



اللجنة الأكاديمية للهندسة المدنية

دفتر

جدولة مشاريع

احمد دودين

Contact us :

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▶ Civilitree Hashemite

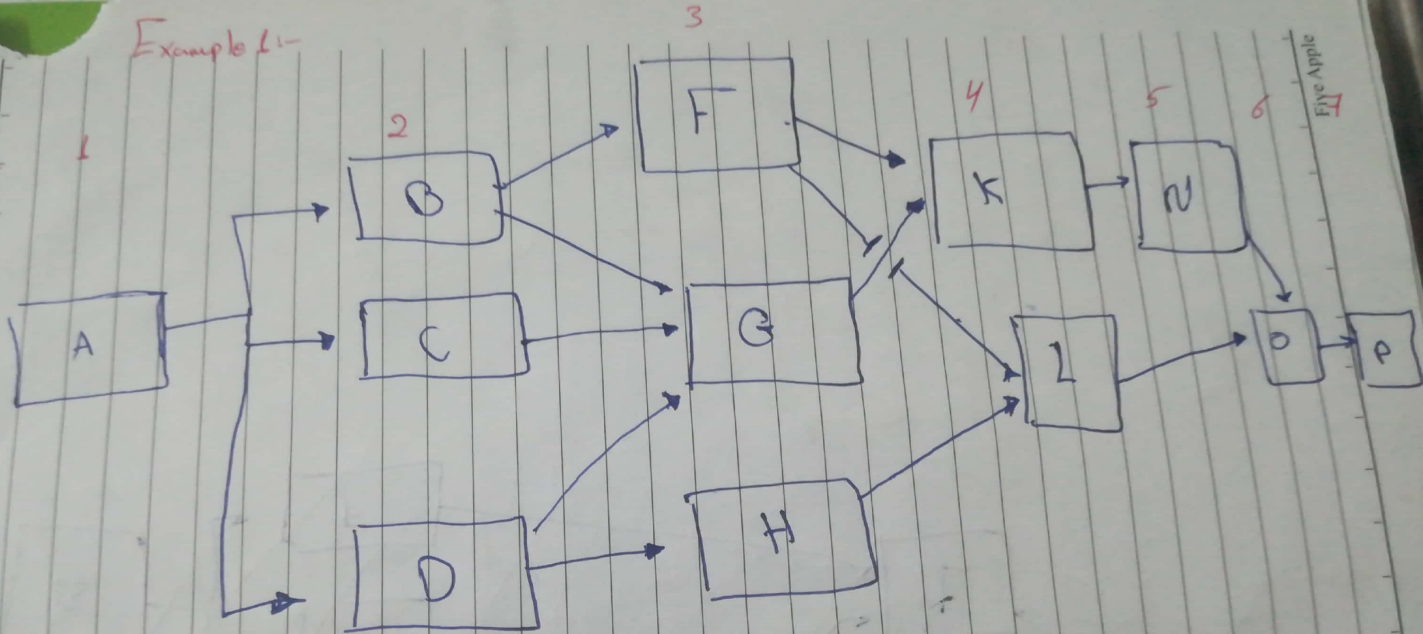
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④ Abbreviation ④ Meaning

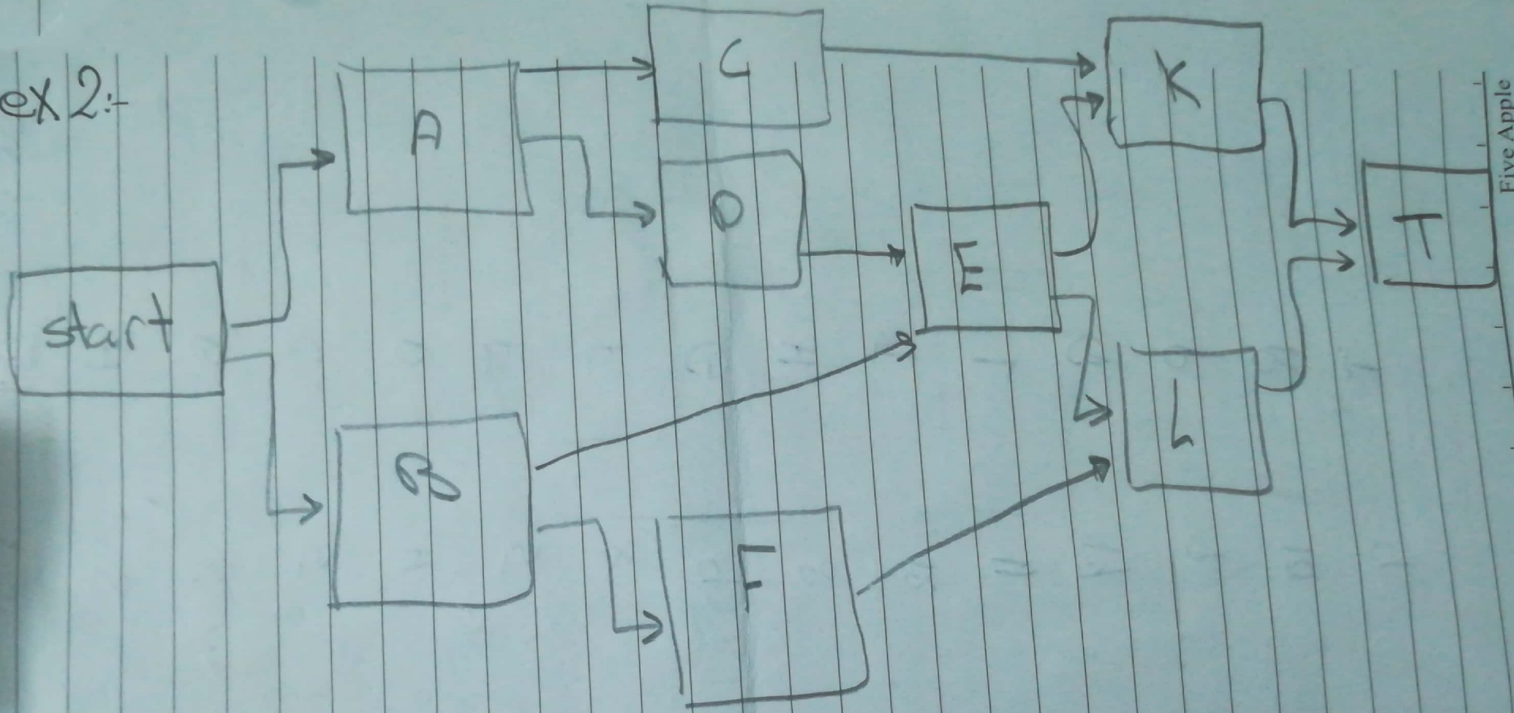
④ AOA	Activity on Arrow.
④ AON	Activity on Node.
④ CPM	Critical Path Method.
④ PERT	Programme Evaluation and Review Technique
④ ES	Early Start.
④ EF	Early Finish.
④ LS	Late Start.
④ LF	Late Finish.
④ CP	Critical Path.
④ PDM	Precedence Diagramming Method.
④ TF	Total Float.
④ FF	Free Float.
④ FS	Finish-To-Start Relationship.
④ SS	Start-To-Start Relationship.
④ SF	Start-To-Finish Relationship.
④ FF	Finish-To-Finish Relationship.
④ ATS	Activity Total Slack.
④ AFS	Activity Free Slack.
④ PERT	Programme Evaluation and Review Technique.

Seq step



Act	suc
A	B, C, D
B	F, G
C	G
D	G, H
F	K, L
G	K
H	L
K	N
L	O
N	O
O	P
P	

ex 2:-



Act depends on

A -

B -

C A

D A

F B

E B, D

K C, E

L F, E

T K, L

ex 3:

Act

Dur

Suc

A

8

B, C, D

B

6

E

C

5

E, F

D

4

G

E

5

H

F

8

I

G

9

I, L

H

8

Q

I

12

P

L

11

R

Q

14

T

P

9

T

R

10

T

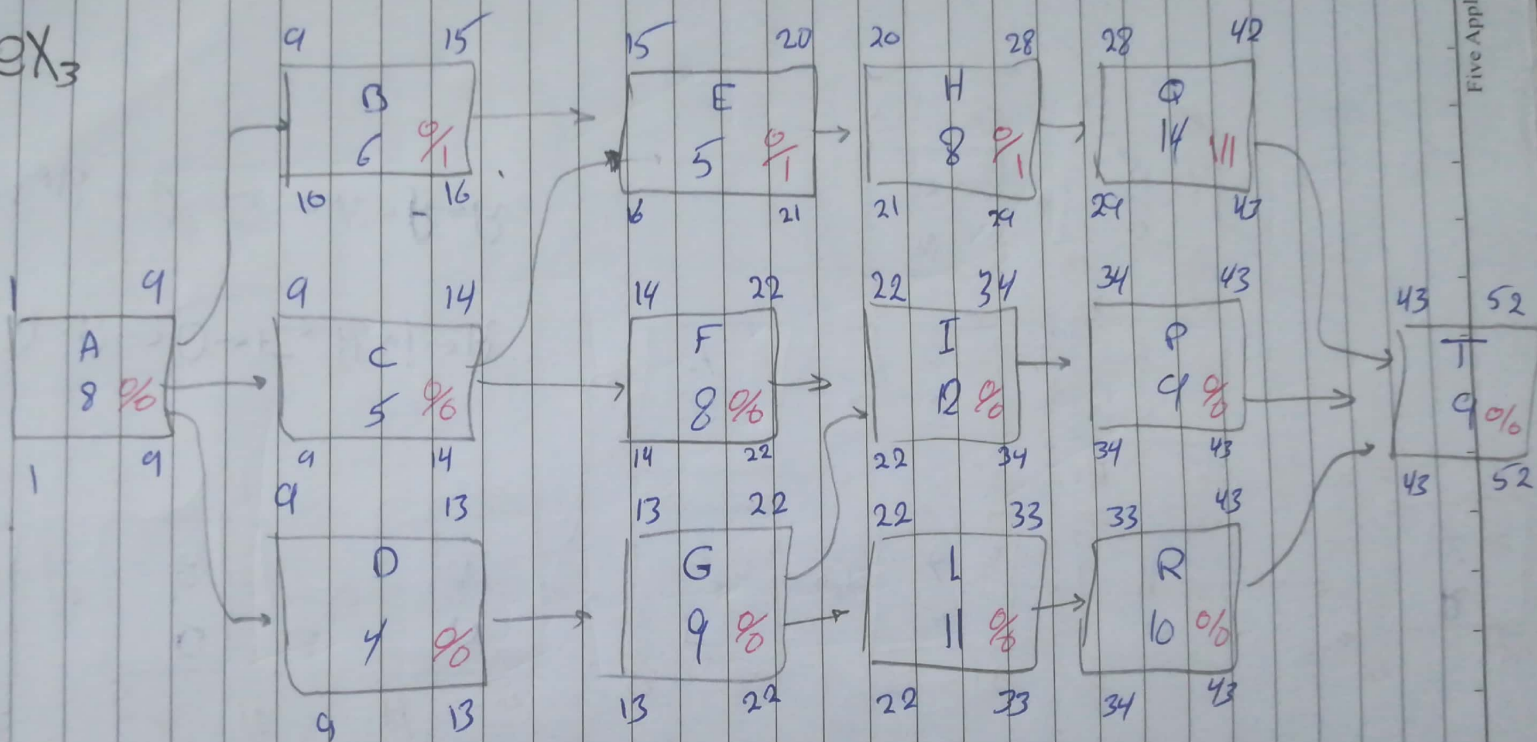
T

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-

FF/TF

EX₃



CR1:- A → C → F → I → P → T
 CR2:- A → D → G → I → P → T
 CR3:- A → D → G → L → R → T

ex 4:-

Act

Pur

depend on

A

5

—

B

8

A

C

12

B

D

9

B

E

5

C

F

9

D

G

7

D

H

12

E, F

M

6

F

J

12

G

N

10

G

L

7

H, M

O

11

M

K

9

J, M

P

8

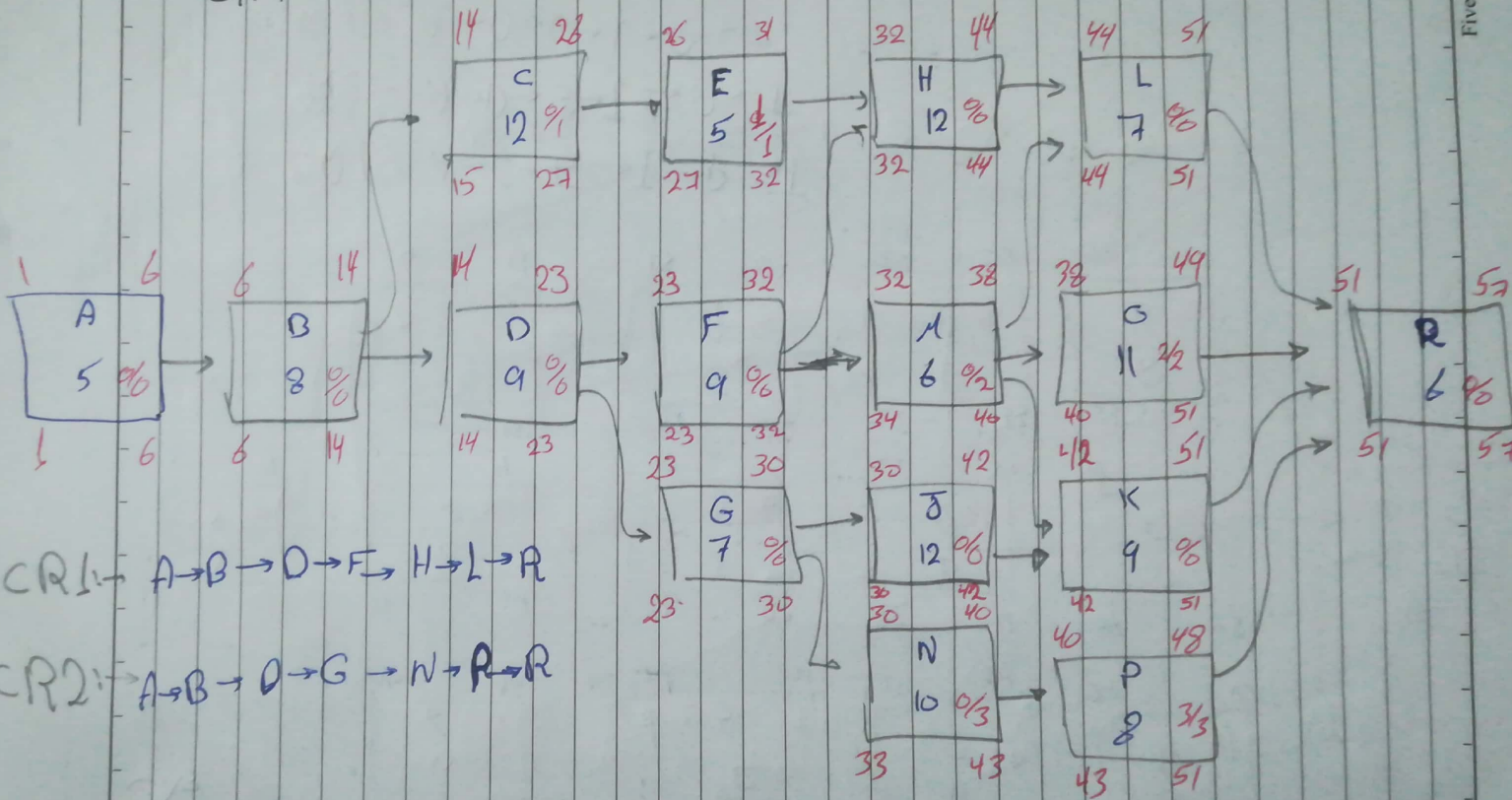
N

R

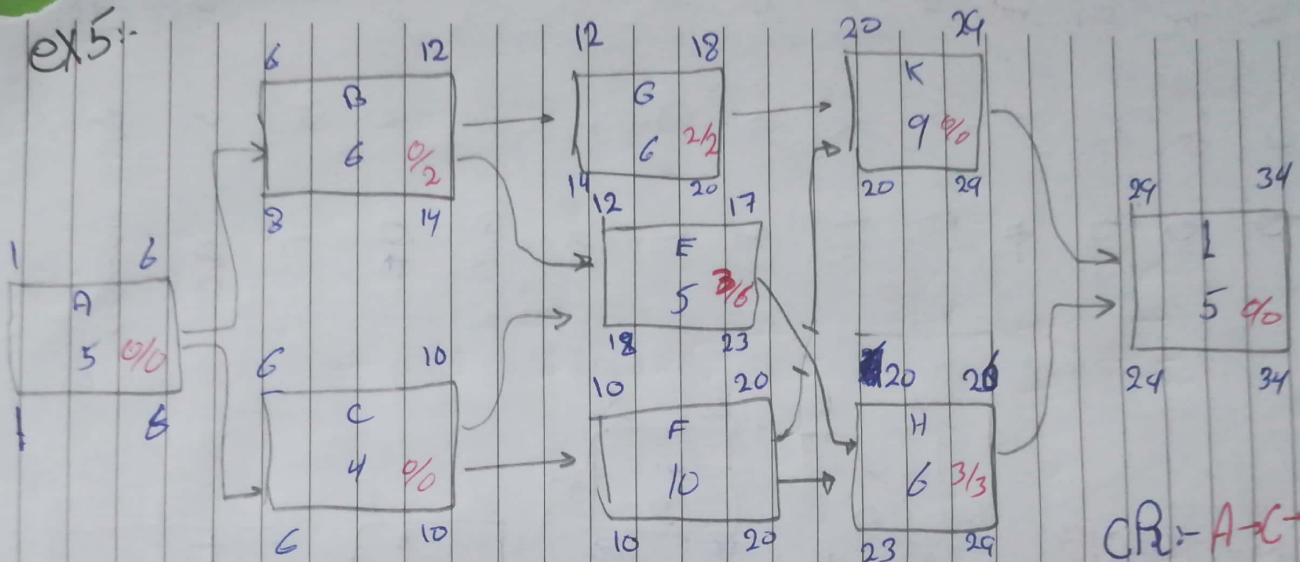
6

L, O, K, P

ex 4:-



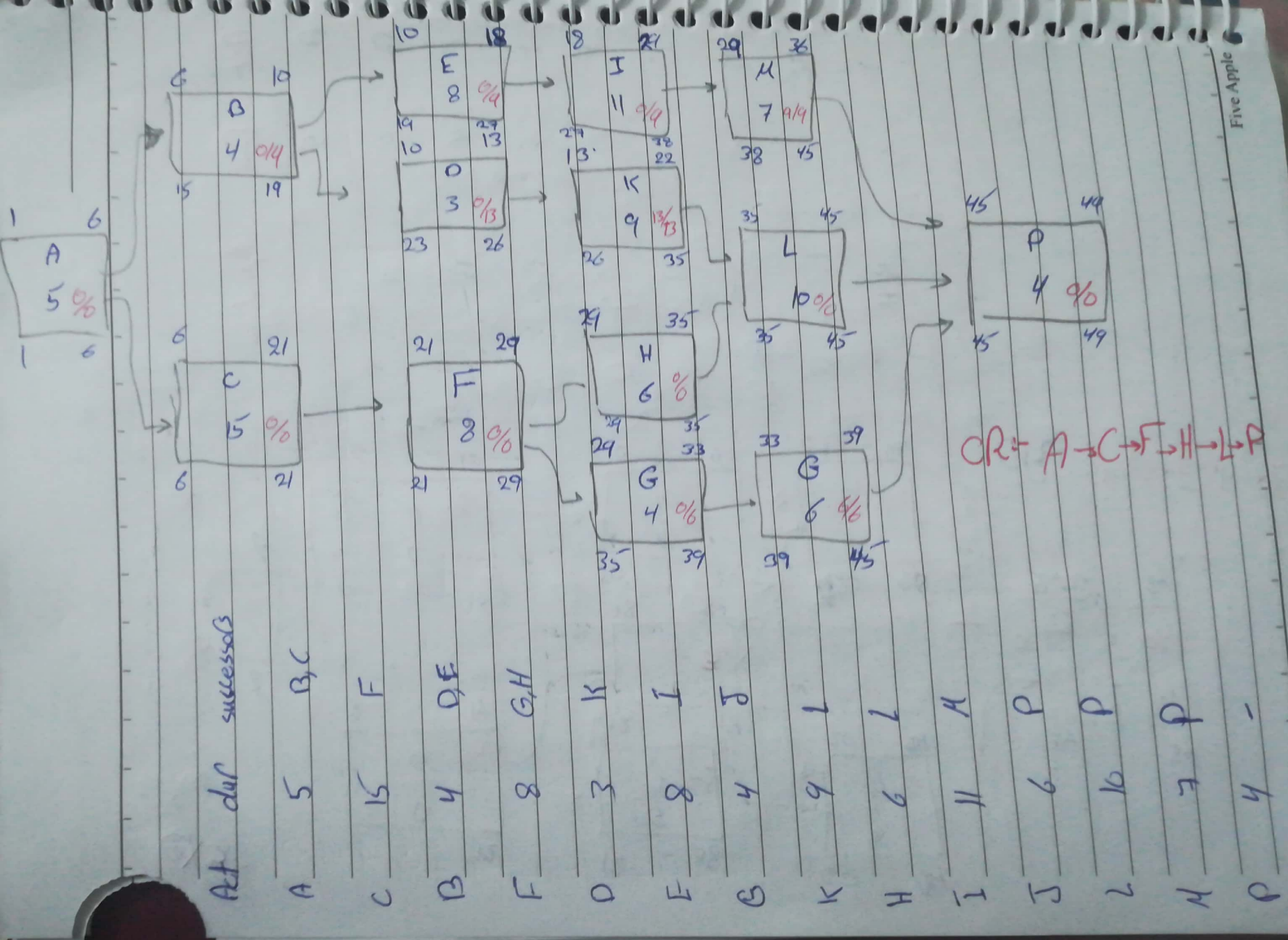
ex 5:-

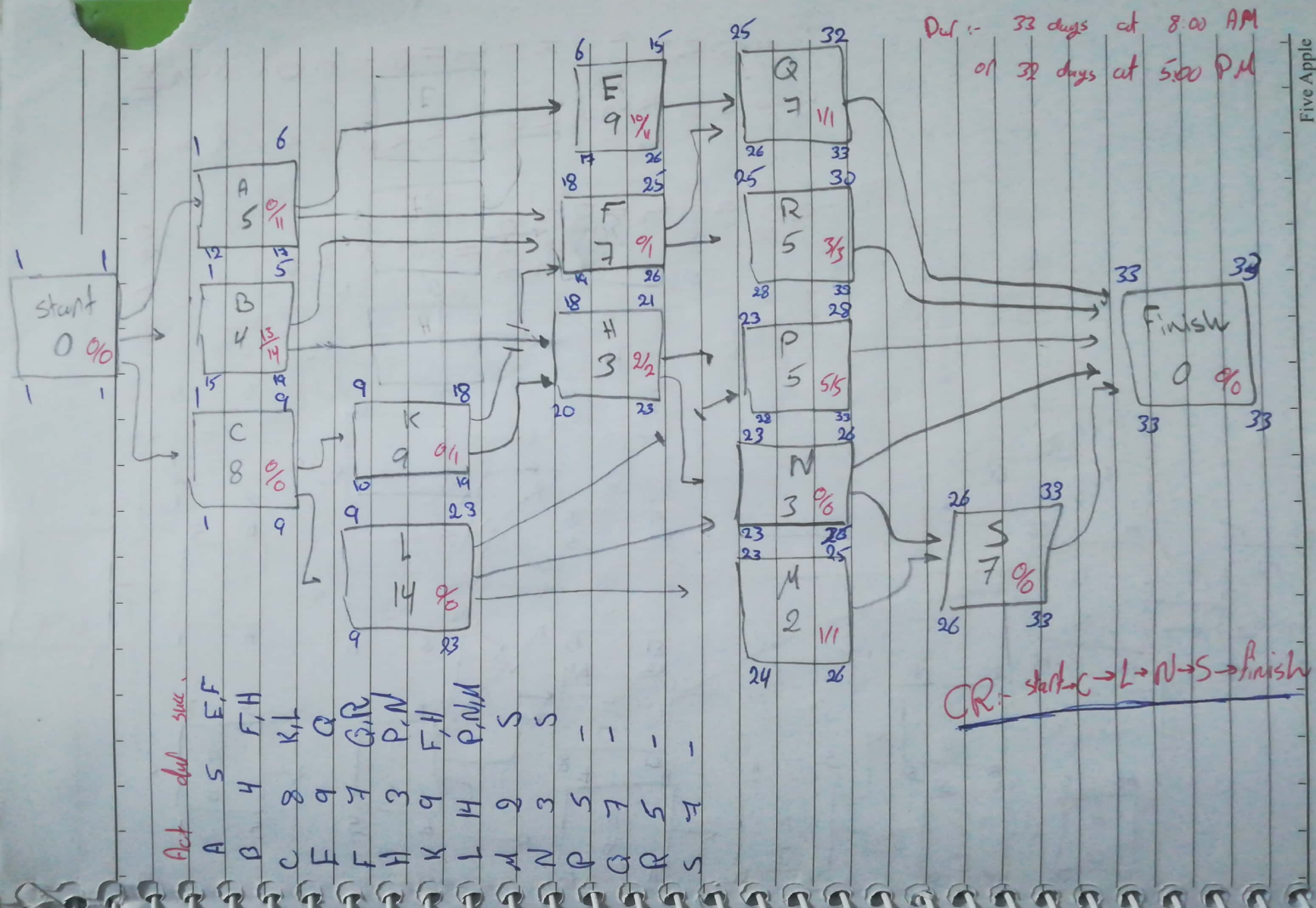


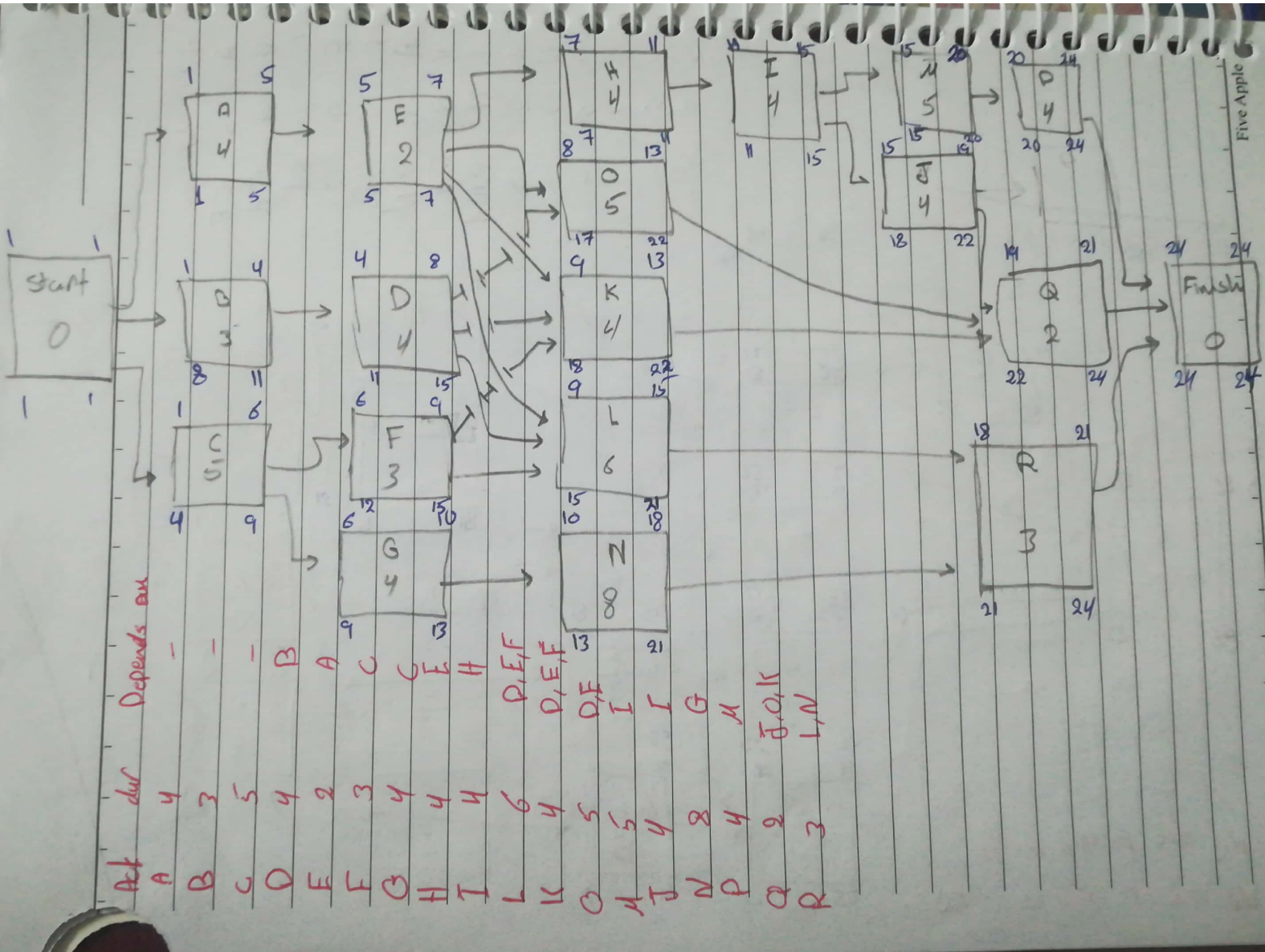
CR: A-C-F-K-L

Act Dur dependson

A	5	-
B	6	A
C	4	B
E	5	B, C
F	10	C
G	6	B
H	6	E, F
K	9	F, G
L	5	K, H







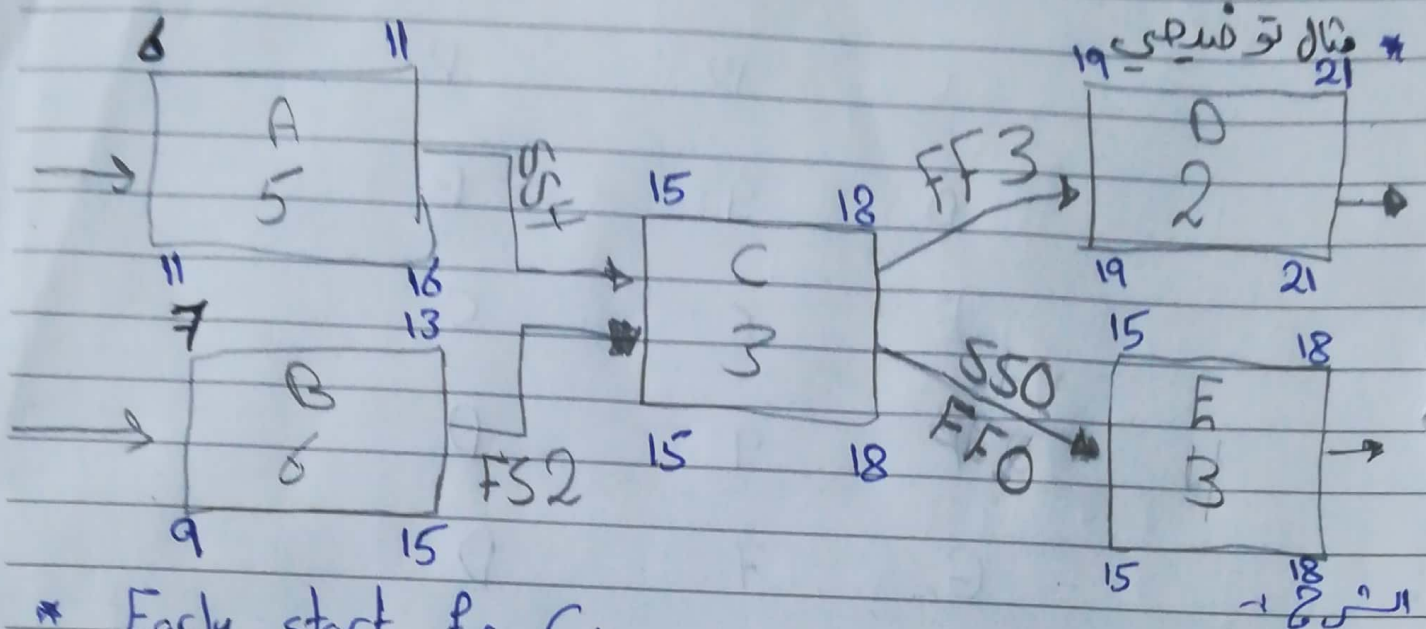
relationship

SF: start to Finish

FS: Finish to start

FF: Finish to Finish

SS: start to start



* Early start for C:-

$$\begin{array}{r} 6 \\ 5 \end{array} + \begin{array}{r} 4 \\ 5 \end{array} = \begin{array}{r} 10 \\ 5 \end{array}$$

$$\begin{array}{r} 13 \\ F \end{array} + \begin{array}{r} 2 \\ to \end{array} = \begin{array}{r} 15 \\ S \end{array}$$

* الرضيا، الأول (SS4) -

* الرضيا، الثاني (FS2) -

بنوفند الأكبر 15

* Early start for D:-

$$\begin{array}{r} 18 \\ F \end{array} + \begin{array}{r} 3 \\ to \end{array} = \begin{array}{r} 21 \\ F \end{array}$$

* هاء العلاقة أعطش ال EF بي ال
بدى ES فيخرج منها ال Duration

$$21 - 2 = 19$$

ES for E

$$\begin{array}{r} 15 \\ S \end{array} + \begin{array}{r} 0 \\ to \end{array} = \begin{array}{r} 15 \\ S \end{array}$$

الرضيا، الأول (SS0) -

الخيار الثاني (FF0) :-

$$\frac{18}{F} + \frac{0}{to} = \frac{18}{F}$$

$$\frac{18}{F} - \frac{3}{dur} = \frac{15}{S}$$

الخيار بينه اعطوني (15)

* Late Finish for C

الخيار الأول (FFB) :-

$$\frac{21}{F} - \frac{3}{to} = \frac{18}{F}$$

الخيار الثاني (SS0) :-

$$\frac{15}{S} - \frac{0}{to} = \frac{15}{S}$$

$$\frac{15}{S} + \frac{3}{dur} = \frac{18}{F}$$

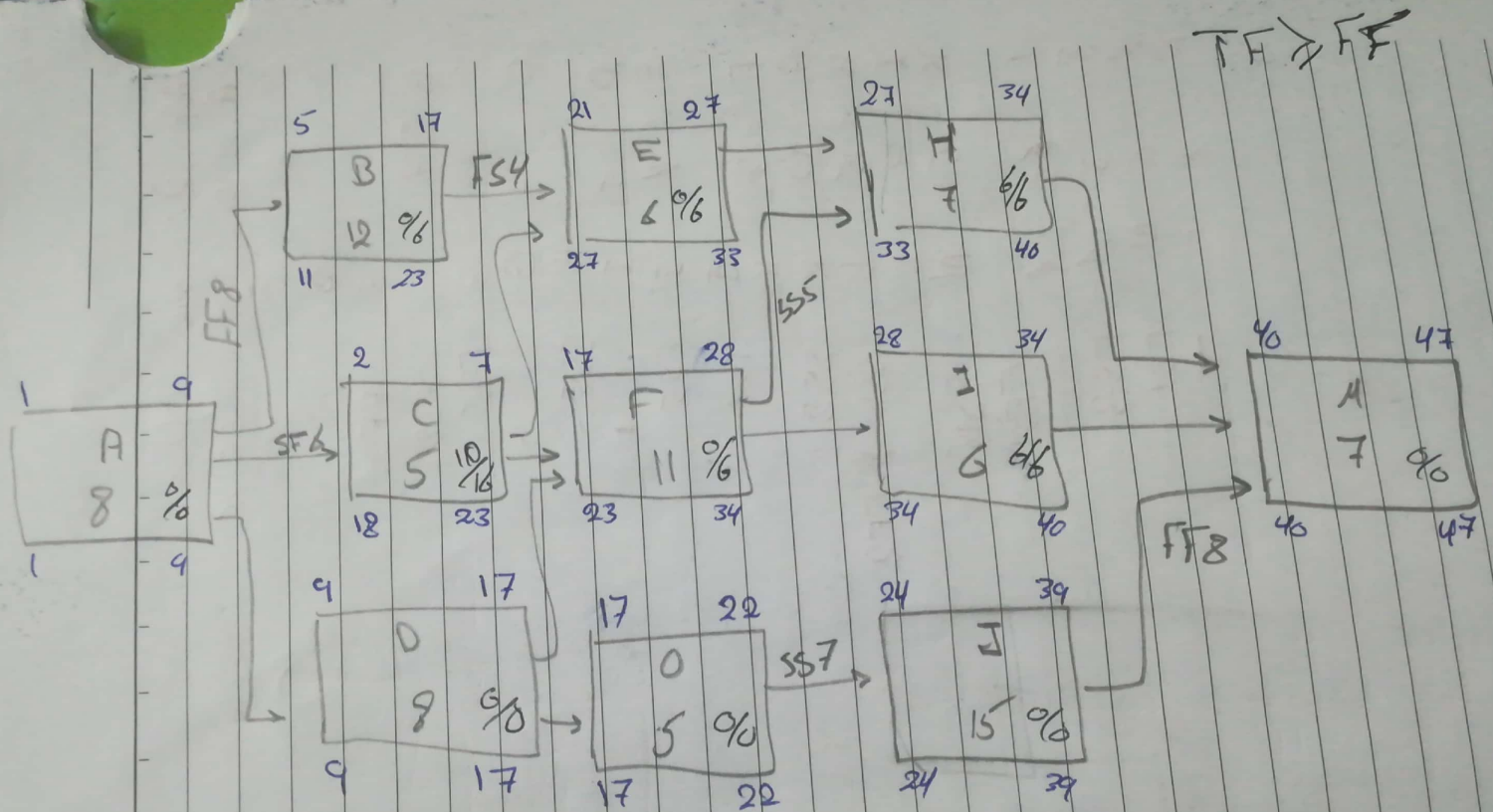
الخيار الثالث (FF0) :-

$$\frac{18}{F} - \frac{0}{to} = \frac{18}{F}$$

* بال Backward بنوفا الرقم الأصغر ب هونة كل الضاراة متاوية

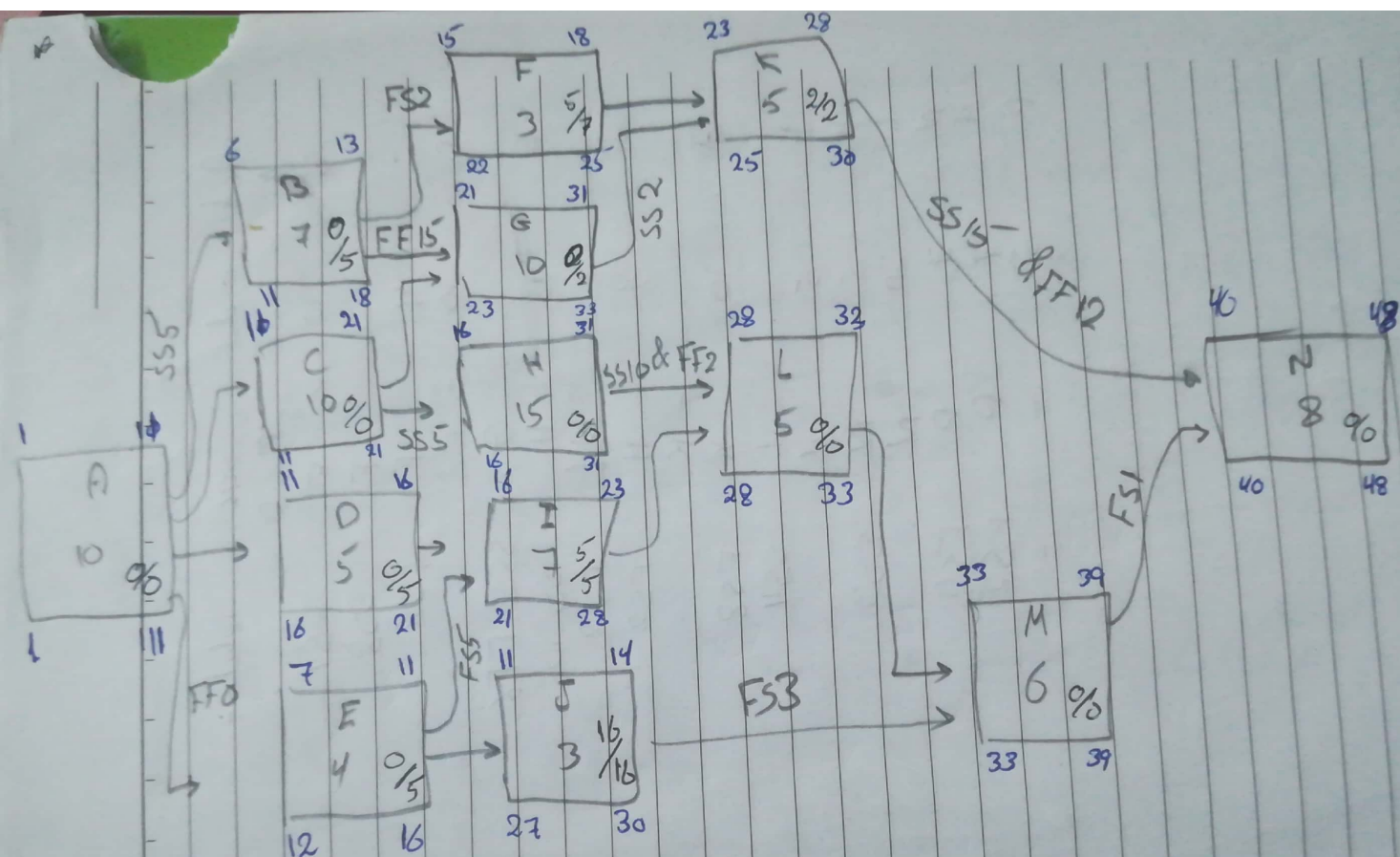
بنوفا 18

* بنوفا بنوفا الآلية على A و B



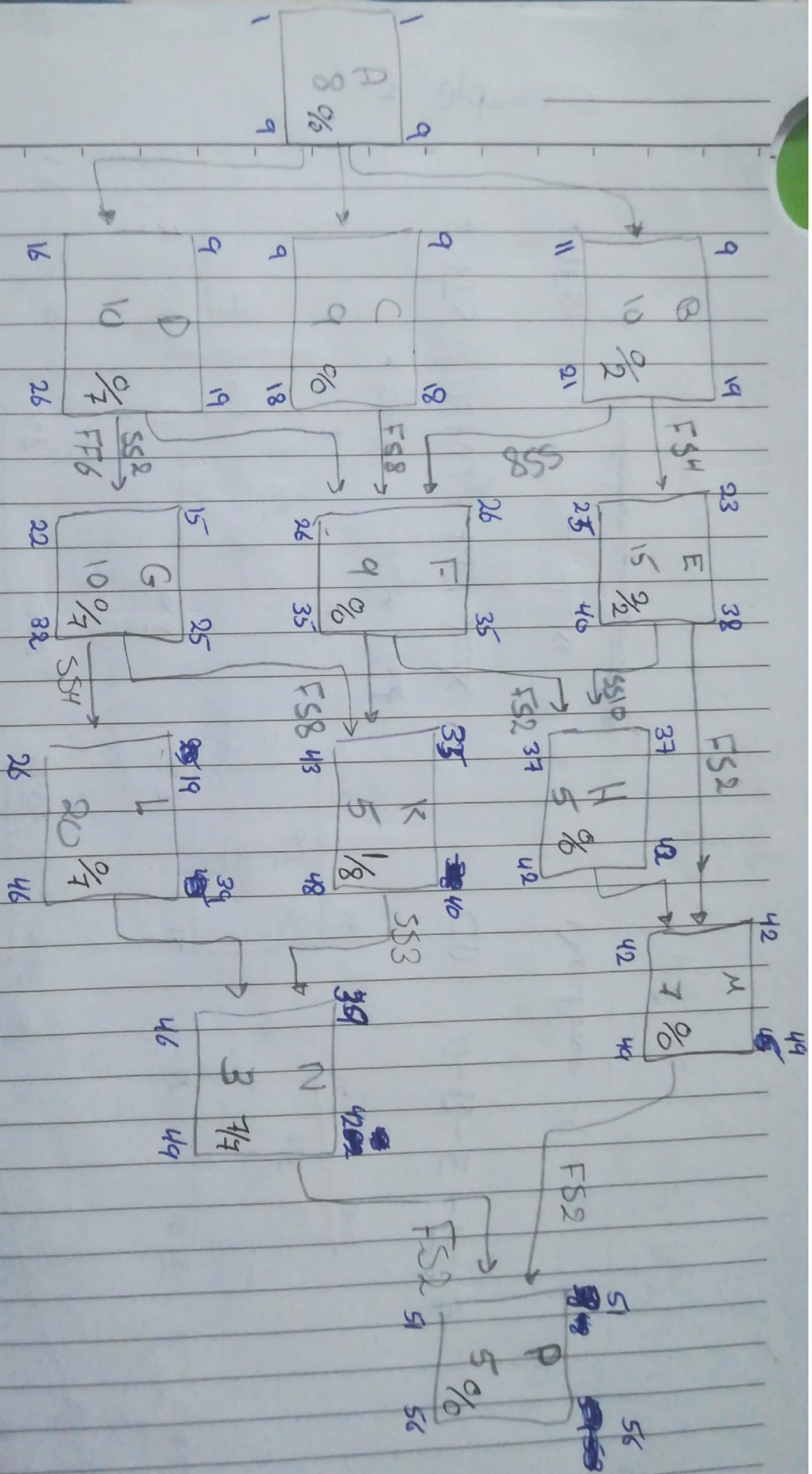
CP: - A - D - O - J - M

Act	Dur	succ	relation
A	10	B	SS5
		C	
		D	
		E	FF0
B * 7		F	FS2
		G	FF5
C	10	G	
		H	SS5
D	5	I	
E	4	I	FS5
		J	
F	3	K	
G	10	K	SS2
H	15	L	SS10 & FF2
I	7	L	
K	5	N	SS15
			FF12
L	5	M	
J	3	M	FS3
M	6	N	FS1
N	8	-	-



CP: A → C → H → L → M → N

Act	dur	src	relation
A	8	B, C, D	
B	10	E	FS4
		F	SS8
C	9	F	FS8
D	10	F	
		G	SS2, FF6
E	15	H	SS10
		H	FS2
F	9	H	FS2
		K	
G	10	K	FS8
		L	SS4
H	5	M	
K	5	N	SS3
L	20	N	
N	7	P	FS2
M	7	P	FS2
P	5	-	-



CP: A → C → F → H → M → P

PERT

Example 1:-

- * AFS:-
- * ATS:- Activity total slack
- * slack window float
- * free slacks

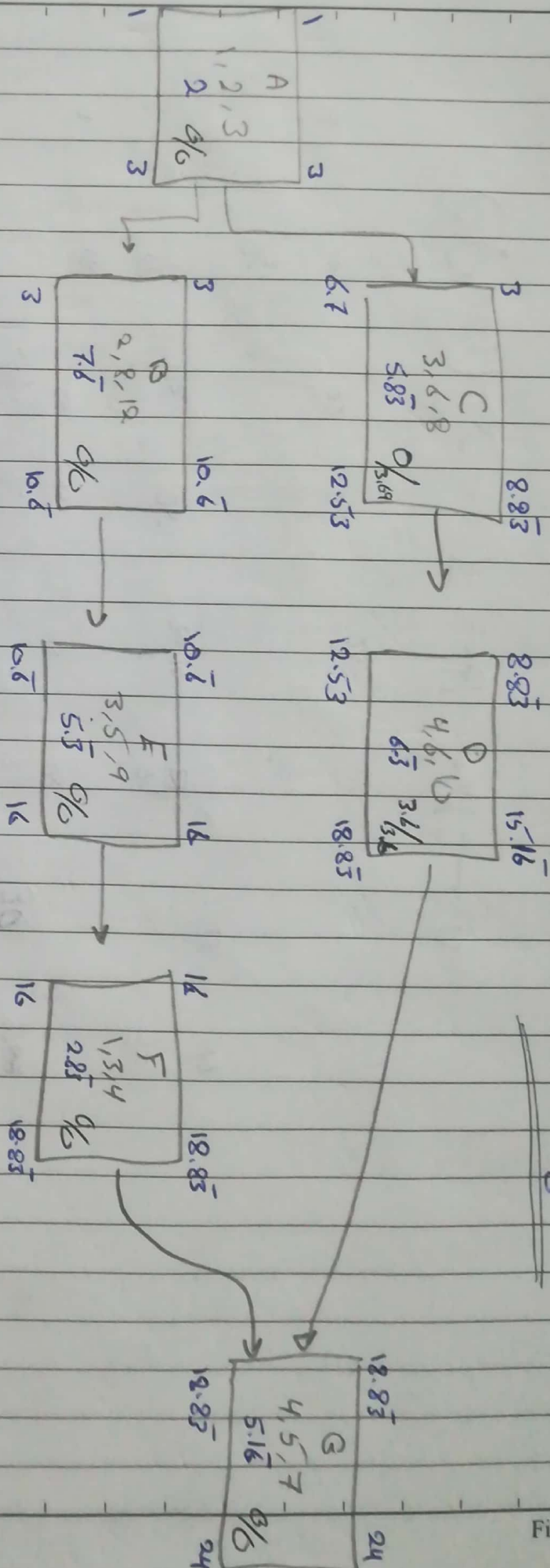
Standard deviation :-

2.095

$$\sigma = \sqrt{\frac{(3-1)^2}{6} + \frac{(12-2)^2}{6} + \frac{(9-5)^2}{6} + \frac{(14-1)^2}{6} + \frac{(7-4)^2}{6}}$$

Durations:- 24 days

CP: A-B-E-F-G

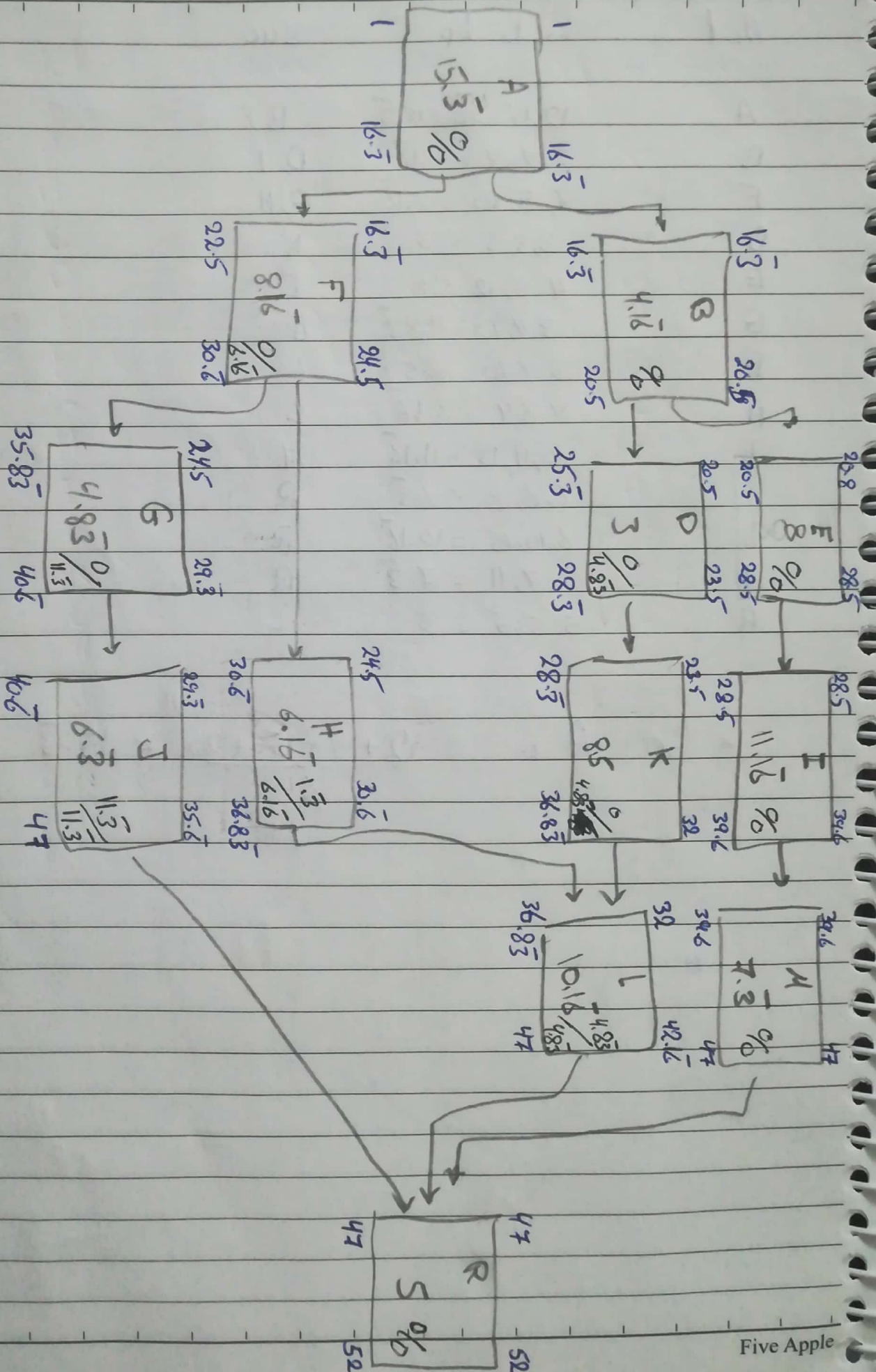


$$t_c = \frac{t_o + 4t_m + t_p}{6}$$

Act	t_o, t_n, t_p	suc
A	$12, 15, 20 = 15.\bar{3}$	B, F
B	$2, 4, 7 = 4.\bar{16}$	D, E
F	$7, 8, 10 = 8.\bar{14}$	G, H
D	$3, 3, 3 = 3$	K
E	$4, 8, 12 = 8$	I
G	$3, 4, 10 = 4.\bar{83}$	J
K	$5, 9, 10 = 8.5$	L
H	$4, 6, 9 = 6.\bar{16}$	L
I	$10, 11, 13 = 11.\bar{16}$	M
J	$6, 6, 8 = 6.\bar{3}$	R
L	$6, 10, 15 = 10.\bar{16}$	R
M	$5, 7, 11 = 7.\bar{3}$	R
R	$5, 5, 5 = 5$	-

* For A :-
$$\frac{12 + 4 \times 15 + 20}{6} = 15.\bar{3}$$

example 2

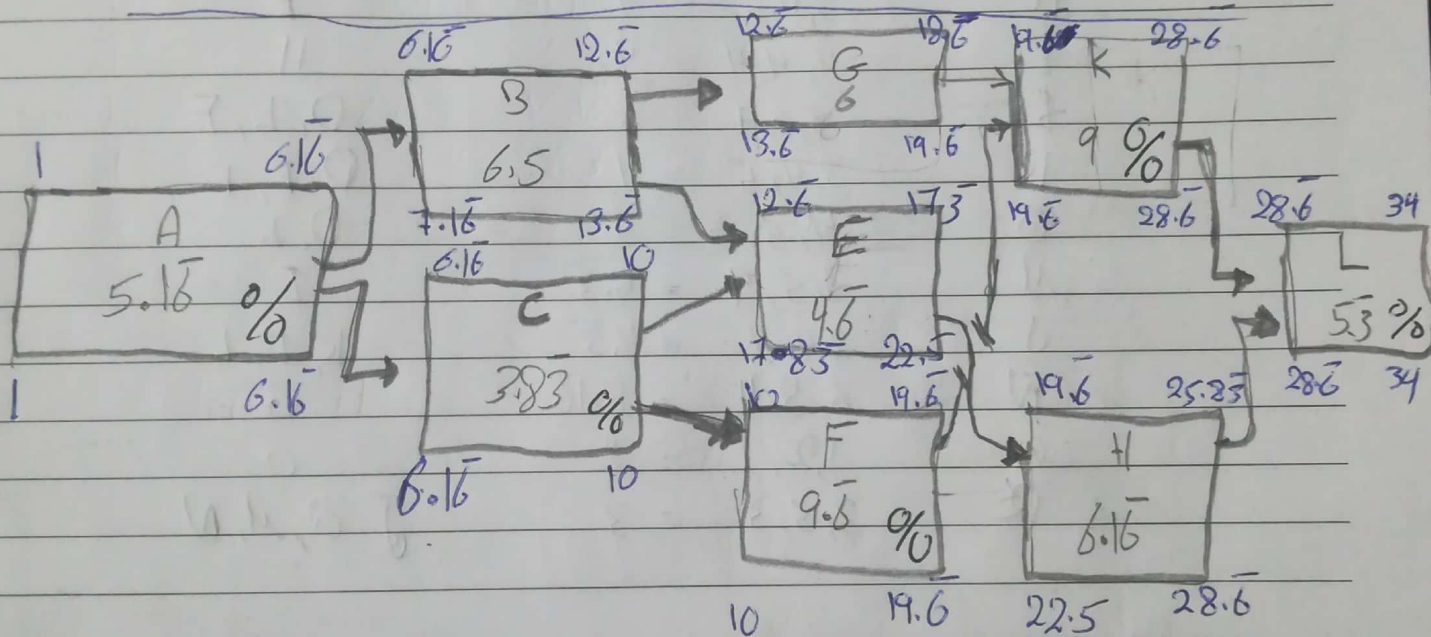


CP:-

A-B-E-I-M-R

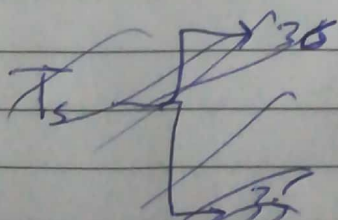
Te:-52

Activity	to, tw, to	dep. on
A	3, 5, 9 = 5.16	-
B	5, 6, 10 = 6.5	A
C	2, 4, 5 = 3.83	A
E	2, 5, 6 = 4.6	B, C
F	6, 10, 12 = 9.6	C
G	4, 6, 8 = 6	B
H	3, 6, 10 = 6.6	E, F
K	7, 9, 11 = 9	F, G
L	4, 5, 8 = 5.3	H, K



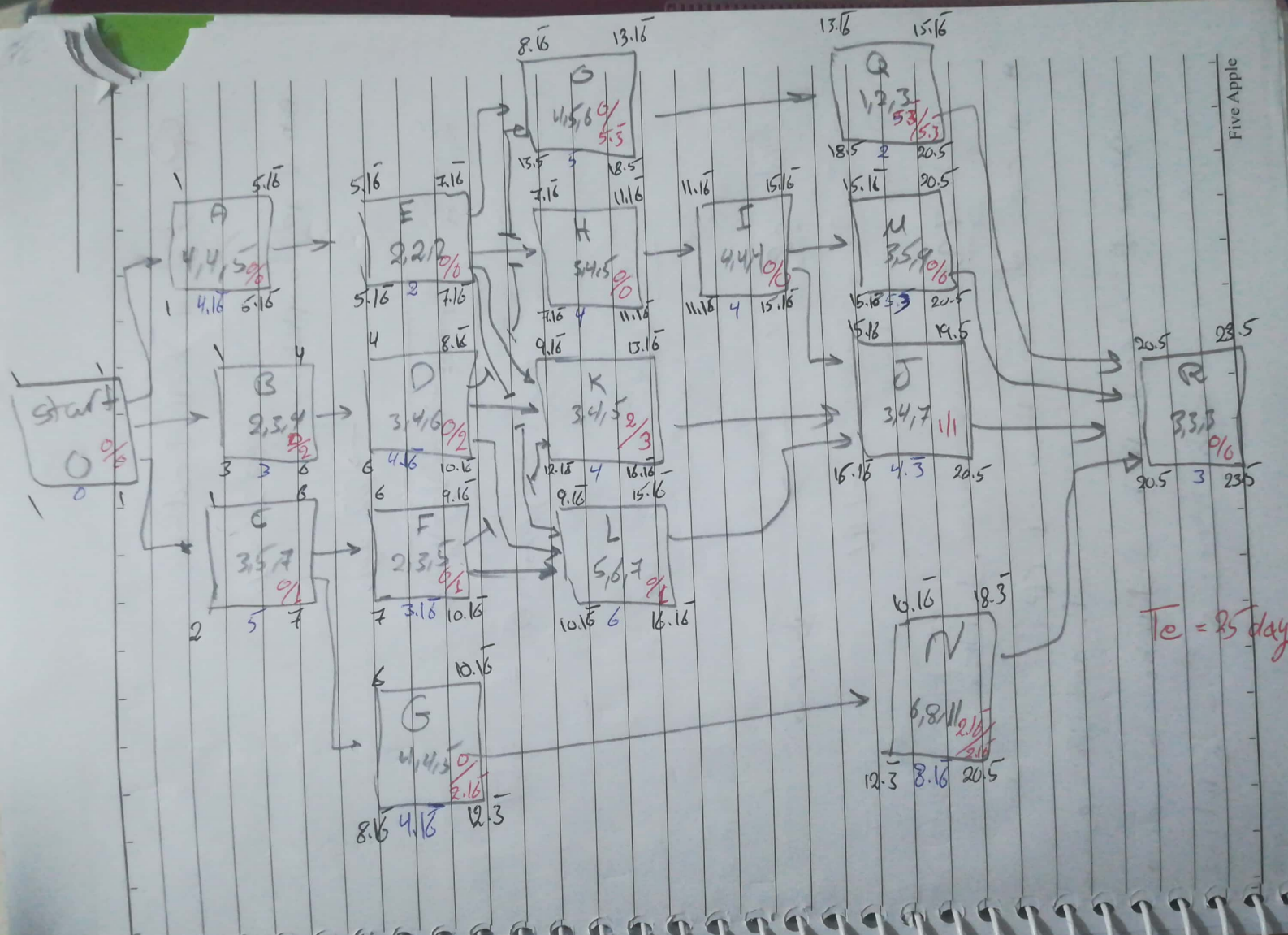
CP = A - C - F - K - L

$$S_{\text{project}} = \sqrt{\left(\frac{3-2}{6}\right)^2 + \left(\frac{8-3}{6}\right)^2 + \left(\frac{12-6}{6}\right)^2 + \left(\frac{11-7}{6}\right)^2 + \left(\frac{8-4}{6}\right)^2} = 1.68$$



* Go to 2-table

Act	Time	Depend on
A	$4, 4, 5 = 4.\overline{16}$	—
B	$2, 3, 4 = 3$	—
C	$3, 5, 7 = 5$	—
D	$3, 4, 6 = 4.\overline{16}$	B
E	$2, 2, 2 = 2$	A
F	$2, 3, 5 = 3.\overline{16}$	C
G	$4, 4, 5 = 4.\overline{16}$	C
H	$3, 4, 5 = 4$	E
I	$4, 4, 4 = 4$	H
L	$5, 6, 7 = 6$	D, E, F
K	$3, 4, 5 = 4$	D, E, F
O	$4, 5, 6 = 5$	D, E
M	$3, 5, 9 = 5.\overline{3}$	I
J	$3, 4, 7 = 4.\overline{3}$	K, I, L
N	$6, 8, 11 = 8.\overline{16}$	G
Q	$1, 2, 3 = 2$	O
R	$3, 3, 3 = 3$	J, Q, M, N



CP₁ - start - A - E - H - I - M - R

prob of proj completion $\left\{ \begin{array}{l} \rightarrow 24 \text{ days} \\ \rightarrow 22 \text{ days} \end{array} \right.$

$$S_{\text{Proj}} = S_{\text{CP}} = \sqrt{V_A + V_E + V_H + V_I + V_M + V_R}$$

$$= \sqrt{\left(\frac{5-4}{6}\right)^2 + 0 + \left(\frac{5-3}{6}\right)^2 + 0 + 1 + 0} = 1.067$$

$$Z = \frac{T_s - T_e}{S_{\text{CP}}} = \frac{24 - 23.5}{1.067} \approx 0.47$$

Prob = 68.08% $\rightarrow$ من الجدول Z

$$Z = \frac{T_s - T_e}{S_{\text{CP}}} = \frac{22 - 23.5}{1.067} = -1.41$$

Prob = 7.93% $\rightarrow$ من الجدول Z

* in case of more than 1 CP:-
CP₁ and CP₂ - بنوع

جدول Z Prob₁ and Prob₂ - بنوع

$$* \text{ Prob} = \text{Prob}_{1 \text{ or } 2} \leq \leq \text{Prob}_{1 \text{ or } 2}$$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5398	0.5398	0.5398	0.5398	0.5398	0.5398	0.5398	0.5398	0.5398
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.99							

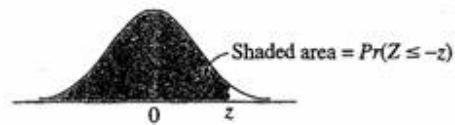


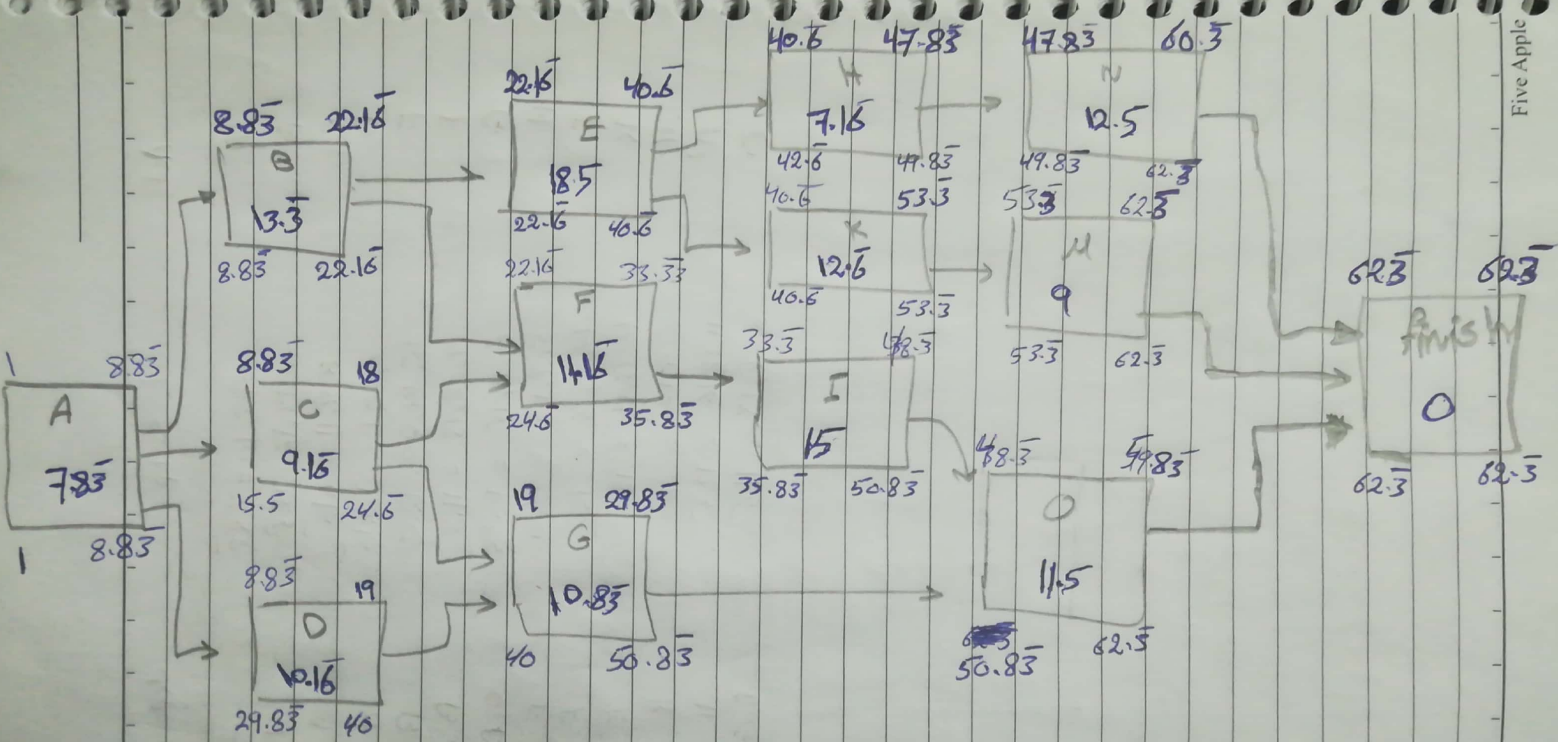
TABLE 1
Standard normal curve areas

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
-3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4602	0.4602	0.4602	0.4602	0.4602	0.4602	0.4602	0.4602	0.4602
-0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

z	Area
-3.50	0.00023263
-4.00	0.00003167
-4.50	0.00000340
-5.00	0.00000029

Source: Computed by M. Longnecker using Splus.

Act	t_o, t_w, t_p	depends on
A	$5, 8, 10 = 7.8\bar{3}$	-
B	$11, 13, 17 = 13.\bar{3}$	A
C	$8, 9, 11 = 9.\bar{6}$	A
D	$6, 10, 15 = 10.\bar{6}$	A
E	$15, 19, 20 = 18.5$	B
F	$9, 12, 13 = 11.\bar{6}$	B, C
G	$6, 11, 15 = 10.8\bar{3}$	C, D
H	$5, 7, 10 = 7.\bar{6}$	E
I	$14, 15, 16 = 15$	F
K	$10, 13, 14 = 12.\bar{6}$	E
M	$6, 9, 12 = 9$	K
N	$11, 12, 16 = 12.5$	H
O	$8, 12, 13 = 11.5$	I, G



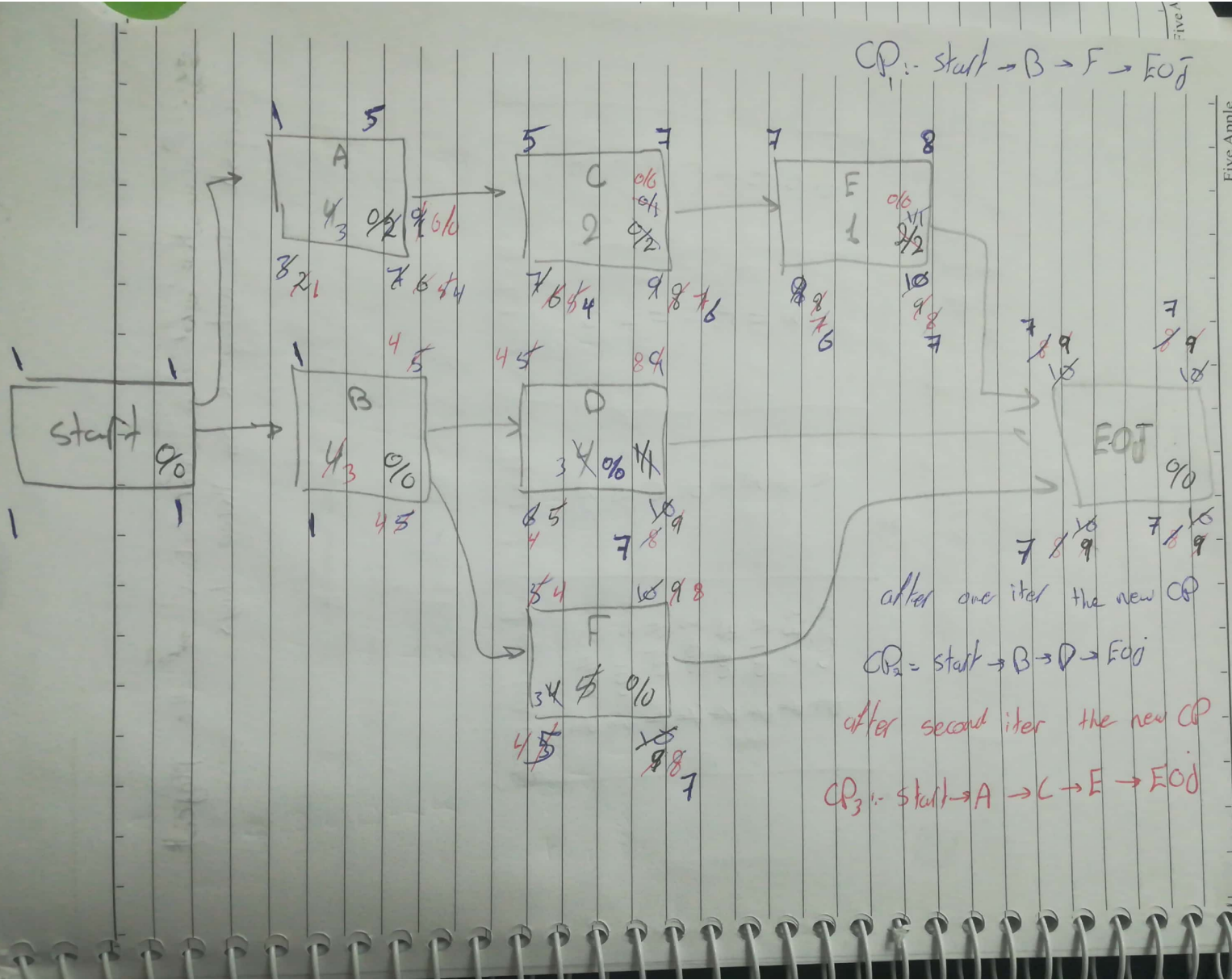
CP = A - B - E - K - M - Finish

Act	Normal Days	expect crashed days	cost per day
A	4	3	250 \$
B	4	3	1500 \$
C	2	1	1500 \$
D	4	1	1500 1500 \$
E	1	1	NA
F	5	2	500 \$

* crash from normal to expect
 - and list act, the crashed and the cost associated with each compression

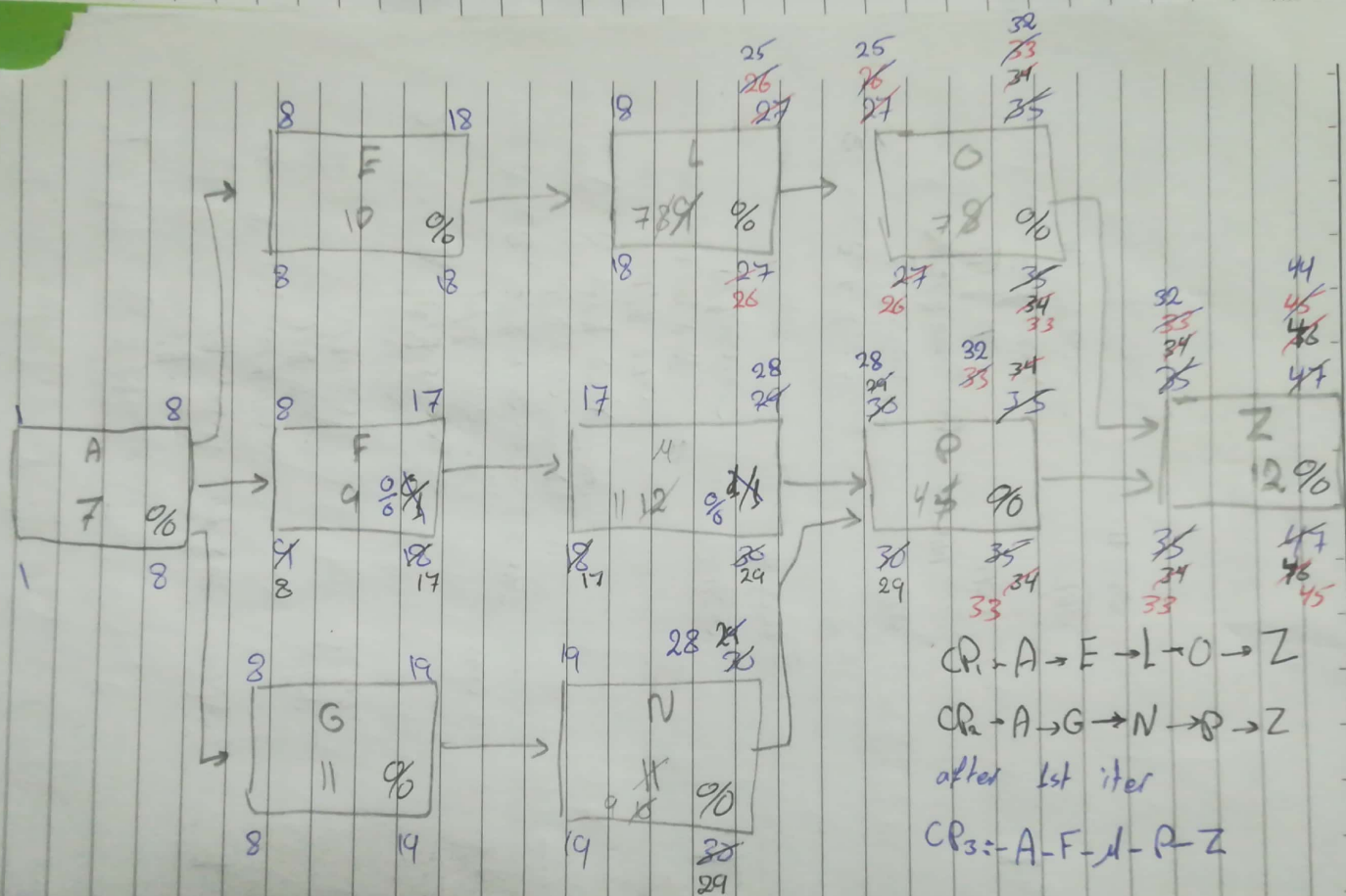
Iter	Crash Pass/cost	Proj dur	Inc cost	curr cost
1	B/\$1500 X F/\$500 ✓	10→9	500	500
2	CP ₁ :- F/\$500 } CP ₂ :- D/\$1500 } ^{2000 X} or joint CP ₁ and CP ₂ B/\$1500 ✓	9→8	1500	2000
3	CP ₁ :- F/\$500 } & CP ₂ :- D/\$1500 } & CP ₃ :- A/\$250 } or:- C/\$1500 X	8→7	500 1500 250 2250	4250
4	CP ₁ :- F/\$500 } & CP ₂ :- D/\$1500 } & CP ₃ :- C/\$1500 }	7→6	500 1500 1500 3500	7750

7 تكمّل بنفس الطريقة على المشروع



ex:- Given the following information of the project,
Crash the network by three days

Act	Normal dur	crashed dur	cost of crash per day
E	10	8	3,400 \$
F	9	7	3,700 \$
G	11	9	4,100 \$
L	9	6	3,400 \$
M	12	9	3,700 \$
N	11	8	4,100 \$
O	8	7	3,300 \$
P	5	4	4,000 \$



iter	crash Pass/cost	Proj dur	Inc cost	Cum. cost
------	--------------------	-------------	-------------	--------------

1	$CP_1: E/\$3400 \times$ $L/\$3400 \times$ $O/\$3300 \checkmark$	47 $\rightarrow$ 46	3300	\$7400
---	---	---------------------	------	--------

	$\& CP_2: G/\$4100 \times$ $N/\$4100 \checkmark$ $P/\$4600 \times$		$\frac{4100}{7400}$	
--	--	--	---------------------	--

2	$CP_1: E/\$3400 \times$ $L/\$3400 \checkmark$		3400	
---	--	--	------	--

	$\& CP_2: G/\$4100 \{any\}$ $N/\$4100 \{4100\} \times$	46 $\rightarrow$ 45		
--	---	---------------------	--	--

	$\& CP_3: F/\$3700 \times$ $M/\$3700 \checkmark$		\$7800	
--	---	--	--------	--

or joint CP_2 & CP_3

	$P/\$4600 \checkmark$		$\frac{4600}{\$8000}$	\$15,400
--	-----------------------	--	-----------------------	----------

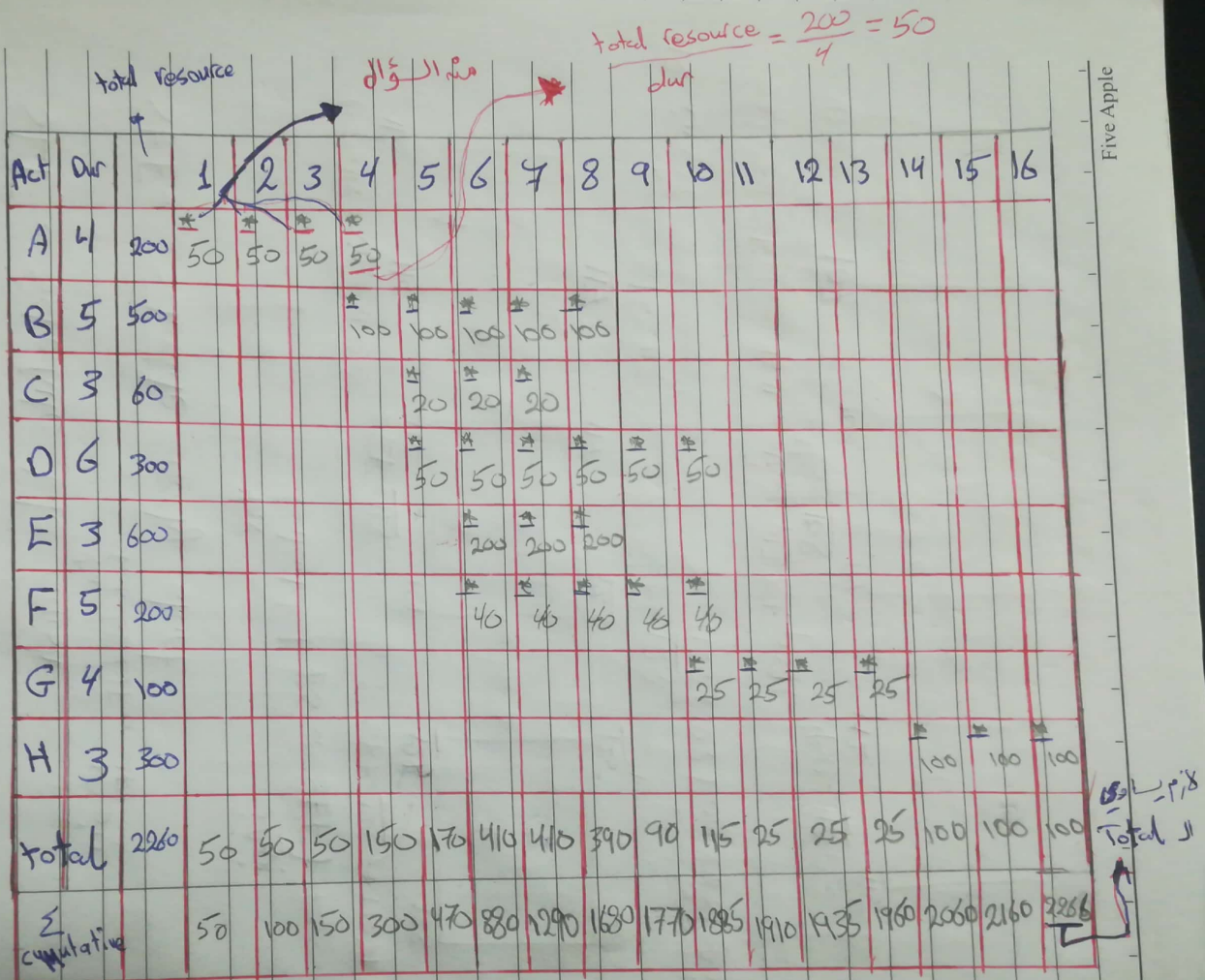
3	$CP_1: E/\$3400 \{any\}$ $L/\$3400 \checkmark$		3400	
---	---	--	------	--

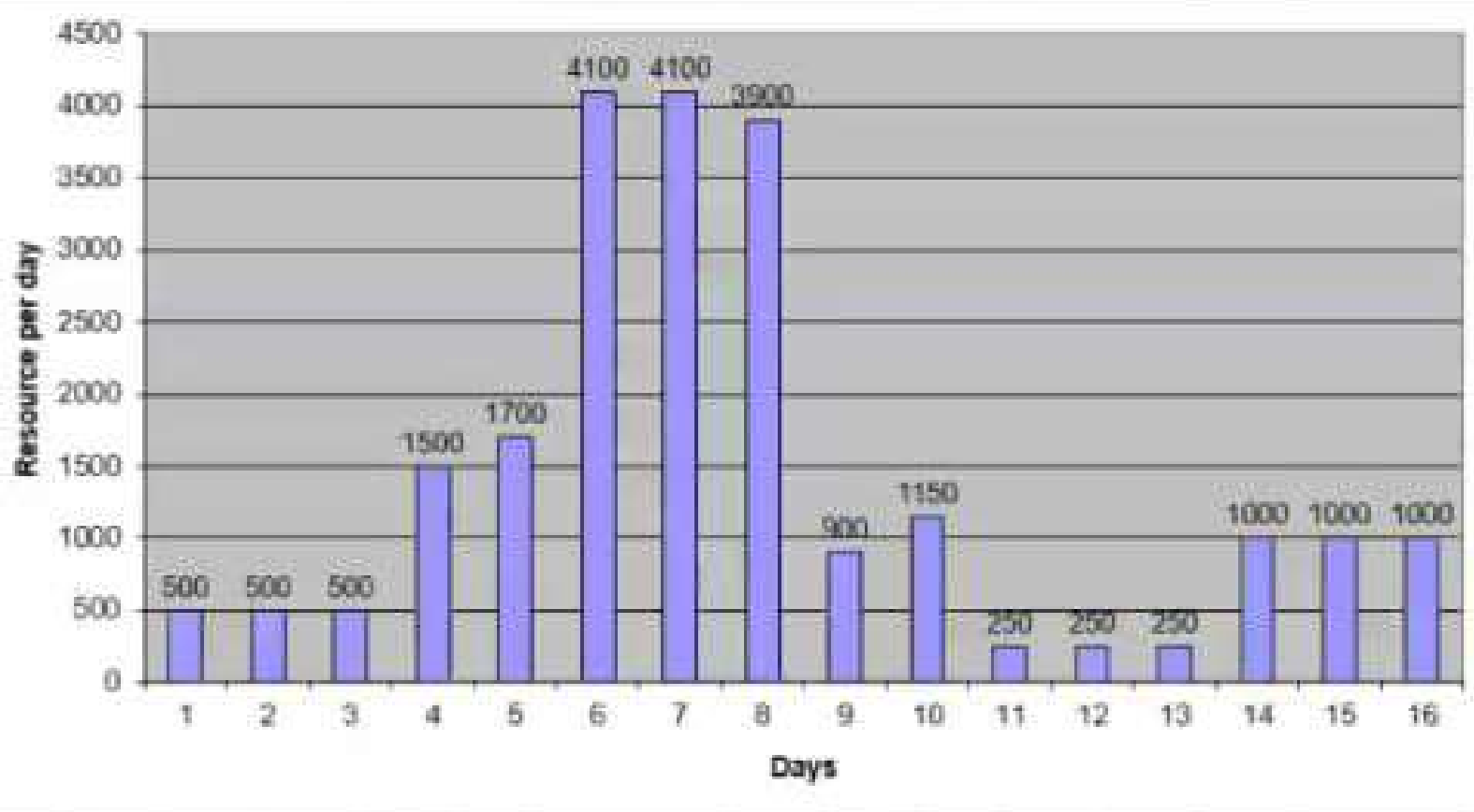
	$\& CP_2: G/\$4100 \{any\}$ $N/\$4100 \checkmark$	45 $\rightarrow$ 44	4100	
--	--	---------------------	------	--

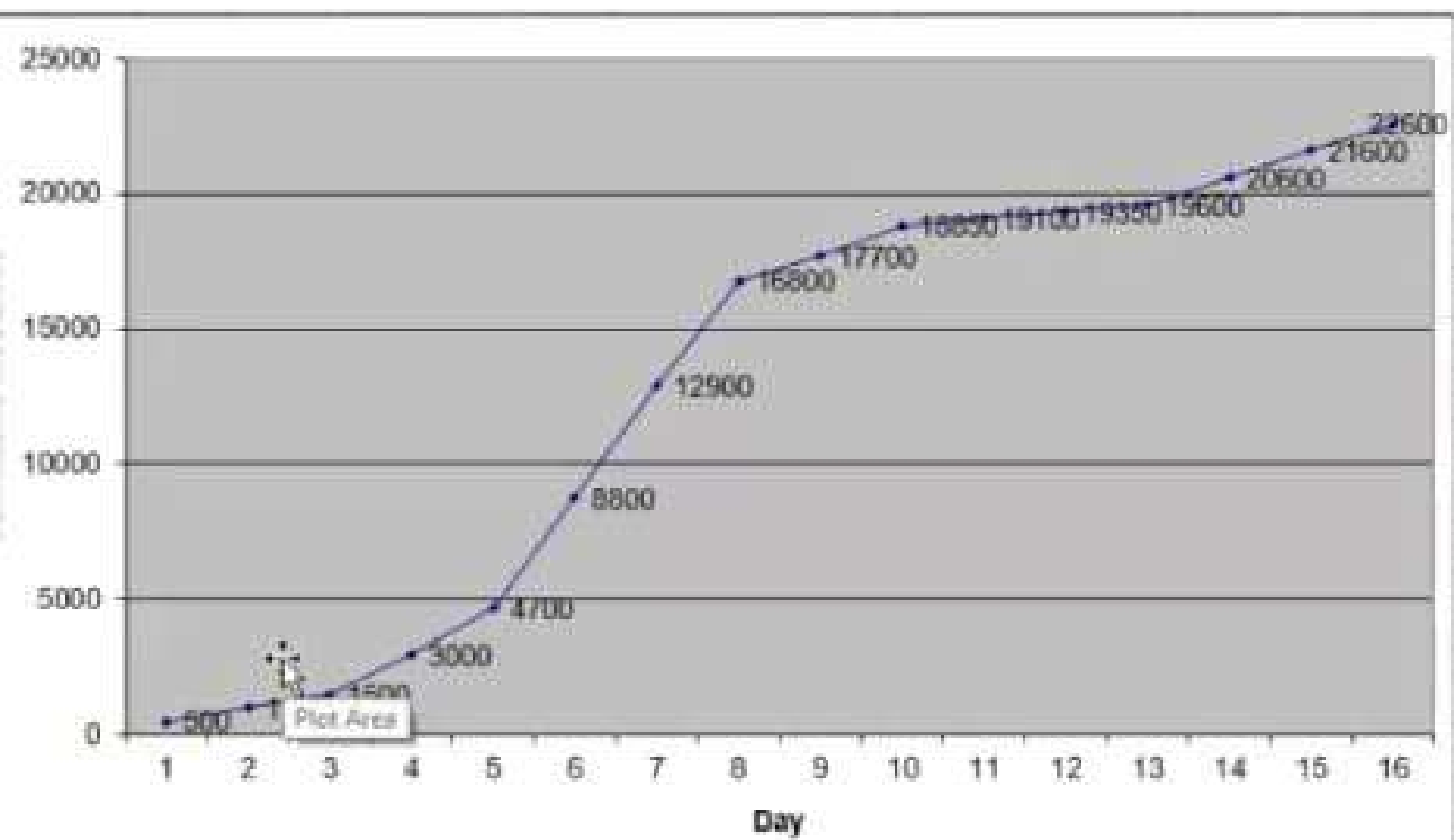
	$\& CP_3: F/\$3700 \times$ $M/\$3700 \checkmark$		$\frac{3700}{11200}$	\$26600
--	---	--	----------------------	---------

Histogram and S-curves

ex:- Given the following bar chart, draw the corresponding resource histogram and S-curve.







$$IF = R * (R_v - R_o - R * N_r)$$

IF:- Activity, # of FF days consumed

R:- # of resource (activity per day)

R_v :- # of resource days that will be vacated

R_o :- # of resource days currently that will be occupied

N_r :- the smaller value of the # of days of FF consumed and the duration of the activity.

* if, $IF \geq 0$, then moving start date of activity will result in a better resource histogram.

ex 1:-

* activity are arranged according to their early start

* Free Float is indicated by (-)

* # of resources are shown in the table :-

Cycle 0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		C	C	-	-	-	-	F	-	-	-	-	-	-			
A		B	D	E	E	E	E	G	G	G	I	I	J	J	K	K	L
		4	4	3	3	3	3	5	5	5	1	1	3	3	4	4	2
		D	-	-	-	-	-	H	H	-	-	-	-	-	-	-	
		3						3	3								

Note:- G depends on C and D

Ans:- 2 Resource

L	13	10	3	3	3	3	12	8	5	1	1	3	3	4	4	2
---	----	----	---	---	---	---	----	---	---	---	---	---	---	---	---	---

cycle 1:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	C	C	-	-	-	-	F	-	-	-	-	-	-	-	-	-
A	B	B	E	E	E	E	G	G	G	I	I	J	J	K	K	L
1	6	6	3	3	3	3	5	5	5	1	1	3	3	4	4	2
	D	-	-	-	-	-	---	---	---	H	H					
	3	-	-	-	-	-	---	---	---	3	3					
↓	13	10	3	3	3	3	9	5	5	4	4	3	3	4	4	2

$$IF(H, 1) = 3 * (12 - 5 - 3 * 1) = 12$$

$$IF(H, 2) = 3 * (20 - 6 - 3 * 2) = 24$$

$$IF(H, 3) = 3 * (20 - 2 - 3 * 2) = 36$$

$$IF(H, 4) = 3 * (20 - 4 - 3 * 2) = 30$$

$$IF(H, 5) = 3 * (20 - 6 - 6) = 24$$

$$IF(H, 6) = 3 * (20 - 7 - 6) = 21$$

$$IF(H, 7) = 3 * (20 - 8 - 6) = 18$$

* There For, move H 3 days.

Cycle 2:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	C	C	-	-	-	-	---	---	---	---	---	---	F			
A	B	B	E	E	E	F	G	G	G	I	I	J	J	K	K	L
1	6	6	3	3	3	3	5	5	5	1	1	3	3	4	4	2
	D	-	-	-	-	-	---	---	---	H	H					
	3	-	-	-	-	-	---	---	---	3	3					
↓	13	10	3	3	3	3	5	5	5	4	4	3	7	4	4	2

$$IF(F, 1) = 4 * (9 - 5 - 4 * 1) = 0$$

$$IF(F, 2) = 4 * (9 - 5 - 4) = 0$$

$$IF(F, 3) = 4 * (9 - 4 - 4) = 4$$

$$IF(F, 4) = 4 * (9 - 4 - 4) = 4$$

$$IF(F, 5) = 4 * (9 - 3 - 4) = 8$$

$$IF(F, 6) = 4 * (9 - 3 - 4) = 8$$

* move F 6 days

Cycle 3:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					C	C							F			
A	B	B	E	E	E	E	G	G	G	I	I	J	J	K	K	L
	D									H	H					
1	9	6	3	3	7	7	5	5	5	4	4	3	7	4	4	2

$$IF(C,1) = 4 * (13 - 3 - 4 * 1) = 24$$

$$IF(C,2) = 4 * (13 - 6 - 4 * 2) = 36$$

$$IF(C,3) = 4 * (13 - 6 - 4 * 2) = 36$$

$$IF(C,4) = 4 * (13 - 6 - 4 * 2) = 36$$

$$IF(D,1) = 3 * (13 - 10 - 3 * 1) = 0$$

$$IF(D,2) = 3 * (13 - 3 - 3 * 1) = 21$$

* Move C 4 days

$$IF(D,3) = 3 * (13 - 3 - 3) = 21$$

$$IF(D,4) = 3 * (13 - 3 - 3) = 21$$

$$IF(D,5) = 3 * (13 - 3 - 3) = 21$$

Cycle 4:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					C	C							F			
A	B	B	E	E	E	E	G	G	G	I	I	J	J	K	K	L
			D							H	H					
1	6	6	3	6	7	7	5	5	5	4	4	3	7	4	4	2

Re-consider Act D:-

$$IF(D,1) = 3 * (9 - 6 - 3 * 1) = 0$$

$$IF(D,2) = 3 * (9 - 3 - 3 * 1) = 9$$

so, Move D 3 days

$$IF(D,3) = 3 * (9 - 3 - 3 * 1) = 9$$

$$IF(D,4) = 3 * (9 - 7 - 3 * 1) = -3$$

$$IF(D,5) = 3 * (9 - 7 - 3 * 1) = -3$$

Cycle 5:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					C ₄	C ₄							F ₄			
A ₁	B ₆	B ₆	E ₃	E ₃	E ₃	E ₃	G ₅	G ₅	G ₅	I ₁	I ₁	J ₃	J ₃	K ₄	K ₄	L ₂
			D ₃							H ₃	H ₃					
1	6	6	6	3	7	7	5	5	5	4	4	3	7	4	4	2

$$IF(D,1) = 3 * (6 - 3 - 3 * 1) = 0$$

$$IF(D,2) = 3 * (6 - 6 - 3 * 1) = -9$$

$$IF(D,3) = 3 * (6 - 6 - 3 * 1) = -9$$

$$IF(C,1) = 4 * (7 - 6 - 4 * 1) = -12$$

$$IF(C,2) = 4 * (14 - 9 - 4 * 2) = -12$$

$$IF(C,3) = 4 * (14 - 9 - 4 * 2) = -12$$

$$IF(C,4) = 4 * (14 - 12 - 4 * 2) = -24$$

So, move D back
one day

Cycle 6:-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
					C ₄	C ₄						F ₄				
A ₁	B ₆	B ₆	E ₃	E ₃	E ₃	E ₃	G ₅	G ₅	G ₅	I ₁	I ₁	J ₃	J ₃	K ₄	K ₄	L ₂
			D ₃							H ₃	H ₃					
1	6	6	6	3	7	7	5	5	5	4	4	7	3	4	4	2

$$IF(F,1) = 4 * (7 - 3 - 4 * 1) = 0$$

$$IF(F,2) = 4 * (7 - 4 - 4 * 1) = -4$$

$$IF(F,3) = 4 * (7 - 4 - 4 * 1) = -4$$

$$IF(F,4) = 4 * (7 - 5 - 4 * 1) = -8$$

move F back
one day

$$IF(F,5) = 4 * (7 - 5 - 4 * 1) = -8$$

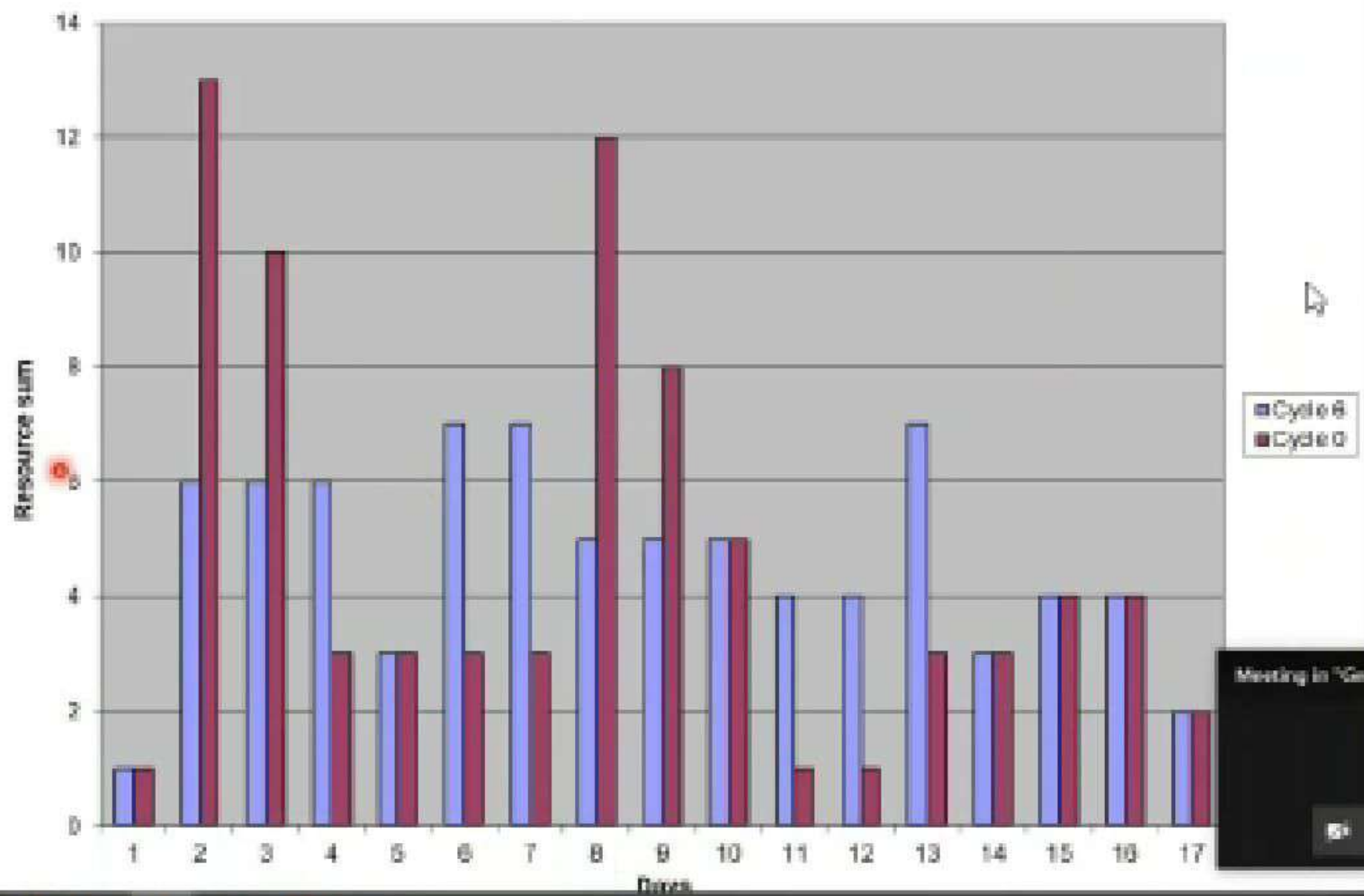
$$IF(F,6) = 4 * (7 - 5 - 4 * 1) = -8$$

$$IF(H,1) = 3 * (4 - 5 - 3 * 1) = -12$$

$$IF(H,2) = 3 * (4 - 10 - 3 * 2) = -24$$

$$IF(H,3) = 3 * (4 - 10 - 3 * 2) = -24$$

Resource Profile Comparison



Constraints

MSO: must start on

SMS: Schedule must start

SLF = Schedule late Finish

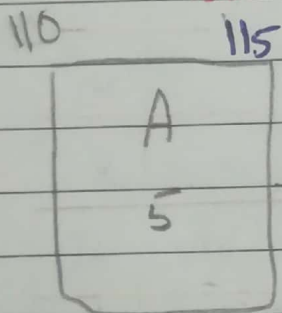
Min
(calculated LF or SLF)

نفس الحق
ونفس الحالة

SEF = Schedule early start

Max
(calculated ES or SEF)

بنوفا الا كبرينه (113 و 115)

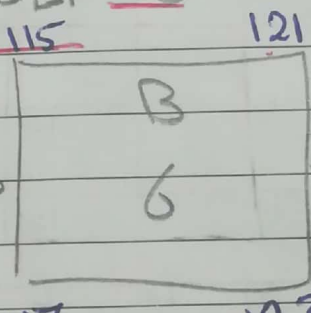


117

SLF = 118

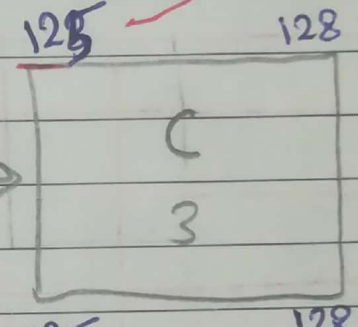
المنزلة 118

SEF = 113



SLF = 123

SEF = 125

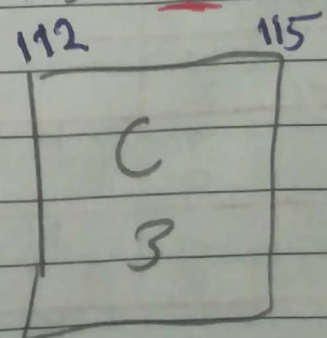
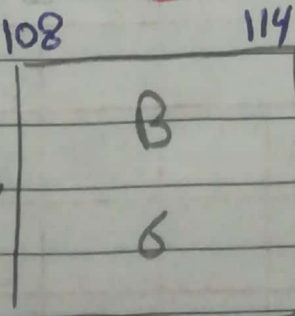
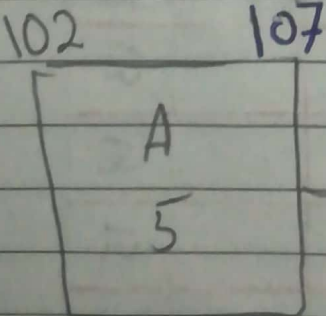


بنوفا الا منبرينه (123 و 125)

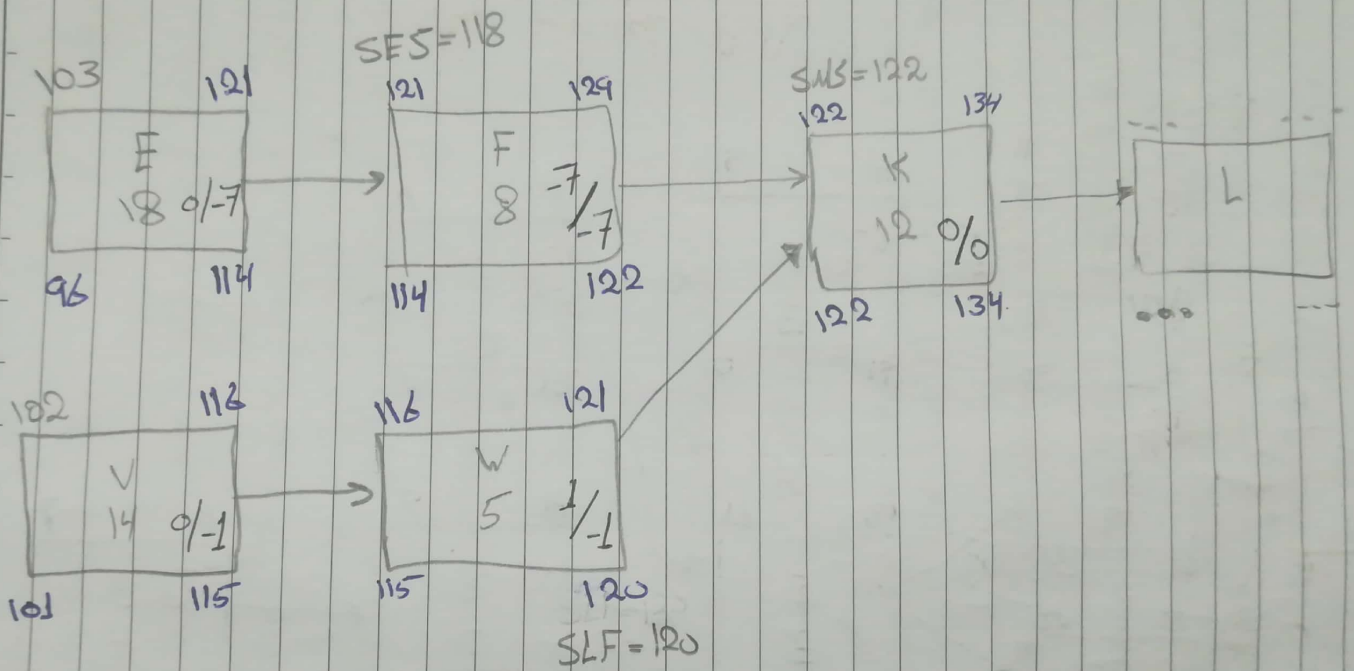
نلتزم بالاً، قام المحطاه بالؤال سواء كانت أكبر أو أصغر

SMS = 108

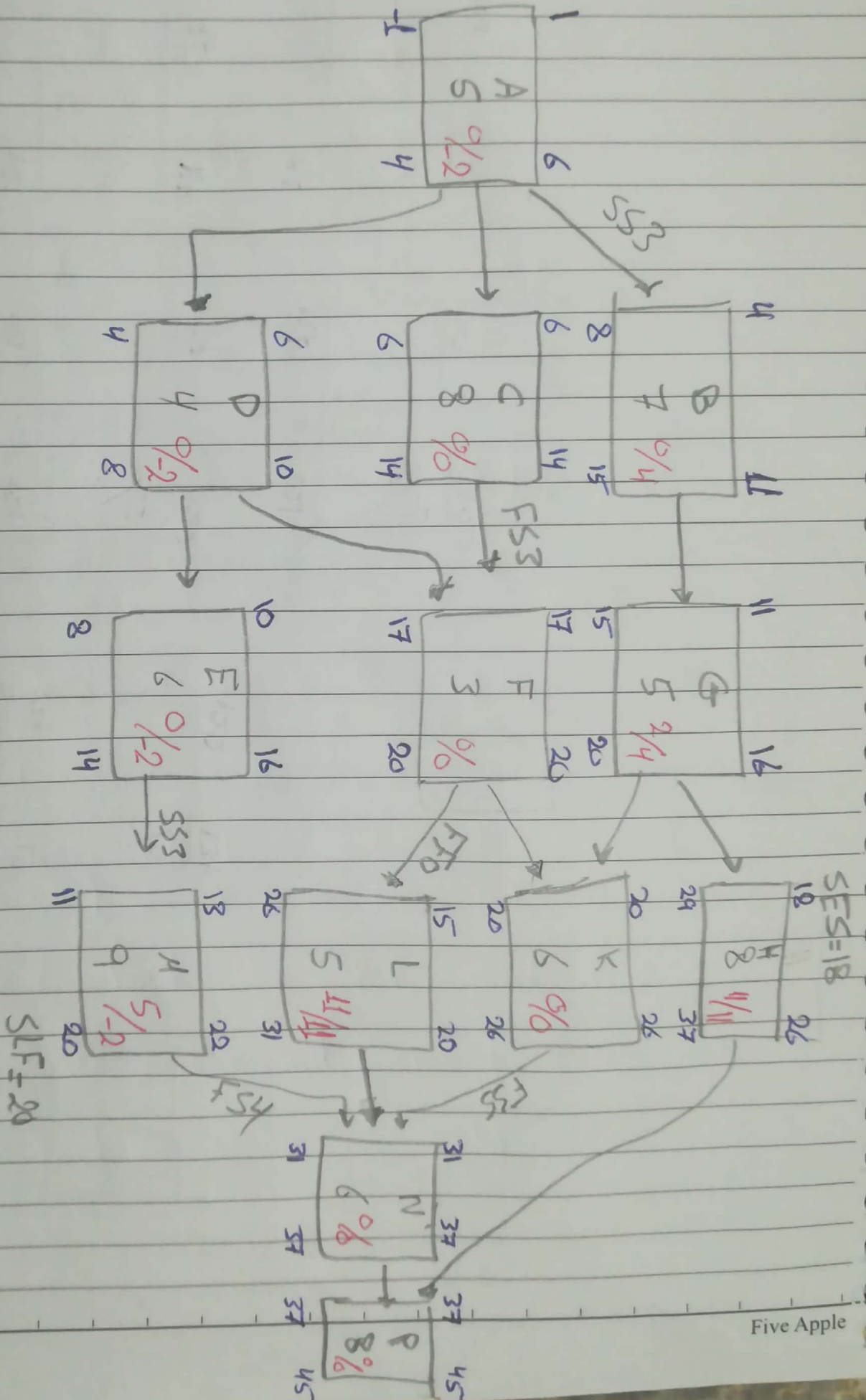
MSO = 112



ex1:-



ex 4:-



Earned value

EV:- earned value

BCWS:- budget cost of work scheduled (Planned)

BCWP:- budget cost of work performed (Earned)

ACWP:- actual cost of work performed (Actual)

BAC:- budget cost at completion

EAC:- estimated cost at completion

Cost variance (CV) = BCWP - ACWP
or use

cost performance (CPI) = (BCWP / ACWP)

* if a +ve variance or performance ≥ 1 indicates a favorable performance (under budget) if else -- (over budget)

Schedule variance (SV) = BCWP - BCWS

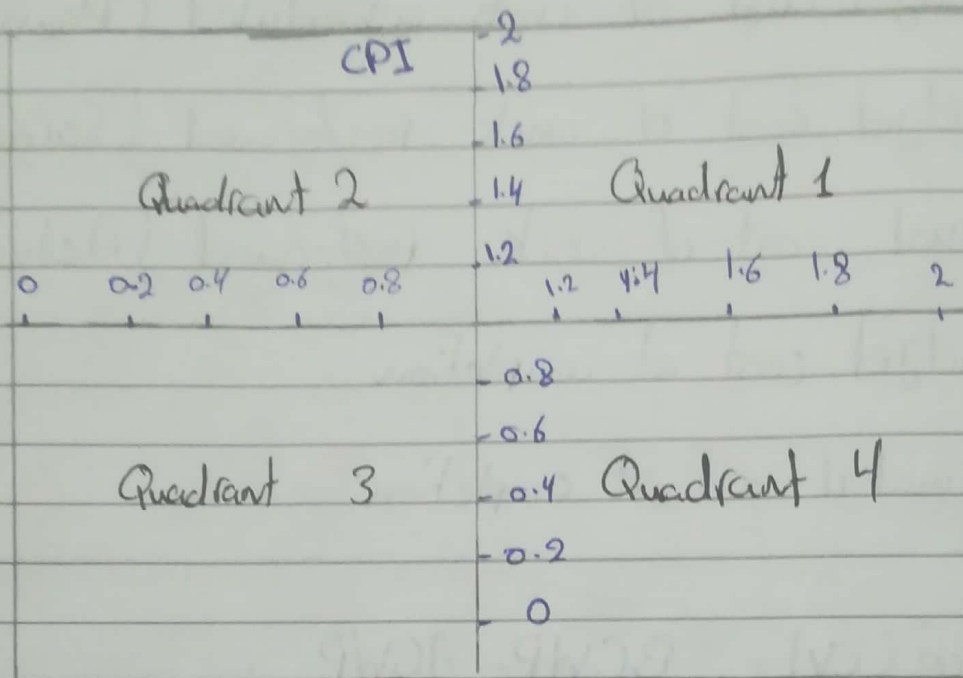
Schedule performance Index (SPI) = (BCWP / BCWS)

if a +ve variance or performance ≥ 1 indicates a favorable performance (ahead of schedule) if else -- (behind of schedule)

% complete of project = $[BCWP / BAC] * 100\%$

$EAC = ACWP + (BAC - BCWP)$

Plotting SPI against CPI



→ Which quadrant is the most favorable?

Quadrant 1, because (ahead of schedule ~~and under budget~~) and under budget

→ Which quadrant is the least favorable?

Quadrant 3, because (behind schedule, over budget)

→ What about the other quadrant?

Quadrant 2: (behind schedule, under budget)

→ Quadrant 4: (ahead of schedule, over budget)

Example 1

- After 3 ½ months:
 - The site work, excavation, foundation, fencing, and rough electrical are completed
 - The framing is one-half complete
 - The rough plumbing is three-fourths complete
 - The paving is half complete
- The incurred costs to date are \$152,000

Activity	Cost (\$)	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Site work	22,000						
Fencing	10,000						
Paving	18,000						
Excavation	30,000						
Foundation	50,000						
Framing	40,000						
Rough Elec	6,000						
Rough plumb.	16,000						
Drywall	13,000						
Suspend ceiling	4,000						
Interior Finish	34,000						
Carpeting	14,000						

* Calculate BCWS:-
- After 3 and 1/2 months.

$$\begin{aligned} * \text{BCWS} &= \text{site work} + \text{fencing} + \text{Paving} + \text{excavation} + \text{foundation} \\ &+ 1/2 \text{ Framing} + 1/2 \text{ rough elec} + 1/2 \text{ rough plumb} \\ &= 22,000 + 10,000 + 18,000 + 30,000 + 50,000 + 1/2(40,000) \\ &+ 1/2(6,000) + 1/2(16,000) = \$161,000 \end{aligned}$$

* ACWP = \$152,000 $\Rightarrow$ معطى في السؤال

$$\begin{aligned} * \text{PCWP} &= \text{site work} + \text{excavation} + \text{foundation} + \text{Fencing} \\ &+ \text{rough elec} + 1/2 \text{ Framing} + 3/4 \text{ rough plumb} \\ &+ 1/2 \text{ Paving} \end{aligned}$$

$$\begin{aligned} &= 22,000 + 30,000 + 50,000 + 10,000 + 6,000 \\ &+ 1/2(40,000) + 3/4(16,000) + 1/2(18,000) = \$159,000 \end{aligned}$$

* الفرق بين BCWS + BCWP

* BCWS: بتدل على عمودي في الجدول المعطى في السؤال عن الفترة المخلو بها إيجاد القيمة عندها وبتدل بقيم الأجزاء التي أتمتها فقط يعني الأجزاء التي تكونت على مدار العمل العمودي ~~والتي لا تزال في العمل~~

* بالنسبة لـ (Framing, rough elec, rough plumb) أخذنا نصف قيمهم لأننا في السؤال طالب عند زمن الشهر الرابع!

* BCWP: هي التكلفة لأجل المجهز في المشروع ويكون من هذه المعطيات:-

* Calc BAC: في كلفة، مع الأمانة في المروع

$$BAC = 22,000 + 18,000 + 18,000 + 39,000 + 50,000 + 40,000 + 8,000 + 16,000 + 13,000 + 4,000 + 34,000 + 14,000 = \underline{257,000}$$

1.) % complete ?

$$= [BCWP / BAC] \times 100\% = (159,000 / 257,000) \times 100\% = 61.9\%$$

2.) CPI ?

$$= BCWP / ACWP = 159,000 / 152,000 = 1.05$$

under Budget

3.) SPI ?

$$= BCWP / BCWS = 159,000 / 164,000 = 0.97$$

behind schedule

4.) EAC ?

$$= ACWP + (BAC - BCWP)$$
$$= 152,000 + (257,000 - 159,000) = 250,000$$

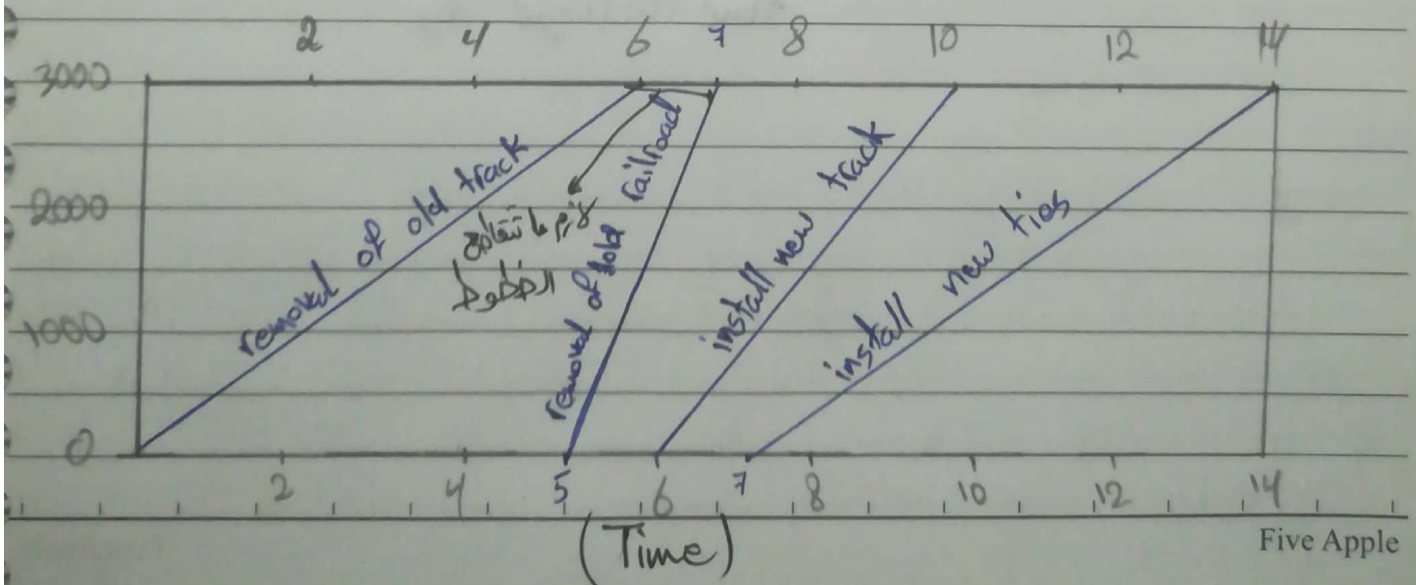
Linear Scheduling Method (LSM)

ex-1 - Develop a linear schedule for a project that consists of replacing the track on an existing railroad line, involving 3,000 ft of track.

* assume a minimum of 1-day time buffer between activities.

activity	Production rate (ft/hr)	Production per day (ft)	Duration for 3000 ft
Removal of old track	62.5	$62.5 \times 8 = 500$	$\frac{3000}{500} = 6$
Removal of old railroad ties	187.5	$187.5 \times 8 = 1500$	$\frac{3000}{1500} = 2$
Installation of new track	93.75	$93.75 \times 8 = 750$	$\frac{3000}{750} = 4$
Installation of new ties	54	$54 \times 8 = 432$	$3000/432 = 7$

8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14



ex 2:- Develop a linear schedule for the project below:-

- A shallow trench for a 1000 ft water line installation will take 10 days.
- It will take 4 day to install the first 400 ft of pipe
- A water meter will then be installed during the following 2 days at the end of the pipe
- After the meter is ~~with then~~ installed, the remaining 600 ft of pipe will be installed in 6 days?

