CHAPTER 17

Theory of Computation

(Solutions to Odd-Numbered Problems)

Review Questions

1. The three statements in our Simple Language are the *increment statement, decrement statement*, and *loop statement*. The increment statement adds 1 to the variable; the decrement statement subtracts 1 from the variable; the loop statement repeats an action (or a series of actions) while the value of the variable is not zero.

3. A problem that can be solved by our Simple Language can also be solved by the Turing machine.

5. One way to delimit the data on a Turing machine tape is the use of two blanks, one at the beginning of the data and one at the end of the data.

7. A transition state diagram is a pictorial representation of a program written for the Turing machine.

9. A Gödel number is an unsigned integer that is assigned to every program that can be written in a specific language. In the halting program, we represent a program as its Gödel number when that program is the input to another program.

Multiple-Choice Questions

11. a
13. b
15. a
17. c
19. d
21. c
23. c
25. c
27. d

Exercises

29. See Algorithm S17.29. After assigning Y to Z, we increment Z (X times).

Algorithm S17.29 *Exercise 29*

```
Temp ← X                                // See solution to Exercise 28
Z ← Y                                   // See solution to Exercise 28
while (Temp)
{
        decr (Temp)
        incr (Z)
}
```

31. See Algorithm S17.31.

Algorithm S17.31 *Exercise 31*

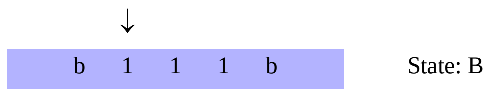
```
Temp ← X                                // See solution to Exercise 28
Z ← 1
while (Temp)
{
        decr (Temp)
        $Z ← Z \times Y$                // See algorithm 17.8 in the text
}
```

33. See Algorithm S17.33.

Algorithm S17.33 *Exercise 33*

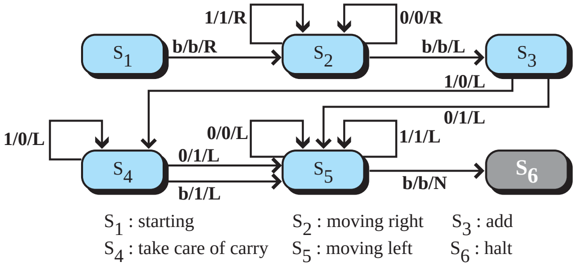
```
Temp ← X + 1
while (X)
{
        decr (X)
        $A_1$
        Temp ← 0
}
while (Temp)
{
        decr (Temp)
        $A_2$
}
```

35. The tape moves to the right and goes to state B as shown below:



37. Figure S17.37 shows the state diagram.

Figure S17.37 *Exercise 37*



39.

			↓				
Start	…	b	b	b	b	…	State: S_1
	X = 0						
				↓			
(S_1, b, b, R, S_2)	…	b	b	b	b	…	State: S_2
	X = 0						
				↓			
(S_2, b, b, N, S_3)	…	b	b	b	b	…	State: S_3 (halt)
	X = 0						

41.

a. (S_1, b, b, R, S_2) — S_1 is the ***starting*** state.

b. $(S_2, 1, 1, R, S_2)$ — S_2 is the ***move right*** state.

c. (S_2, b, b, L, S_3)

d. $(S_3, 1, b, L, S_3)$ — S_3 is the ***move left*** state. 1 is changed to b.

e. (S_3, b, b, N, S_4) — S_4 is the ***halt*** state.

43. We use a single 1 to represent 0, two 1’s to represent 1, three 1’s to represent 2, …, and $n + 1$ 1’s to represent n.

45. Algorithm S17.45 shows the statements for the macro and the Gödel number for each statement.

Algorithm S17.45 *Exercise 45*

```
$X_2 \leftarrow 0$                 // Gödel Number: CF2DBF2E
incr $X_2$                         // Gödel Number: AF2
incr $X_2$                         // Gödel Number: AF2
```

The Gödel number for the macro is then $(CF2DBF2EAF2AF2)_{16}$. Notice that this micro does not preserve the value of X_2. The Gödel number for the macro will be longer if we want to preserve X_2.