



# Examination Preparation Booklet

Flowcharting/Computer  
Work Scheduling

Booklet No. 25



CIVIL SERVICE EMPLOYEES ASSOCIATION, INC.

LOCAL 1000, AFSCME, AFL-CIO

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Booklet #25

# **Flowcharting/Computer Work Scheduling**

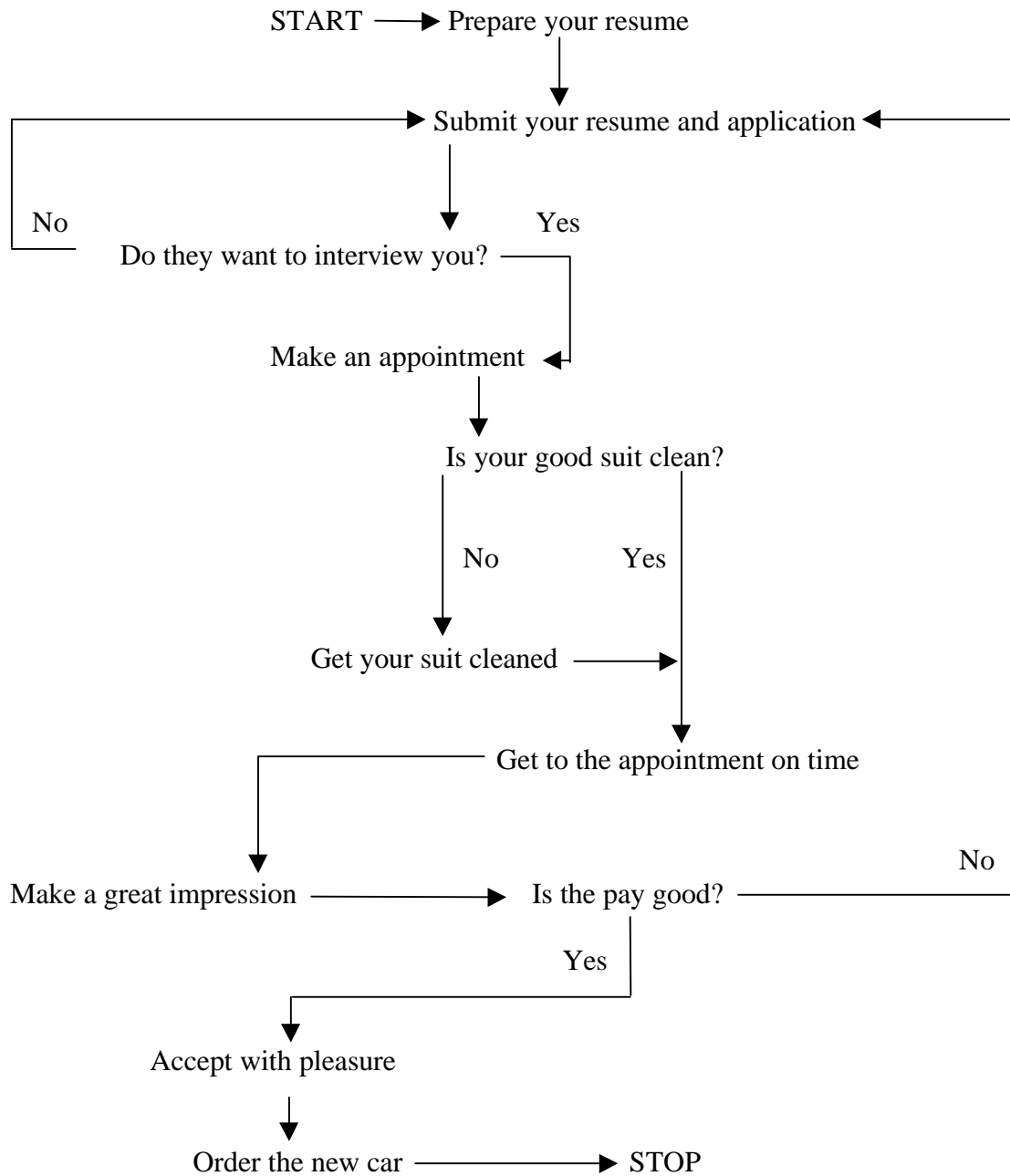
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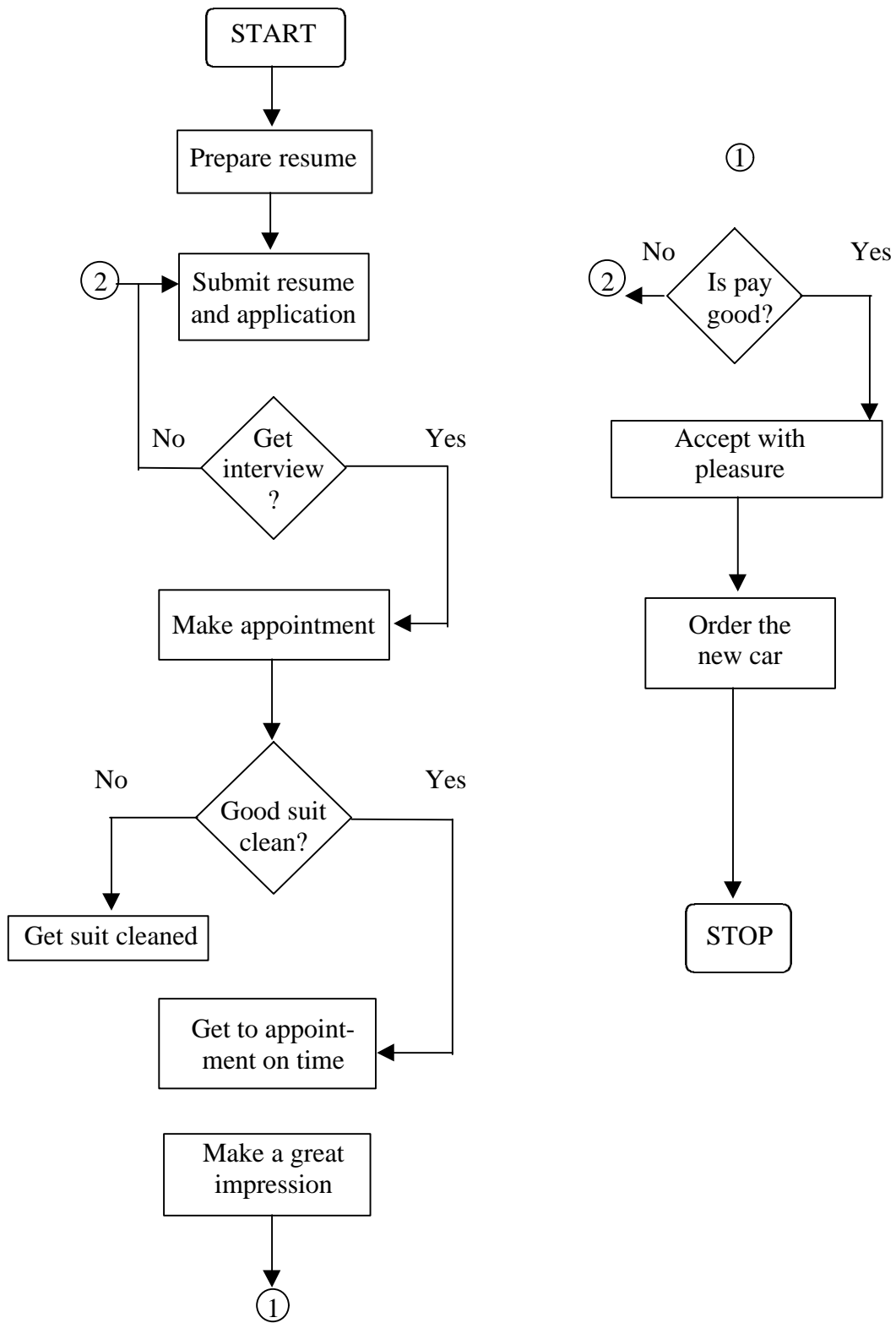
## FLOWCHARTING

When you program a computer, you must first think through what you want to get done. It is necessary to take small organized steps. The ordering of your thoughts is called an algorithm. It is a step-by-step process to complete a certain task.





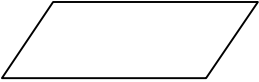
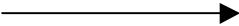


For instance, imagine that you are looking for a new job. You need a plan of action. Your algorithm:



This is the flowchart that goes with your algorithm. Compare them. Note the use of shapes for each step. These are symbols.



FLOWCHART SYMBOLS make flowcharts uniform and easier to read:

	START or STOP	Indicates the beginning or end of a computer program (also known as terminal)
	INPUT	Indicates information that is fed into the computer
	PROCESS	Gives the work or action to be performed
	DECISION	Indicates that a choice is to be made
	OUTPUT	Gives the process results (Note: same as INPUT box)
	FLOWLINE	Connects symbols and shows direction
	CONNECTOR	Continues a chart to another point on the same page
	OFF-PAGE CONNECTOR	Continues a chart to another page

## POINTS TO REMEMBER:

An OVAL means the beginning and end of a flowchart; it indicates the terminal points. If you trace it, you will see that one flowline leads out from **START** and into **STOP**.

A PARALLELOGRAM has two purposes, to show input and to show output. Input is information given to the computer. Information gotten from the computer is called output and is also put into a parallelogram. A parallelogram should have one line leading in and one line leading out.

A RECTANGLE represents work done. One task is presented in each box. It will always have one flowline, leading in and one leading out.

A DIAMOND represents a decision. It is always phrased as a question which can be answered yes or no. A diamond will have one flowline leading in and two leading out, one marked YES and one marked NO.

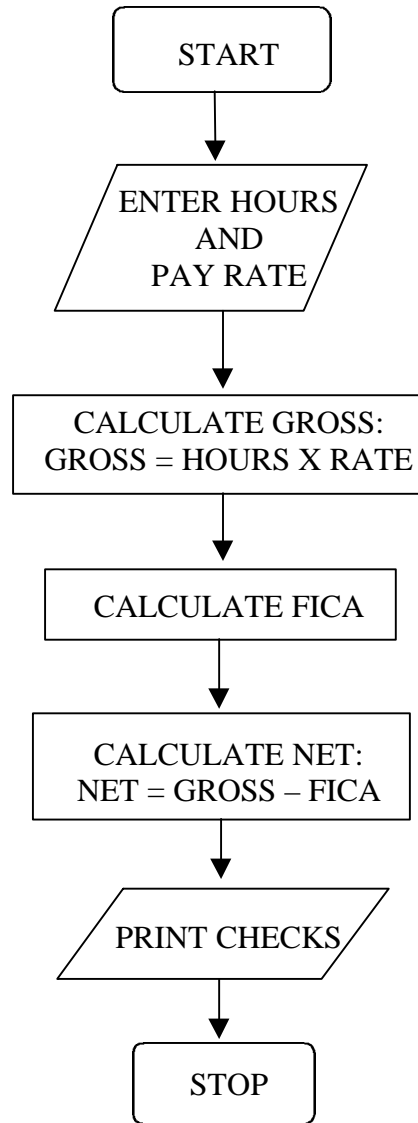
A LINE with arrows indicates the direction of the flowchart. These FLOWLINES are always vertical or horizontal and meet each other at right angles. They must never cross each other.

A CIRCLE is used when the flowchart does not fit in the space. One circle has a number which corresponds to another circle on the same page.

A PENTAGON means that a flowchart will be continued on the next page. The number put in the first pentagon matches the number in a second pentagon found on the following page.

NOTE: Flowcharts should follow a top-to-bottom and left-to-right progression as much as possible.

Once the job is yours, a flowchart such as the one below may be used to determine what your weekly paycheck is.



This is a very simple program flowchart, but may be all that is necessary to show the basic procedure. Note the two parallelograms and how their messages differ from those of the rectangles. A programmer might then take this and expand it to show other things -- how FICA is determined, for example. You might want to try this if you know the formula for calculating FICA.

On page 6, you will see three flowcharts which are used to solve math problems. The first is an incomplete chart for finding the average of five numbers. The second computes the batting average (B) of a baseball player, given his at-bats (A) and his hits (H). The third determines whether a given number is positive or negative. Complete each by enclosing the steps with the correct symbols and connecting with arrows. Since page 7 gives you the answers, you might want to fold the booklet over or cover the page as you are working to keep from looking at it.

#1

#2

#3

START

START

START

ENTER 29,467,  
53,902,84

ENTER H,A

ENTER X=50,Y=30

$S=29+467+53+$   
 $902+84$

$B=H/A$

$D=X-Y$

$A=S/5$

PRINT B

D>0?      YES  
            NO

PRINT A

STOP

PRINT NEGATIVE  
NUMBER

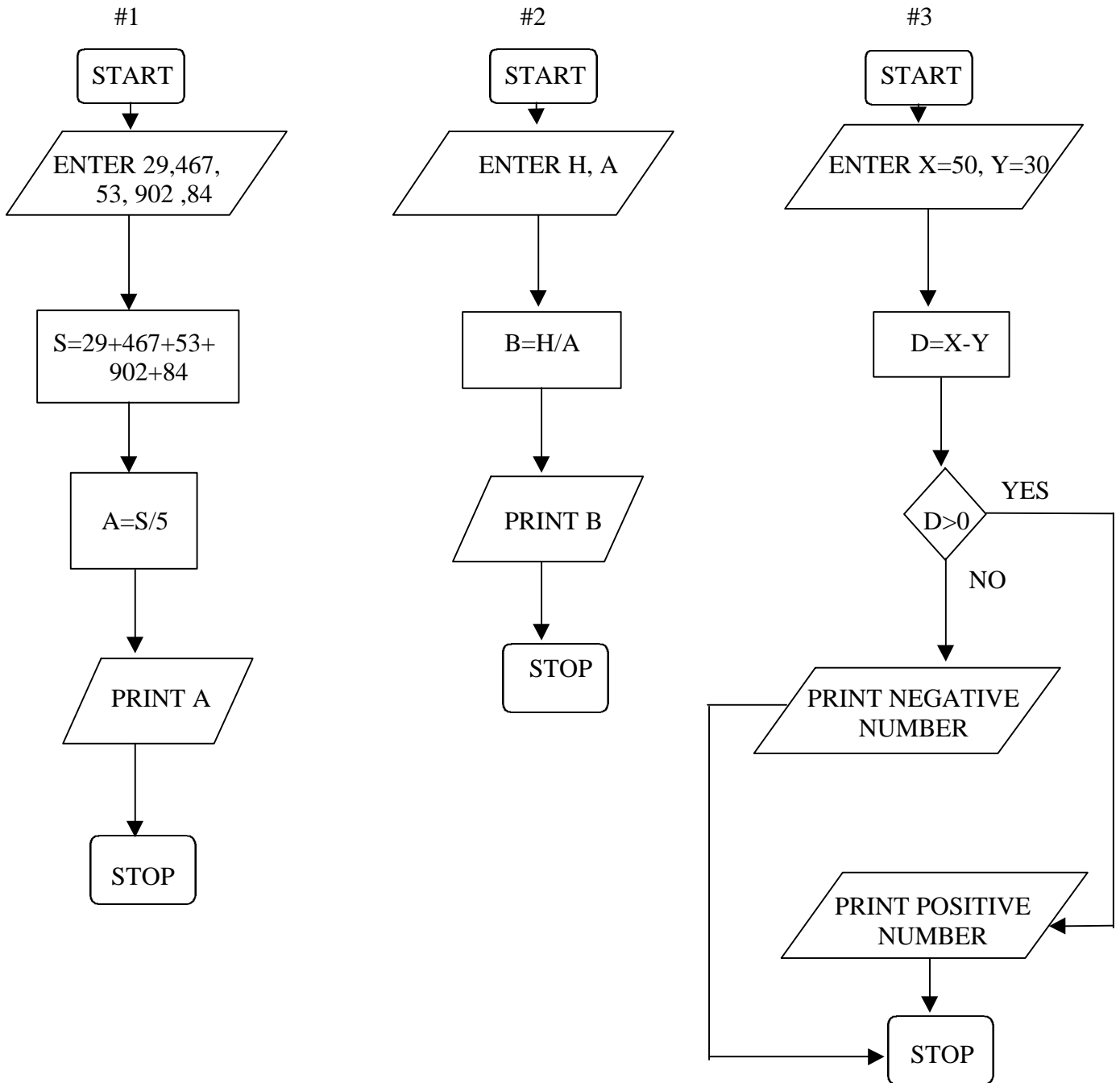
STOP

PRINT POSITIVE  
NUMBER

STOP



Did your charts look like this? If so, great! If not, review pages 3-4. You may be wondering why there is an option to print negative number when the answer is obviously positive. Both options are needed in order to cover all variations of a problem. What if this were a "real" program, and it had to handle a problem in which  $D = Y - X$ ? Then the answer would have been 30-50, or -20.



## LOOPS:

A loop in a flowchart comes out of a decision box and enables you to return to an earlier point in the chart. To understand the use of the loop, let's look back at the flowchart for job-hunting which was on page 2. There are two loops represented by this flowchart.

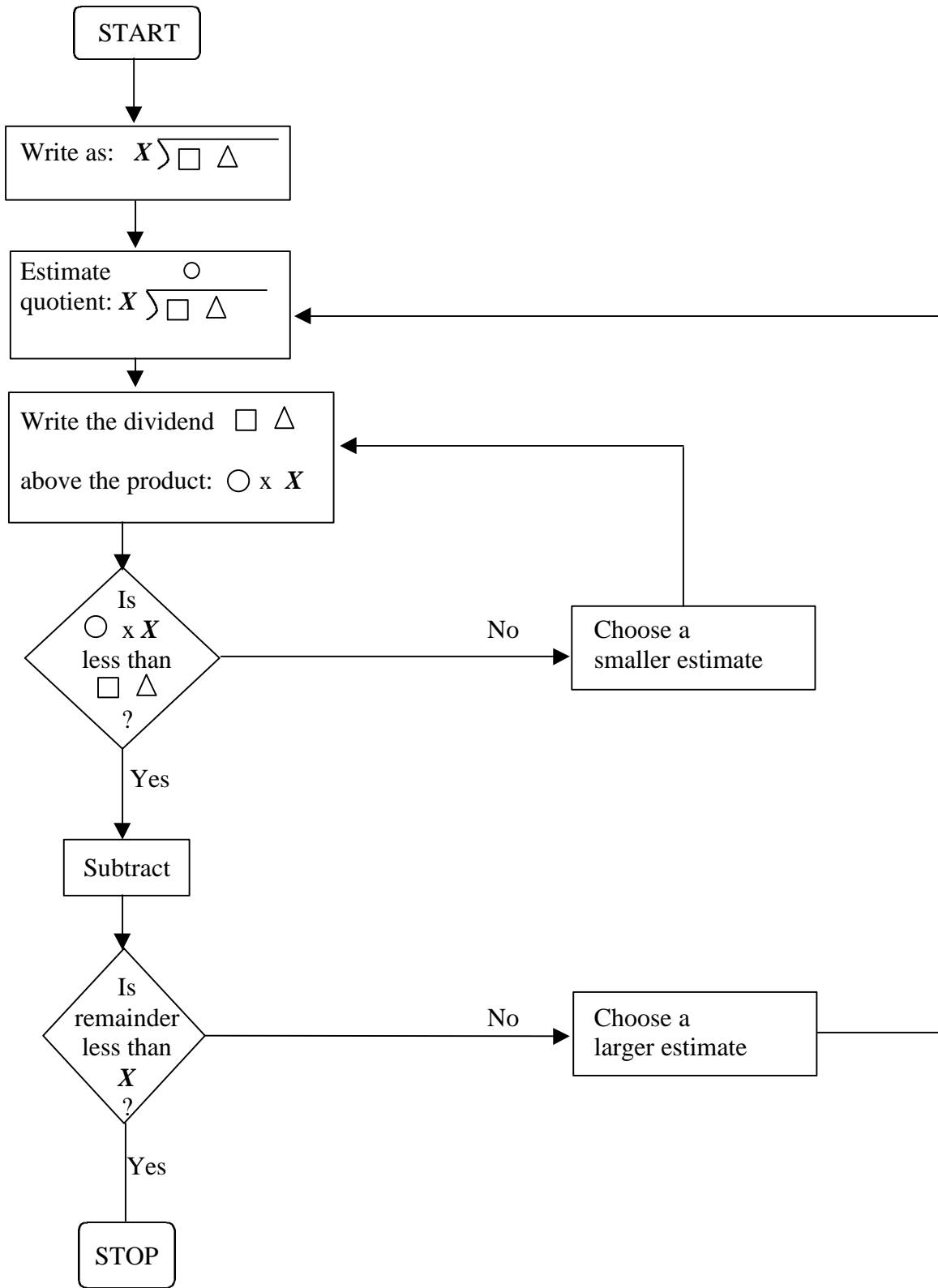
The first came out of the diamond-shaped decision box reading, "Get interview?" If the answer was "Yes," you proceeded to make an appointment. If "No," you "looped" back up to an earlier point and continued the job-hunt by submitting resume and application to another possible employer.

The second loop came from a "No" response to the decision box, "Is pay good?" When you decided "Yes," the pay was good, you proceeded to accept the job. If you decided, "No," the pay was not good, you returned to an earlier point, submitting your resume and application elsewhere. The flowchart then guided you to repeat the same steps you had taken before. (NOTE: Loops always flow from decisions, symbolized in this guide by diamond-shaped boxes, and always return you to an earlier point. Understanding this simple process will help you trace through and understand the most complex flowchart.)

The flowchart that follows shows how to divide a number between 10 and 100 by a number that is less than 10. Study it and then answer the following:

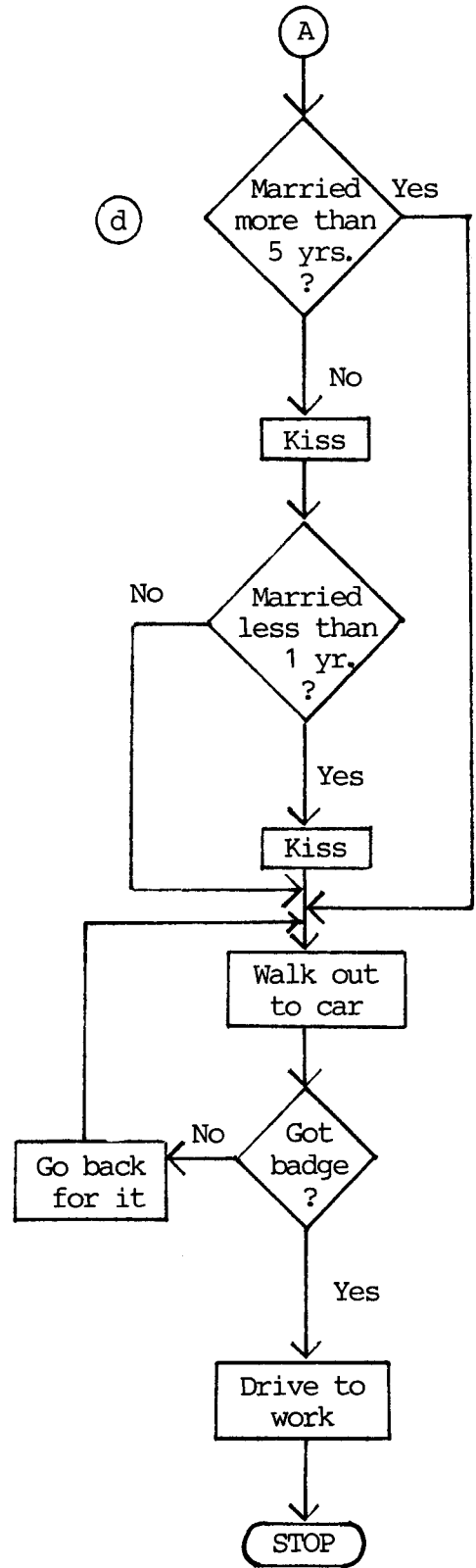
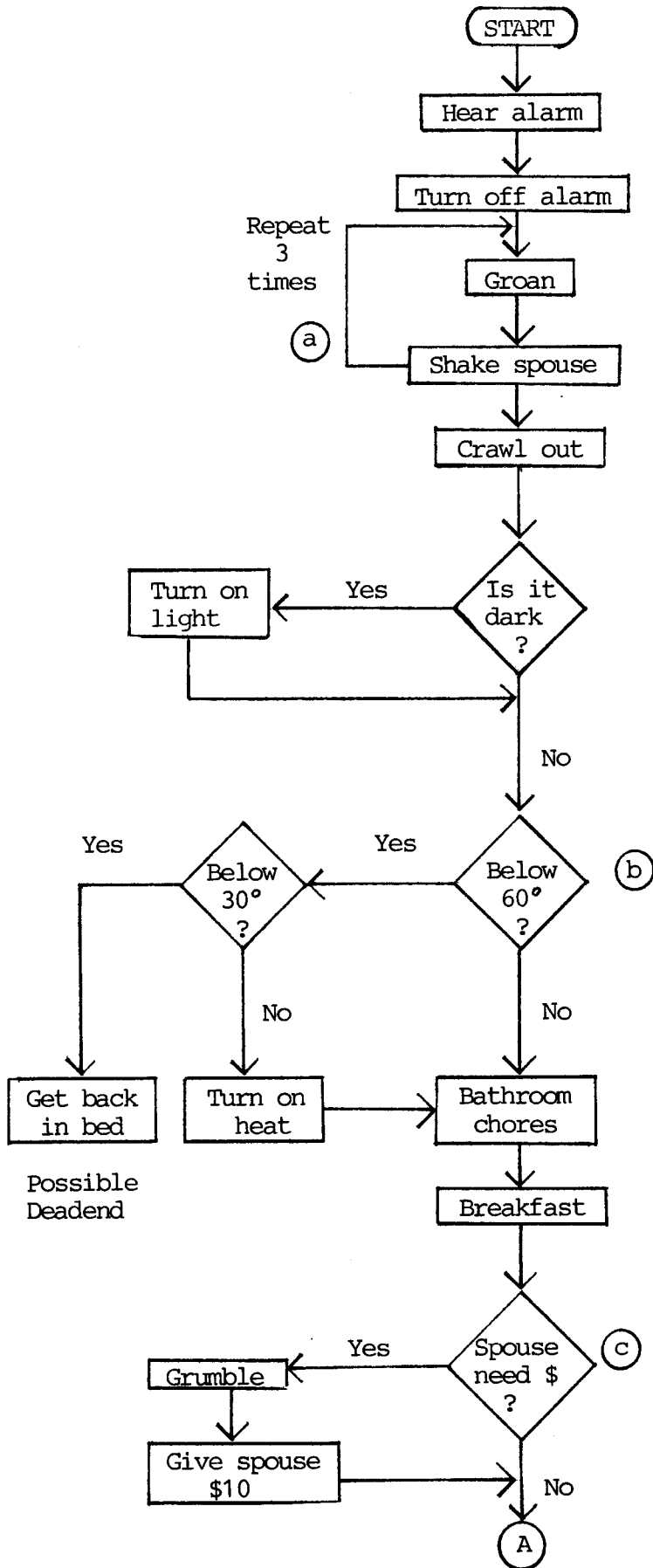
1. This flowchart shows how many loops?
2. What decision is made first?
3. What should you do if the answer is "Yes" ?
4. What should you do if the answer is "No"?
5. What is the second decision?
6. What should you do if the answer is "No"?

(Answers are on page 15.)

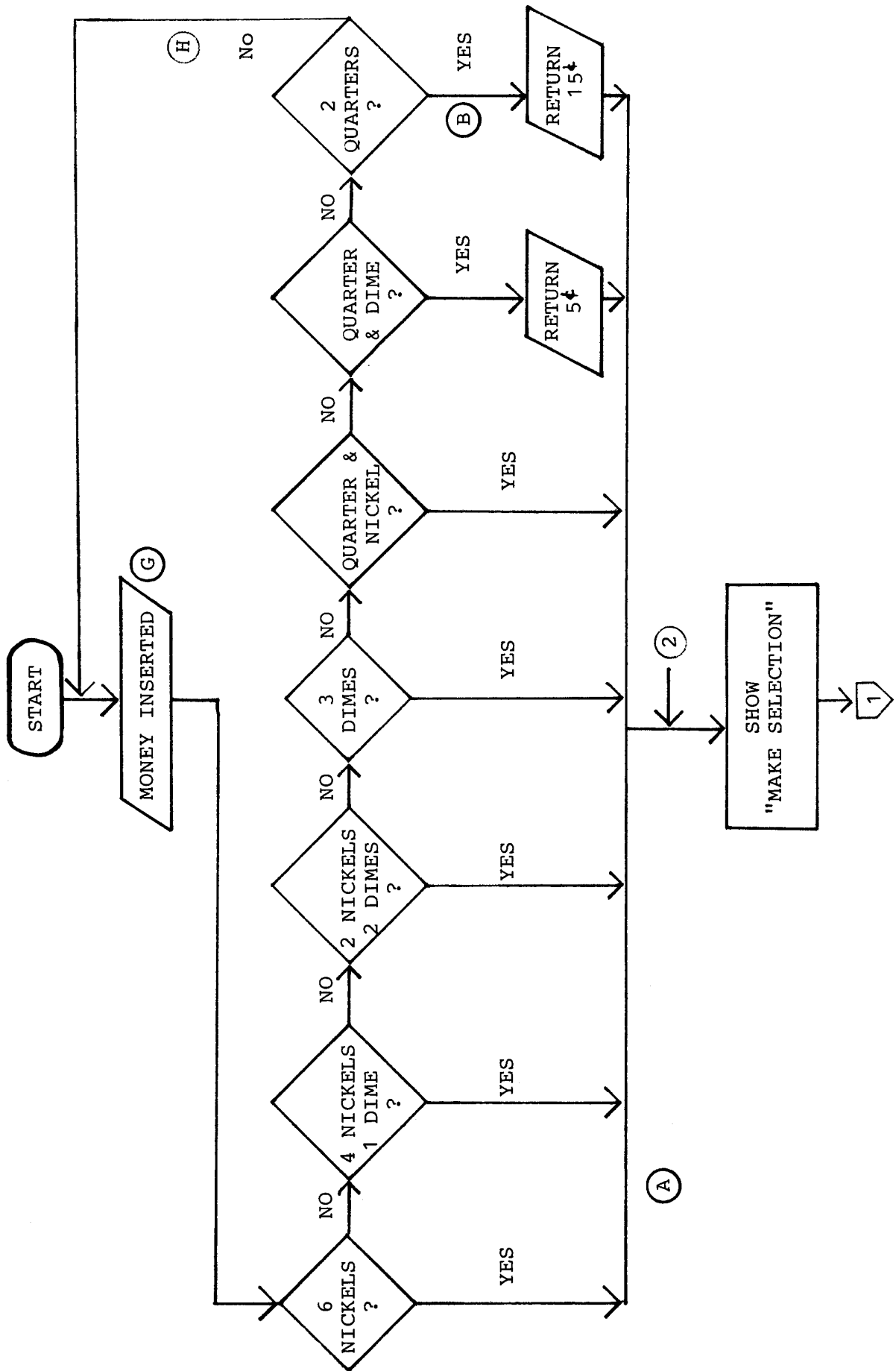


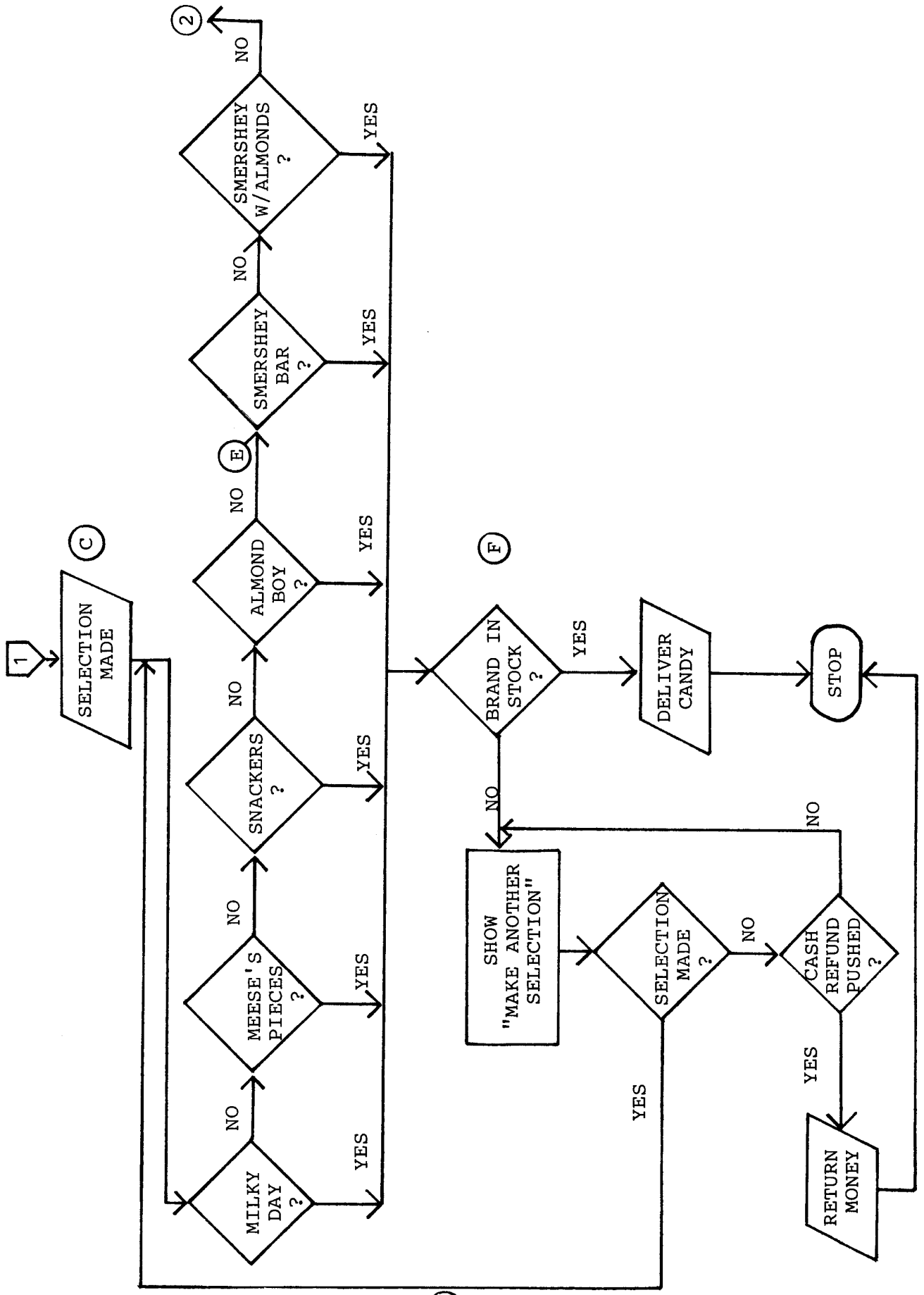
On the following page is an old, almost classic example of flow-charting which has been titled "How to Get to Work in the Morning. Its original source is unknown. Use it to answer the questions that follow below. Answers to these questions can be found on page 16.

1. Look at point (a) . Does this represent a loop? Why or why not?
2. How many loops do you find in the chart? Do all the decision boxes in the chart produce loops? How can you tell?
3. What is the first decision?
4. If "Yes," what do you do?
5. Look at the box that contains (b) . Could that box read "How cold?" Why or why not?
6. Which step comes next if the answer at point(c) is "No"?
7. If the answer to the step at point (d) is "Yes," what happens?
8. How many times does someone who is married more than 5 years get kissed?
9. How many times does a newly-wed get kissed?
10. If point (d) had to be located on another page because of space limitations, what should (A) be changed to?



CANDY MACHINE FLOWCHART





Please study the flowchart for a candy vending machine, then answer the following questions. The answers are on page 17.

1. How many brands of candy are available?
2. What is the price of each?
3. What coins may be used?
4. At point (A), what is the next function?
5. At point (B), what is the next function?
6. Why is point (C) a parallelogram?
7. What three steps immediately preceded point (D)?
8. If one were to reach point (H), what would that most likely mean?
9. What might we call point (D)?
10. At point (E), what brands have been eliminated as selection options?
11. At point (E), what brands are still selection options?
12. Why is the box at (F) a diamond shape?
13. What does a "Yes" decision at (F) lead to?
14. Name two indicated input points.
15. Name two output boxes.



ANSWERS to Questions 1-6:

1. Two.
2. "Is  $O \times X$  (the product) less than  $\square \Delta$  (the dividend)?"
3. Subtract the product from the dividend.
4. "Choose a smaller estimate" and go back to "Write the dividend  $\square \Delta$  above the product  $O \times X$ " to then see if the product is less than the dividend. In other words, you repeat the steps as the loop indicates.
5. "Is the remainder less than  $X$  (the divisor)?"
6. "Choose a larger estimate" and loop back to repeat the steps as the arrows indicate. You go all the way back to the rectangle immediately preceding the first decision box.

NOTE: Now look back at the flowchart again. See that the lines forming the loops never intersect (cross) each other.

ANSWERS to "HOW TO GET TO WORK IN THE MORNING":

1. No, point (a) doesn't represent a loop. You know this because it doesn't flow from a decision box, a diamond-shaped box that requires a "Yes" or "No" answer.

2. There is only one loop in the chart.

No, all the decision boxes in the chart don't produce loops. Only once does it come from a decision box and direct you back to repeat steps. This is at "Got badge?" Remember, loops refer you back to an earlier part in the chart. The only other item that looks like a loop is from "Shake spouse." It's not a loop, however, it's a way of telling you to repeat an action without taking up space.

3. "Is it dark?" is the first decision.

4. If the answer is "Yes," then you should "Turn on light."

5. No, because decision boxes must be able to be answered "Yes" or "No" only.

6. The next step is point (d) , "Married more than 5 years?"

7. If the answer to the step at point (d) is "Yes," you walk out to your car.

8. Someone who is married more than 5 years doesn't get kissed at all.

9. A newly-wed gets kissed twice.

10. Under these circumstances (A) should be changed to A ; it would become an "off-page connector."

ANSWERS to the "CANDY MACHINE FLOWCHART":

1. 6
2. 30 cents
3. Quarters, nickels and dimes
4. "Show 'make selection'"
5. "Return 15¢"
6. It's a parallelogram because that shape signals input. We are assuming that a candy machine is a computer. In that case, the "keyboard" is the knobs or buttons that are pushed to make a selection or to get a refund. The "keyboard operator" is any person who comes to buy candy. He/she "enters" the data (the selection or the money), and so this is considered input.
7.
  - (1) The selection made was not in stock.
  - (2) The consumer was signalled to make another selection.
  - (3) Another selection was made.
8. The "operator" did not put in enough money, he or she put in the wrong coins or wrong combination of coins, or the machine is out of order. By the time we get to point  $\textcircled{\text{H}}$ , all likely, possible combinations of the coins that will be taken have been exhausted. The flaw here is that there is no detailed provision for occurrences like: putting in pennies, or putting in too much money. If the person were to put in three quarters, how would he or she get one back? This flowchart doesn't tell us, and this is a flaw in the algorithm.
9. A loop
10. Milky Day, Meese's Pieces, Snackers, and Almond Boy
11. Smershey Bar and Smershey with Almonds
12. It is a decision box. It asks whether or not the brand is in stock.
13. "Deliver candy"
- 14.0  $\textcircled{\text{G}}$  and  $\textcircled{\text{C}}$
15. "Deliver candy," "Return 5¢," "Return 15¢," and/or "Return money."

## COMPUTER WORK SCHEDULING

Questions 1-10 are based on the following information.

Assume that you are in charge of scheduling computer time for a typical work day which runs from 8 AM to 5 PM, and must schedule the work as efficiently as possible. For the sake of this exercise, assume that no time is lost in setting up jobs; a job is begun as soon as the previous job is completed. Listed below are the times that it takes each job to run and a number of conditions that also need to be met. The table on the following page will help you organize this information. You will find that some jobs have to be run at a certain time, but other jobs are more flexible. For example: Let's say that Job X and Job Y are interchangeable; there is nothing in the conditions to tell you which must come first. In a case like this, the only thing you can do is make a note indicating this fact on your table.

### JOB RUN-TIMES:

JOB	A	B	C	D	E	F	G
MINUTES	65	43	121	47	100	23	125

JOB	H	I	J	K	L	M	N
MINUTES	185	150	115	80	65	91	92

### CONDITIONS:

- 1) Jobs A, C, and I must be started at 8 AM. (Remember there is no set-up time, so all three can start exactly at 8 AM.)
- 2) There are three tape drives that may be used: Drive 1, Drive 2, and Drive 3. Job A is run in Drive 1, Job C in Drive 2, and Job I in Drive 3.
- 3) Job E must be completed before Jobs F or B may be started.
- 4) All jobs must be finished by 5 PM of this day.
- 5) Job E must be started before 9:40 AM.
- 6) Job J must be completed before noon.
- 7) No job may be started between noon and 1 PM.
- 8) Jobs D and L must each be run separately; no job may be run while either one is being run.
- 9) Jobs D and L both must be completed before 3 PM.
- 10) Each job must be processed without interruption; it cannot be stopped and another run in the middle of it. No job needs to be run more than once.



1. Job K should be run in:
  - a. Drive 1
  - b. Drive 2
  - c. Drive 3
  - d. either Drive 1 or 3
  
2. Which drive may have been in use continuously from 8 to 3?
  - a. Drive 1
  - b. Drive 2
  - c. Drive 3
  - d. no drive was in use continuously
  
3. Which of the following must be true?
  - a. Jobs E and G must be run on the same drive.
  - b. Jobs C and J must be run on the same drive.
  - c. Job N should follow Job M.
  - d. Job L must follow Job D.
  
4. Job J should be completed at:
  - a. 11:56
  - b. 11:38
  - c. 11:00
  - d. 10:55
  
5. All the jobs should be completed by:
  - a. 4:35
  - b. 3:53
  - c. 4:45
  - d. 4:53

6. If the jobs have been scheduled most efficiently, how many jobs will have been completed by noon?
- a. 6
  - b. 7
  - c. 8
  - d. 9
7. Of the following, some are definitely true, and some are definitely false. One of them, however, may or may not be true. Which one could be either true or false?
- a. Job D is run after Job H is completed.
  - b. Job J is begun after Job F.
  - c. Job D follows Job L.
  - d. Job K is completed before Job B.
8. Job L is completed just after:
- a. 12:00
  - b. 12:45
  - c. 1:00
  - d. 2:00
9. What is the last job to finish?
- a. Job H
  - b. Job G
  - c. Job M
  - d. Job N
10. At what time should Job G be started?
- a. 11:38
  - b. 1:48
  - c. 3:53
  - d. 2:05

Questions 11-20 are based on the following information.

Assume for the purposes of this exercise that you are responsible for scheduling computer time. In order to correctly schedule this work, you must comply with the conditions below and use the table on the following page. The table is partially completed, and these items may not be moved to comply with Conditions 1-17. (Please note that this is purely an intellectual exercise. We know that no one would do things this way in real life and that many of the conditions make no sense, but we had to set arbitrary limits to make the problem workable.)

CONDITIONS:

- 1) There are usually ten hours (7 to 5) of processing time Monday through Friday, and six hours (8 to 2) Saturday.
- 2) There is a 90-minute block of downtime for maintenance beginning at 9:00 AM on Tuesday, and two 30-minute blocks of downtime for maintenance on Thursday, one ends at 8:15 AM, the other ends at 3:30 PM.
- 3) New jobs will be started at 7:00 AM and noon of each weekday, and 8:00 AM and noon on Saturday. No morning jobs will run past noon, no afternoon jobs will run past 5:00 PM during the week and 2:00 PM on Saturday. All available slots must be filled.
- 4) There are 13 different jobs, but some jobs need to be run more than once. Each job must be run separately, and only one run of any particular job is allowed each day.
- 5) Only Job 9 may be run during maintenance downtime.
- 6) Jobs 3 and 12 each run for 30 minutes.
- 7) Job 7 runs for 5 hours.
- 8) Jobs 5, 1, and 11 all run for 3 hours.
- 9) Job 6 runs for 1 hour.
- 10) Jobs 10, 4, 13, and 8 run for 2 hours.
- 11) Jobs 2 and 9 both run for 90 minutes.
- 12) Job 3 is run daily and as soon in the day as possible. A Job 3 run is given priority over other jobs marked ASAP.
- 13) Job 2 is run three times a week and must be totally completed before 7:00 AM on Friday.
- 14) Job 4 runs four times weekly; Jobs 9 and 5 run three times weekly.



- 15) Jobs 1 and 13 run two times a week; Job 13 must run on consecutive days.
- 16) Jobs 8, 11, 4, and 13 must be completed ASAP (as soon as possible).
- 17) Jobs 7, 11, 12, 8 and 10 need only be run once.

As we said, the table has been partially completed. You must assume that the scheduling is correct and work the conditions around what has been given you. For example: Even though Condition 12 says that Job 3 must be run as early in the day as possible, it could not be the first job run on Wednesday because that honor goes to Job 1.

The table is set up so that the number of slots corresponds to the number of jobs that are to be run in that time block. For example: Friday morning only has two slots open; therefore, only two jobs, totalling five hours, are possible in this time period.

	MON	TUE	WED	THURS	FRI	SAT	
7:00		4	1				
	2			9			8:00
						5	
12:00	4				3		12:00
	6		13		1		
5:00							

11. When will the final run of Job 4 be completed?
- a. first thing Saturday morning
  - b. before noon on Friday
  - c. before 7:00 AM on Friday
  - d. before 5 PM on Wednesday
12. What is the last job on Saturday?
- a. Job 4
  - b. Job 10
  - c. Job 5
  - d. Job 8
13. How many hours of actual processing (running) time were there this week?
- a. 56
  - b. 55.5
  - c. 53.5
  - d. 66
14. What is the third job run on Thursday?
- a. Job 6
  - b. Job 9
  - c. Job 13
  - d. Job 4
15. How many jobs are run on at least three consecutive days?
- a. 2
  - b. 3
  - c. 4
  - d. 5

16. What is the second job run on Monday afternoon?

- a. Job 11
- b. Job 8
- c. Job 5
- d. Job I

17. How many times is Job 6 run this week?

- a. 2
- b. 3
- c. 4
- d. 5

18. Which of the following is the first job to have all of its weekly runs completed?

- a. Job 4
- b. Job 9
- c. Job 12
- d. Job 1

19. What is the third job run on Wednesday?

- a. Job 9
- b. Job 3
- c. Job 6
- d. Job 2

20. Which of the following jobs was not run on Thursday?

- a. Job 4
- b. Job 2
- c. Job 6
- d. Job 5

## ANSWERS AND EXPLANATIONS TO COMPUTER WORK SCHEDULING

The easiest way to answer these questions (and to explain them) is to complete the table. (NOTE: We gave you a table to complete, but it's possible that you would be given a question like this and not be able to write in the booklet. This is unlikely, but if it should occur, you will have to create a table of your own on scrap paper.) The first two conditions give us a very good start. Condition 1 tells us which jobs are to be run first and Condition 2 tells us which drives they go in. The first entries would look like this:

```

Drive 1  A-----▶ 9:05
Drive 2  C-----▶ 10:01
Drive 3  I-----▶ 10:30
  
```

According to Condition 5, Job E must be started before 9:40 AM. Job C will not be completed until 10:01, and Job I will not finish until 10:30. Therefore, Job E must be run in Drive 1. It must immediately follow Job A due to Condition 3. Only Job F's running time is short enough that it could precede Job E and still allow Job E to be started by 9:40. (9:05 plus 23 minutes is only 9:28.) According to Condition 3, though, Job E must be completed before Job F can be started, so Job F cannot precede Job E in Drive 1.

Since Job J must be completed before noon (Condition 6), it must immediately follow Job C in Drive 2. If it followed Job I, it would overrun the allotted time by 25 minutes. (10:30 plus 115 minutes, or an hour and 55 minutes, would be 12:25.) If it followed Job E, it would finish even later. (10:45 plus 115 minutes is 12:40.) The table would now look like this:

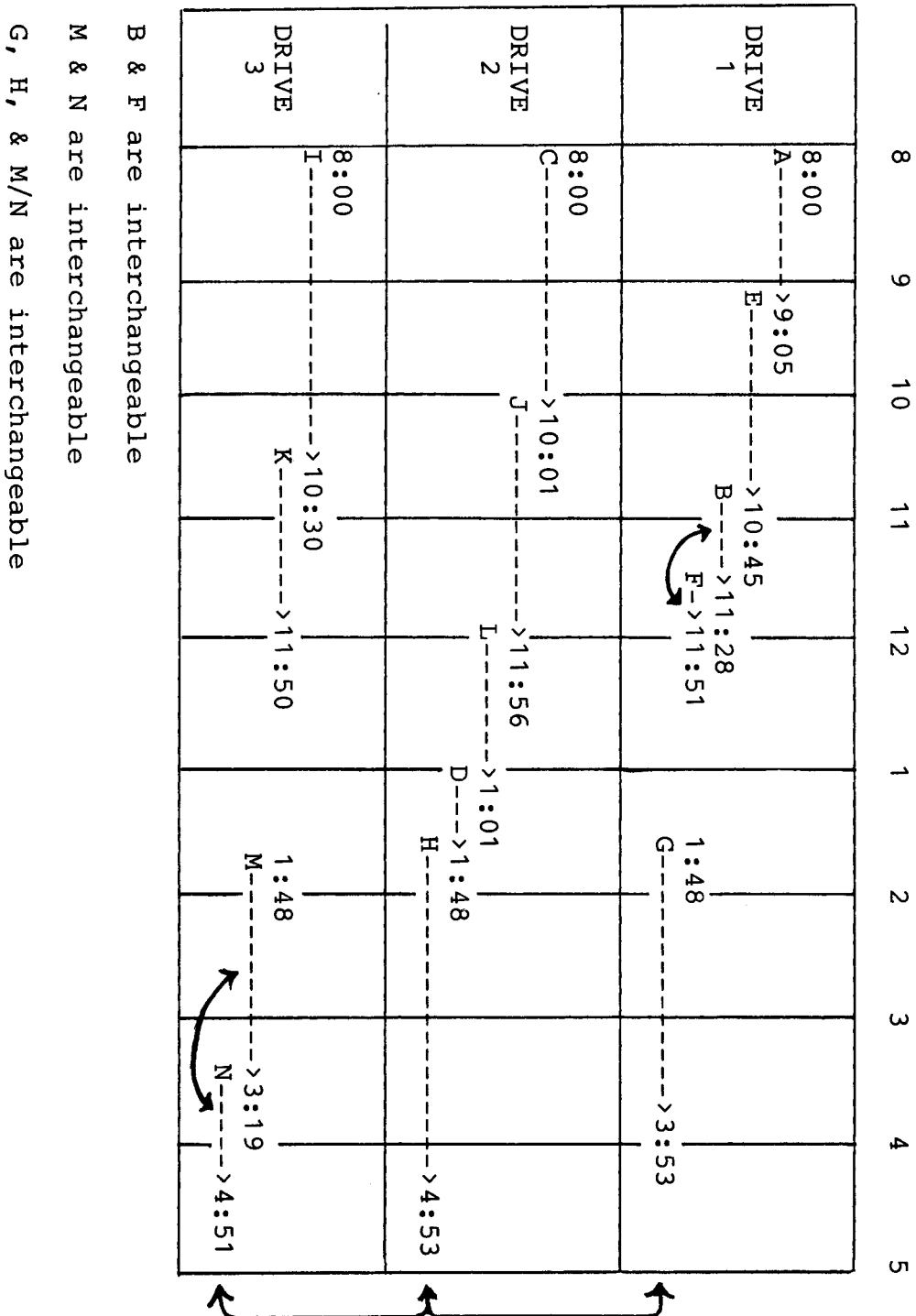
```

Drive 1  A-----▶ 9:05  E-----▶ 10:45
Drive 2  C-----▶ 10:01  J-----▶ 11:56
Drive 3  I-----▶ 10:30
  
```

Things begin to get a bit more complicated and more difficult to explain, so bear with us. In order to make your calculations easier, you may want to translate the minutes into hours and minutes if you have not already done so. You may also want to cross off each job as we eliminate it. There are a number of conditions that determine what jobs come next. Condition 7 says that no job may be started between noon and 1 PM.. To be most efficient then, a job must be started at or before noon and run to 1:00 PM. (Technically, using the word between means that jobs could be started exactly at, and no later than, noon and exactly at, and no earlier than, 1:00.) A job that would end in the middle of the lunch hour would leave some slack time, and so should be avoided whenever possible for the sake of efficiency. Condition 8 says that Jobs D and L must be run separately and that no job may be run while either one is being run. By playing around with the jobs and their times, you will see that the only possible way to run the jobs is to start Job L just before noon and to run Job D immediately after Job L finishes. Neither of these jobs can be started until Job J is completed at 11:56, because they can't be run while another job is running. If we started Job D



At this point, it really doesn't matter which drives are used for the remaining jobs. Nor does it matter if Job M follows job N or vice versa. We've given a possible set-up below. Note that no runs may start until Job D is completed at 1:48 and that Jobs M and N must be in the same drive.



Now the answers to the questions:

- 1 The answer is choice c. As we've already seen, Job K has to follow Job I in Drive 3 because otherwise it could not be run.
2. The answer is choice b. While no drive must be used continuously, the only one that could be used continuously is Drive 2. It doesn't need to be used continuously because Job L and/or Job D could have been placed in either Drive 1 or Drive 3. It's the only one that could have been used continuously because both Drives 1 and 3 complete their morning runs before 11:56, the earliest time that Job L could be started.
3. The answer is choice b. Job J must be run in Drive 2, after Job C, if it is to be completed before noon, as Condition 6 says it must. Choice a may or may not be true. Job G could just as easily be run in either Drive 2 or Drive 3 as in Drive 1. Choice c is incorrect because M may follow N just as easily. Choice d is false; Job L must precede Job D.
4. The answer is choice a. The conditions say that no time is lost during set-up, so it's conceivable that Job J could end as early as 11:56.
5. The answer is choice d. If the jobs are run in the most efficient manner, with no time wasted, three afternoon jobs would start at 1:48, and the fourth job would start at either 3:19 or 3:20, depending on whether Job M or Job N were run first. Job M/N would finish by 4:51, Job G would end at 3:53, and Job H would be completed at 4:53. (Again, no time is lost in setting up jobs.)
6. The answer is choice c. If as many jobs were run as possible, then eight jobs would have been completed before noon: A, E, B, F, C, J, I, and K.
7. The answer is choice d. Choice a is false because there is no way that Job D could be completed before 3 PM (Condition 9) if it followed Job H. We know that choice b is false from our work with the table. Choice c is necessarily true. Otherwise, Job L couldn't be started until 1:00 (due to Condition 7) and wouldn't be completed until 2:05. This wouldn't leave enough time for Job H to finish before 5. Choice d may or may not be true. If Job F were run before Job B, then choice d would be true; if it were run after Job B, then choice d would be false.
8. The answer is choice C. If the jobs were run as efficiently as possible, Job L would be completed at 1:01.
9. The answer is choice a. If the jobs were run as efficiently as possible, Job H would be the last to be completed.
10. The answer is choice b, 1:48.

The next problem was designed to be a bit more difficult. Again, we have to complete the table before we can answer any of the questions. Perhaps, the first thing we should do is put the information contained in the "Conditions" into some kind of workable form. For example:

JOB	HOURS	TIMES RUN	ADDITIONAL CONSIDERATIONS
1	3	2	
2	1.5	3	Completed by 7:00 AM Friday
3	.5	6	As early in day as possible
4	2	4	ASAP
5	3	3	
6	1		
7	5	1	
8	2	1	ASAP
9	1.5	3	During main. downtime TU, TH
10	2	1	
11	3	1	ASAP
12	.5	1	
13	2	2	On consecutive days; ASAP

The next thing we might do is to figure out how many hours are already accounted for in the table, and, when possible, how many hours are available in each empty slot. This step is possible because of the guidelines established by Condition 3. The morning and afternoon blocks are both five hours long, and jobs must fit neatly into their allotted time slots within these 5-hour blocks. (This is one of the more unrealistic aspects of this question, but it was necessary to set artificial limits in order to make it workable and "explainable.") The table below is the same as the original table given on page 23, except that next to each job given there are small circled numbers that tell how many hours it takes to complete the job. Where possible, these are also given for otherwise empty boxes.



	MON	TUE	WED	THURS	FRI	SAT
7:00		② 4	③ 1			
	①.5 2			①.5 9		
						③ 5
12:00	② 4	5			①.5 3	②
	②				①.5	
	① 6		② 13		③ 1	
5:00						

The next step is to fill in the most obvious numbers and then to see how many empty slots we can find the times for. We know that Job 7 can only be run on Tuesday afternoon because that afternoon alone has a single, 5-hour slot. And we know that one run of Job 9 must be put in the second slot on Tuesday morning. We know this because the first job is Job 4, a 2-hour job that starts at 7:00 and ends at 9:00, and because there is a 90-minute block of downtime for maintenance beginning at 9:00 on Tuesday (Condition 2). Only Job 9 can be run during maintenance time (Condition 5). We cannot use the third run of Job 9 to cover the Thursday afternoon maintenance time because there has already been one run of Job 9 scheduled that day and only one run of a particular job is allowed each day (Condition 4). We can also enter all missing runs of Job 3 because Condition 12 says that it is run daily and is given priority over all other runs whenever possible. (Notice that there is already a Job 3 scheduled for Friday afternoon, so we cannot install another one that morning.) After entering all these runs, we also will know the times allotted to some of the empty slots. For example: The remaining Tuesday morning slot is a 1-hour job because Job 4 is 2 hours, Job 9 is 1.5 hours, and Job 3 is .5 hours. This is a total of four hours, one hour short of the five hours available in the morning. The table would now look like the one on the following page:

	MON	TUE	WED	THURS	FRI	SAT
7:00	⑤ 3	② 4	③ 1	⑤ 3		
	①.5 2	①.5 9	⑤ 3	①.5 9		⑤ 3
	③	⑤ 3				③ 5
		①				⑤
12:00	② 4	⑤ 7		③	⑤ 3	②
	②			①.5	①.5	
	① 6		② 13		③ 1	
5:00						

Now, we can fill in more slots.

Monday morning's 3-hour slot should go to Job 11 because it needs to be filled ASAP (Condition 16), and it's the only 3-hour job that needs to be completed quickly.

Monday afternoon's 2-hour slot goes to Job 8 because it too should be filled ASAP (Condition 16). Of the other 2-hour jobs that should be run ASAP, Job 4 has already been run that day so it cannot be run again (Condition 4), and Job 13 needs to be run on either Tuesday or Thursday in order to be run consecutively with Wednesday's prescheduled run (Condition 15)

Tuesday morning's remaining 1-hour slot can only be filled by Job 6 because no other jobs take just one hour to run, and all slots must be filled (Condition 3).

After adding Job 3, Wednesday's morning slot is only 1.5 hours long. But we don't know yet whether Job 2 or 9 will be run here.

Friday afternoon's 1.5 hour slot can only be filled by Job 9. Job 2 is the only other 1.5 hour job and it has to be completed by Friday morning (Condition 13). Since this accounts for all runs of Job 9, it means that Job 2 is run on Wednesday morning.

There is some computer downtime between 3:00 and 3:30 on Thursday afternoon. Job 9 has

already been run that day, and no other jobs may be run during downtime (Condition 5). That period is blocked out, and we can see that the last slot on Thursday afternoon is 1.5 hours long. All of Job 2 must be finished by Friday morning (Condition 13), Job 9 has already been run that day, and there are no other 1.5 hour jobs. So -- Job 2 is the last job run on Thursday afternoon.

Finally Job 12, has to be run on Saturday morning because it is the only half-hour job we have.

With all these fill-ins, the table would now look like this:

	MON	TUE	WED	THURS	FRI	SAT	
7:00	3	4	1	⓪.5 3			
	2	9	3	⓪.1.5 9	⓪.5	3	8:00
	11	3	2			5	
		6		⓪.3		12	
12:00	4	7		⓪.3	3	⓪.2	12:00
	8		⓪.3		9		
				⓪.1.5 2			
	6		⓪.2 13		1		
5:00							

You may have noticed that there are now small numbered circles on the lines between certain empty slots. These indicate how much time is available in the two slots added together, since we have no way of knowing as yet how much time is allotted to each slot.

It's probably wise at this point to go back to the list of information about the job to see how many have been eliminated. Go through the table and tally the ones that you have and figure out how many more you need. You will find our tally on the next page. (You may have been doing this all along, a wise move.)

JOB	HOURS	TIMES RUN	HAVE	NEED	ADDITIONAL CONSIDERATIONS
1	3	2	2	0	
2	1.5	3	3	0	By 7:00 AM Friday
3	.5	6	6	0	As early in day as possible
4	2	4	2	2	ASAP
5	3	3	2	2	
6	1	?	2	?	
7	5	1	1	0	
8	2	1	1	0	ASAP
9	1.5	3	3	0	maintenance time T, TH
10	2	1	0	1	
11	3	1	1	0	ASAP
12	.5	1	1	0	
13	2	2	1	1	Consecutive days, ASAP

From this you can see that Jobs 1, 2, 3, 7, 8, 9, 11, and 12 are completed. You can also figure out how many jobs of varying lengths you have left.

HOURS:

.5	--	0	
1	--	?	Job 6
1.5	--	0	
2	--	4	Job 4 (2), Job 10, Job 13
3	--	2	Job 5

You also know or can figure out a number of other things. Again, this gets complicated, so go over it carefully.

- 1) Any 1-hour slot has to be for Job 6.
- 2) All remaining jobs take a whole number of hours, as opposed to a fraction of an hour or an hour and a fraction.
- 3) There is a 3-hour job slot on Thursday afternoon, and the only 3-hour job left is Job 5, so Job 5 must go there.
- 4) Since we have filled all the slots on Tuesday and on Thursday afternoon, we have to assume that Job 13 is to be run on Thursday morning. (According to Condition 15, Job 13 has to be run on consecutive days, and it's already filled in for Wednesday.) There are two slots, totalling three hours, on Thursday morning. One has to be a 2-hour job, the other a 1-hour job because we only have jobs that total whole numbers of hours left. The 1-hour job has to be Job 6.
- 5) Since Job 13 and Job 6 are the only possibilities for Thursday morning, and since Job 13 is marked ASA? and Job 6 is not, Job 6 follows Job 13.

- 6) Since Job 10 is the only 2-hour job left that is not marked ASAP, it can safely be placed in the Saturday afternoon 2-hour slot.
- 7) There are now two blocks left, Wednesday afternoon and Friday morning. Wednesday has two slots, totalling three hours. It has to consist of Jobs 4 and 6. Since Job 4 is marked ASAP and Job 6 is not, Job 4 precedes Job 6 on Wednesday afternoon. Friday morning consists of two slots, totalling five hours. It has to be made up of Job 5 and Job 4. Since Job 4 is marked ASAP and Job 5 is not, Job 4 precedes Job 5 on Friday morning.

The table is now complete, as you can see below.

	MON	TUE	WED	THURS	FRI	SAT	
7:00	3	4	1	3	4		
	2	9	3	9	5	3	8:00
	11	3	2	13		5	
		6		6		12	
12:00	4	7	4	5	3	10	12:00
	8		6	2	9		
	6		13		1		
5:00							

Now, to answer the questions.

11. The answer is choice b. See table.

12. The answer is choice b. See table.

13. The answer is choice b. Because Job 9 could be run during maintenance time, most of the time was not wasted. The half hour of downtime on Thursday afternoon was the only time actually taken away from processing time. This was true because Job 9 could not be run twice in the same day (Condition 4). There are five 10-hour days and one 6-hour day. This is 56 hours minus the half hour, or 55.5 hours of processing time.

14. The answer is choice c. The jobs run on Thursday morning are 3, 9, 13, and 6. Job 9 is given in the second slot, Job 3 must be first because it has to be scheduled as early in the day as possible and this takes priority over everything else except slots already filled. Since Job 13 must be completed ASAP and Job 6 doesn't, Job 13 takes precedence and is in the third slot.

15. The answer is choice C. Jobs 4, 3, 6, and 5 are all run on at least three consecutive days.

16. The answer is choice b. This is a 2-hour slot. Of the 2-hour jobs, Jobs 4, 13, and 8 all should be completed ASAP. But Job 4 has already been run that day, and Job 13 must be run on consecutive days. Since Job 13 is already scheduled for Wednesday, it must be run on either Tuesday or Thursday to fulfill the condition. This means that Job 8 is the only possible choice.

17. The answer is choice c. Job 6 is run on Monday, Tuesday, Wednesday, and Thursday.

18. The answer is choice a. Of the choices given, Jobs 4, 9, and I all complete their runs on Friday. Job 4 is run first on Friday, so it is the first to be completed.

19. The answer is choice d. See the table.

20. The answer is choice a. See the table.

## ANSWER KEY FOR COMPUTER WORK SCHEDULING

- |       |       |
|-------|-------|
| 1. c  | 11. b |
| 2. b  | 12. b |
| 3. b  | 13. b |
| 4. a  | 14. c |
| 5. d  | 15. c |
| 6. c  | 16. b |
| 7. d  | 17. c |
| 8. c  | 18. a |
| 9. a  | 19. d |
| 10. b | 20. a |

Thank you and good luck!