

Chapter *11*

Nested Loops

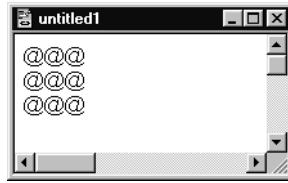
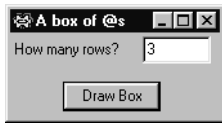


Figure 11.1
The input and output for the program in Figure 11.2.

```
MODULE Pbox11A;
IMPORT Dialog, TextModels, TextViews, Views, PboxMappers;
VAR
  d*: RECORD
    numRows*: INTEGER;
  END;

PROCEDURE DrawBox*;
VAR
  md: TextModels.Model;
  vw: TextViews.View;
  fm: PboxMappers.Formatter;
  i, j: INTEGER;
BEGIN
  md := TextModels.dir.New();
  fm.ConnectTo(md);
  FOR i := 1 TO d.numRows DO
    FOR j := 1 TO d.numRows DO
      fm.WriteChar("@")
    END;
    fm.WriteLine
  END;
  vw := TextViews.dir.New(md);
  Views.OpenView(vw)
END DrawBox;

BEGIN
  d.numRows := 0
END Pbox11A.
```

Figure 11.2

A procedure that prints a box of @ characters with nested loops.

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO d.numRows DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total				

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO d.numRows DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total			1	

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
■ fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO d.numRows DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total				2

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1		3	
fm.ConnectTo(md);	1				
■ FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	0				
fm.WriteChar("@")	0				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	3				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	1	3	
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	1				
fm.WriteChar("@")	0				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	4				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	1	3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	1				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 5

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	2	3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	2				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	6				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	2	3	@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	2				
fm.WriteChar("@")	2				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 7

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	3	3	@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	3				
fm.WriteChar("@")	2				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	8				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	3	3	@@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	3				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 9

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	4	3	@@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	4				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 10

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1		3	@@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO d.numRows DO	4				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 11

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2		3	@@@
fm.ConnectTo(md);	1				
■ FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	4				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	12				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	1	3	@@@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	5				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

13

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	1	3	@@@
fm.ConnectTo(md);	1				@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	5				
fm.WriteChar("@")	4				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

14

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	2	3	@@@
fm.ConnectTo(md);	1				@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	6				
fm.WriteChar("@")	4				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

15

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	2	3	@@@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	6				
fm.WriteChar("@")	5				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 16

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	3	3	@@@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	7				
fm.WriteChar("@")	5				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

17

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	3	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	7				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

18

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	4	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	8				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

19

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2		3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO d.numRows DO	8				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 20

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3		3	@@@
fm.ConnectTo(md);	1				@@@
■ FOR i := 1 TO d.numRows DO	3				
FOR j := 1 TO d.numRows DO	8				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	21				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	1	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				
FOR j := 1 TO d.numRows DO	9				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 22

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	1	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@
FOR j := 1 TO d.numRows DO	9				
fm.WriteChar("@")	7				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 23

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	2	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@
FOR j := 1 TO d.numRows DO	10				
fm.WriteChar("@")	7				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	24				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	2	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@@
FOR j := 1 TO d.numRows DO	10				
fm.WriteChar("@")	8				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

25

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	3	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@@
FOR j := 1 TO d.numRows DO	11				
fm.WriteChar("@")	8				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

26

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	3	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@@@
FOR j := 1 TO d.numRows DO	11				
fm.WriteChar("@")	9				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

27

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	4	3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@@@
FOR j := 1 TO d.numRows DO	12				
fm.WriteChar("@")	9				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 28

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3		3	@@@
fm.ConnectTo(md);	1				@@@
FOR i := 1 TO d.numRows DO	3				@@@
FOR j := 1 TO d.numRows DO	12				
fm.WriteChar("@")	9				
END;					
fm.WriteLine	3				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

29

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	4		3	@@@
fm.ConnectTo(md);	1				@@@
■ FOR i := 1 TO d.numRows DO	4				@@@
FOR j := 1 TO d.numRows DO	12				
fm.WriteChar("@")	9				
END;					
fm.WriteLine	3				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	30				

	i	j	d.numRows	Text model
md := TextModels.dir.New();	1		3	@@@
fm.ConnectTo(md);	1			@@@
FOR i := 1 TO d.numRows DO	4			@@@
FOR j := 1 TO d.numRows DO	12			
fm.WriteChar("@")	9			
END;				
fm.WriteLine	3			
END;				
vw := TextViews.dir.New(md);	1			
Views.OpenView(vw)	0			
<hr/>				
Total	31			

	i	j	d.numRows	Text model
md := TextModels.dir.New();	1		3	@@@
fm.ConnectTo(md);	1			@@@
FOR i := 1 TO d.numRows DO	4			@@@
FOR j := 1 TO d.numRows DO	12			
fm.WriteChar("@")	9			
END;				
fm.WriteLine	3			
END;				
vw := TextViews.dir.New(md);	1			
Views.OpenView(vw)	1			
<hr/>				
Total	32			

Statement	d.numRows = 0	d.numRows = 3	d.numRows = n
(1)	1	1	1
(2)	1	1	1
(3)	1	4	$n + 1$
(4)	0	12	$n(n + 1)$
(5)	0	9	n^2
(6)	0	3	n
(7)	1	1	1
(8)	1	1	1
Total:	5	32	$2n^2 + 3n + 5$

Figure 11.3

Statement execution count for the procedure DrawBox in Figure 11.2.

```
FOR i := 1 TO d.numRows DO
  FOR j := 1 TO i DO
    fm.WriteChar("@")
  END;
  fm.WriteLine
END;
```

Figure 11.4

An algorithm for printing a triangle of @ characters.

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO i DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total				0

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO i DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total			1	

	i	j	d.numRows	Text model
md := TextModels.dir.New();			3	
fm.ConnectTo(md);				
FOR i := 1 TO d.numRows DO				
FOR j := 1 TO i DO				
fm.WriteChar("@")				
END;				
fm.WriteLine				
END;				
vw := TextViews.dir.New(md);				
Views.OpenView(vw)				
<hr/>				
Total				2

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1		3	
fm.ConnectTo(md);	1				
■ FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO i DO	0				
fm.WriteChar("@")	0				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	3				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	1	3	
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO i DO	1				
fm.WriteChar("@")	0				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	4				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	1	3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO i DO	1				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 5

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1	2	3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO i DO	2				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	0				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	6				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	1		3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	1				
FOR j := 1 TO i DO	2				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 7

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2		3	@
fm.ConnectTo(md);	1				
■ FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	2				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	8				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	1	3	@
fm.ConnectTo(md);	1				
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	3				
fm.WriteChar("@")	1				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	9				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	1	3	@
fm.ConnectTo(md);	1				@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	3				
fm.WriteChar("@")	2				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 10

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	2	3	@
fm.ConnectTo(md);	1				@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	4				
fm.WriteChar("@")	2				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	11				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	2	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	4				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

12

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2	3	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	5				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	1				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	13				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	2		3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	2				
FOR j := 1 TO i DO	5				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

14

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3		3	@
fm.ConnectTo(md);	1				@@
■ FOR i := 1 TO d.numRows DO	3				
FOR j := 1 TO i DO	5				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	15				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	1	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	3				
FOR j := 1 TO i DO	6				
fm.WriteChar("@")	3				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	16				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	1	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	3				@
FOR j := 1 TO i DO	6				
fm.WriteChar("@")	4				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

17

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	2	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	3				@
FOR j := 1 TO i DO	7				
fm.WriteChar("@")	4				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	18				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	2	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	3				@@
FOR j := 1 TO i DO	7				
fm.WriteChar("@")	5				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

19

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	3	3	@
fm.ConnectTo(md);	1				@@
FOR i := 1 TO d.numRows DO	3				@@
FOR j := 1 TO i DO	8				
fm.WriteChar("@")	5				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 20

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	3	3	@
fm.ConnectTo(md);	1				@ @
FOR i := 1 TO d.numRows DO	3				@ @ @
FOR j := 1 TO i DO	8				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total

21

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3	4	3	@
fm.ConnectTo(md);	1				@ @
FOR i := 1 TO d.numRows DO	3				@ @ @
FOR j := 1 TO i DO	9				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	2				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	22				

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	3		3	@
fm.ConnectTo(md);	1				@ @
FOR i := 1 TO d.numRows DO	3				@ @ @
FOR j := 1 TO i DO	9				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	3				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				

Total 23

		i	j	d.numRows	Text model
md := TextModels.dir.New();	1	4		3	@
fm.ConnectTo(md);	1				@ @
■ FOR i := 1 TO d.numRows DO	4				@ @ @
FOR j := 1 TO i DO	9				
fm.WriteChar("@")	6				
END;					
fm.WriteLine	3				
END;					
vw := TextViews.dir.New(md);	0				
Views.OpenView(vw)	0				
<hr/>					
Total	24				

	i	j	d.numRows	Text model
md := TextModels.dir.New();	1		3	@
fm.ConnectTo(md);	1			@ @
FOR i := 1 TO d.numRows DO	4			@ @ @
FOR j := 1 TO i DO	9			
fm.WriteChar("@")	6			
END;				
fm.WriteLine	3			
END;				
vw := TextViews.dir.New(md);	1			
Views.OpenView(vw)	0			
<hr/>				
Total	25			

	i	j	d.numRows	Text model
md := TextModels.dir.New();	1		3	@
fm.ConnectTo(md);	1			@ @
FOR i := 1 TO d.numRows DO	4			@ @ @
FOR j := 1 TO i DO	9			
fm.WriteChar("@")	6			
END;				
fm.WriteLine	3			
END;				
vw := TextViews.dir.New(md);	1			
Views.OpenView(vw)	1			
<hr/>				
Total	26			

Statement	d.numRows = 0	d.numRows = 3	d.numRows = n
(1)	1	1	1
(2)	1	1	1
(3)	1	4	$n + 1$
(4)	0	$2 + 3 + 4$	$2 + 3 + 4 + \dots + (n + 1)$
(5)	0	$1 + 2 + 3$	$1 + 2 + 3 + \dots + n$
(6)	0	3	n
(7)	1	1	1
(8)	1	1	1

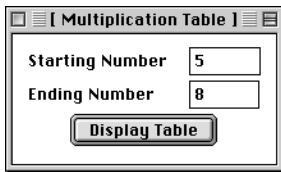
Figure 11.5

Counting individual statements for the algorithm to draw a triangle.

Statement	d.numRows = 0	d.numRows = 3	d.numRows = n
(1)	1	1	1
(2)	1	1	1
(3)	1	4	$n + 1$
(4)	0	9	$\frac{1}{2}n^2 + \frac{3}{2}n$
(5)	0	6	$\frac{1}{2}n^2 + \frac{1}{2}n$
(6)	0	3	n
(7)	1	1	1
(8)	1	1	1
Total:	5	26	$n^2 + 4n + 5$

Figure 11.6

Statement execution count for the algorithm to print a triangle.

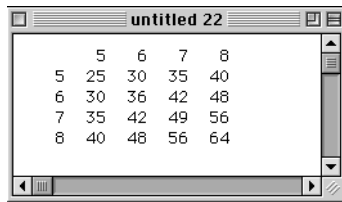


[Multiplication Table]

Starting Number

Ending Number

Display Table



	5	6	7	8
5	25	30	35	40
6	30	36	42	48
7	35	42	49	56
8	40	48	56	64

Figure 11.7

The input and output for a program that displays a multiplication table.

```
MODULE Pbox11B;
IMPORT Dialog, TextModels, TextViews, Views, PboxMappers;
VAR
  d*: RECORD
    startNum*, endNum*: INTEGER;
  END;

PROCEDURE MakeMultiplicationTable*;
VAR
  md: TextModels.Model;
  vw: TextViews.View;
  fm: PboxMappers.Formatter;
  i, j: INTEGER;
```

Figure 11.8

A program that produces the multiplication table shown in Figure 11.7.

```
BEGIN
  md := TextModels.dir.New();
  fm.ConnectTo(md);
  FOR j := 1 TO 4 DO
    fm.WriteChar(TextModels.digitspace)
  END;
  FOR j := d.startNum TO d.endNum DO
    fm.WriteLine(j, 4)
  END;
  fm.WriteLine;
  FOR i := d.startNum TO d.endNum DO
    fm.WriteLine(i, 4);
    FOR j := d.startNum TO d.endNum DO
      fm.WriteLine(i * j, 4)
    END;
    fm.WriteLine
  END;
  vw := TextViews.dir.New(md);
  Views.OpenView(vw)
END MakeMultiplicationTable;
```

```
BEGIN
  d.startNum := 0; d.endNum := 0
END Pbox11B.
```
