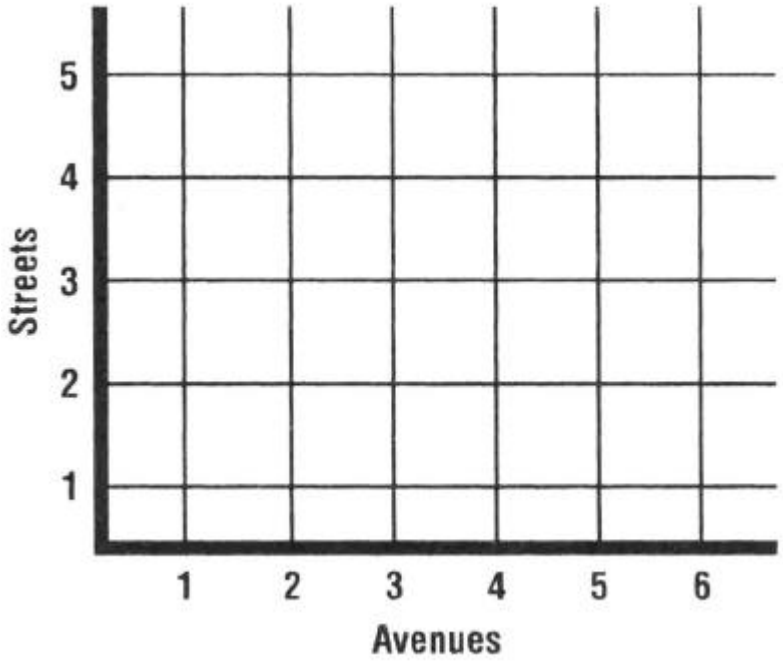
Karel the Robot

1. **Nicolas Wirth ... “Algorithms + Data Structures => Programs”**
   - **deal with each separately ... algorithms first**
   - **algorithm ... “a finite set of unambiguous, executable instructions that will ultimately terminate if followed”**

2. **Concept of Karel... a language ... similar to standard procedural programming languages like Pascal, C , or BASIC**
   - **no data ... just algorithms**
   - **invented for teaching purposes ... has the essential elements of a commericial language … but its fun**

3. **Karel’s World**
   - **streets and avenues**



- **walls**

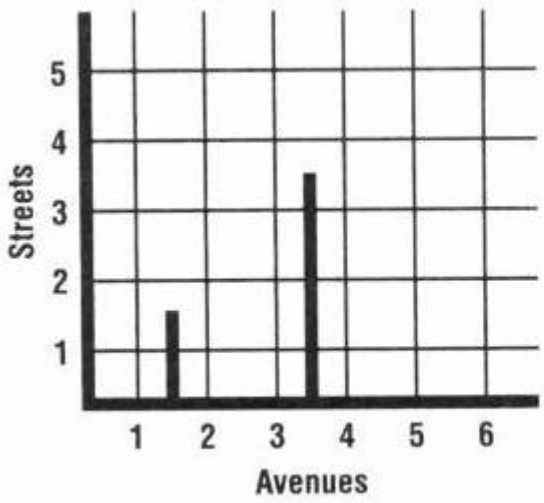


Fig. A: North/South Wall Segments

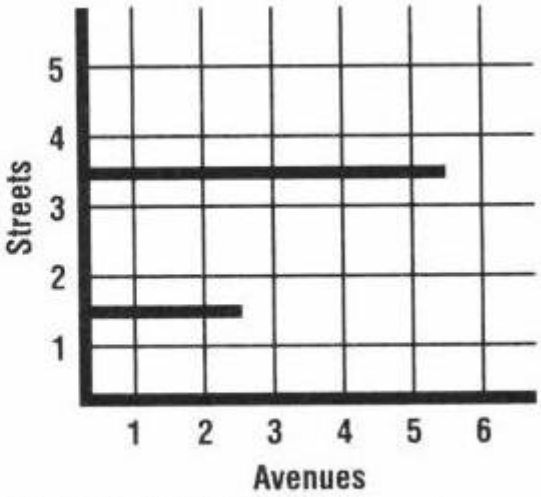
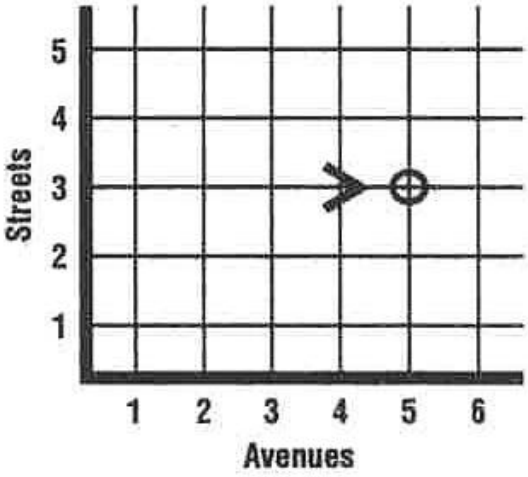
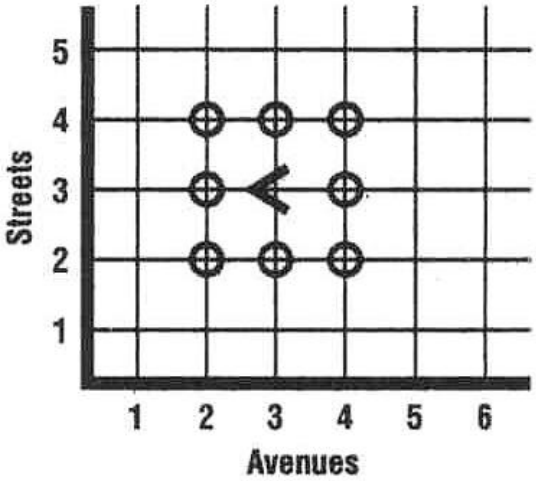


Fig. C: East/West Wall Segments

- **beepers**





- **the beeper bag … used to store beepers … may be filled at start of program**

- **navigating in the world ... doing tasks given by the Robot Master (the program)**

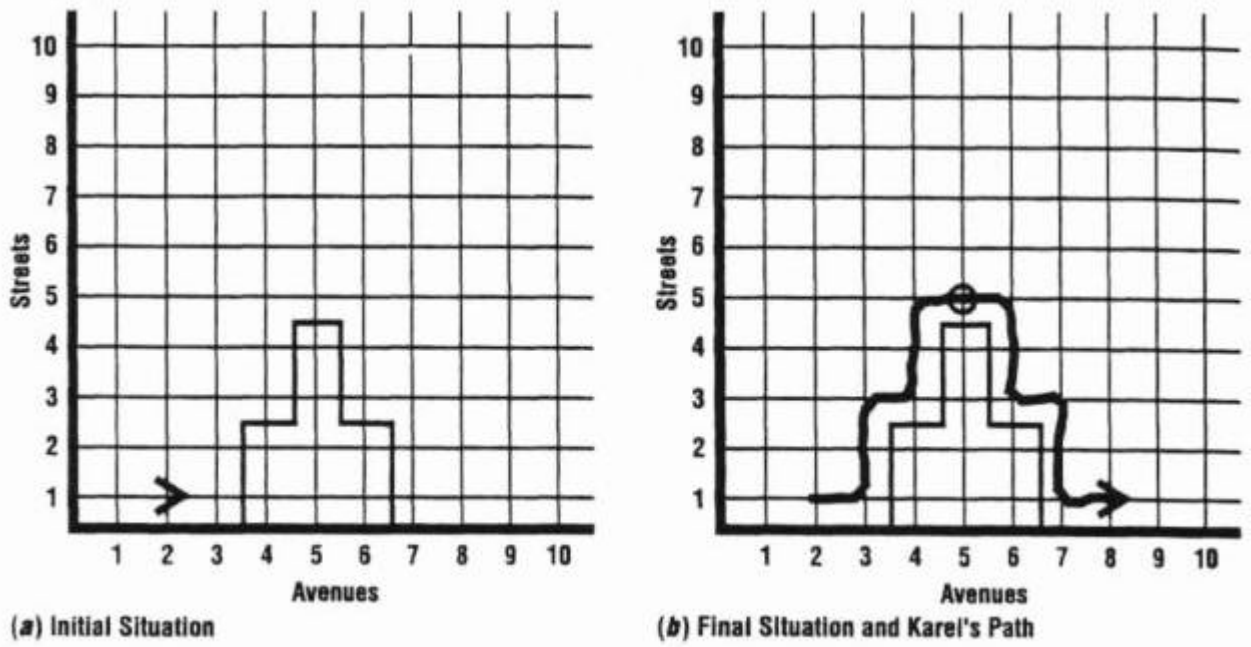


Figure 2–8 The Mountain-Climbing Task

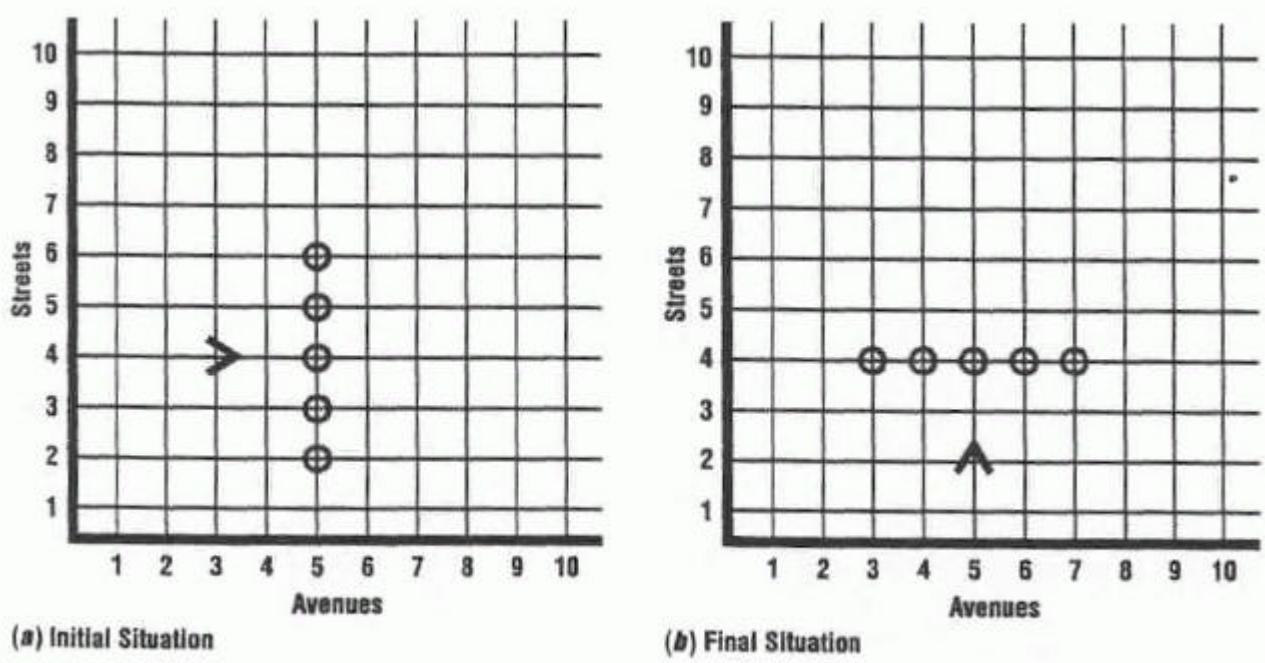


Figure 2–10 The Rearrange the Beepers Task

5. **Karel's Capability to Act ... primitive actions**
   - **Move;**
   - **TurnLeft;**
   - **PickBeeper;**
   - **PutBeeper;**
   - **TurnOff;**

6. **Karel's Capability of Sensing the Environment (Sensory Perceptions) … these are Karel's "tests"**
   - **Radar (Echo Locator)**
     - **front-is-clear/blocked, left-is-clear/blocked, right-is-clear/blocked**
   - **Hearing (Microphone)**
     - **next-to-a-beeper, not-next-to-a-beeper**
   - **Sensor Arm**
     - **any-beepers-in-beeper-bag, no-beepers-in-beeper-bag**
   - **Direction (Compass)**
     - **facing-north, facing-south, facing-east, facing-west**
     - **not-facing-north, not-facing-south, not-facing-east, not-facing-west**

7. **Karel's Capability of Making Decisions**

   IF <TEST> THEN <ACTION 1> ELSE <ACTION 2>;

   <TEST> ***is one of the boolean "tests" in item 6 above.***

8. **Karel's Capability to Do Repetitive Things ... like a good Robot should**
   - **ITERATE N TIMES <ACTION>;**

- **WHILE <TEST> DO <ACTION>;**

9. **Karel's Capability to Learn New Actions**
   - **DEFINE-NEW-INSTRUCTION <NAME> AS <ACTION>;**

10. **Karel's Capability to do Complex Tasks**
    - **BEGIN ... END;**

11. **Karel has a specific program structure as follows:**

```
BEGINNING-OF-PROGRAM

    DEFINE-NEW-INSTRUCTION <name1> AS
        BEGIN
            <instruction 1>;
            <instruction 2>;
            ...
            <instruction n>;
        END;

    DEFINE-NEW-INSTRUCTION <name2> AS
        BEGIN
            <instruction 1>;
            <instruction 2>;
            ...
            <instruction n>;
        END;

    BEGINNING-OF-EXECUTION
        <instruction 1>;
        ...
        ...
        <instruction n>;
    END-OF-EXECUTION

END-OF-PROGRAM
```

12. **Karel Programming**
    - **Similar to DRC … write program in an editor. Execute in a simulator.**
    - **Karel has hearing only (can't read) and therefore can't distinguish upper case, lower case letters**
    - **Karel needs a semi-colon to terminate instructions (;).**
    - **Karel is a very formal robot ... needs a specific structure to the programs**
    - **Karel's syntax is very exact! It permits no errors.**
    - **To make programs more readable to humans, we:**
        - **skip spaces, and**
        - **indent**

13. **An example of a Karel problem. Karel is on 2nd Street and 2nd Avenue facing east. On the corner of 5th Street and 4th Avenue is a beeper. Karel's job is to get the beeper and move it two blocks east and 3 blocks north.**
14. **Steps in the solution**
    - **Sketch the initial situation**
    - **Sketch the solution**
    - **Get the main idea … algorithm … "walk it through" with a partner or on paper**
    - **Write the program**
    - **Test the program**
    - **Fix errors**
    - **Repeat the "test and fix" until the program works correctly.**

15. **We are using a new simulator from Otterbein College. The link is at:**

- http://math.otterbein.edu/Class/Csc100/Karel/web/Karel/karel.htm
- **The link has a reasonably good tutorial.**
- **The new simulator introduces two changes in the syntax of Karel**
  - ***BEGIN / END is used to "block structure" the action in:***
    - → ***IF <test>***

      THEN BEGIN <action1>END

      ELSE BEGIN <action2> END;
    - → ***ITERATE N TIMES BEGIN <action>END;***
    - → ***WHILE <test> DO BEGIN <action> END;***
    - → ***DEFINE-NEW-INSTRUCTION <name> AS***

      BEGIN <actions> END;
  - ***Statements are terminated with a semi-colon (;) not separated by a semicolon. This is a change from the version in the standard Karel textbook and is being done because of a new simulator we are using. It corresponds to the structure of C/Java rather than Pascal.***

BNF for Karel

BNF is the Backus-Naur Form of describing a programming language

::= this symbol is called a *production.* Each definition in BNF is called a *production*.

< > words within the angle braces are names of objects

| a symbol which represents alternative choices

[ ] anything within square braces is repeated 0 or more times

```
program ::=      BEGINNING-OF-PROGRAM
                     [<new-instruction>]
                     BEGINNING-OF-EXECUTION
                          <instruction> [<instruction>]
                     END-OF-EXECUTION
                 END-OF-PROGRAM

<new-instruction>  ::=  DEFINE-NEW-INSTRUCTION <name> AS
                                BEGIN <instruction> END ;

<instruction> ::= <primitive> | <conditional> | <repeat>

<primitive>   ::=   move; | turnleft; | pickbeeper; | putbeeper; | turnoff;

<conditional>   ::=     IF <test > THEN BEGIN <instruction> END
                            ELSE BEGIN <instruction> END;      |
                        IF <test > THEN BEGIN<instruction>END;

<repeat>   ::=     WHILE <test > DO BEGIN <instruction> END;     |
                   ITERATE <integer> TIMES BEGIN <instruction> END;

<test>  ::=   <side>-is-clear | <side>-is-blocked | next-to-a-beeper |
                   not-next to a beeper | facing-<direction>  |
                   not-facing-<direction> | any-beepers-in-beeper-bag |
                   no-beepers-in-beeper-bag
```

<side> ::= front | left | right

<direction> ::= north | south | east | west

<name> ::= <letter> [<character>]

<letter> ::= a..z | A..Z

<character> ::= <letter> | <digit> | -

<digit> ::= 0..9

<integer> ::= <digit> [<digit>] // practical limit of 5 digits

Karel Programming Summary

Primitive Instructions

- move;
- turnleft;
- pickbeeper;
- putbeeper;
- turnoff;

Conditional Instructions

- IF <test>
  THEN BEGIN <actions> END;
- IF <test>
  THEN BEGIN <actions1> END
  ELSE BEGIN <actions2> END;

Repetition Instructions

- ITERATE N TIMES BEGIN <actions> END;
- WHILE <test> DO BEGIN <actions> END;

Mechanism for Block Structuring

- BEGIN <actions> END;

Mechanism for Defining a New Instruction

- DEFINE-NEW-INSTRUCTION <name> AS
  BEGIN <actions> END;

Program Structure

```
BEGINNING-OF-PROGRAM

     DEFINE-NEW-INSTRUCTION <name> AS
          BEGIN <actions> END;
     DEFINE-NEW-INSTRUCTION <name> AS
          BEGIN <actions> END;
     …
     DEFINE-NEW-INSTRUCTION <name> AS
          BEGIN <actions> END;

     BEGINNING-OF-EXECUTION
          <instruction>
          <instruction>
          …
          <instruction>
     END-OF-EXECUTION

END-OF-PROGRAM
```

Tests

- front-is-clear, front-is-blocked, left-is-clear, left-is-blocked, right-is-clear, right-is-blocked
- next-to-a-beeper, not-next-to-a-beeper
- any-beepers-in-beeper-bag, no-beepers-in-beeper-bag
- facing-north, not-facing-north, facing-south, not-facing-south, facing-east, not-facing-east, facing-west, not-facing-west