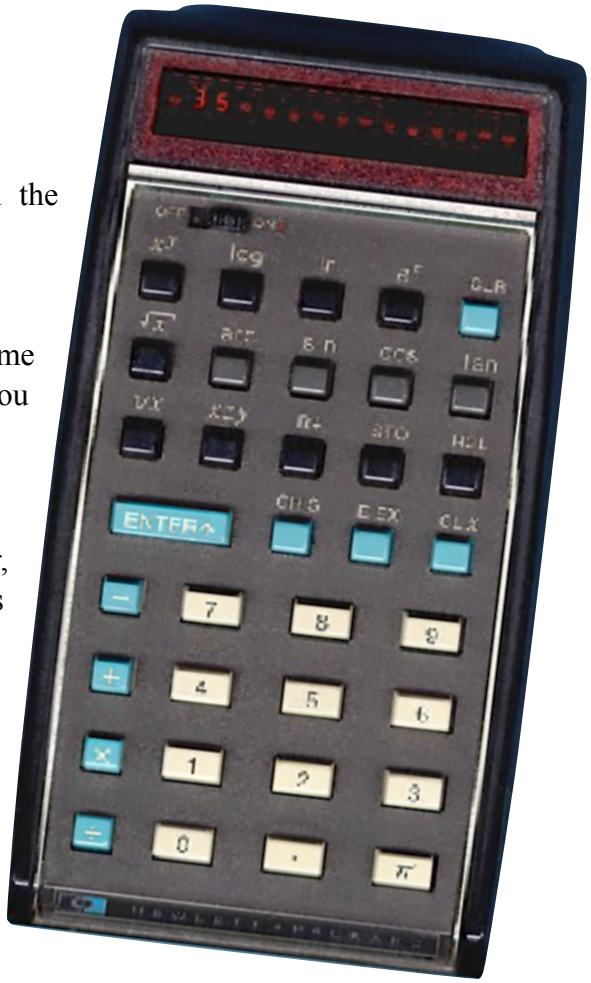
Prac 3: HP-35



Task

Write a program to emulate calculations performed on the HP-35 calculator.

Automatic Testing

This task is available for automatic testing using the name **`hp-35`**. You can run the demo using **`demo hp-35`** and you can test your work using **`try hp-35 <<filename>>`**.

Background

The HP-35 was the first scientific hand-held calculator, released in 1972 and an immediate success with engineers and scientists. Amongst other features, it used an unusual way of entering numbers, called RPN. RPN (reverse Polish notation, named for Polish mathematician Jan Lukasiewicz) allows complex calculations to be entered without the use of parentheses. The key difference is that operators are entered *after* the operands, rather than between them

The HP-35 implemented RPN using a stack of 4 registers, referred to as X, Y , Z, and T. The value in the X register is the one shown on the calculator's LED display; the other registers are used for temporary values during calculations. New values are entered into the X register, with existing values "pushed" up the register stack: the old value of X goes into Y, the old value of Y goes into Z, the old value of Z goes into T, and the old value of T is lost.

Single-operand functions (such as square root) use and replace the value in the X register; other registers are unchanged. Functions that operate on 2 values (such as the arithmetic operators) use the values in Y and X, with the result going back into X. Values in the Z and T registers are "dropped" down the stack, with Z overwriting the old Y and T overwriting the old Z. The value of T is preserved, providing a simple way to do calculations with repeated values.

This scheme allows calculations to be entered without using parentheses. For example, you could compute the compound expression (5 + 4)/(3 - 2) like this:

```
5 ENTER 4 + 3 ENTER 2 - ÷
```

Hints

You'll need to define the class **`HPStack`** to represent the calculator's operand stack, with operations such as **`push`** (push all values up 1 level and store a value into X), **`pop`** (drop all values down 1 level and return the old X value), and **`peek`** (return the current X value). The simplest approach is to use an array to store the register values, with the methods manipulating the array elements.

The calculator should read and process tokens representing numbers and operator keys, with the current value of the X register displayed after processing each line. It should exit when all lines of input have been processed.

A suitable **main** function will contain code such as this:

```
HPStack stack;
string line;
while (getline(cin, line)) {
  stringstream expression(line);
  string token;
  while (expression >> token) {
    if (isdigit(token[0])) {
      stack.push(atof(token.data()));
    } else if (token == "+") {  // other arithmetic ops similar
      double x = stack.pop();
      double y = stack.pop();
      stack.push(y + x);
    }
  }
  cout << stack.peek();
}
```

Level 1: Basic

Implement the arithmetic operations so that the calculator can compute basic expressions:

```
5 4 + 3 2 - /              // should be 9
3 4 5 6 + + +              // should be 18
1.23 4.5 67 / *            // should be 0.0826119
```

Level 2: Scientific

Implement π (**pi**) and the functions **chs** (change the sign of X), 1/x (**recip**), **log** (decimal logarithm), **ln** (natural logarithm), e^x (**exp**), √x (**sqrt**), **sin**, **cos**, **tan** (and their inverses **arcsin**, **arccos**, and **arctan**), and x^y (**pow**). The function names should be accepted in either upper or lower case. Use the functions in the **cmath** library to do the actual work! The predefined constant **M_PI** contains the value of pi.

```
PI 2 / SIN                 // should be 1 (or very close)
100 100 * sqrt             // should be 100
1E-5 LOG CHS               // should be 5
5 EXP LN                   // should be 5
3 recip 8 pow              // should be 2
2 1 arctan cos pow         // should be 0.5
```

Level 3: Memory

Implement **STO** (store X into memory) and **RCL** (recall from memory into X, pushing other values up), **CLR** (set all registers to 0), and **CLx** (drop the X value).

```
100 sto 2 * rcl /          // should be 2
1 2 clx 3 +                // should be 4
1 2 3 4 clr + + +          // should be 0
```

Level 4: Stack Control

Implement x⇄y (**swap** X and Y), R↓ (**roll** the stack down, with each register moved into the register below it and X moved into T), and **ENTER**↑ (push all values up the stack, preserving X and losing T). (Note that this interpretation of ENTER is not identical to that on the original calculator, where it is also used to separate consecutive numbers).

```
2 8 swap /                 // should be 4
1 2 3 4                    // should be 4
roll roll                  // now 2
roll roll                  // back to 4
2 enter enter enter        // 2
+ + + +                    // 10
```