

TEST BANK



NINTH EDITION

Flexible Edition

**OPERATIONS
MANAGEMENT**

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CHAPTER 3: PROJECT MANAGEMENT

TRUE/FALSE

1. The ES of an activity that has only one predecessor is simply the EF of that predecessor.
True (Determining the project schedule, moderate)
2. One phase of a large project is scheduling.
True (The importance of project management, easy)
3. A project organization works best for an organization when the project resides in only one of its functional areas.
False (Project planning, moderate)
4. By their very nature, projects have a limited lifetime, and that sets project management apart from the management of more traditional activities.
True (Project planning, moderate)
5. One responsibility of a project manager is to make sure that the project meets its quality goals.
True (Project planning, moderate)
6. Work Breakdown Structure is a useful tool in project management because it addresses the timing of individual work elements.
False (Project planning, moderate)
7. Project managers have their own code of ethics, established by the Project Management Institute.
True (Ethical issues faced in project management, moderate) {AACSB: Ethical Reasoning}
8. Ethical issues which can arise in projects include bid rigging, bribery, and "low balling."
True (Ethical issues faced in project management, easy) {AACSB: Ethical Reasoning}
9. Gantt charts give a timeline for each of a project's activities, but do not adequately show the interrelationships of activities.
True (Project scheduling, moderate)
10. PERT, but not CPM, has the ability to consider the precedence relationships in a project.
False (Project scheduling, moderate)
11. The shortest of all paths through the network is the critical path.
False (Project management techniques: PERT and CPM, moderate)
12. The fundamental difference between PERT and CPM is that PERT uses the beta distribution for crashing projects while CPM uses cost estimates.
False (Project management techniques: PERT and CPM, moderate)
13. Slack is the amount of time an activity can be delayed without delaying the entire project.
True (Project management techniques: PERT and CPM, moderate)

14. Every network has at least one critical path.
True (Project management techniques: PERT and CPM, moderate)
15. The critical path can be determined by use of either the "forward pass" or the "backward pass."
False (Project management techniques: PERT and CPM, moderate)
16. The PERT pessimistic time estimate is an estimate of the minimum time an activity will require.
False (Project management techniques: PERT and CPM, easy)
17. The standard deviation of project duration is the average of the standard deviation of all activities on the critical path.
False (Project management techniques: PERT and CPM, moderate)
18. In PERT analysis, the identification of the critical path can be incorrect if a noncritical activity takes substantially more than its expected time.
True (Project management techniques: PERT and CPM, difficult)
19. Shortening the project's duration by deleting unnecessary activities is called "project crashing."
False (Cost-time trade-offs and project crashing, moderate)
20. In project management, crashing an activity must consider the impact on all paths in the network.
True (Cost-time trade-offs and project crashing, moderate)

MULTIPLE CHOICE

21. Which of the following statements regarding Bechtel is **true**?
 - a. Its competitive advantage is project management.
 - b. Bechtel was the construction contractor for the Hoover Dam.
 - c. While helping to rebuild Iraq, Bechtel's crews had to travel under armed escort.
 - d. Bechtel's procurement program is global in nature.
 - e. All of the above are true.**e (Global company profile, easy)**
22. Which of the following statements about Bechtel is **true**?
 - a. Even though Bechtel is over 100 years old, the Kuwaiti oil fields was its first "project."
 - b. Bechtel is the world's premier manager of massive construction and engineering projects.
 - c. Bechtel's competitive advantage is supply chain management.
 - d. While its projects are worldwide, its network of suppliers is largely in the U.S.
 - e. All of the above are true.**b (Global company profile, moderate)**
23. The phases of project management are
 - a. planning, scheduling, and controlling
 - b. planning, programming, and budgeting
 - c. planning, organizing, staffing, leading, and controlling
 - d. different for manufacturing projects than for service projects
 - e. GANTT, CPM, and PERT**a (The importance of project management, easy)**

24. **A project organization**
- is effective for companies with multiple large projects
 - is appropriate only in construction firms
 - often fails when the project cuts across organizational lines
 - is formed to ensure that programs (projects) get proper management and attention
 - a and d are both true**
- e (Project planning, moderate)**
25. Which of the following statements regarding project management is **false**?
- Gantt charts give a timeline for each of a project's activities, but do not adequately show the interrelationships of activities.
 - A project organization works best for a project that is temporary but critical to the organization.
 - Project organization works well when the work contains simple, independent tasks.
 - Gantt charts and PERT/CPM are never used together.
 - None of the above is true.
- c (Project planning, moderate)**
26. A code of ethics especially for project managers
- has been established by the Project Management Institute
 - has been formulated by the Federal government
 - has been formulated by the World Trade Organization
 - is inappropriate, since everyone should use the same guidance on ethical issues
 - does not exist at this time
- a (Project planning, moderate) {AACSB: Ethical Reasoning}**
27. Divulging information to some bidders on a project to give them an unfair advantage
- is the same thing as altering a status report
 - is bribery
 - is permitted by NAFTA
 - is known as bid rigging
 - is acceptable for private corporations but not for government agencies
- d (Project planning, moderate) {AACSB: Ethical Reasoning}**
28. Ethical issues that may arise in projects large and small include
- bid rigging
 - expense account padding
 - compromised safety or health standards
 - bribery
 - All of the above are true.
- e (Project planning, easy) {AACSB: Ethical Reasoning}**
29. Which of the following statements regarding Gantt charts is **true**?
- Gantt charts give a timeline and precedence relationships for each activity of a project.
 - Gantt charts use the four standard spines of Methods, Materials, Manpower, and Machinery.
 - Gantt charts are visual devices that show the duration of activities in a project.
 - Gantt charts are expensive.
 - All of the above are true.
- c (Project scheduling, moderate)**

30. Which of the following statements regarding critical paths is **true**?
- The shortest of all paths through the network is the critical path.
 - Some activities on the critical path may have slack.
 - Every network has exactly one critical path.
 - On a specific project, there can be multiple critical paths, all with exactly the same duration.
 - The duration of the critical path is the average duration of all paths in the project network.
- d (Project management techniques: PERT and CPM, moderate)**
31. Which of the following statements regarding CPM is **true**?
- The critical path is the shortest of all paths through the network.
 - The critical path is that set of activities that has positive slack.
 - Some networks have no critical path.
 - All activities on the critical path have their LS equal their predecessor's EF.
 - All of the above are false.
- d (Project management techniques: PERT and CPM, moderate)**
32. A simple CPM network has three activities, A, B, and C. A is an immediate predecessor of B and of C. B is an immediate predecessor of C. The activity durations are A=4, B=3, C=8.
- The critical path is A-B-C, duration 15.
 - The critical path is A-C, duration 12.
 - The critical path is A-B-C, duration 13.5
 - The critical path cannot be determined without knowing PERT expected activity times.
 - The network has no critical path.
- a (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
33. A simple CPM network has three activities, D, E, and F. D is an immediate predecessor of E and of F. E is an immediate predecessor of F. The activity durations are D=4, E=3, F=8.
- The critical path is D-E-F, duration 15.
 - The critical path is D-F, duration 12.
 - Slack at D is 3 units
 - Slack at E is 3 units
 - Both **a** and **c** are true
- a (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
34. A simple CPM network has five activities, A, B, C, D, and E. A is an immediate predecessor of C and of D. B is also an immediate predecessor of C and of D. C and D are both immediate predecessors of E.
- There are two paths in this network.
 - There are four paths in this network.
 - There are five paths in this network.
 - There are 25 paths through this network.
 - None of these statements is true.
- b (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**

35. Activity D on a CPM network has predecessors B and C, and has successor F. D has duration 6. B's earliest finish is 18, while C's is 20. F's late start is 26. Which of the following is **true**?
- B is a critical activity.
 - C is completed before B.
 - D has no slack but is not critical.
 - D is critical, and has zero slack.
 - All of the above are true.
- d (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
36. Which of the following statements regarding CPM networks is **true**?
- There can be multiple critical paths on the same project, all with different durations.
 - The early finish of an activity is the latest early start of all preceding activities.
 - The late start of an activity is its late finish plus its duration.
 - If a specific project has multiple critical paths, all of them will have the same duration.
 - All of the above are true.
- d (Project management techniques: PERT and CPM, moderate)**
37. Activity M on a CPM network has predecessors N and R, and has successor S. M has duration 5. N's late finish is 18, while R's is 20. S's late start is 14. Which of the following is **true**?
- M is critical and has zero slack.
 - M has no slack but is not critical.
 - The last start time of S is impossible.
 - N is a critical activity.
 - S is a critical activity.
- c (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
38. Which of the following statements concerning CPM activities is **false**?
- The early finish of an activity is the early start of that activity plus its duration.
 - The late finish is the earliest of the late start times of all successor activities.
 - The late start of an activity is its late finish less its duration.
 - The late finish of an activity is the earliest late start of all preceding activities.
 - The early start of an activity is the latest early finish of all preceding activities.
- d (Project management techniques: PERT and CPM, difficult)**
39. The time an activity will take assuming very unfavorable conditions is
- the optimistic time
 - the pessimistic time
 - the activity variance
 - the minimum time
 - exactly twice as long as the expected time
- b (Project management techniques: PERT and CPM, moderate)**

40. The critical path for the network activities shown below is _____ with duration _____.

Activity	Duration	Immediate Predecessors
A	4	---
B	2	A
C	7	--
D	4	A
E	5	B,C,D

- a. A-B-D; 10
- b. A-B-E; 11
- c. C-E; 12
- d. A-D-E; 13
- e. A-B-C-D-E; 22

d (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}

41. The critical path for the network activities shown below is _____ with duration _____.

Activity	Duration	Immediate Predecessors
A	2	--
B	4	--
C	6	A,B
D	1	A,B
E	2	B,C,D

- a. A-D-E; 5
- b. B-E; 6
- c. B-D-E; 7
- d. A-C-E; 10
- e. B-C-E; 12

e (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}

42. The _____ distribution is used by PERT analysis to calculate expected activity times and variances.

- a. Normal
- b. Beta
- c. Alpha
- d. Gaussian
- e. Binomial

b (Project management techniques: PERT and CPM, easy)

43. The expected activity time in PERT analysis is calculated as
- the simple average of the optimistic, pessimistic, and most likely times
 - the weighted average of **a**, **m**, and **b**, with **m** weighted 4 times as heavily as **a** and **b**
 - the sum of the optimistic, pessimistic, and most likely times
 - the sum of the optimistic, pessimistic, and most likely times, divided by six
 - the sum of the activity variances, divided by six

b (Project management techniques: PERT and CPM, moderate)

44. The critical path for the network activities shown below is _____ with duration _____.

Activity	Duration	Immediate Predecessors
A	10	---
B	8	---
C	2	A
D	4	A
E	5	B,C, D

- A-C; 12
- A-D-E; 19
- B-E; 13
- A-B-C-D-E; 29
- none of the above

b (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}

45. Which of the following statements regarding PERT times is **true**?
- The optimistic time estimate is an estimate of the minimum time an activity will require.
 - The optimistic time estimate is an estimate of the maximum time an activity will require.
 - The probable time estimate is calculated as $t = (a + 4m + b)$.
 - Pessimistic time estimate is an estimate of the minimum time an activity will require.
 - Most likely time estimate is an estimate of the maximum time an activity will require.

a (Project management techniques: PERT and CPM, moderate)

46. Which of the following statements regarding PERT times is **true**?
- Expected time is an estimate of the time an activity will require if everything goes as planned.
 - The optimistic time estimate is an estimate of the maximum time an activity will require.
 - The probable time estimate is calculated as $t = (a + 4m + b)/6$.
 - Pessimistic time estimate is an estimate of the minimum time an activity will require.
 - Most likely time estimate is an estimate of the maximum time an activity will require.

c (Project management techniques: PERT and CPM, moderate)

47. The Beta distribution is used in project management to
- calculate slack on activities not on the critical path
 - calculate the probability that a project will be completed within its budget
 - calculate pessimistic and optimistic activity times
 - determine which activity should be crashed
 - none of the above

e (Project management techniques: PERT and CPM, moderate)

48. The Beta distribution is used in project management to
- determine which activity should be crashed
 - calculate the probability that a project will be completed within its budget
 - calculate expected activity times
 - calculate slack for activities on the critical path
 - none of the above
- c (Project management techniques: PERT and CPM, moderate)**
49. In a PERT network, non-critical activities that have little slack need to be monitored closely
- because PERT treats all activities as equally important
 - because near-critical paths could become critical paths with small delays in these activities
 - because slack is undesirable and needs to be eliminated
 - because they are causing the entire project to be delayed
 - because they have a high risk of not being completed
- b (Project management techniques: PERT and CPM, moderate)**
50. Which of the following statements regarding PERT analysis is **true**?
- Each activity has two estimates of its duration.
 - Project variance is the sum of all activity variances.
 - Project standard deviation is the sum of all critical activity standard deviations.
 - Only critical activities contribute to the project variance.
 - None of the above is true.
- d (Project management techniques: PERT and CPM, moderate)**
51. A project being analyzed by PERT has 60 activities, 13 of which are on the critical path. If the estimated time along the critical path is 214 days with a project variance of 100, the probability that the project will take 224 days or more to complete is
- near zero
 - 0.0126
 - 0.1587
 - 0.8413
 - 2.14
- c (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
52. An activity on a PERT network has these time estimates: optimistic = 2, most likely = 5, and pessimistic = 10. Its expected time is
- 5
 - 5.33
 - 5.67
 - 17
 - none of these
- b (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**

53. An activity on a PERT network has these time estimates: optimistic = 1, most likely = 2, and pessimistic = 5. Its expected time is
- 2
 - 2.33
 - 2.67
 - 8
 - none of these
- b (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
54. An activity on a PERT network has these time estimates: optimistic = 2, most likely = 3, and pessimistic = 8. Its expected time and variance (if it is a critical activity) are
- 3.67; 1
 - 3.67; 6
 - 4.33; 1
 - 4.33; 6
 - none of these
- a (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
55. A local project being analyzed by PERT has 42 activities, 13 of which are on the critical path. If the estimated time along the critical path is 105 days with a project variance of 25, the probability that the project will be completed in 95 days or less is
- 0.4
 - 0.0228
 - 0.3444
 - 0.9772
 - 4.2
- b (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
56. A project being analyzed by PERT has 38 activities, 16 of which are on the critical path. If the estimated time along the critical path is 90 days with a project variance of 25, the probability that the project will be completed in 88 days or less is
- 0.0228
 - 0.3446
 - 0.6554
 - 0.9772
 - 18
- b (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
57. A PERT project has 45 activities, 19 of which are on the critical path. The estimated time for the critical path is 120 days. The sum of all activity variances is 64, while the sum of variances along the critical path is 36. The probability that the project can be completed between days 108 and 120 is
- 2.00
 - 0.0227
 - 0.1058
 - 0.4773
 - 0.9773
- d (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**

58. A contractor's project being analyzed by PERT has an estimated time for the critical path of 120 days. The sum of all activity variances is 81; the sum of variances along the critical path is 64. The probability that the project will take 130 or more days to complete is
- 0.1056
 - 0.1335
 - 0.8512
 - 0.8943
 - 1.29
- a (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}**
59. Analysis of a PERT problem shows the estimated time for the critical path to be 108 days with a variance of 64. There is a .90 probability that the project will be completed before approximately day _____.
- 98
 - 108
 - 109
 - 115
 - 118
- e (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
60. A project whose critical path has an estimated time of 120 days with a variance of 100 has a 20% chance that the project will be completed before day _____ (rounded to nearest day).
- 98
 - 112
 - 120
 - 124
 - 220
- b (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
61. A project whose critical path has an estimated time of 820 days with a variance of 225 has a 20% chance that the project will be completed before day _____ (rounded to nearest day).
- 631
 - 689
 - 807
 - 833
 - 1009
- c (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**
62. Contract requirements state that a project must be completed within 180 working days, or it will incur penalties for late completion. Analysis of the activity network reveals an estimated project time of 145 working days with a project variance of 400. What is the probability that the project will be completed before the late-payment deadline?
- 0.0401
 - 0.4599
 - 0.8056
 - 0.9599
 - near 1.0000, or almost certain
- d (Project management techniques: PERT and CPM, difficult) {AACSB: Analytic Skills}**

63. Which of these statements regarding time-cost tradeoffs in CPM networks is **true**?
- a. Crashing is not possible unless there are multiple critical paths.
 - b. Crashing a project often reduces the length of long-duration, but noncritical, activities.
 - c. Activities not on the critical path can never be on the critical path, even after crashing.
 - d. Crashing shortens the project duration by assigning more resources to one or more of the critical tasks.
 - e. None of the above is true.
- d (Cost-time trade-offs and project crashing, moderate)**
64. What was the name of the construction project to rebuild the Pentagon after the terrorist attacks on Sept. 11, 2001?
- a. Project Panther
 - b. Project Pit Bull
 - c. Project Python
 - d. Project Piranha
 - e. Project Phoenix
- e (Project management techniques: PERT and CPM, moderate)**
65. Which of the following statements regarding time-cost tradeoffs in CPM networks is **false**?
- a. "Project Crashing" shortens project duration by assigning more resources to critical tasks.
 - b. Crashing sometimes has the reverse result of lengthening the project duration.
 - c. Crashing must consider the impact of crashing an activity on all paths in the network.
 - d. Activities not on the critical path can become critical after crashing takes place.
 - e. All of the above are true.
- b (Cost-time trade-offs and project crashing, moderate)**
66. If an activity whose normal duration is 13 days can be shortened to 10 days for an added cost of \$1,500, the crash cost per period is
- a. \$500
 - b. \$750
 - b. \$1,500
 - d. \$13,000
 - e. \$15,000
- a (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}**

67. Two activities are candidates for crashing on a CPM network. Activity details are in the table below. To cut one day from the project's duration, activity _____ should be crashed first, adding _____ to project cost.

Activity	Normal Time	Normal Cost	Crash Duration	Crash Cost
One	8 days	\$6,000	6 days	\$6,800
Two	10 days	\$4,000	9 days	\$5,000

- a. One; \$400
 - b. One; \$6,800
 - c. Two; \$1,000
 - d. Two; \$5,000
 - e. One or two should be crashed; \$1,400
- a (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}**
68. If an activity whose normal duration is 15 days can be shortened to 10 days for an added cost of \$2,000, the crash cost per period is
- a. \$400
 - b. \$2,000
 - c. \$10,000
 - d. \$20,000
 - e. \$30,000
- a (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}**
69. A network has been crashed to the point where all activities are critical. Additional crashing
- a. is unnecessary
 - b. is impossible
 - c. is prohibitively expensive
 - d. may require crashing multiple tasks simultaneously
 - e. can be done, but all critical tasks must be reduced in duration
- d (Cost-time trade-offs and project crashing, moderate)**

70. Two activities are candidates for crashing on a CPM network. Activity details are in the table below. To cut one day from the project's duration, activity _____ should be crashed first, adding _____ to project cost.

Activity	Normal Time	Normal Cost	Crash Duration	Crash Cost
B	4 days	\$6,000	3 days	\$8,000
C	6 days	\$4,000	4 days	\$6,000

- a. B; \$2,000
- b. B; \$8,000
- c. C; \$1,000
- d. C; \$2,000
- e. C; \$6,000

c (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}

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71. _____ is an organization formed to ensure that programs (projects) receive the proper management and attention.
Project organization (Project planning, easy)
72. _____ divides a project into more and more detailed components.
Work breakdown structure or WBS (Project planning, moderate)
73. The _____ has established a code of ethics especially for project managers.
Project Management Institute, (Project planning, easy) {AACSB: Ethical Reasoning}
74. _____ is a network technique using only one time factor per activity that enables managers to schedule, monitor, and control large and complex projects.
Critical path method or CPM (Project management techniques: PERT and CPM, easy)
75. A diagram of all activities and the precedence relationships that exist between these activities in a project is a(n) _____.
network (Project management techniques: PERT and CPM, moderate)
76. The _____ is the computed longest time path(s) through a network.
critical path (Project management techniques: PERT and CPM, easy)
77. The network analysis method that allows activity times to vary is _____.
PERT or Program Evaluation and Review Technique (Project management techniques: PERT and CPM, moderate)
78. _____ is the amount of time an individual activity in a network can be delayed without delaying the entire project.
Slack time (Project management techniques: PERT and CPM, easy)
79. The _____ distribution is appropriate for calculating expected activity times and activity variances in PERT networks.
Beta (Project management techniques: PERT and CPM, easy)

80. _____ is decreasing activity time in a network to reduce time on the critical path so total completion time is reduced.
Crashing (Cost-time trade-offs and project crashing, easy)

SHORT ANSWER

81. What are the three phases of a project? Describe each in a sentence or two.
The three phases are planning, scheduling, and controlling. Planning includes goal setting, defining the project, and team organization. Scheduling relates people, money, and supplies to specific activities and relates activities to each other. Controlling is where the firm monitors resources, costs, quality, and budgets. It also revises or changes plans and shifts resources to meet time and cost demands. (Introduction, moderate)
82. Identify the responsibilities of project managers.
Project managers are directly responsible for making sure that (1) all necessary activities are finished in proper sequence and on time; (2) the project comes in within budget; (3) the project meets its quality goals; and (4) the people assigned to the project receive the motivation, direction, and information needed to do their jobs. (Project planning, moderate)
83. What is a project organization?
A project organization is a form of management so that people and other resources are pooled for a limited amount of time to complete a specific goal or project. (Project planning, moderate)
84. Describe some of the challenges faced in the construction of the new 11-story building at Arnold Palmer Hospital in Orlando, Florida.
Prior to beginning actual construction, regulatory and funding issues added, as they do with most projects, substantial time to the overall project. Cities have zoning and parking issues, the EPA has drainage and waste issues, and regulatory authorities have their own requirements, as do issuers of bonds. (Project controlling, moderate)
85. What are some of the ethical issues faced by project managers? Which of these are likely to occur before a project begins, which are likely to occur while the project is underway, and which may occur after a project is complete? Illustrate any one of these from recent news.
A project manager, trying to select firms to undertake a project, might be exposed to bid rigging, low balling, or bribery on the part of firms competing for business. Once a project is underway, expense account padding, use of substitute (substandard) materials, or ignoring regulatory requirements are possible. Those who report on completed projects might not be truthful about the project's success (consider the massive changes that took place at NASA after two shuttle disasters, and note the very recent failure of the FBI's Carnivore software) (Project planning and project scheduling, moderate) {AACSB: Ethical Reasoning}
86. Identify and describe briefly each of the purposes of project scheduling.
It shows the relationship of each activity to others and to the whole project. It identifies the precedence relationship among activities. It encourages the setting of realistic time and cost estimates for each activity. It helps make better use of people, money, and material resources by identifying critical bottlenecks in the project. (Project scheduling, moderate)

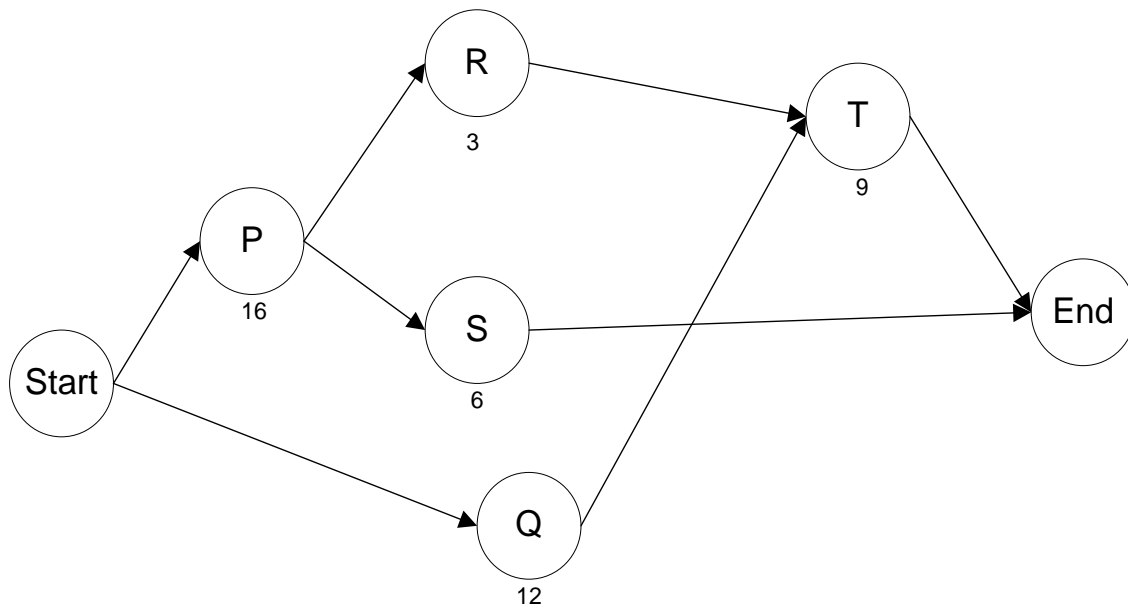
87. What is the objective of critical path analysis?
Critical path analysis determines the longest path through a network of activities. This longest path is the key to making the schedule that provides for completing all activities in the shortest time. Critical path analysis identifies those activities critical to timely completion of all activities so they can receive management focus. (Project management techniques: PERT and CPM, moderate)
88. Explain why the critical path is the longest, not the shortest, path through a network.
Critical path is that set of activities in a project network that controls the duration of the entire project. The controlling element to completion of all activities is the longest path; any shorter path will not allow for all activities to be completed. (Project management techniques: PERT and CPM, moderate)
89. Define slack.
Slack is the amount of time an activity can be delayed without delaying the entire project, assuming its preceding activities are completed as early as possible. (Project management techniques: PERT and CPM, moderate)
90. Identify, in order, the six steps basic to both PERT and CPM.
**1. Define the project and prepare the WBS.
2. Develop the relationships among the activities.
3. Draw the network connecting all of the activities.
4. Assign the time and/or cost estimates to each activity.
5. Compute the critical path—the longest time path through the network.
6. Use the network to help plan, schedule, monitor, and control the project.
(Project management techniques: PERT and CPM, moderate)**
91. What is the basic difference between PERT and CPM?
The basic difference between PERT and CPM is that PERT requires three time estimates of activity completion time, whereas CPM uses only a single estimate. (Project management techniques: PERT and CPM, moderate)
92. PERT calculations typically include the duration variance of each activity. What is the purpose of this calculation—what's the role of variances in PERT analysis?
The activity variances influence the probability of project completion. Specifically, the sum of the variances of the critical tasks equals the variance of the project. Further, large variances on noncritical tasks need to be monitored. Such an activity might have an actual completion time so large that the task becomes a critical task. (Project management techniques: PERT and CPM, moderate)
93. Describe the differences between a Gantt chart and a PERT/CPM network.
The differences between a Gantt chart and a PERT/CPM network are mainly that PERT/CPM has the ability to consider precedence relationships and interdependence of activities. (Project management techniques: PERT and CPM, moderate)

94. Briefly discuss what is meant by critical path analysis. What are critical path activities and why are they important?
The critical path consists of those tasks that determine the overall project completion time (or that will delay the completion of the project if they are delayed); these must be managed most closely to ensure timely completion of the project. Critical path analysis is the determination of which task elements are on, or likely to be on, the critical path (the longest path through the network). (Determining the project schedule, moderate)
95. What are the earliest activity start time and latest activity start time, and how are they computed?
The earliest start time is the earliest time at which an activity may start and still satisfy all precedence requirements. The latest start time is the latest time at which an activity may start and still satisfy both precedence requirements and the overall project completion time. (Determining the project schedule, moderate)
96. How is the expected completion time of a project activity, and of a PERT project, computed?
The expected completion time of a project activity uses the Beta distribution; expected time is the weighted average of optimistic, most likely, and pessimistic time estimates. Expected completion of a PERT project is the sum of the expected times for individual activities that are on the critical path. (Determining the project schedule, moderate)
97. Describe in words how to calculate a project's standard deviation. What assumption allows that calculation to be accurate?
Add the variances of the activities on the critical path and then take the square root. We can do this because we assume that the activities are independent. (Variability in activity times, difficult)
98. Briefly describe the concept of cost/time trade-off and how it is used.
Cost/time trade-off is fundamentally PERT with additional information provided that enables one to monitor and control project cost and to study possible cost/time trade-offs. This can be done by making a budget for the entire project using the activity cost estimates and by monitoring the budget as the project takes place. Using this approach, we can determine the extent to which a project is incurring a cost overrun or a cost underrun. In addition, we can use the same technique to determine the extent to which a project is ahead of schedule or behind schedule. (Cost-time trade-offs and project crashing, moderate)

99. What are the advantages of using PERT and CPM?
The advantages include its usefulness for scheduling and controlling large projects, its straightforward concept, its graphical displays of relationships between activities, its critical path and slack time analysis, its ability to document processes, its wide range of applicability, and its usefulness in monitoring schedules and costs. (A critique of PERT and CPM, moderate)

PROBLEMS

100. Consider the network pictured below.
- Enumerate all paths through this network.
 - Calculate the critical path for the network.
 - What is the minimum duration of the project?
 - How much slack exists at each activity?



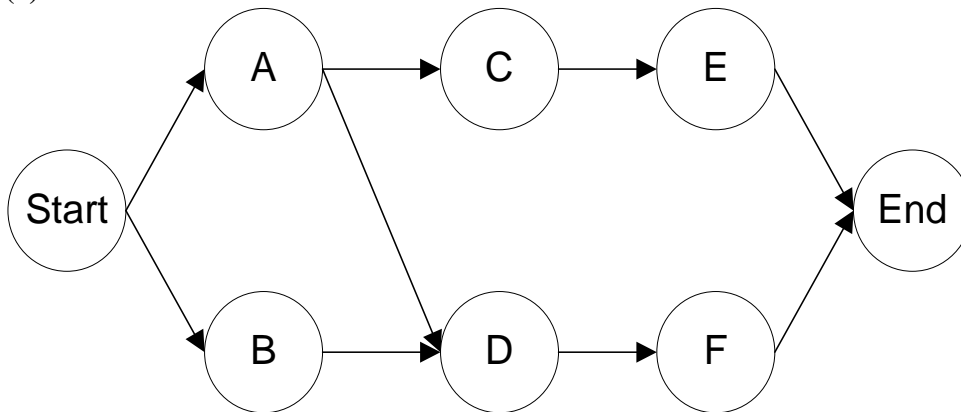
(a) Possible paths are P-S (length 22), P-R-T (length 28), and Q-T (length 21). (b) The longest of these, P-R-T, is the critical path, at 28 time units. (c) There is no slack at P, R, or T since these are critical tasks. S has 6 units slack, since the path it is on totals only 22 units, compared to the critical path length of 28. Q has 7 units of slack since it is on a 21 length path, 7 less than the maximum. (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}

101. A network consists of the activities in the following list. Times are given in weeks.

Activity	Preceding	Time
A	--	8
B	--	3
C	A	7
D	A, B	3
E	C	4
F	D	6

- Draw the network diagram.
- Calculate the ES, EF, LS, LF, and Slack for each activity.
- What is project completion time?

(a)



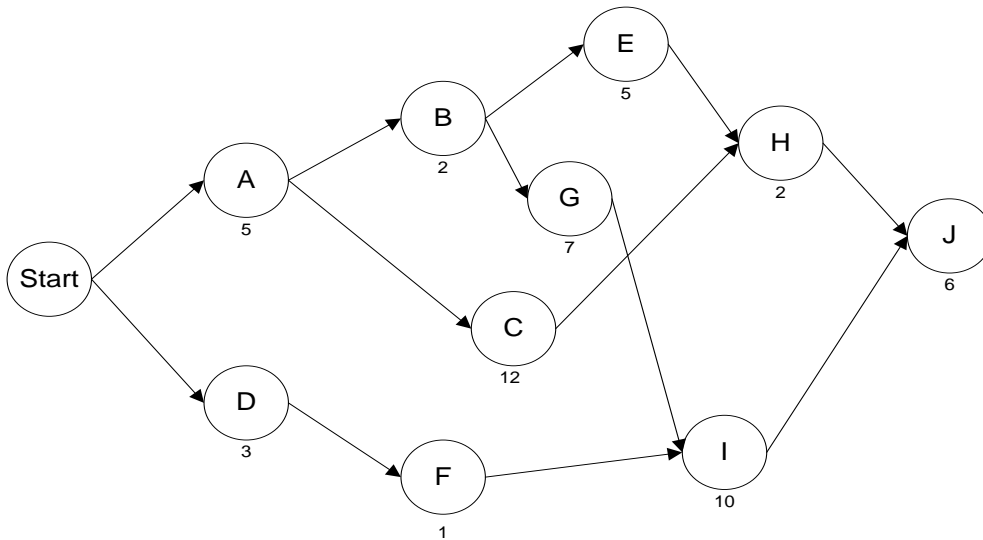
(b,c)

Results

Task	Early Start	Early Finish	Late Start	Late Finish	Slack
A	0	8	0	8	0
B	0	3	7	10	7
C	8	15	8	15	0
D	8	11	10	13	2
E	15	19	15	19	0
F	11	17	13	19	2
Project		19			

(Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}

102. The network below represents a project being analyzed by Critical Path Methods. Activity durations are A=5, B=2, C=12, D=3, E=5, F=1, G=7, H=2, I=10, and J=6.



- What task must be on the critical path, regardless of activity durations?
- What is the duration of path A-B-E-H-J?
- What is the critical path of this network?
- What is the length of the critical path?
- What is slack time at activity H?
- What is the Late Finish of activity H?
- If activity C were delayed by two time units, what would happen to the project duration?

(a) J; (b) 20; (c) A-B-G-I-J; (d) 30; (e) 5; (f) 24; (g) no impact.

Results

Task	Early Start	Early Finish	Late Start	Late Finish	Slack
A	0	5	0	5	0
B	5	7	5	7	0
C	5	17	10	22	5
D	0	3	10	13	10
E	7	12	17	22	10
F	3	4	13	14	10
G	7	14	7	14	0
H	17	19	22	24	5
I	14	24	14	24	0
J	24	30	24	30	0
Project		30			

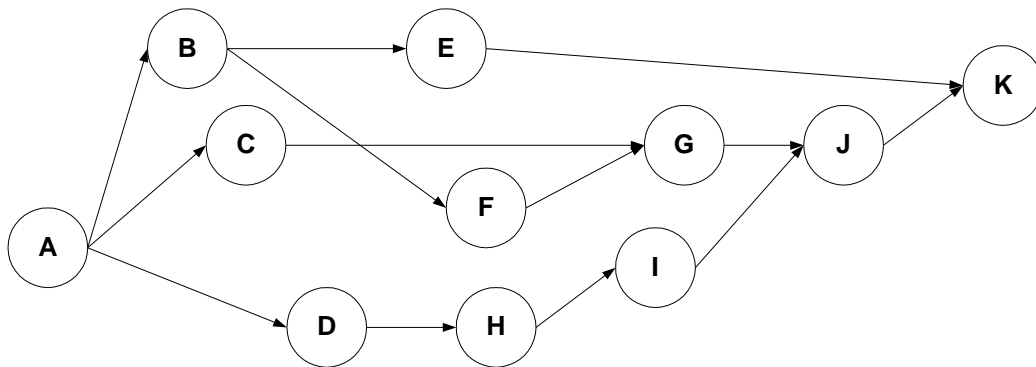
(Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}

103. A network consists of the following list. Times are given in weeks.

Activity	Preceding	Duration
A	--	9
B	A	2
C	A	12
D	A	5
E	B	6
F	B	8
G	C, F	3
H	D	2
I	H	8
J	G, I	6
K	E, J	2

- Draw the network diagram.
- Which activities form the critical path?
- How much slack exists at activities A and F?
- What is the duration of the critical path?

(a) Network diagram



(b) paths A-D-H-I-J-K and A-C-G-J-K are critical; (c) A has no slack; F has 2 units (d) 32
 (Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}

104. A partially solved PERT problem is detailed in the table below. Times are given in weeks.

Activity	Preceding	Optimistic Time	Probable Time	Pessimistic Time	Expected Time	Variance
A	--	7	9	14		1.361
B	A	2	2	8		0
C	A	8	12	16		0
D	A	3	5	10		1.361
E	B	4	6	8		0
F	B	6	8	10		0
G	C, F	2	3	4		0
H	D	2	2	8		1.000
I	H	6	8	16		2.778
J	G, I	4	6	14		2.778
K	E, J	2	2	5		0.250

- Calculate the expected time for each activity. Enter these values in the appropriate column in the table above.
- Which activities form the critical path?
- What is the estimated time of the critical path?
- What are the project variance and the project standard deviation?
- What is the probability of completion of the project after week 40?

(a) A=9.5 B=3 C=12 D=5.5 E=6 F=8 G=3 H=3 I=9 J=7 K=2.5

(b) A-D-H-I-J-K; (c) 36.5; (d) 9.53, 3.09; (e) 0.13.

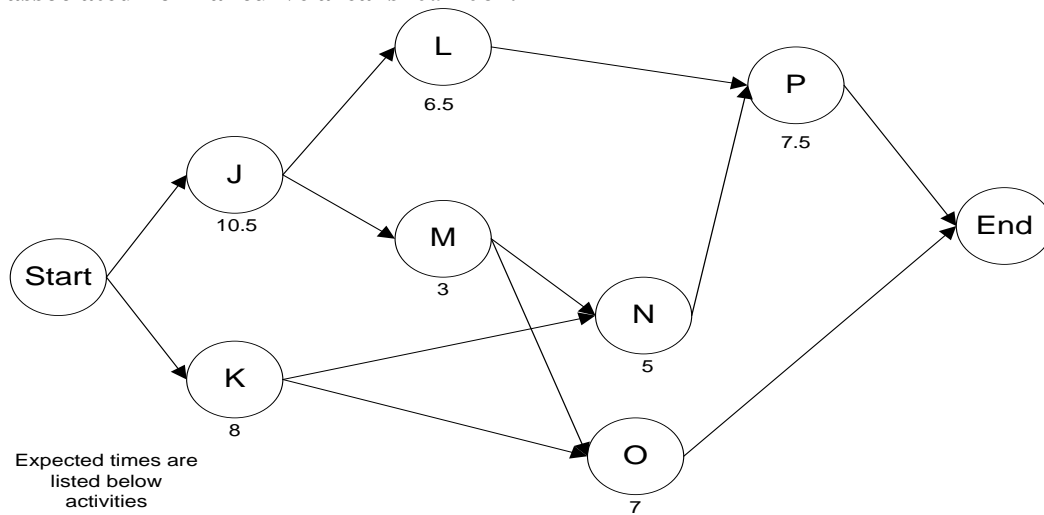
(Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}

105. Consider the network described in the table below.

Activity	Immediate Predecessor(s)	Pessimistic	Probable	Optimistic
J	--	15	10	8
K	--	9	8	7
L	J	10	6	5
M	J	3	3	3
N	K,M	9	5	1
O	K,M	10	7	4
P	L,N	10	8	3

- Calculate the expected duration of each activity.
- Calculate the expected duration and variance of the critical path.
- Calculate the probability that the project will be completed in fewer than 30 time units.

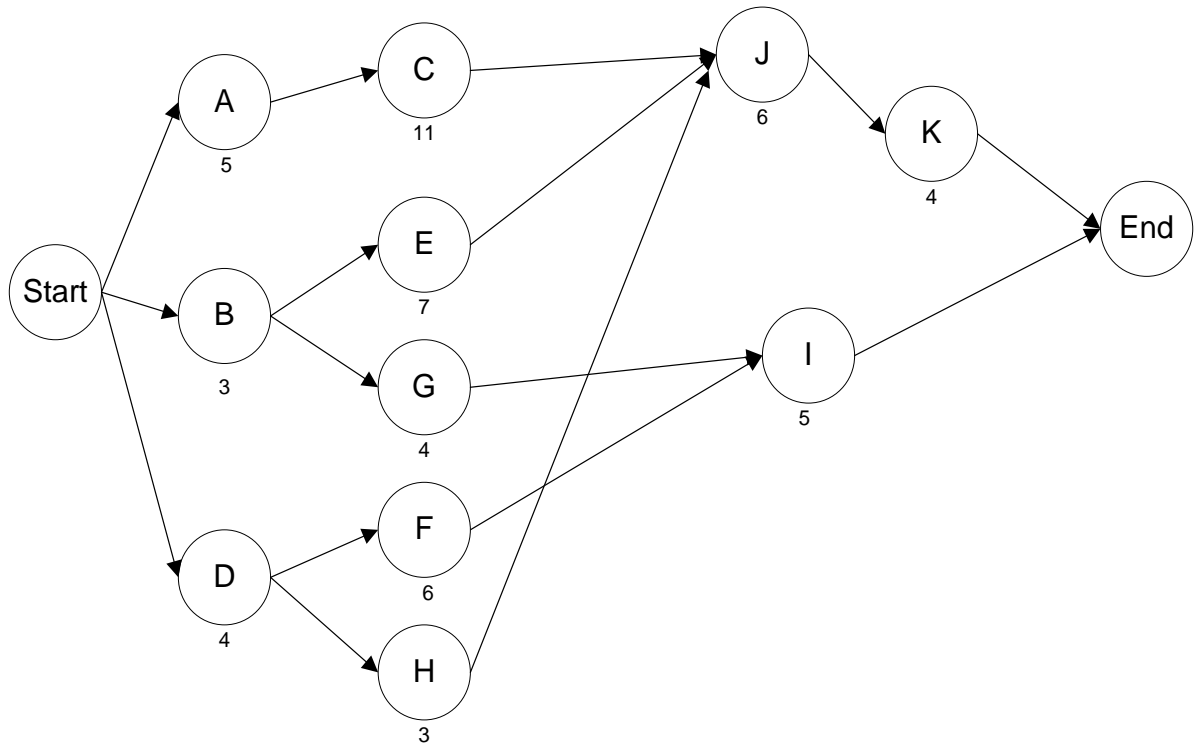
(a) See table below. (b) Tasks J-M-N-P are critical. The sum of their expected durations is 26.00; the sum of their variances is 4.50. (c) The standard deviation along the path is = 2.12; the probability that Duration < 30 is the probability that $z < (30 - 26.00)/2.12 = 1.89$. The associated normal curve area is 0.97062.



Task	Early Start	Early Finish	Late Start	Late Finish	Slack	Mean	Variance
J	0	10.5	0	10.5	0	10.5	1.361111
K	0	8	5.5	13.5	5.5	8	
L	10.5	17	19.5	26	9	6.5	
M	10.5	13.5	10.5	13.5	0	3	0
N	13.5	18.5	13.5	18.5	0	5	1.777778
O	13.5	20.5	19	26	5.5	7	
P	18.5	26	18.5	26	0	7.5	1.361111
Project		26				Project	4.5
						Std.dev	2.12132

(Project management techniques: PERT and CPM, mod.) {AACSB: Analytic Skills}

106. The network below represents a project being analyzed by Critical Path Methods. Activity durations are indicated on the network.



- Identify the activities on the critical path.
- What is the duration of the critical path?
- Calculate the amount of slack time at activity H.
- If activity I were delayed by ten time units, what would be the impact on the project duration?

(a) Critical activities are A-C-J-K; (b) The critical path is 26 time units; (c) Slack at H is 9 units; (d) I has 11 units slack--a ten unit delay would have no impact on the project.

Task	Early Start	Early Finish	Late Start	Late Finish	Slack
A	0	5	0	5	0
B	0	3	6	9	6
C	5	16	5	16	0
D	0	4	9	13	9
E	3	10	9	16	6
F	4	10	15	21	11
G	3	7	17	21	14
H	4	7	13	16	9
I	10	15	21	26	11
J	16	22	16	22	0
K	22	26	22	26	0
Project		26			

(Project management techniques: PERT and CPM, mod.) {AACSB: Analytic Skills}

107. Three activities are candidates for crashing on a CPM network. Activity details are in the table below.

Activity	Normal Time	Normal Cost	Crash Duration	Crash Cost
X	8 days	\$6,000	6 days	\$8,000
Y	3 days	\$1,800	2 days	\$2,400
Z	12 days	\$5,000	9 days	\$7,700

- What is the crash cost per unit time for each of the three activities?
 - Which activity should be crashed first to cut one day from the project's duration; how much is added to project cost?
 - Which activity should be the next activity crashed to cut a second day from the project's duration; how much is added to project cost?
- (a) crash cost X = \$1,000 per day; crash cost Y = \$600 per day ; crash cost Z = \$900 per day
 (b) select Y, adding \$600; (c) select Z, adding \$900
 (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}**
108. Three activities are candidates for crashing on a CPM network. Activity details are in the table below.

Activity	Normal Time	Normal Cost	Crash Duration	Crash Cost
A	9 days	\$8,000	7 days	\$12,000
B	5 days	\$2,000	3 days	\$10,000
C	12 days	\$9,000	11 days	\$12,000

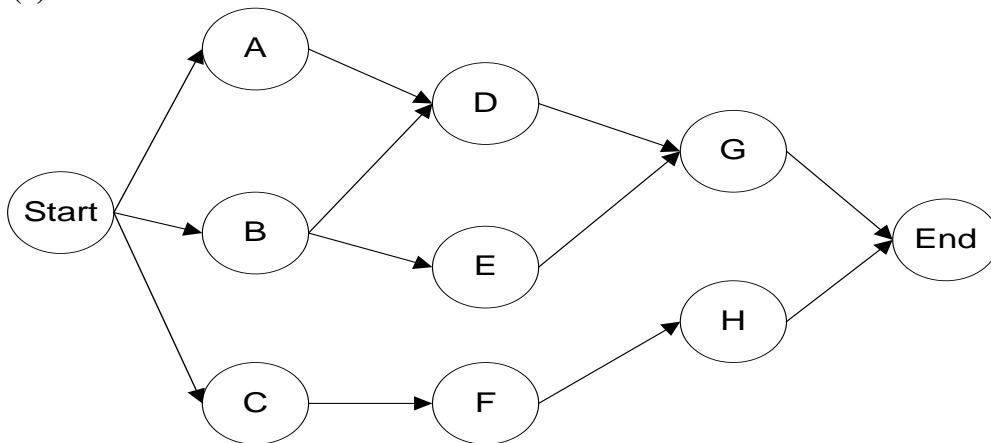
- What is the crash cost per unit time for activity A?
 - What is the crash cost per unit time for activity B?
 - Which activity should be crashed first to cut one day from the project's duration; how much is added to project cost?
 - Which activity should be the next activity crashed to cut a second day from the project's duration; how much is added to project cost?
 - Assuming no other paths become critical, how much can this project be shortened at what total added cost?
- (a) \$2,000; (b) \$4,000; (c) A, \$2,000; (d) A again, \$2,000 additional; (e) 5 days, \$15,000.
 (Cost-time trade-offs and project crashing, moderate) {AACSB: Analytic Skills}**

109. A network consists of the following list. Times are given in weeks.

Activity	Preceding	Optimistic	Probable	Pessimistic
A	--	5	11	14
B	-	3	3	9
C	--	6	10	14
D	A, B	3	5	7
E	B	4	6	11
F	C	6	8	13
G	D, E	2	4	6
H	F	3	3	9

- Draw the network diagram.
- Calculate the expected duration and variance of each activity.
- Calculate the expected duration and variance of the critical path.
- Calculate the probability that the project will be completed in less than 28 weeks.

(a)



(b,c)

<u>Task</u>	<u>Expected time</u>	<u>Variance</u>	<u>Std. dev.</u>	<u>Slack</u>	<u>Variance</u>
A	10.5	2.25	1.5	3	
B	4	1	1	8	
C	10	1.778	1.333	0	1.778
D	5	0.444	0.667	3	
E	6.5	1.361	1.167	8	
F	8.5	1.361	1.167	0	1.361
G	4	0.444	0.667	3	
H	4	1	1	0	1
Project	22.5			Project	4.139
				Std. dev.	2.034

(d) $z = (28-22.5)/2.03 = 2.71, (P \leq 28) = .997$

(Project management techniques: PERT and CPM, moderate) {AACSB: Analytic Skills}