SOLUTIONS

WORK BREAKDOWN STRUCTURES

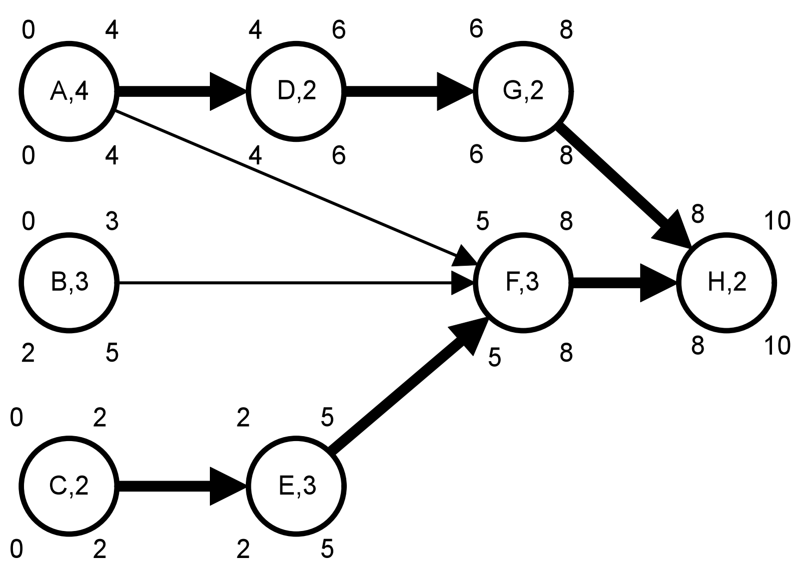
1. Answers will vary

CPM

You have decided to take up music video making in your spare time and are about to shoot a scene. The tasks involved, along with task times and precedence requirements, are given below.

TASK	DESCRIPTION	IMMEDIATE PREDECESSORS	TASK TIME (in hours)
A	Set up and decorate the set	__	4
B	Check the script	__	3
C	Apply makeup	__	2
D	Fix the stage lighting	A	2
E	Put on costumes	C	3
F	Dress rehearsal	A, B, E	3
G	Check audio/video equipment	D	2
H	Shoot the scene	F, G	2

1. Draw the network diagram for this project. How long will it take to complete the project?



Critical paths: ADGH, CEFH

Taking the time along 1 of the 2 longest (i.e. critical) paths from A to H: ADGH, we get

Time(Project) = Time A + Time D + Time G + Time H

= 4 + 2 + 2 + 2 = 10 hrs

2. If tasks B and C are delayed by one hour each, how is the project completion time affected?

   B has a slack time of 2 hrs, so it will not affect the completion time. C is however on the one of the critical paths, the project delay will be 1 hr.

3. If tasks C and E are delayed by one hour each, how is the project completion time affected?

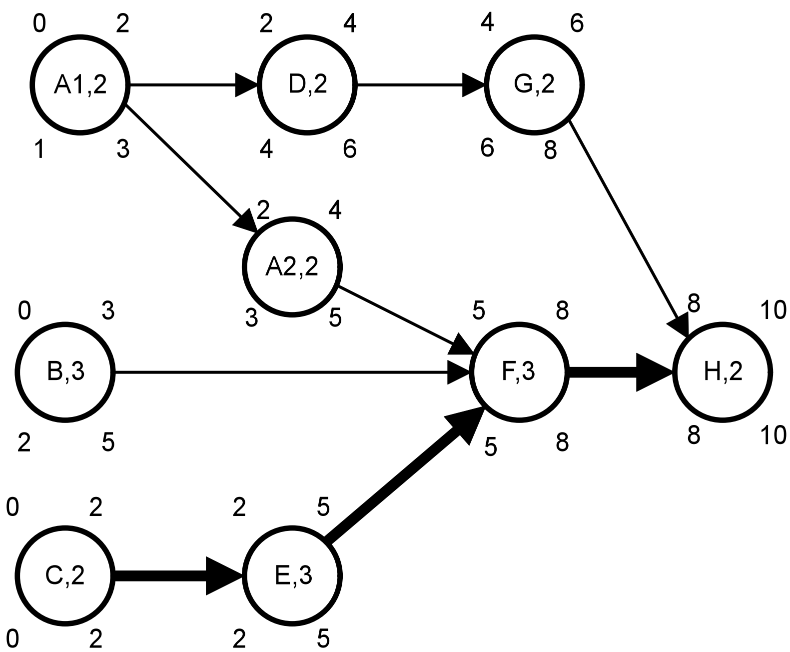
   Since they are both on a critical path, their delays are cumulative, so there will be a two hour delay.

4. You have been given some money that you may use to speed up any one task in the project. Explain how you would select a task to speed up.

   Go one week at a time. First find the cheapest way to reduce the critical path by one hour. You may need to crash more than one node to do this, if you have more than one critical path. (Note the reduction in task times may change the crash cost for the next hour saved on a chosen activity.) Then re-determine the critical path(s), and hunt down the next cheapest reduction, and so on. In this paticular case, you have at least 2 critical paths to worry about.

5. You notice in fact that task A can be split into two tasks, "set up the stage" (task A1) and "decorate the stage" (task A2), each of which takes 2 hours. Also, the crew can fix the stage lighting (task D) while the stage is being decorated. However, the stage must be set up before it is decorated, and before the stage lighting is fixed. Draw a revised network for the project, and identify the critical path.

The new critical path is CEFH.



6. What does this tell you about the effect of aggregation of tasks on managing a project? More specifically, what are the tradeoffs involved in splitting a task?

   Separation of tasks gives you more flexibility in scheduling and potentially a shorter project duration. In fact, the The ADGH critical path disappeared. Unfortunately, since you had two critical paths, you have to reduce duration of both in order to improve the project time. Since A is not on the CEFH path, no duration reduction occurs.

PERT

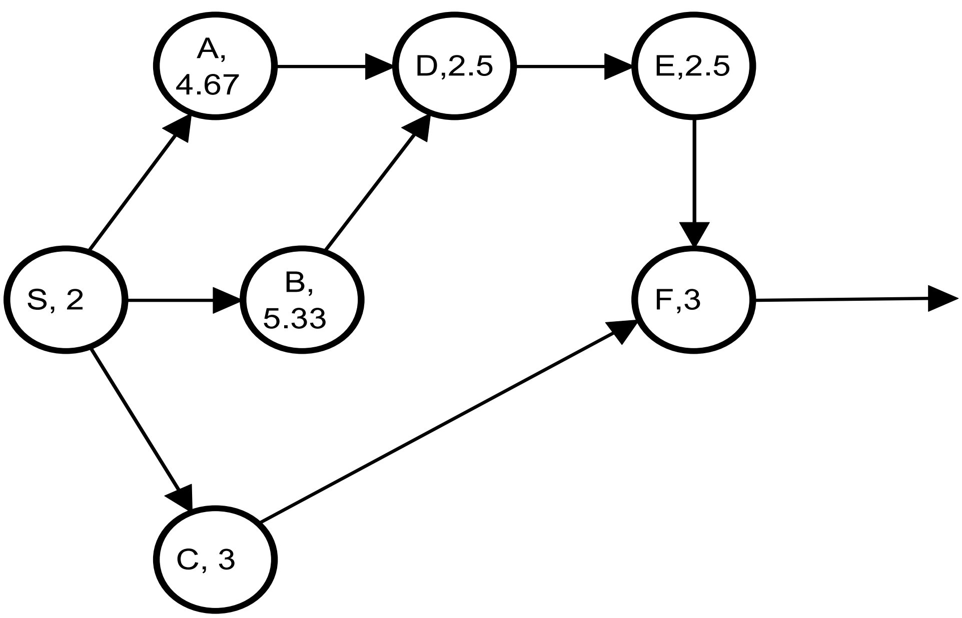
Marianna D'Andrea at *The Enterprise Dynamics Simulation Institute,* a computer-simulation consulting firm, has acquired a new client whose project is rather complicated. Furthermore the client is quite concerned about how soon the flight simulator can be delivered as the client has a hard deadline in 14 weeks when they must decide which components of their new software system (if any) to outsource.

Marianna works with a team of associates. Marianna herself interviews the client and deploys the flight simulator. Katerina builds the model while Marianna gathers data. Taddeo develops the graphical user interface for the model. Guido calibrates and tests the model.

The appropriate activities, along with their duration information, are shown below.

1. Complete the expected duration and variance for the empty cells in the table below. All durations are in weeks

Activity	Description	Prede-cessors	a	m	b	Expected Duration	σ^2
S	Interview Client	-	2	2	2	**2**	**0**
A	Build Model	S	2	4	10	**4.667**	**1.778**
B	Gather Data	S	X	5	X	5.333	1
C	Develop GUI	S	2	3	4	**3**	**0.111**
D	Calibrate	A,B	X	2	X	2.5	0.694
E	Test	D	X	2	X	2.5	0.694
F	Deploy Flight Simulator	C,E	X	3	X	3	0.444



2. For the PERT diagram above, fill in the durations for each activity.

3. Calculate the expected project completion time. Identify the critical path.

CP = SBDEF

E(Completion Time) = E(Crit Path) = $\bar{T}_{CP}$ **= 2 + 5.33 + 2.5 + 2.5 + 3 = 15.33 weeks**

4. What is the probability that the project will be complete within the allotted 14 weeks?
   Var (Completion) = Var (Crit Path) = 0+1+0.694+0.694+0.444=2.832 weeks^2

   ⇨ Std Dev(Completion) = $\sqrt{2.832}$ = 1.683 weeks

$$Z_{14} = \frac{14 - 15.33}{1.683} = -0.79 \quad \text{=>} \quad \Pr\left\{\bar{T}_{CP} \le 14\right\} = 21.5\%$$

5. Marianna is verrry nervous. She wants to know when you can guarantee that the project will be complete with 95.0% certainty. (Hint: Compare the 95th percentiles of the critical path and the next longest path.).

$$\Pr\left\{\bar{T}_{CP} \le X\right\} = 95\% \quad \text{=>} \quad Z_x = 1.64$$

$$\text{=>} \ T_{CP} = \bar{T}_{CP} + z_x\left(\sigma_{CP}\right) = 15.33 \text{ weeks} + 1.64\left(1.683 \text{ weeks}\right) = 18.1 \text{ weeks}$$

Note that to be sure, we should check out the P95 of the path SADEF as well, since it is a near-critical path and activity A has a higher variance than activity B.

$\bar{T}_{SADEF}$ **= 2 + 4.67 + 2.5 + 2.5 + 3 = 14.67 weeks**

Var (SADEF) = 0+1.778+0.694+0.694+0.444=3.61 weeks^2

⇨ **Std Dev(SADEF) =** $\sqrt{3.61}$ **= 1.9 weeks**

$$\Pr\left\{\bar{T}_{SADEF} \le X\right\} = 95\% \quad \text{=>} \quad Z_x = 1.64$$

$$\text{=>} \ T_{SADEF}^{P95} = \bar{T}_{SADEF} + z_x\left(\sigma_{SADEF}\right) = 14.67 \text{ weeks} + 1.64\left(1.9 \text{ weeks}\right) = 17.8 \text{ weeks}$$

Strictly speaking, this means that the P95 is 18.1 weeks, which is indeed determined by the critical path. However, the real lesson here is that we that we need to watch what's going on with activity A despite the fact that it isn't on the critical path, because the P95 of SADEF is awfully close to the critical path's.

6. Consider the scenario in which Marianna is pulled off the current project immediately after interviewing the client (activity S) leaving Katerina to complete Marianna's remaining

activities as well as her own. In this case, when can Katerina guarantee that the project will be done with 95 percent certainty?

Because of Resource contention for Katerina at A&B, the CP is now SABDEF. Note that the dependence between A & B is caused, not by the nature of the tasks themselves, but rather that they share a resource.

E(Completion Time) = E(Crit Path) = $\overline{T}_{CP}$ **= 2 + <u>4.67</u>+5.33 + 2.5 + 2.5 + 3 = 20.0 weeks &**

Var (Completion) = Var (Crit Path) = 0+<u>1.778</u>+1+0.694+0.694+0.444=4.61 weeks^2

⇨ **Std Dev(Completion) =** $\sqrt{4.61}$ **= 2.15 weeks**

$$T_{CP} = \overline{T}_{CP} + z_x\left(\sigma_{CP}\right) = 20.0 \text{ weeks} + 1.64\left(2.15 \text{ weeks}\right) = 23.5 \text{ weeks}$$

7. Assume that Marianna is not pulled off of the project and Katerina does not replace her (i.e. ignore the previous sub-problem.) If each employee on the project is paid $3000 per day working on the project, what are the P5, the P50, and P95 for the budget of this project? (A P95 is the 95th percentile of the budget distribution, a P50 is the 50th percentile of the budget distribution, and a P5 is the 5th percentile.) Hint: For a normal distribution, the P5 = the mean – 1.64 x std deviation, and the P95 = the mean + 1.65 x the standard deviation.

First, we'll figure out the number of person weeks involved in completing the project, then we'll convert it to dollars.

Expected Person Weeks = 2 + 4.6667 + 5.333 + 3 + 2.5 + 2.5 + 3 = 23 person weeks

Variance of Person Weeks = 0 + 1.7778 + 1 + 0.111 +0.694 + 0.694 + 0.444 = 4.72 (person weeks)^2 → Std Deviation of Person Weeks = 2.17 person weeks

Person Weeks ~ Norm (23, 2.17)

P95 of person weeks = mean person weeks + 1.64 * std.dev. person weeks = 23 + 1.64*2.17 = 26.6 person weeks

P50 of person weeks = mean person weeks + 0 * std.dev. person weeks = 23 + 0*2.17 = 23 person weeks

P5 of person weeks = mean person weeks - 1.64 * std.dev. person weeks = 23 - 1.64*2.17 = 19.4 person weeks

Note that we have to make an assumption with regard to the number of days worked per week by each consultant. We'll assume 5 days, which yields a cost of $15 K/person/week for work on the project.

(P5, P50, P95) for the budget = $15 K/person week x (P5, P50, P95) for person weeks

= $15 K/person week x (19.4, 23, 26.6) person weeks

= ($292 K, $345 K, $398 K)