GROUP 4
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GRAMMAR

```
statements  : NEWLINE* statement (NEWLINE+ statement)* NEWLINE*

statement          : KEYWORD:RETURN expr?
                                    : KEYWORD:CONTINUE
                                    : KEYWORD:BREAK
                                    : expr

expr        : KEYWORD:VAR IDENTIFIER EQ expr
            : comp-expr ((KEYWORD:AND|KEYWORD:OR) comp-expr)*

comp-expr   : NOT comp-expr
            : arith-expr ((EE|LT|GT|LTE|GTE) arith-expr)*

arith-expr  :     term ((PLUS|MINUS) term)*

term        : factor ((MUL|DIV) factor)*

factor      : (PLUS|MINUS) factor
            : power

power       : call (POW factor)*

call        : atom (LPAREN (expr (COMMA expr)*)? RPAREN)?

atom        : INT|FLOAT|STRING|IDENTIFIER
            : LPAREN expr RPAREN
            : list-expr
            : if-expr
            : for-expr
            : while-expr
            : func-def

list-expr   : LSQUARE (expr (COMMA expr)*)? RSQUARE

if-expr     : KEYWORD:IF expr KEYWORD:THEN
              (statement if-expr-b|if-expr-c?)
            | (NEWLINE statements KEYWORD:END|if-expr-b|if-expr-c)

if-expr-b   : KEYWORD:ELIF expr KEYWORD:THEN
              (statement if-expr-b|if-expr-c?)
            | (NEWLINE statements KEYWORD:END|if-expr-b|if-expr-c)
```

```
if-expr-c   : KEYWORD:ELSE
              statement
            | (NEWLINE statements KEYWORD:END)

for-expr    : KEYWORD:FOR IDENTIFIER EQ expr KEYWORD:TO expr
              (KEYWORD:STEP expr)? KEYWORD:THEN
              statement
            | (NEWLINE statements KEYWORD:END)

while-expr  : KEYWORD:WHILE expr KEYWORD:THEN
              statement
            | (NEWLINE statements KEYWORD:END)

func-def    : KEYWORD:FUN IDENTIFIER?
              LPAREN (IDENTIFIER (COMMA IDENTIFIER)*)? RPAREN
              (ARROW expr)
            | (NEWLINE statements KEYWORD:END)
```

SAMPLE CODE

```
# This is a very useful piece of software

FUN oopify(prefix) -> prefix + "oop"

FUN join(elements, separator)
      VAR result = ""
      VAR len = LEN(elements)

      FOR i = 0 TO len THEN
            VAR result = result + elements/i
            IF i != len - 1 THEN VAR result = result + separator
      END

      RETURN result
END

FUN map(elements, func)
      VAR new_elements = []

      FOR i = 0 TO LEN(elements) THEN
            APPEND(new_elements, func(elements/i))
      END

      RETURN new_elements
END

PRINT("Greetings universe!")

FOR i = 0 TO 5 THEN
```

```
      PRINT(join(map(["l", "sp"], oopify), ", "))
END
```

SCANNER SOURCE FILE

```
#######################################
# IMPORTS
#######################################

from strings_with_arrows import *

import string
import os
import math

#######################################
# CONSTANTS
#######################################

DIGITS = '0123456789'
LETTERS = string.ascii_letters
LETTERS_DIGITS = LETTERS + DIGITS

#######################################
# ERRORS
#######################################

class Error:
  def __init__(self, pos_start, pos_end, error_name, details):
    self.pos_start = pos_start
    self.pos_end = pos_end
    self.error_name = error_name
    self.details = details

  def as_string(self):
    result  = f'{self.error_name}: {self.details}\n'
    result += f'File {self.pos_start.fn}, line {self.pos_start.ln + 1}'
    result += '\n\n' + string_with_arrows(self.pos_start.ftxt, self.pos_start,
self.pos_end)
    return result

class IllegalCharError(Error):
  def __init__(self, pos_start, pos_end, details):
    super().__init__(pos_start, pos_end, 'Illegal Character', details)

  def __repr__(self):
    return f'{self.details}'
```

```
class ExpectedCharError(Error):
  def __init__(self, pos_start, pos_end, details):
    super().__init__(pos_start, pos_end, 'Expected Character', details)

  def __repr__(self):
    return f'{self.details}'

class InvalidSyntaxError(Error):
  def __init__(self, pos_start, pos_end, details=''):
    super().__init__(pos_start, pos_end, 'Invalid Syntax', details)

  def __repr__(self):
    return f'{self.details}'


class RTError(Error):
  def __init__(self, pos_start, pos_end, details, context):
    super().__init__(pos_start, pos_end, 'Runtime Error', details)
    self.context = context

  def __repr__(self):
    return f'{self.details}'

  def as_string(self):
    result  = self.generate_traceback()
    result += f'{self.error_name}: {self.details}'
    result += '\n\n' + string_with_arrows(self.pos_start.ftxt, self.pos_start,
self.pos_end)
    return result

  def generate_traceback(self):
    result = ''
    pos = self.pos_start
    ctx = self.context

    while ctx:
      result = f'  File {pos.fn}, line {str(pos.ln + 1)}, in
{ctx.display_name}\n' + result
      pos = ctx.parent_entry_pos
      ctx = ctx.parent

    return 'Traceback (most recent call last):\n' + result

#######################################
# POSITION
#######################################

class Position:
  def __init__(self, idx, ln, col, fn, ftxt):
```

```
    self.idx = idx
    self.ln = ln
    self.col = col
    self.fn = fn
    self.ftxt = ftxt

  def advance(self, current_char=None):
    self.idx += 1
    self.col += 1

    if current_char == '\n':
      self.ln += 1
      self.col = 0

    return self

  def copy(self):
    return Position(self.idx, self.ln, self.col, self.fn, self.ftxt)

#######################################
# TOKENS
#######################################

TT_INT        = 'INT'
TT_FLOAT      = 'FLOAT'
TT_STRING     = 'STRING'
TT_IDENTIFIER = 'IDENTIFIER'
TT_KEYWORD    = 'KEYWORD'
TT_PLUS       = 'PLUS'
TT_MINUS      = 'MINUS'
TT_MUL        = 'MUL'
TT_DIV        = 'DIV'
TT_POW        = 'POW'
TT_EQ         = 'EQ'
TT_LPAREN     = 'LPAREN'
TT_RPAREN     = 'RPAREN'
TT_LSQUARE    = 'LSQUARE'
TT_RSQUARE    = 'RSQUARE'
TT_EE         = 'EE'
TT_NE         = 'NE'
TT_LT         = 'LT'
TT_GT         = 'GT'
TT_LTE        = 'LTE'
TT_GTE        = 'GTE'
TT_COMMA      = 'COMMA'
TT_ARROW      = 'ARROW'
TT_NEWLINE    = 'NEWLINE'
TT_EOF        = 'EOF'
```

```
KEYWORDS = [
  'VAR',
  'AND',
  'OR',
  'NOT',
  'IF',
  'ELIF',
  'ELSE',
  'FOR',
  'TO',
  'STEP',
  'WHILE',
  'FUN',
  'THEN',
  'END',
  'RETURN',
  'CONTINUE',
  'BREAK',
]

class Token:
  def __init__(self, type_, value=None, pos_start=None, pos_end=None):
    self.type = type_
    self.value = value

    if pos_start:
      self.pos_start = pos_start.copy()
      self.pos_end = pos_start.copy()
      self.pos_end.advance()

    if pos_end:
      self.pos_end = pos_end.copy()

  def matches(self, type_, value):
    return self.type == type_ and self.value == value

  def __repr__(self):
    if self.value: return f'{self.type}:{self.value}'
    return f'{self.type}'

#######################################
# LEXER
#######################################

class Lexer:
  def __init__(self, fn, text):
    self.fn = fn
    self.text = text
    self.pos = Position(-1, 0, -1, fn, text)
```

```
    self.current_char = None
    self.advance()

  def advance(self):
    self.pos.advance(self.current_char)
    self.current_char = self.text[self.pos.idx] if self.pos.idx <
len(self.text) else None

  def make_tokens(self):
    tokens = []

    while self.current_char != None:
      if self.current_char in ' \t':
        self.advance()
      elif self.current_char == '#':
        self.skip_comment()
      elif self.current_char in ';\n':
        tokens.append(Token(TT_NEWLINE, pos_start=self.pos))
        self.advance()
      elif self.current_char in DIGITS:
        tokens.append(self.make_number())
      elif self.current_char in LETTERS:
        tokens.append(self.make_identifier())
      elif self.current_char == '"':
        tokens.append(self.make_string())
      elif self.current_char == '+':
        tokens.append(Token(TT_PLUS, pos_start=self.pos))
        self.advance()
      elif self.current_char == '-':
        tokens.append(self.make_minus_or_arrow())
      elif self.current_char == '*':
        tokens.append(Token(TT_MUL, pos_start=self.pos))
        self.advance()
      elif self.current_char == '/':
        tokens.append(Token(TT_DIV, pos_start=self.pos))
        self.advance()
      elif self.current_char == '^':
        tokens.append(Token(TT_POW, pos_start=self.pos))
        self.advance()
      elif self.current_char == '(':
        tokens.append(Token(TT_LPAREN, pos_start=self.pos))
        self.advance()
      elif self.current_char == ')':
        tokens.append(Token(TT_RPAREN, pos_start=self.pos))
        self.advance()
      elif self.current_char == '[':
        tokens.append(Token(TT_LSQUARE, pos_start=self.pos))
        self.advance()
      elif self.current_char == ']':
```

```
      tokens.append(Token(TT_RSQUARE, pos_start=self.pos))
      self.advance()
    elif self.current_char == '!':
      token, error = self.make_not_equals()
      if error: return [], error
      tokens.append(token)
    elif self.current_char == '=':
      tokens.append(self.make_equals())
    elif self.current_char == '<':
      tokens.append(self.make_less_than())
    elif self.current_char == '>':
      tokens.append(self.make_greater_than())
    elif self.current_char == ',':
      tokens.append(Token(TT_COMMA, pos_start=self.pos))
      self.advance()
    else:
      pos_start = self.pos.copy()
      char = self.current_char
      self.advance()
      return [], IllegalCharError(pos_start, self.pos, "'" + char + "'")

  tokens.append(Token(TT_EOF, pos_start=self.pos))
  return tokens, None

def make_number(self):
  num_str = ''
  dot_count = 0
  pos_start = self.pos.copy()

  while self.current_char != None and self.current_char in DIGITS + '.':
    if self.current_char == '.':
      if dot_count == 1: break
      dot_count += 1
    num_str += self.current_char
    self.advance()

  if dot_count == 0:
    return Token(TT_INT, int(num_str), pos_start, self.pos)
  else:
    return Token(TT_FLOAT, float(num_str), pos_start, self.pos)

def make_string(self):
  string = ''
  pos_start = self.pos.copy()
  escape_character = False
  self.advance()

  escape_characters = {
    'n': '\n',
```

```
      't': '\t'
    }

    while self.current_char != None and (self.current_char != '"' or
escape_character):
      if escape_character:
        string += escape_characters.get(self.current_char, self.current_char)
      else:
        if self.current_char == '\\':
          escape_character = True
        else:
          string += self.current_char
      self.advance()
      escape_character = False

    self.advance()
    return Token(TT_STRING, string, pos_start, self.pos)

  def make_identifier(self):
    id_str = ''
    pos_start = self.pos.copy()

    while self.current_char != None and self.current_char in LETTERS_DIGITS +
'_':
      id_str += self.current_char
      self.advance()

    tok_type = TT_KEYWORD if id_str in KEYWORDS else TT_IDENTIFIER
    return Token(tok_type, id_str, pos_start, self.pos)

  def make_minus_or_arrow(self):
    tok_type = TT_MINUS
    pos_start = self.pos.copy()
    self.advance()

    if self.current_char == '>':
      self.advance()
      tok_type = TT_ARROW

    return Token(tok_type, pos_start=pos_start, pos_end=self.pos)

  def make_not_equals(self):
    pos_start = self.pos.copy()
    self.advance()

    if self.current_char == '=':
      self.advance()
      return Token(TT_NE, pos_start=pos_start, pos_end=self.pos), None
```

```
    self.advance()
    return None, ExpectedCharError(pos_start, self.pos, "'=' (after '!')")

  def make_equals(self):
    tok_type = TT_EQ
    pos_start = self.pos.copy()
    self.advance()

    if self.current_char == '=':
      self.advance()
      tok_type = TT_EE

    return Token(tok_type, pos_start=pos_start, pos_end=self.pos)

  def make_less_than(self):
    tok_type = TT_LT
    pos_start = self.pos.copy()
    self.advance()

    if self.current_char == '=':
      self.advance()
      tok_type = TT_LTE

    return Token(tok_type, pos_start=pos_start, pos_end=self.pos)

  def make_greater_than(self):
    tok_type = TT_GT
    pos_start = self.pos.copy()
    self.advance()

    if self.current_char == '=':
      self.advance()
      tok_type = TT_GTE

    return Token(tok_type, pos_start=pos_start, pos_end=self.pos)

  def skip_comment(self):
    self.advance()

    while self.current_char != '\n':
      self.advance()

    self.advance()


def execute_run(fn):

    with open(fn, "r") as f:
      script = f.read()
```

```
    tokens, error = run(fn, script)

    return tokens, error


def run(fn, text):
  # Generate tokens
  lexer = Lexer(fn, text)
  tokens, error = lexer.make_tokens()
  if error: return None, error

  return tokens, error
```

RUN SCANNER SOURCE FILE

```
#---------------------------
#     MAIN SCANNER
#---------------------------

############################
#     IMPORTS
############################

import basic_scanner

while True:
      text = input('basic scanner> ')
      if text.strip() == "": continue

      if 'RUN' in text:
            fn = text.strip("(\"\")RUN")
            result, error = basic_scanner.execute_run(fn)
      else:
            result, error = basic_scanner.run('<stdin>', text)

      if error:
            print(error.as_string())
      elif result:
            print(repr(result))
```

:SCANNER OUTPUT ON SAMPLE CODE

PARSING STRATEGY DESCRIPTION

An LL parser (Left-to-right, leftmost derivation) is a top-down parser for a restricted context-free language. It parses the input from Left to right, performing Leftmost derivation of the sentence. An LL parser is called an LL(k) parser if it uses k tokens of lookahead when parsing a sentence.

The first L indicates that the input is read from left to right.

The second L says that it produces a left-to-right derivation.

And the 1 says that it uses one lookahead token

The parser needs to find a production to use for nonterminal N when it sees lookahead token t.

To select which production to use, it suffices to have a table that has, as a key, a pair (N, t) and gives the number of productions to use.

Justification:

LL1 parsing saves work, avoiding construction of errors. It allows for consistency-checking of the grammar and automatic error-detection and possibly recovery in the resulting parser

PARSER SOURCE FILE

```
########################################
# IMPORTS
########################################

from basic_scanner import *
```

```
#####################################
# NODES
#####################################

class NumberNode:
  def __init__(self, tok):
    self.tok = tok

    self.pos_start = self.tok.pos_start
    self.pos_end = self.tok.pos_end

  def __repr__(self):
    return f'{self.tok}'

class StringNode:
  def __init__(self, tok):
    self.tok = tok

    self.pos_start = self.tok.pos_start
    self.pos_end = self.tok.pos_end

  def __repr__(self):
    return f'{self.tok}'

class ListNode:
  def __init__(self, element_nodes, pos_start, pos_end):
    self.element_nodes = element_nodes

    self.pos_start = pos_start
    self.pos_end = pos_end

  def __repr__(self):
    return f'{self.element_nodes}'

class VarAccessNode:
  def __init__(self, var_name_tok):
    self.var_name_tok = var_name_tok

    self.pos_start = self.var_name_tok.pos_start
    self.pos_end = self.var_name_tok.pos_end

  def __repr__(self):
    return f'{self.var_name_tok}'

class VarAssignNode:
  def __init__(self, var_name_tok, value_node):
    self.var_name_tok = var_name_tok
    self.value_node = value_node
```

```
    self.pos_start = self.var_name_tok.pos_start
    self.pos_end = self.value_node.pos_end

  def __repr__(self):
    return f'{self.var_name_tok, self.value_node}'

class BinOpNode:
  def __init__(self, left_node, op_tok, right_node):
    self.left_node = left_node
    self.op_tok = op_tok
    self.right_node = right_node

    self.pos_start = self.left_node.pos_start
    self.pos_end = self.right_node.pos_end

  def __repr__(self):
    return f'({self.left_node}, {self.op_tok}, {self.right_node})'

class UnaryOpNode:
  def __init__(self, op_tok, node):
    self.op_tok = op_tok
    self.node = node

    self.pos_start = self.op_tok.pos_start
    self.pos_end = node.pos_end

  def __repr__(self):
    return f'({self.op_tok}, {self.node})'


class IfNode:
  def __init__(self, cases, else_case):
    self.cases = cases
    self.else_case = else_case

    self.pos_start = self.cases[0][0].pos_start
    self.pos_end = (self.else_case or self.cases[len(self.cases) -
1])[0].pos_end

  def __repr__(self):
    return f'({self.cases}, {self.else_case})'


class ForNode:
  def __init__(self, var_name_tok, start_value_node, end_value_node,
step_value_node, body_node, should_return_null):
    self.var_name_tok = var_name_tok
    self.start_value_node = start_value_node
    self.end_value_node = end_value_node
```

```
    self.step_value_node = step_value_node
    self.body_node = body_node
    self.should_return_null = should_return_null

    self.pos_start = self.var_name_tok.pos_start
    self.pos_end = self.body_node.pos_end

  def __repr__(self):
    return f'{self.var_name_tok, self.start_value_node,
self.end_value_node,self.step_value_node, self.body_node,
self.should_return_null}'


class WhileNode:
  def __init__(self, condition_node, body_node, should_return_null):
    self.condition_node = condition_node
    self.body_node = body_node
    self.should_return_null = should_return_null

    self.pos_start = self.condition_node.pos_start
    self.pos_end = self.body_node.pos_end

  def __repr__(self):
    return f'{self.condition_node, self.body_node, self.should_return_null}'


class FuncDefNode:
  def __init__(self, var_name_tok, arg_name_toks, body_node,
should_auto_return):
    self.var_name_tok = var_name_tok
    self.arg_name_toks = arg_name_toks
    self.body_node = body_node
    self.should_auto_return = should_auto_return

    if self.var_name_tok:
      self.pos_start = self.var_name_tok.pos_start
    elif len(self.arg_name_toks) > 0:
      self.pos_start = self.arg_name_toks[0].pos_start
    else:
      self.pos_start = self.body_node.pos_start

    self.pos_end = self.body_node.pos_end

  def __repr__(self):
    return f'{self.var_name_tok, self.arg_name_toks, self.body_node,
self.should_auto_return}'


class CallNode:
```

```
  def __init__(self, node_to_call, arg_nodes):
    self.node_to_call = node_to_call
    self.arg_nodes = arg_nodes

    self.pos_start = self.node_to_call.pos_start

    if len(self.arg_nodes) > 0:
      self.pos_end = self.arg_nodes[len(self.arg_nodes) - 1].pos_end
    else:
      self.pos_end = self.node_to_call.pos_end

  def __repr__(self):
    return f'{self.node_to_call, self.arg_nodes}'


class ReturnNode:
  def __init__(self, node_to_return, pos_start, pos_end):
    self.node_to_return = node_to_return

    self.pos_start = pos_start
    self.pos_end = pos_end

  def __repr__(self):
    return f'{self.node_to_return}'


class ContinueNode:
  def __init__(self, pos_start, pos_end):
    self.pos_start = pos_start
    self.pos_end = pos_end

class BreakNode:
  def __init__(self, pos_start, pos_end):
    self.pos_start = pos_start
    self.pos_end = pos_end


#######################################
# PARSE RESULT
#######################################

class ParseResult:
  def __init__(self):
    self.error = None
    self.node = None
    self.last_registered_advance_count = 0
    self.advance_count = 0
    self.to_reverse_count = 0
```

```
  def register_advancement(self):
    self.last_registered_advance_count = 1
    self.advance_count += 1

  def register(self, res):
    self.last_registered_advance_count = res.advance_count
    self.advance_count += res.advance_count
    if res.error: self.error = res.error
    return res.node

  def try_register(self, res):
    if res.error:
      self.to_reverse_count = res.advance_count
      return None
    return self.register(res)

  def success(self, node):
    self.node = node
    return self

  def failure(self, error):
    if not self.error or self.last_registered_advance_count == 0:
      self.error = error
    return self

#######################################
# PARSER
#######################################

class Parser:
  def __init__(self, tokens):
    self.tokens = tokens
    self.tok_idx = -1
    self.advance()

  def advance(self):
    self.tok_idx += 1
    self.update_current_tok()
    return self.current_tok

  def reverse(self, amount=1):
    self.tok_idx -= amount
    self.update_current_tok()
    return self.current_tok

  def update_current_tok(self):
    if self.tok_idx >= 0 and self.tok_idx < len(self.tokens):
      self.current_tok = self.tokens[self.tok_idx]
```

```
def parse(self):
  res = self.statements()
  if not res.error and self.current_tok.type != TT_EOF:
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      "Token cannot appear after previous tokens"
    ))
  return res

###################################

def statements(self):
  res = ParseResult()
  statements = []
  pos_start = self.current_tok.pos_start.copy()

  while self.current_tok.type == TT_NEWLINE:
    res.register_advancement()
    self.advance()

  statement = res.register(self.statement())
  if res.error: return res
  statements.append(statement)

  more_statements = True

  while True:
    newline_count = 0
    while self.current_tok.type == TT_NEWLINE:
      res.register_advancement()
      self.advance()
      newline_count += 1
    if newline_count == 0:
      more_statements = False

    if not more_statements: break
    statement = res.try_register(self.statement())
    if not statement:
      self.reverse(res.to_reverse_count)
      more_statements = False
      continue
    statements.append(statement)

  return res.success(ListNode(
    statements,
    pos_start,
    self.current_tok.pos_end.copy()
  ))
```

```
  def statement(self):
    res = ParseResult()
    pos_start = self.current_tok.pos_start.copy()

    if self.current_tok.matches(TT_KEYWORD, 'RETURN'):
      res.register_advancement()
      self.advance()

      expr = res.try_register(self.expr())
      if not expr:
        self.reverse(res.to_reverse_count)
      return res.success(ReturnNode(expr, pos_start,
self.current_tok.pos_start.copy()))

    if self.current_tok.matches(TT_KEYWORD, 'CONTINUE'):
      res.register_advancement()
      self.advance()
      return res.success(ContinueNode(pos_start,
self.current_tok.pos_start.copy()))

    if self.current_tok.matches(TT_KEYWORD, 'BREAK'):
      res.register_advancement()
      self.advance()
      return res.success(BreakNode(pos_start,
self.current_tok.pos_start.copy()))

    expr = res.register(self.expr())
    if res.error:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        "Expected 'RETURN', 'CONTINUE', 'BREAK', 'VAR', 'IF', 'FOR', 'WHILE',
'FUN', int, float, identifier, '+', '-', '(', '[' or 'NOT'"
      ))

    return res.success(expr)

  def expr(self):
    res = ParseResult()

    if self.current_tok.matches(TT_KEYWORD, 'VAR'):
      res.register_advancement()
      self.advance()

      if self.current_tok.type != TT_IDENTIFIER:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          "Expected identifier"
        ))
```

```
      var_name = self.current_tok
      res.register_advancement()
      self.advance()

      if self.current_tok.type != TT_EQ:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          "Expected '='"
        ))

      res.register_advancement()
      self.advance()
      expr = res.register(self.expr())
      if res.error: return res
      return res.success(VarAssignNode(var_name, expr))

    node = res.register(self.bin_op(self.comp_expr, ((TT_KEYWORD, 'AND'),
(TT_KEYWORD, 'OR'))))

    if res.error:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        "Expected 'VAR', 'IF', 'FOR', 'WHILE', 'FUN', int, float, identifier,
'+', '-', '(', '[' or 'NOT'"
      ))

    return res.success(node)

  def comp_expr(self):
    res = ParseResult()

    if self.current_tok.matches(TT_KEYWORD, 'NOT'):
      op_tok = self.current_tok
      res.register_advancement()
      self.advance()

      node = res.register(self.comp_expr())
      if res.error: return res
      return res.success(UnaryOpNode(op_tok, node))

    node = res.register(self.bin_op(self.arith_expr, (TT_EE, TT_NE, TT_LT,
TT_GT, TT_LTE, TT_GTE)))

    if res.error:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        "Expected int, float, identifier, '+', '-', '(', '[', 'IF', 'FOR',
'WHILE', 'FUN' or 'NOT'"
```

```
      ))

    return res.success(node)

  def arith_expr(self):
    return self.bin_op(self.term, (TT_PLUS, TT_MINUS))

  def term(self):
    return self.bin_op(self.factor, (TT_MUL, TT_DIV))

  def factor(self):
    res = ParseResult()
    tok = self.current_tok

    if tok.type in (TT_PLUS, TT_MINUS):
      res.register_advancement()
      self.advance()
      factor = res.register(self.factor())
      if res.error: return res
      return res.success(UnaryOpNode(tok, factor))

    return self.power()

  def power(self):
    return self.bin_op(self.call, (TT_POW, ), self.factor)

  def call(self):
    res = ParseResult()
    atom = res.register(self.atom())
    if res.error: return res

    if self.current_tok.type == TT_LPAREN:
      res.register_advancement()
      self.advance()
      arg_nodes = []

      if self.current_tok.type == TT_RPAREN:
        res.register_advancement()
        self.advance()
      else:
        arg_nodes.append(res.register(self.expr()))
        if res.error:
          return res.failure(InvalidSyntaxError(
            self.current_tok.pos_start, self.current_tok.pos_end,
            "Expected ')', 'VAR', 'IF', 'FOR', 'WHILE', 'FUN', int, float,
identifier, '+', '-', '(', '[' or 'NOT'"
          ))

        while self.current_tok.type == TT_COMMA:
```

```
        res.register_advancement()
        self.advance()

        arg_nodes.append(res.register(self.expr()))
        if res.error: return res

      if self.current_tok.type != TT_RPAREN:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          f"Expected ',' or ')'"
        ))

      res.register_advancement()
      self.advance()
    return res.success(CallNode(atom, arg_nodes))
  return res.success(atom)

def atom(self):
  res = ParseResult()
  tok = self.current_tok

  if tok.type in (TT_INT, TT_FLOAT):
    res.register_advancement()
    self.advance()
    return res.success(NumberNode(tok))

  elif tok.type == TT_STRING:
    res.register_advancement()
    self.advance()
    return res.success(StringNode(tok))

  elif tok.type == TT_IDENTIFIER:
    res.register_advancement()
    self.advance()
    return res.success(VarAccessNode(tok))

  elif tok.type == TT_LPAREN:
    res.register_advancement()
    self.advance()
    expr = res.register(self.expr())
    if res.error: return res
    if self.current_tok.type == TT_RPAREN:
      res.register_advancement()
      self.advance()
      return res.success(expr)
    else:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        "Expected ')'"
```

```
        ))

    elif tok.type == TT_LSQUARE:
      list_expr = res.register(self.list_expr())
      if res.error: return res
      return res.success(list_expr)

    elif tok.matches(TT_KEYWORD, 'IF'):
      if_expr = res.register(self.if_expr())
      if res.error: return res
      return res.success(if_expr)

    elif tok.matches(TT_KEYWORD, 'FOR'):
      for_expr = res.register(self.for_expr())
      if res.error: return res
      return res.success(for_expr)

    elif tok.matches(TT_KEYWORD, 'WHILE'):
      while_expr = res.register(self.while_expr())
      if res.error: return res
      return res.success(while_expr)

    elif tok.matches(TT_KEYWORD, 'FUN'):
      func_def = res.register(self.func_def())
      if res.error: return res
      return res.success(func_def)

    return res.failure(InvalidSyntaxError(
      tok.pos_start, tok.pos_end,
      "Expected int, float, identifier, '+', '-', '(', '[', IF', 'FOR',
'WHILE', 'FUN'"
    ))

  def list_expr(self):
    res = ParseResult()
    element_nodes = []
    pos_start = self.current_tok.pos_start.copy()

    if self.current_tok.type != TT_LSQUARE:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected '['"
      ))

    res.register_advancement()
    self.advance()

    if self.current_tok.type == TT_RSQUARE:
      res.register_advancement()
```

```
      self.advance()
    else:
      element_nodes.append(res.register(self.expr()))
      if res.error:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          "Expected ']', 'VAR', 'IF', 'FOR', 'WHILE', 'FUN', int, float,
identifier, '+', '-', '(', '[' or 'NOT'"
        ))

      while self.current_tok.type == TT_COMMA:
        res.register_advancement()
        self.advance()

        element_nodes.append(res.register(self.expr()))
        if res.error: return res

      if self.current_tok.type != TT_RSQUARE:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          f"Expected ',' or ']'"
        ))

      res.register_advancement()
      self.advance()

    return res.success(ListNode(
      element_nodes,
      pos_start,
      self.current_tok.pos_end.copy()
    ))

  def if_expr(self):
    res = ParseResult()
    all_cases = res.register(self.if_expr_cases('IF'))
    if res.error: return res
    cases, else_case = all_cases
    return res.success(IfNode(cases, else_case))

  def if_expr_b(self):
    return self.if_expr_cases('ELIF')

  def if_expr_c(self):
    res = ParseResult()
    else_case = None

    if self.current_tok.matches(TT_KEYWORD, 'ELSE'):
      res.register_advancement()
      self.advance()
```

```
    if self.current_tok.type == TT_NEWLINE:
      res.register_advancement()
      self.advance()

      statements = res.register(self.statements())
      if res.error: return res
      else_case = (statements, True)

      if self.current_tok.matches(TT_KEYWORD, 'END'):
        res.register_advancement()
        self.advance()
      else:
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          "Expected 'END'"
        ))
    else:
      expr = res.register(self.statement())
      if res.error: return res
      else_case = (expr, False)

  return res.success(else_case)

def if_expr_b_or_c(self):
  res = ParseResult()
  cases, else_case = [], None

  if self.current_tok.matches(TT_KEYWORD, 'ELIF'):
    all_cases = res.register(self.if_expr_b())
    if res.error: return res
    cases, else_case = all_cases
  else:
    else_case = res.register(self.if_expr_c())
    if res.error: return res

  return res.success((cases, else_case))

def if_expr_cases(self, case_keyword):
  res = ParseResult()
  cases = []
  else_case = None

  if not self.current_tok.matches(TT_KEYWORD, case_keyword):
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      f"Expected '{case_keyword}'"
    ))
```

```
    res.register_advancement()
    self.advance()

    condition = res.register(self.expr())
    if res.error: return res

    if not self.current_tok.matches(TT_KEYWORD, 'THEN'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'THEN'"
      ))

    res.register_advancement()
    self.advance()

    if self.current_tok.type == TT_NEWLINE:
      res.register_advancement()
      self.advance()

      statements = res.register(self.statements())
      if res.error: return res
      cases.append((condition, statements, True))

      if self.current_tok.matches(TT_KEYWORD, 'END'):
        res.register_advancement()
        self.advance()
      else:
        all_cases = res.register(self.if_expr_b_or_c())
        if res.error: return res
        new_cases, else_case = all_cases
        cases.extend(new_cases)
    else:
      expr = res.register(self.statement())
      if res.error: return res
      cases.append((condition, expr, False))

      all_cases = res.register(self.if_expr_b_or_c())
      if res.error: return res
      new_cases, else_case = all_cases
      cases.extend(new_cases)

    return res.success((cases, else_case))

  def for_expr(self):
    res = ParseResult()

    if not self.current_tok.matches(TT_KEYWORD, 'FOR'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
```

```
    f"Expected 'FOR'"
  ))

res.register_advancement()
self.advance()

if self.current_tok.type != TT_IDENTIFIER:
  return res.failure(InvalidSyntaxError(
    self.current_tok.pos_start, self.current_tok.pos_end,
    f"Expected identifier"
  ))

var_name = self.current_tok
res.register_advancement()
self.advance()

if self.current_tok.type != TT_EQ:
  return res.failure(InvalidSyntaxError(
    self.current_tok.pos_start, self.current_tok.pos_end,
    f"Expected '='"
  ))

res.register_advancement()
self.advance()

start_value = res.register(self.expr())
if res.error: return res

if not self.current_tok.matches(TT_KEYWORD, 'TO'):
  return res.failure(InvalidSyntaxError(
    self.current_tok.pos_start, self.current_tok.pos_end,
    f"Expected 'TO'"
  ))

res.register_advancement()
self.advance()

end_value = res.register(self.expr())
if res.error: return res

if self.current_tok.matches(TT_KEYWORD, 'STEP'):
  res.register_advancement()
  self.advance()

  step_value = res.register(self.expr())
  if res.error: return res
else:
  step_value = None
```

```
    if not self.current_tok.matches(TT_KEYWORD, 'THEN'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'THEN'"
      ))

    res.register_advancement()
    self.advance()

    if self.current_tok.type == TT_NEWLINE:
      res.register_advancement()
      self.advance()

      body = res.register(self.statements())
      if res.error: return res

      if not self.current_tok.matches(TT_KEYWORD, 'END'):
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          f"Expected 'END'"
        ))

      res.register_advancement()
      self.advance()

      return res.success(ForNode(var_name, start_value, end_value, step_value,
body, True))

    body = res.register(self.statement())
    if res.error: return res

    return res.success(ForNode(var_name, start_value, end_value, step_value,
body, False))

  def while_expr(self):
    res = ParseResult()

    if not self.current_tok.matches(TT_KEYWORD, 'WHILE'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'WHILE'"
      ))

    res.register_advancement()
    self.advance()

    condition = res.register(self.expr())
    if res.error: return res
```

```
    if not self.current_tok.matches(TT_KEYWORD, 'THEN'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'THEN'"
      ))

    res.register_advancement()
    self.advance()

    if self.current_tok.type == TT_NEWLINE:
      res.register_advancement()
      self.advance()

      body = res.register(self.statements())
      if res.error: return res

      if not self.current_tok.matches(TT_KEYWORD, 'END'):
        return res.failure(InvalidSyntaxError(
          self.current_tok.pos_start, self.current_tok.pos_end,
          f"Expected 'END'"
        ))

      res.register_advancement()
      self.advance()

      return res.success(WhileNode(condition, body, True))

    body = res.register(self.statement())
    if res.error: return res

    return res.success(WhileNode(condition, body, False))

  def func_def(self):
    res = ParseResult()

    if not self.current_tok.matches(TT_KEYWORD, 'FUN'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'FUN'"
      ))

    res.register_advancement()
    self.advance()

    if self.current_tok.type == TT_IDENTIFIER:
      var_name_tok = self.current_tok
      res.register_advancement()
      self.advance()
      if self.current_tok.type != TT_LPAREN:
```

```
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      f"Expected '('"
    ))
else:
  var_name_tok = None
  if self.current_tok.type != TT_LPAREN:
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      f"Expected identifier or '('"
    ))

res.register_advancement()
self.advance()
arg_name_toks = []

if self.current_tok.type == TT_IDENTIFIER:
  arg_name_toks.append(self.current_tok)
  res.register_advancement()
  self.advance()

  while self.current_tok.type == TT_COMMA:
    res.register_advancement()
    self.advance()

    if self.current_tok.type != TT_IDENTIFIER:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected identifier"
      ))

    arg_name_toks.append(self.current_tok)
    res.register_advancement()
    self.advance()

  if self.current_tok.type != TT_RPAREN:
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      f"Expected ',' or ')'"
    ))
else:
  if self.current_tok.type != TT_RPAREN:
    return res.failure(InvalidSyntaxError(
      self.current_tok.pos_start, self.current_tok.pos_end,
      f"Expected identifier or ')'"
    ))

res.register_advancement()
self.advance()
```

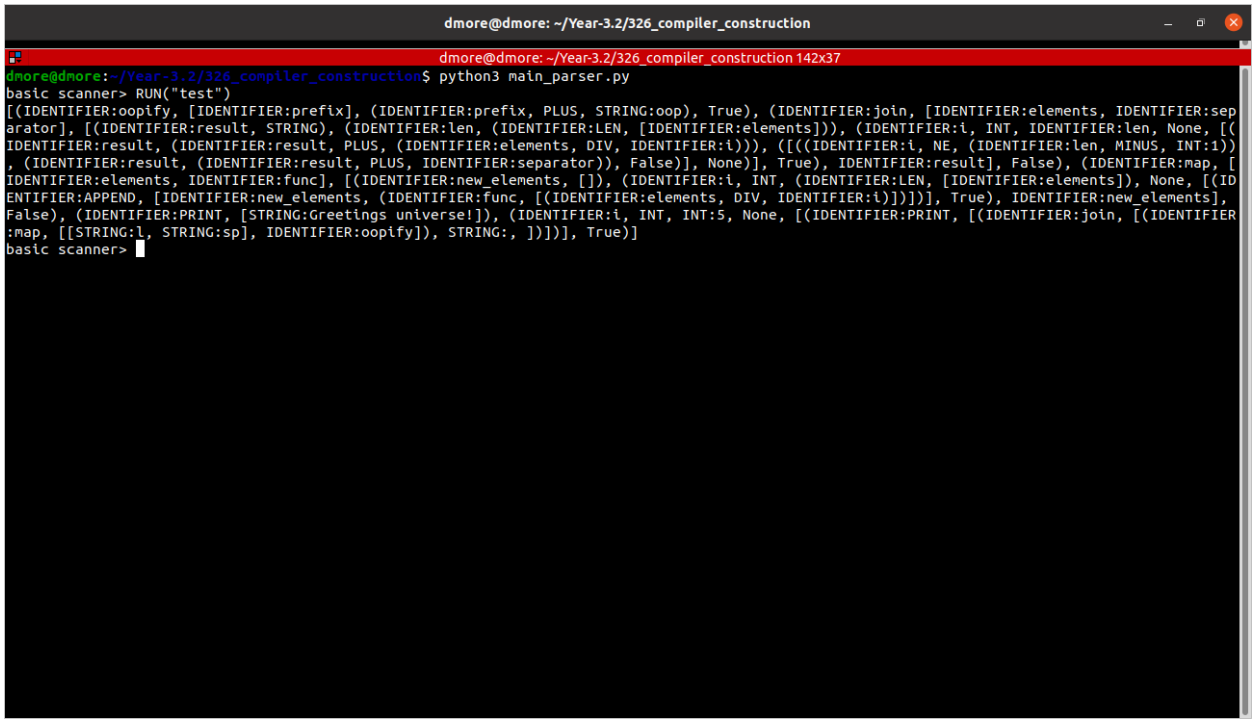
```
    if self.current_tok.type == TT_ARROW:
      res.register_advancement()
      self.advance()

      body = res.register(self.expr())
      if res.error: return res

      return res.success(FuncDefNode(
        var_name_tok,
        arg_name_toks,
        body,
        True
      ))

    if self.current_tok.type != TT_NEWLINE:
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected '->' or NEWLINE"
      ))

    res.register_advancement()
    self.advance()

    body = res.register(self.statements())
    if res.error: return res

    if not self.current_tok.matches(TT_KEYWORD, 'END'):
      return res.failure(InvalidSyntaxError(
        self.current_tok.pos_start, self.current_tok.pos_end,
        f"Expected 'END'"
      ))

    res.register_advancement()
    self.advance()

    return res.success(FuncDefNode(
      var_name_tok,
      arg_name_toks,
      body,
      False
    ))

  ###################################

  def bin_op(self, func_a, ops, func_b=None):
    if func_b == None:
      func_b = func_a
```

```
    res = ParseResult()
    left = res.register(func_a())
    if res.error: return res

    while self.current_tok.type in ops or (self.current_tok.type,
self.current_tok.value) in ops:
      op_tok = self.current_tok
      res.register_advancement()
      self.advance()
      right = res.register(func_b())
      if res.error: return res
      left = BinOpNode(left, op_tok, right)

    return res.success(left)


def execute_run(fn):

    with open(fn, "r") as f:
      script = f.read()

    ast = run(fn, script)

    return ast[0], ast[1]


def run(fn, text):
  # Generate tokens
  lexer = Lexer(fn, text)
  tokens, error = lexer.make_tokens()
  if error: return None, error

  # Generate AST
  parser = Parser(tokens)
  ast = parser.parse()
  if ast.error: return None, ast.error

  return ast.node, ast.error
```

RUN PARSER SOURCE FILE

```
#---------------------------
#     MAIN Parser
#---------------------------

############################
#     IMPORTS
############################

import basic_parser
```

```
while True:
	text = input('basic scanner> ')
	if text.strip() == "": continue

	if 'RUN' in text:
		fn = text.strip("(\"\")RUN")
		result, error = basic_parser.execute_run(fn)
	else:
		result, error = basic_parser.run('<stdin>', text)

	if error:
		print(error.as_string())
	elif result:
		print(repr(result))
```



:PARSER OUTPUT ON SAMPLE CODE