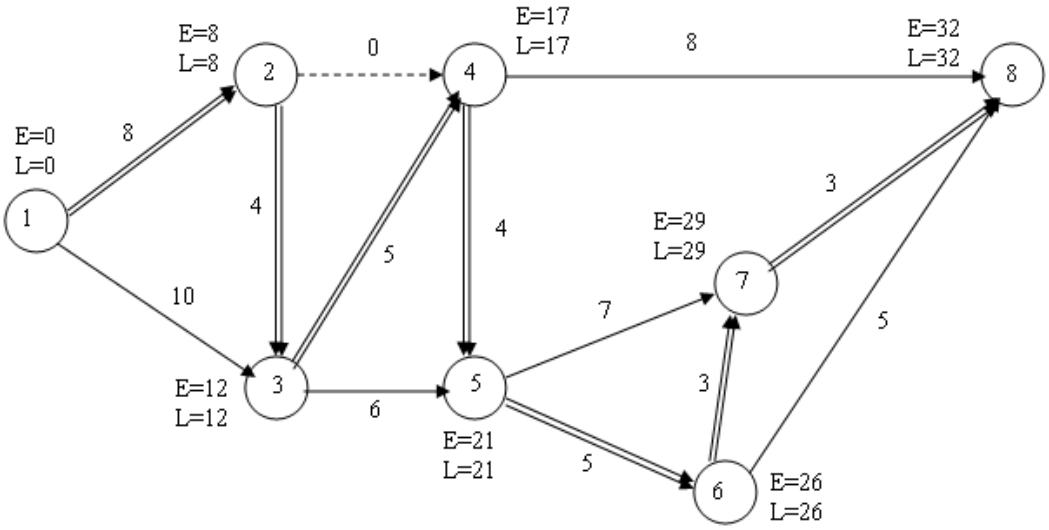
independent float of activity I - 2= 0 – (2 – 2) = 0,

independent float of activity 2 – 4 = 0 – (16 – 10) = – 6 ≈ 0 and so on.

Independent floats of various activities are calculated in column 9 of the Table. If independent float of an activity is negative, it is taken as zero.

**EXAMPLE**

For the network given in Fig, determine the total, free, and independent floats for each activity. Times for activities are in months.




**SOLUTION**

The computations of earliest start, earliest finish, latest start and latest finish times along with floats are given in Table

| Activity | Duration | Start time | | Finish time | | Float | | |
|---|---|---|---|---|---|---|---|---|
| | | Earliest | Latest | Earliest | Latest | Total | Free | Independent |
| 1-2 | 8 | 0 | 0 | 8 | 8 | 0 | 0 | 0 |
| 1-3 | 10 | 0 | 2 | 10 | 12 | 2 | 2 | 2 |
| 2-3 | 4 | 8 | 8 | 12 | 12 | 0 | 0 | 0 |
| 24 | 0 | 8 | 17 | 8 | 17 | 9 | 9 | 9 |
| 3-4 | 5 | 12 | 12 | 17 | 17 | 0 | 0 | 0 |
| 3-5 | 6 | 12 | 15 | 18 | 21 | 3 | 3 | 3 |
| 4-5 | 4 | 17 | 17 | 21 | 21 | 0 | 0 | 0 |
| 4-8 | 8 | 17 | 24 | 25 | 32 | 7 | 7 | 7 |
| 5-6 | 5 | 21 | 21 | 26 | 26 | 0 | 0 | 0 |
| 5-7 | 7 | 21 | 22 | 28 | 29 | 1 | 1 | 1 |
| 6-7 | 3 | 26 | 26 | 29 | 29 | 0 | 0 | 0 |
| 6-8 | 5 | 26 | 27 | 31 | 32 | 1 | 1 | 1 |
| 7-8 | 3 | 29 | 29 | 32 | 32 | 0 | 0 | 0 |

Activities 1-2, 2-3, 3-4, 4-5, 5-6, 6-7 and 7-8 have zero float and hence are critical. The path 1-2-34-5- 6-7-8 is the critical path with the project duration of 32 months. Total, free and independent floats are calculated as explained in example 4 and are represented in the last four columns of the above table.

**EXAMPLE :**Estimated times for the jobs of a project are given below:

| Job: | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (weeks) : | 13 | 5 | 8 | 10 | 9 | 7 | 7 | 12 | 8 | 9 | 4 | 17 |

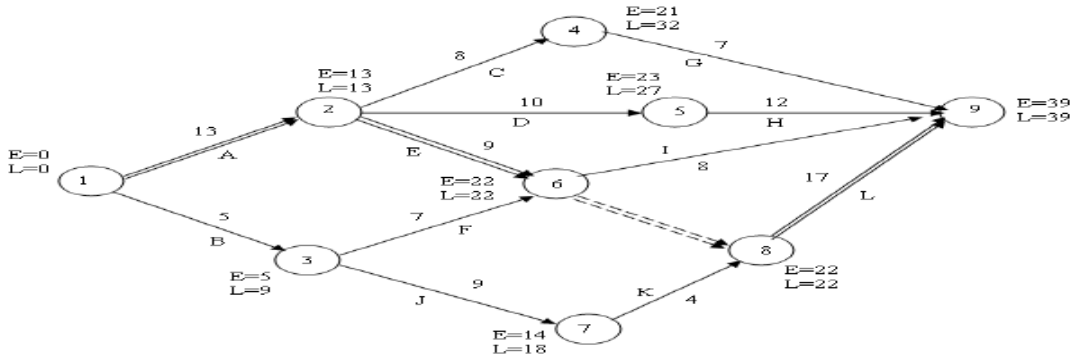
The constraints governing the jobs are as fo1lows:

A and B are start jobs; A controls C, D and E; B controls F and J; G depends upon C; H depends on D; E and F control I and L; K follows J; L is also controlled by K; G, H, I and L are the last jobs. Draw the network, determine float for each activity, project duration and the critical path.

**SOLUTION**

The network obtained by using the given precedence relationship is shown in Fig. Events have been numbered using the Fulkerson's rule. Note that a dummy activity 6-8 has been included to draw the network. The earliest start times and latest completion times of the activities can be computed by

using the forward and backward pass methods. Critical path is 1-2-6-8-9 and project duration is 39 weeks.



**EXERCISES**

1.Define 'project', and give some application areas of project management. Explain different phases of project management.

2. Distinguish between CPM and PERT.

3. Discuss the guidelines for constructing a project network.

4. Define the following: (a) total float, (b) free float, and (c) critical path.

5- A construction company has listed down various activities that are involved in constructing a building. These are summarized along with predecessor(s) details in the table.

| Activity | Immediate predecessor(s) |
|---|---|
| A | — |
| B | — |
| C | A |
| D | B |
| E | A, B |
| F | C, D |
| G | F, B |
| H | E, G |
| I | H, G |
| J | I, F |
| K | J, L |
| L | A |
| M | K |

Draw a project network for the above project

6. Consider the details of a project as shown in the table .

| Activity | Immediate predecessor(s) | Duration (months) |
|---|---|---|
| A | - | 4 |
| B | - | 8 |
| C | - | 5 |
| D | A | 4 |
| E | A | 5 |
| F | B | 7 |
| G | B | 4 |
| H | C | 8 |
| I | C | 3 |
| J | D | 6 |
| K | E | 5 |
| L | F | 4 |
| M | G | 12 |
| N | H | 7 |
| O | I | 10 |
| P | J,K,L | 5 |
| Q | M,N,O | 8 |

(a) Construct the CPM network.

(b) Determine the critical path.

(c) Compute total floats and free floats for non-critical activities.

7. A project schedule has the following characteristics.

| Activity | 1-2 | 1-3 | 2-4 | 3-4 | 3-5 | 4-9 | 5-6 | 5-7 | 6-8 | 7-8 | 8-10 | 9-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time(days) | 4 | 1 | 1 | 1 | 6 | 5 | 4 | 8 | 1 | 2 | 5 | 7 |

From the above information, you are required to

(i) Construct a network diagram.

(ii) Compute the earliest event time and latest event time

(iii) Determine the critical path and total project duration

(iv) Compute total, free float for each activity.

**8.**The following Table shows the job of a project with their duration in days. Draw the network and determine the critical path. Also calculate all the free floats of each activity.

| Job | 1-2 | 1-3 | 1-4 | 2-5 | 3-7 | 4-6 | 5-7 | 5-8 | 6-7 | 6-9 | 7-10 | 8-10 | 9-10 | 10-11 | 11-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Duration (days) | 10 | 8 | 9 | 8 | 16 | 7 | 7 | 7 | 8 | 5 | 12 | 10 | 15 | 8 | 5 |

9. The activities involved in Alpha Garment Manufacturing Company are listed with their time estimates as in the following table:

| Activity | Description | Immediate predecessor(s) | Duration(days) |
|---|---|---|---|
| A | Forecast sales volume | — | 10 |
| B | Study competitive market | — | 7 |
| C | Design item and facilities | A | 5 |
| D | Prepare production plan | C | 3 |
| E | Estimate cost of production | D | 2 |
| F | Set sales price | B, E | 1 |
| G | Prepare budget | F | 14 |

Draw the network for the given activities and carry out the critical path calculations.