```lua
-- Week 3, Activity 05
-- Empty statements
--
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local lpeg = require "lpeg"
local pt = require "pt"
local loc = lpeg.locale()


--------------------------------------------------------------------------------
-- FRONTEND: PARSER
-- Our frontend is a parser that gets a source code as input and produces an
-- intermediate representation of the program (an AST)
--------------------------------------------------------------------------------

------------------------------ Initial patterns: -------------------------------

-- White spaces and "end of subject"
local spc = loc.space^0
local eos = -lpeg.P(1)

-- Basic identifiers
local alpha = lpeg.R("az", "AZ", "__")
local digit = loc.digit
local alphanum = alpha + digit
local dot = lpeg.P(".")
local ID = lpeg.C(alpha * alphanum^0) * spc

-- Numeric constants
local sign = lpeg.S("+-")
local hexpre = lpeg.P("0") * lpeg.S("Xx")
local hexdig = lpeg.R("AF", "af", "09")
local hexdec = hexpre * hexdig^1 * spc
local expSym = lpeg.S("Ee")
local sufEXP = (expSym * sign^-1 * digit^1)^-1 * spc
local decimal = ((digit^1 * dot^-1 * digit^0) + (dot^-1 * digit^1)) * sufEXP * spc

-- Punctuators:
local OP = lpeg.P("(") * spc
local CP = lpeg.P(")") * spc
local OB = lpeg.P("{") * spc
local CB = lpeg.P("}") * spc
local SC = lpeg.P(";") * spc

-- Numeric operators (binary and unary)
local opPot = lpeg.C(lpeg.P("^")) * spc
local opMul = lpeg.C(lpeg.S("*/%")) * spc
local opAdd = lpeg.C(lpeg.S("+-")) * spc
local opUnaMin = lpeg.P("-") * spc
local opUnaPlus = lpeg.P("+") * spc

-- Relational and equality operators
local lt = lpeg.C(lpeg.P("<")) * spc
local lte = lpeg.C(lpeg.P("<=")) * spc
local gt = lpeg.C(lpeg.P(">")) * spc
local gte = lpeg.C(lpeg.P(">=")) * spc
local eq = lpeg.C(lpeg.P("==")) * spc
local neq = lpeg.C(lpeg.P("!=")) * spc
local opRel = (lte + gte + lt + gt + eq + neq) * spc
```

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-- Assignments for statements
local Assign = lpeg.P("=") * spc

--------------------------- Functions for the Parser: --------------------------

-- Function to get a number and return a node for an AST represeenting a number:
local function nodeNum(numero)
   return { tag = "numero",
            val = numero }
end

-- Function to get a variable and return a node for as AST
local function nodeVar(var)
   return { tag = "variable",
            var = var }
end

-- Function to get an assignment and return a node for AST
local function nodeAssign(id, exp)
   return { tag = "assign",
            id = id,
            exp = exp }
end

-- Function to get a statement and, optionally, a list of statements,
-- and return a note for AST:
local function nodeSeq(st1, st2)
   if st2 == nil then
      return st1
   else
      return { tag = "seq",
               st1 = st1,
               st2 = st2 }
   end
end

-- Function to treat an empty block:
local function nodeNull()
   return { tag = "nothing" }
end

-- Functions to fold a list and convert the list to an AST:
--  input: list: {n1, "+", n2, "+", n3, ...}
--  output: AST: {...{ op = "+", e1 = {op = "+", e1 = n1, e2 = n2}, e2 = n3}...}

-- foldBinEsq = operators with left-associativity
local function foldBinEsq(list)
   local tree = list[1]
   for i = 2, #list, 2 do
      tree = { tag = "binop",
               esq = tree,
               op = list[i],
               dir = list[i + 1] }
   end
   return tree
end

-- foldBinDir = operator with right-associativity
local function foldBinDir(list)
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   local tree = list[#list]
   for i = #list - 1, 2, -2 do
      tree = { tag = "binop",
               esq = list[i - 1],
               op = list[i],
               dir = tree }
   end
   return tree
end

-- foldUnaMinus = unary minus
local function foldUnaMin(numero)
   return { tag = "menos_unario" , op = numero }
end

-- foldUnaPlus = unary plus
local function foldUnaPlus(numero)
   return { tag = "mais_unario", op = numero }
end

-------------------- Our grammar for mathematic expression: --------------------

local numero = spc * ((hexdec / tonumber) + (decimal / tonumber)) / nodeNum * spc
local var = ID / nodeVar               -- variables
local stat = lpeg.V"stat"              -- a statement
local stats = lpeg.V"stats"            -- a list of statements
local block = lpeg.V"block"            -- a block of code
local primary = lpeg.V"primary"        -- primary (for recursion and parenthesis)
local pot = lpeg.V"pot"                -- exponentials
local unarymp = lpeg.V"unarymp"        -- unary minus or unary plus
local term = lpeg.V"term"              -- multiplicative expressions
local exp = lpeg.V"exp"                -- aditive expressions
local rel = lpeg.V"rel"                -- relational expressions

grammar = lpeg.P{"stats",
   stats = stat * (SC * stats)^-1 / nodeSeq,
   block = OB * stats * SC^-1 * CB + OB * SC^-1 * CB / nodeNull,
   stat = block + ID * Assign * rel / nodeAssign + rel,
   primary = spc * numero + OP * rel * CP + var,
   pot = lpeg.Ct(spc * primary * (opPot * primary)^0) / foldBinDir,
   unarymp = (opUnaMin * unarymp / foldUnaMin) +
             (opUnaPlus * unarymp / foldUnaPlus) + pot,
   term = lpeg.Ct(spc * unarymp * (opMul * unarymp)^0) / foldBinEsq,
   exp = lpeg.Ct(spc * term * (opAdd * term)^0) / foldBinEsq,
   rel = lpeg.Ct(spc * exp * (opRel * exp)^0) / foldBinEsq
}
grammar = spc * grammar * eos

---------------------------------- The parser per si: --------------------------
local function parse(input)
   return grammar:match(input)
end


--------------------------------------------------------------------------------
-- BACKEND: CODE GENERATOR
-- Our backend is a code generator that get's an AST and generate the final
-- output of the compiler
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-- Function to add opcodes:
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local function addCode(state, op)
   local code = state.code
   code[#code + 1] = op
end

-- Operators:
local ops = {["+"] = "add", ["-"] = "sub",
             ["*"] = "mul", ["/"] = "div", ["%"] = "rem",
             ["^"] = "exp",
             ["<="] = "lte", [">="] = "gte", ["=="] = "eq", ["!="] = "ne",
             [">"] = "gt", ["<"] = "lt"}

-- Function to specify the operations by type (tag) of node:
local function codeExp(state, ast)
   if ast.tag == "numero" then
      addCode(state, "push")
      addCode(state, ast.val)
   elseif ast.tag == "variable" then
      addCode(state, "load")
      addCode(state, ast.var)
   elseif ast.tag == "binop" then
      codeExp(state, ast.esq)
      codeExp(state, ast.dir)
      addCode(state, ops[ast.op])
   elseif ast.tag == "menos_unario" then
      codeExp(state, ast.op)
      addCode(state, "inverter")
   elseif ast.tag == "mais_unario" then
      codeExp(state, ast.op)
      addCode(state, "manter")
   else
      error("invalid tree")
   end
end

-- Function to assign expressions to variables:
local function codeStat(state, ast)
   if ast.tag == "assign" then
      codeExp(state, ast.exp)  -- evaluates the expression to get the value assign
ed
      addCode(state, "store")
      addCode(state, ast.id)
   elseif ast.tag == "seq" then
      codeStat(state, ast.st1)
      codeStat(state, ast.st2)
   elseif ast.tag == "nothing" then
      -- do nothing here
   else
      codeExp(state, ast)
      --error("invalid tree")
   end
end

-- The compiler per si:
local function compile(ast)
   local state = { code = {} }
   codeStat(state, ast)
   return state.code
end
```

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-------------------------------------------------------------------------------
-- INTERPRETER
-- Receives the intermediate code produced by the compiler and empty stack and,
-- when finished, leaves the result of the expression on the top of the stack.
-------------------------------------------------------------------------------
-- The interpreter:
local function run(code, mem, stack)
   local pc = 1                     -- program counter
   local top = 0                    -- top of stack
   while pc <= #code do
      if code[pc] == "push" then
         pc = pc + 1
         top = top + 1
         stack[top] = code[pc]
      elseif code[pc] == "add" then
         stack[top - 1] = stack[top - 1] + stack[top]
         top = top - 1
      elseif code[pc] == "sub" then
         stack[top - 1] = stack[top - 1] - stack[top]
         top = top - 1
      elseif code[pc] == "mul" then
         stack[top - 1] = stack[top - 1] * stack[top]
         top = top - 1
      elseif code[pc] == "div" then
         stack[top - 1] = stack[top - 1] / stack[top]
         top = top - 1
      elseif code[pc] == "rem" then
         stack[top - 1] = stack[top - 1] % stack[top]
         top = top - 1
      elseif code[pc] == "exp" then
         stack[top - 1] = stack[top - 1] ^ stack[top]
         top = top - 1
      elseif code[pc] == "gte" then
         stack[top - 1] = (stack[top - 1] >= stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "lte" then
         stack[top - 1] = (stack[top - 1] <= stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "gt" then
         stack[top - 1] = (stack[top - 1] > stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "lt" then
         stack[top - 1] = (stack[top - 1] < stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "eq" then
         stack[top - 1] = (stack[top - 1] == stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "ne" then
         stack[top - 1] = (stack[top - 1] ~= stack[top]) and 1 or 0
         top = top - 1
      elseif code[pc] == "inverter" then
         stack[top] = -stack[top]
      elseif code[pc] == "manter" then
         -- do nothing
      elseif code[pc] == "load" then
         pc = pc + 1
         local id = code[pc]
         top = top + 1
         stack[top] = mem[id]
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      elseif code[pc] == "store" then
         pc = pc + 1
         local id = code[pc]
         mem[id] = stack[top]
         top = top - 1
      else
         error("unknown instruction")
      end
      pc = pc + 1
   end
end


--------------------------------------------------------------------------------
-- RUN!
-- Let's read some source code and execute the interpreter!
--------------------------------------------------------------------------------

-- Get's the source code (only a number for now):
local input = io.read("a")

-- The frontend (parser) generates as AST:
local ast = parse(input)
print(pt.pt(ast))

-- The backend (code generator) compiles AST to intermediate code:
local code = compile(ast)
print(pt.pt(code))

-- We run the interpreter passing as arguments the
-- intermediate code, a memory for global variables, and the stack:
local stack = {}
local mem = {k0 = 0, k1 = 1, k10 = 10}  -- test variables
run(code, mem, stack)
print(stack[1])
print(mem.result)
```