Things You Need to Memorize

There are a few things you do need to memorize for the exam—for example, some math formulas and the Process Group and Knowledge Area mapping.

However, a general study tip is that you do not need to memorize the inputs, tools and techniques, and outputs for the processes. Rather, you can learn about these things and then use logic to figure out the correct answer to test questions that ask about them. For such questions, first determine what is being asked for and eliminate things that are not of that type. For example, if a tool or technique is asked for, eliminate answers that are inputs or outputs and then select the applicable tool. If it is an input/output, ask whether this should already be done or will be done later.

Memorizing the Process Group and Knowledge Area Mapping

A series of activities follow to help you memorize the Process Group and Knowledge Area map used in this *Learning System.* Memorizing this chart is just the start, however, as you also need to know the details and nuances of each process. Memorizing this map will help you put things in the right order overall.

The first memorization activity is to photocopy Exhibit 1-1, cut out the Process Groups, Knowledge Areas, and processes, and arrange them in the correct order. Do this activity once a day until you can do it without any errors. One of the items is titled "[Progressively Elaborate]." Use this to remind yourself that one pass through the planning process is never enough.

Exhibit 1-2, Exhibit 1-3, and Exhibit 1-4 are worksheets you can also photocopy and do daily. Each provides a little less help on filling out the Process Group and Knowledge Area map.

Memorizing Math

Exhibit 1-5 and Exhibit 1-6 provide two sheets for memorizing all of the formulas you will need to know for the exam. The first lists all of the formula names; the second lists nothing. Photocopy these sheets and fill the first out at least once a day until you can do so without referring to your notes. Once you are comfortable with this, write out both the formula names and the formulas each day. Exhibit 1-7 shows a completed sheet for your reference.

Exhibit 1-1: Cut Out Process Groups, Knowledge Areas, and Processes and Put in Order

Initiating	Planning	Executing
Monitoring and Controlling	**Closing**	**Integration Management**
Scope Management	**Schedule Management**	**Cost Management**
Quality Management	**Resource Management**	**Communications Management**
Risk Management	**Procurement Management**	**Stakeholder Management**
Develop Project Charter	*Identify Stakeholders*	*Develop Project Management Plan*
Plan Scope Management	*Collect Requirements*	*Define Scope*
Create WBS	*Plan Schedule Management*	*Define Activities*
Sequence Activities	*Estimate Activity Durations*	*Develop Schedule*
Plan Cost Management	*Estimate Costs*	*Determine Budget*
Plan Quality Management	*Plan Resource Management*	*Estimate Activity Resources*
Plan Communications Management	*Plan Risk Management*	*Identify Risks*
Perform Qualitative Analysis	*Perform Quantitative Analysis*	*Plan Risk Responses*
Plan Procurement Management	*Plan Stakeholder Engagement*	*[Progressively Elaborate]*
Direct and Manage Project Work	*Manage Project Knowledge*	*Manage Quality*
Acquire Resources	*Develop Team*	*Manage Team*
Manage Communications	*Implement Risk Responses*	*Conduct Procurements*
Manage Stakeholder Engagement	*Monitor and Control Project Work*	*Perform Integrated Change Control*
Validate Scope	*Control Scope*	*Control Schedule*
Control Costs	*Control Quality*	*Control Resources*
Monitor Communications	*Monitor Risks*	*Control Procurements*
Monitor Stakeholder Engagement	*Close Project or Phase*	

Exhibit 1-2: Fill in the Missing Processes Next to Each Bullet

KNOWLEDGE AREAS	PROCESS GROUPS				
	Initiating	Planning	Executing	Monitoring and Controlling	Closing
Project Integration Management	•	•	• •	• •	•
Project Scope Management		• • • •		• •	
Project Schedule Management		• • • • •		•	
Project Cost Management		• • •		•	
Project Quality Management		•	•	•	
Project Resource Management		• •	• • •	•	
Project Communications Management		•	•	•	
Project Risk Management		• • • • •	•	•	
Project Procurement Management		•	•	•	
Project Stakeholder Management	•	•	•	•	

Exhibit 1-3: Fill in the Missing Processes

KNOWLEDGE AREAS	PROCESS GROUPS				
	Initiating	Planning	Executing	Monitoring and Controlling	Closing
Project Integration Management					
Project Scope Management					
Project Schedule Management					
Project Cost Management					
Project Quality Management					
Project Resource Management					
Project Communications Management					
Project Risk Management					
Project Procurement Management					
Project Stakeholder Management					

Exhibit 1-4: Fill in the Project Management Process Group and Knowledge Area Mapping

KNOWLEDGE AREAS	PROCESS GROUPS				

Exhibit 1-5: Blank Formula Sheet with Formula Names

Formula Name	Formula	Definition/Notes
Triangular distribution estimate		
Beta distribution estimate (PERT)		
Activity standard deviation (SD, sigma, or σ)		Normal distribution 1 SD = 2 SD = 3 SD = 6 SD =
Critical path		
Early finish (EF) (forward pass)		Ignore ±1 if *same* day (ES = 0).
Early start (ES)		1st activity = 0 if subsequent is *same* day; if *next* day, = 1.
Late start (LS) (backward pass)		
Late finish (LF)		
Total float (TF)		_____ on critical path
Free float		Usually 0
Planned value (PV)		
Earned value (EV)		
Actual cost (AC)		

Formula Name	Formula	Definition/Notes
Cost variance (CV)		A negative CV indicates that project is _____ budget.
Cost performance index (CPI)		<1 is _____ .
Schedule variance (SV)		A negative SV indicates that project is _____ schedule.
Schedule performance index (SPI)		<1 is _____ .
Estimate at completion (EAC)—redo all estimates		
EAC—using actual CPI		
EAC—using budgeted rates		
EAC—using actual CPI and SPI		
Estimate to complete (ETC)		Expected cost to finish project
Variance at completion (VAC)		
To-complete performance index (TCPI)—budget achievable		Default method
To-complete performance index (TCPI)—budget unachievable		
Communication channels		May need to add one for yourself as project manager
Expected monetary value (EMV)		
Point of total assumption (PTA)		

Exhibit 1-6: Blank Formula Sheet

Formula Name	Formula

Formula Name	Formula

Exhibit 1-7: Completed Formula Sheet

Formula Name	Formula	Definition/Notes
Triangular distribution estimate	$E = \dfrac{O + M + P}{3}$	Basic average
Beta distribution estimate (PERT)	$E = \dfrac{O + 4M + P}{6}$	Weighted average
Activity standard deviation (SD, sigma, or σ)	$SD = \dfrac{P - O}{6}$	Normal distribution 1 SD = 68.26% (confidence) 2 SD = 95.46% 3 SD = 99.73% 6 SD = 99.9997%
Critical path	Longest duration path sum	To find, sum all path durations.
Early finish (EF) (forward pass)	$EF = ES + Duration - 1$	Ignore ±1 if *same* day (ES = 0).
Early start (ES)	$ES = $ Highest predecessor EF + 1	1st activity = 0 if subsequent is *same* day; if *next* day, = 1.
Late start (LS) (backward pass)	$LS = LF - (Duration - 1)$	For last activity, copy from top.
Late finish (LF)	$LF = $ Lowest successor LS $- 1$	
Total float (TF)	$TF = LS - ES$ or $LF - EF$	0 on critical path
Free float	Successor ES $-$ Predecessor EF or Successor ES $-$ Predecessor EF $- 1$	Usually 0
Planned value (PV) **4 weeks of 8-week US$100k project** **4/8 US$100k = US$50k or US$100k/8 = US$12.5k/wk 4 = US$50k**	$\dfrac{\text{Portion of Schedule Completed}}{\text{Total Planned Schedule}} \times BAC$ or BAC Rate × Schedule Used	Work planned to be completed BAC Rate (% complete) = Budget/Budgeted Periods
Earned value (EV) **30% complete US$100k = US$30k**	$EV = BAC \times$ Actual % Complete	Planned value of work actually completed by now
Actual cost (AC)	Actual expenditure	Actually spent currently
Cost variance (CV)	$CV = EV - AC$	A negative CV indicates that project is over budget.

Formula Name	Formula	Definition/Notes
Cost performance index (CPI)	$CPI = \dfrac{EV}{AC}$	<1 is rate to miss budget.
Schedule variance (SV)	$SV = EV - PV$	A negative SV indicates that project is behind schedule.
Schedule performance index (SPI)	$SPI = \dfrac{EV}{PV}$	<1 is rate to miss schedule.
Estimate at completion (EAC)—redo all estimates	$EAC_{New} = AC + \text{Bottom-Up ETC}$	Repeat with all new estimates.
EAC—using actual CPI	$EAC_{CPI} = \dfrac{BAC}{CPI}$	Variances are typical.
EAC—using budgeted rates	$EAC_{BAC} = AC + (BAC - EV)$	Variances are atypical.
EAC—using actual CPI and SPI	$EAC_{CPI \times SPI} = AC + \dfrac{BAC - EV}{CPI \times SPI}$	Poor cost performance but firm deadline
Estimate to complete (ETC)	$ETC = EAC - AC$	Expected cost to finish project
Variance at completion (VAC)	$VAC = BAC - EAC$	Negative is over budget.
To-complete performance index (TCPI)—budget achievable	$TCPI_{BAC} = \dfrac{BAC - EV}{BAC - AC}$	Default method
To-complete performance index (TCPI)—budget unachievable	$TCPI_{EAC} = \dfrac{BAC - EV}{EAC - AC}$	BAC is no longer viable.
Communication channels	$\text{Number of Channels} = \dfrac{n(n-1)}{2}$	May need to add one for yourself as project manager
Expected monetary value (EMV)	$EMV = \text{Probability} \times \text{Impact}$ or $EMV = \text{Probability} \times (\text{Impact} - \text{Cost})$	Find net impact (Impact – Cost) before multiplying by probability.
Point of total assumption (PTA)	$PTA = \text{Target Cost} +$ $\dfrac{(\text{Ceiling Price} - \text{Target Price})}{\text{Buyer's Share Ratio}}$	Target Price = Target Cost + Target Profit

Study Worksheet

A worksheet with some alternative ways to test your knowledge is provided below as a study aid. These questions are drawn from a selection of the chapters in the course. An answer key follows.

1. List the three things that distinguish project management as a profession.

    _____

    _____

    _____

2. List the 12 principles of project management from *The Standard for Project Management.*

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

3. List four qualities of a good steward.

    _____

    _____

    _____

    _____

4. To ensure that value is realized from a project, teams should focus on _____ instead of on _____.

5. Building quality into processes and deliverables should focus on meeting _____ for deliverables.

6. List five qualities of optimized risk responses.

    _____

    _____

    _____

    _____

    _____

7. List the eight Performance Domains from the *PMBOK® Guide—Seventh Edition.*

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

8. List the six steps in the stakeholder engagement process.

    _____

    _____

    _____

    _____

    _____

    _____

9. Put the following elements in order from broadest to narrowest focus within the OPM hierarchy. (1 indicates broadest focus; 5 indicates narrowest focus.)
   a) Program management
   b) Portfolio management
   c) Organizational project management (OPM)
   d) Management of organizational strategy
   e) Project management

10. Number and write out the Knowledge Areas in the space below.

_____

_____

_____

_____

_____

_____

_____

_____

11. Write out the Process Groups in order.

_____

_____

_____

_____

12. Indicate the order of the following processes (from first to last) and indicate to which Knowledge Area (KA) and Process Group (PG) each belongs. A few have been filled in for you.

Process	KA	PG
Estimate Activity Resources		
Plan Scope Management		
Define Activities		
Create WBS		
Identify Stakeholders		
Develop Schedule		
Plan Cost Management	Cost	Planning
Develop Project Charter		
Plan Schedule Management	Schedule	Planning
Develop Project Management Plan		
Sequence Activities		
Determine Budget		
Estimate Activity Durations		
Estimate Costs		
Collect Requirements		
Define Scope		

13. Indicate the order of the following Project Risk Management processes and indicate to which Process Group each belongs.

Process	Order	PG
Monitor Risks		
Perform Qualitative Analysis		
Plan Risk Responses		
Identify Risks		
Implement Risk Responses		
Perform Quantitative Analysis		
Plan Risk Management		

14. Indicate the order of the following Project Scope Management processes and indicate to which Process Group each belongs.

Process	Order	PG
Create WBS		
Collect Requirements		
Validate Scope		
Define Scope		
Plan Scope Management		
Control Scope		

15. Indicate the order of the following Project Schedule Management processes and indicate to which Process Group each belongs.

Process	Order	PG
Sequence Activities		
Develop Schedule		
Control Schedule		
Define Activities		
Estimate Activity Durations		
Plan Schedule Management		

16. Describe some Project Integration Management tasks for each of the Process Groups.

_____

_____

_____

_____

_____

_____

_____

17. A project has the following activities and dependencies:

Activity ID	Description	Predecessor
A	Research and design outline	None
B	Review and revise outline	A
C	Procure software platform	A
D	Write first draft	B
E	Review first draft	D
F	Write second draft	E
G	Review and revise second draft	F
H	Design online content	B
I	Write first draft online content	H
J	Review and revise online content	I
K	Develop online software	C, H
L	Test online software	K
M	Edit and control quality	G, J, L

Based only on the above information, other than the last activity, which activity likely has the most risk of schedule slippage?

a) A
b) B
c) K
d) J

18. Develop a project schedule network diagram using the information in question 17.

Based only on the above chart, what is the critical path?

a) A-B-D-E-F-G-M
b) A-B-H-I-J-M
c) A-C-K-L-M
d) There is not enough information to calculate the critical path.

19. Refer to the following duration information for the same project as in the last question:

Activity ID	Description	Duration (Weeks)	Predecessor
A	Research and design outline	4	None
B	Review and revise outline	3	A
C	Procure software platform	8	A
D	Write first draft	9	B
E	Review first draft	2	D
F	Write second draft	4	E
G	Review and revise second draft	3	F
H	Design online content	6	B
I	Write first draft online content	5	H
J	Review and revise online content	3	I
K	Develop online software	11	C, H
L	Test online software	3	K
M	Edit and control quality	3	G, J, L

List all possible project paths and their total durations in the space below. Use the diagram you created in question 18 to help determine the paths. Mark which one is the critical path on your diagram and below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

20. Use the information from the prior question to add just enough information to the diagram you created in question 18 to answer the following question: What is the earliest week that activity J can finish if activity A starts on week 1?
    a) 19
    b) 21
    c) 25
    d) 27

21. Use the information from question 19 to add just enough information to the diagram you created in question 18 to answer the following question: What is the latest week that activity C can start if activity A starts on week 1?
    a) 5
    b) 6
    c) 7
    d) 12

22. Use the information from question 19 to add just enough information to the diagram you created in question 18 to answer the following question: What is the total float of activity F?
    a) 0
    b) 1
    c) 2
    d) 6

23. Use the diagram you completed in the prior question to answer this question: Which activity pairing has the most free float of those listed? (Choose only an option in which free float is calculated correctly.)
    a) B-D: 6 weeks
    b) G-M: 3 weeks
    c) J-M: 6 weeks
    d) C-K: 1 week

24. Facing a deadline constraint of 29 weeks, what is the best place to add a lead of one week? Note that all mandatory or discretionary dependency information shown below is correct.
    a) From activities A to C, since this is a discretionary dependency
    b) From activities B to H, since this is a discretionary dependency
    c) From activities K to L, since this is a mandatory dependency
    d) From activities E to F, since this is a mandatory dependency

19

25. During the fifth week of the project, changes are proposed to the written content, and the writer for activity D now estimates that it will take 11 weeks instead of nine. In addition, the writer is scheduled to do five weeks of work on a different project after first draft but before second draft, which requires a lag of three weeks between activities E and F. A lead time of one week between activities B and H was previously approved and is still in the new schedule baseline. To get the project done by the week 29 milestone, the project manager proposes that there be a start-to-start relationship between activities F and G with a lag of one week and a finish-to-start relationship between activities G and M with a lead of one week. These changes are submitted to integrated change control and are approved. They are summarized in the table below. Construct a new network diagram with these relationships.

Activity ID	Description	Duration (Weeks)	Predecessor	PDM and Lead or Lag
A	Research and design outline	4	None	None
B	Review and revise outline	3	A	FS
C	Procure software platform	8	A	FS
D	Write first draft	9	B	FS
E	Review first draft	2	D	FS
F	Write second draft	4	E	FS + 3
G	Review and revise second draft	3	F	SS + 1
H	Design online content	6	B	FS – 1
I	Write first draft online content	5	H	FS
J	Review and revise online content	3	I	FS
K	Develop online software	11	C, H	C: FS, H: FS
L	Test online software	3	K	FS
M	Edit and control quality	3	G, J, L	G: FS – 1, J: FS, L: FS

Based on the differences between the network diagram you just created and the one created for questions 18 through 23, is the finish-to-start lead time between activities B and H really needed?
a) No, it is no longer on the critical path, so it should be removed to reduce risk.
b) Yes, it is still on the critical path and should remain.
c) While it is no longer on the critical path, it can remain to add a buffer for later delays.
d) While it is no longer on the critical path, it is too late to propose a change to this activity.

26. What is the new critical path for this project?
    a) A-B-D-E-F-G-M
    b) A-B-H-K-L-M
    c) A-C-K-L-M
    d) All paths except A-B-H-I-J-M are now on the critical path.

27. Match the names of the following quality pioneers with the catchwords often associated with them.

    Deming   Fishbone diagram

    Juran   Zero defects

    Crosby   Design quality in.

    Ishikawa   PDCA

    Taguchi   Pareto principle

28. List the major characteristics of the Six Sigma approach to quality management.

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

29. List the steps in the sender-receiver communications model.

1.
2.
3.
4.
5.
6.

Worksheet Answers

Answers to the worksheet question follow.

1. A recognized body of knowledge formed by consensus—the *PMBOK® Guide*; standards and vocabulary that allow professionals to promote common understanding—the standard and glossary in the *PMBOK® Guide*; a means of ensuring that the profession's members are competent—the PMP certification (and others).

2. The 12 principles of project management:
   - Be a diligent, respectful, and caring steward.
   - Create a collaborative project team environment.
   - Effectively engage with stakeholders.
   - Focus on value.
   - Recognize, evaluate, and respond to system interactions.
   - Demonstrate leadership behaviors.
   - Tailor based on context.
   - Build quality into processes and deliverables.
   - Navigate complexity.
   - Optimize risk responses.
   - Embrace adaptability and resiliency.
   - Enable change to achieve the envisioned future state.

3. Stewards act with integrity, care, and trustworthiness and maintain internal and external compliance.

4. To ensure that value is realized from a project, teams should focus on the intended outcome instead of on specific deliverables.

5. Building quality into processes and deliverables should focus on meeting acceptance criteria for deliverables.

6. Risk responses should be appropriate given the importance of the risk, be cost-effective, be realistic for the given project, be agreed upon by relevant stakeholders, and be assigned to a responsible person.

7. The eight Performance Domains are as follows:
   - Stakeholder
   - Team
   - Development Approach and Life Cycle
   - Planning
   - Project Work
   - Delivery
   - Measurement
   - Uncertainty

8. Stakeholder engagement process: Identify, understand, analyze, prioritize, engage, and monitor.

9. a: 4, b: 3, c: 2, d: 1, e: 5. Organizational strategy is translated into the organizational project management hierarchy, which is then implemented as portfolio management, program management, and project management.

10. The Knowledge Areas are as follows:

    1. Project Integration Management
    2. Project Scope Management
    3. Project Schedule Management
    4. Project Cost Management
    5. Project Quality Management
    6. Project Resource Management
    7. Project Communications Management
    8. Project Risk Management
    9. Project Procurement Management
    10. Project Stakeholder Management

11. Initiating, Planning, Executing, Monitoring and Controlling, Closing

12.

Process	KA	PG
Estimate Activity Resources	Resource	Planning
Plan Scope Management	Scope	Planning
Define Activities	Schedule	Planning
Create WBS	Scope	Planning
Identify Stakeholders	Stakeholder	Initiating
Develop Schedule	Schedule	Planning
Plan Cost Management	Cost	Planning
Develop Project Charter	Integration	Initiating
Plan Schedule Management	Schedule	Planning
Develop Project Management Plan	Integration	Planning
Sequence Activities	Schedule	Planning
Determine Budget	Cost	Planning
Estimate Activity Durations	Schedule	Planning
Estimate Costs	Cost	Planning
Collect Requirements	Scope	Planning
Define Scope	Scope	Planning

13.

Process	Order	PG
Monitor Risks	7	Monitoring and Controlling
Perform Qualitative Analysis	3	Planning
Plan Risk Responses	5	Planning
Identify Risks	2	Planning
Implement Risk Responses	6	Executing
Perform Quantitative Analysis	4	Planning
Plan Risk Management	1	Planning

14.

Process	Order	PG
Create WBS	4	Planning
Collect Requirements	2	Planning
Validate Scope	5	Monitoring and Controlling
Define Scope	3	Planning
Plan Scope Management	1	Planning
Control Scope	6	Monitoring and Controlling

15.

Process	Order	PG
Sequence Activities	3	Planning
Develop Schedule	5	Planning
Control Schedule	6	Monitoring and Controlling
Define Activities	2	Planning
Estimate Activity Durations	4	Planning
Plan Schedule Management	1	Planning

16. During **Initiating,** integration is used to define the project objectives and get formal project authorization in the form of a project charter, which is used to identify stakeholders and becomes the basis for Planning processes.

    During **Planning,** integration involves taking the charter plus the plans from each of the other Knowledge Areas and ensuring that everything fits together in a cohesive project management plan.

    During **Executing,** integration involves providing leadership and management to team members who are performing the activities as well as implementing approved changes.

    During **Monitoring and Controlling**, integration involves transforming project data into actionable information and reports. Perform Integrated Change Control is a key process; it uses the term "integrated" to emphasize that the project manager always analyzes proposed changes for their impacts and tradeoffs in constraints. Change requests can come from Executing or Monitoring and Controlling activities. Approved changes are then documented and communicated to stakeholders.

    During **Closing,** integration involves ensuring that the final results meet expectations and objectives (by integrating with the Validate Scope process) and are accepted if possible and all activities (including procurements) are finalized before formally completing the phase or project.

17. c. There is a larger risk of schedule slippage whenever an activity has two or more precedent activities. At these points, a delay in any preceding activity could delay this and all later dependent activities.
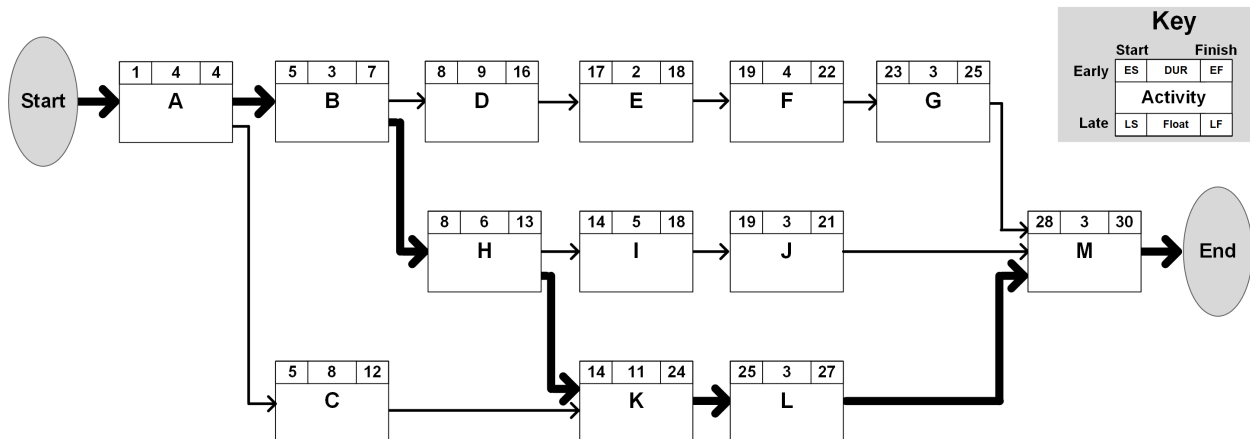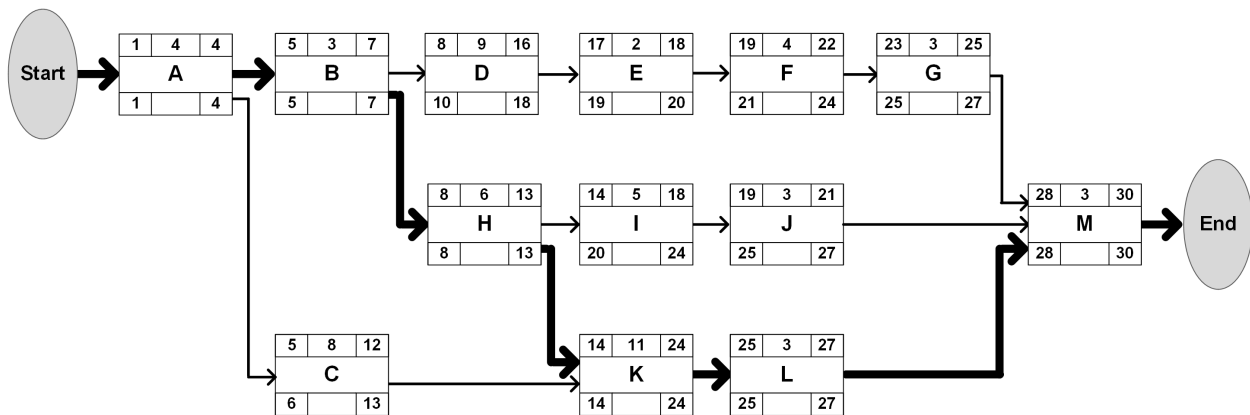
18. d
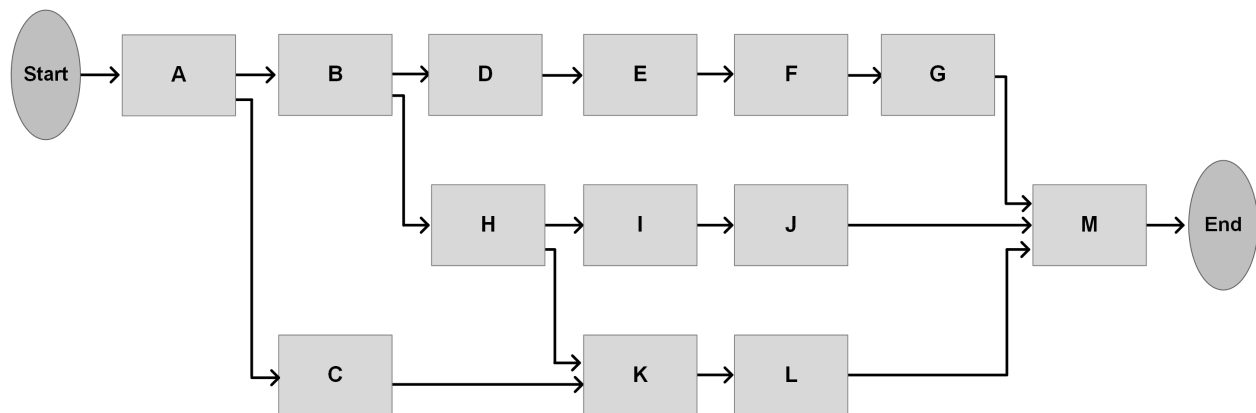
19.

A-B-D-E-F-G-M = 4 + 3 + 9 + 2 + 4 + 3 + 3 = 28
A-B-H-I-J-M = 4 + 3 + 6 + 5 + 3 + 3 = 24
A-B-H-K-L-M = 4 + 3 + 6 + 11 + 3 + 3 = 30
This is the critical path.
A-C-K-L-M = 4 + 8 + 11 + 3 + 3 = 29

20. b

Key

	Start		Finish
Early	ES	DUR	EF
		Activity	
Late	LS	Float	LF

Start → A [1 | 4 | 4]

B [5 | 3 | 7] → D [8 | 9 | 16] → E [17 | 2 | 18] → F [19 | 4 | 22] → G [23 | 3 | 25]

H [8 | 6 | 13] → I [14 | 5 | 18] → J [19 | 3 | 21]

C [5 | 8 | 12] → K [14 | 11 | 24] → L [25 | 3 | 27]

M [28 | 3 | 30] → End

21. b

Start → A [1 | 4 | 4] / [1 | | 4]

B [5 | 3 | 7] / [5 | | 7] → D [8 | 9 | 16] / [10 | | 18] → E [17 | 2 | 18] / [19 | | 20] → F [19 | 4 | 22] / [21 | | 24] → G [23 | 3 | 25] / [25 | | 27]

H [8 | 6 | 13] / [8 | | 13] → I [14 | 5 | 18] / [20 | | 24] → J [19 | 3 | 21] / [25 | | 27]

C [5 | 8 | 12] / [6 | | 13] → K [14 | 11 | 24] / [14 | | 24] → L [25 | 3 | 27] / [25 | | 27]

M [28 | 3 | 30] / [28 | | 30] → End

22. c

Key

	Start		Finish
Early	ES	DUR	EF
		Activity	
Late	LS	Float	LF

Start → A [1 | 4 | 4] / [1 | 0 | 4]

B [5 | 3 | 7] / [5 | 0 | 7] → D [8 | 9 | 16] / [10 | 2 | 18] → E [17 | 2 | 18] / [19 | 2 | 20] → F [19 | 4 | 22] / [21 | 2 | 24] → G [23 | 3 | 25] / [25 | 2 | 27]

H [8 | 6 | 13] / [8 | 0 | 13] → I [14 | 5 | 18] / [20 | 6 | 24] → J [19 | 3 | 21] / [25 | 6 | 27]

C [5 | 8 | 12] / [6 | 1 | 13] → K [14 | 11 | 24] / [14 | 0 | 24] → L [25 | 3 | 27] / [25 | 0 | 27]

M [28 | 3 | 30] / [28 | 0 | 30] → End

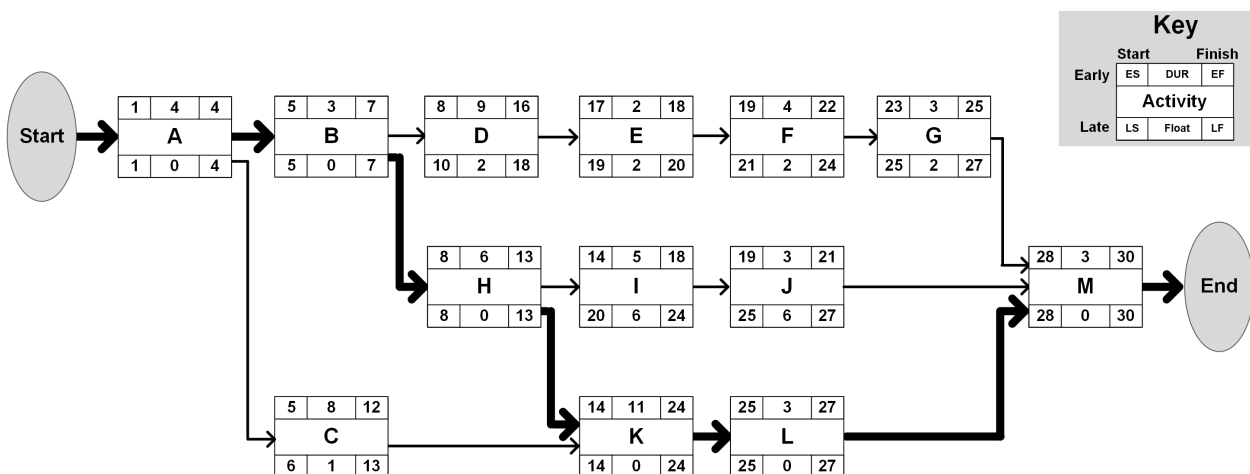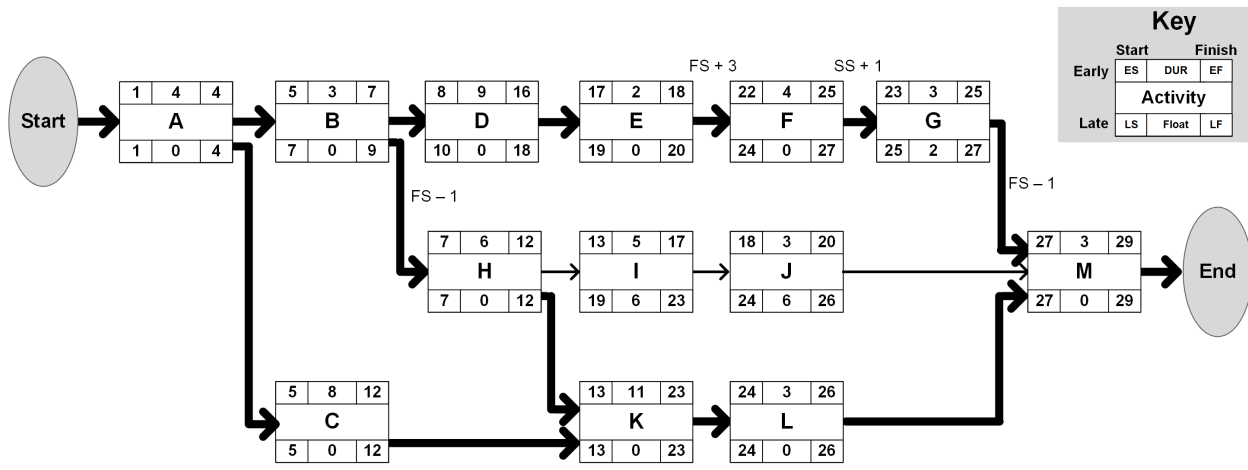**23. c**

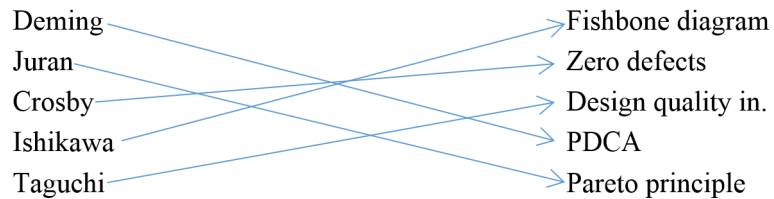24. b

25. b

26. d. See the diagram for question 25.

27. The quality pioneers are matched with their catchwords as follows.

Deming — Fishbone diagram
Juran — Zero defects
Crosby — Design quality in.
Ishikawa — PDCA
Taguchi — Pareto principle

28. The major characteristics of the Six Sigma approach to quality management are full integration with the organization's business strategy, demonstration of the positive financial impact of implementing the Six Sigma methodology, and fact-based decision making.

29. The order of the steps is as follows.

1. A sender encodes a message.
2. The sender transmits the message in a medium.
3. The receiver decodes the message.
4. The receiver acknowledges the message in a medium.
5. The receiver encodes feedback in a medium.
6. The sender decodes the feedback.