

| | | | |
|------|--------------------|---|---|
| [1] | <PROGRAM> | → | <IDENT><ENV><DATA><PROC> |
| [2] | <IDENT> | → | identification division <END_INST> program-id. ID<END_INST> author. <WORDS><END_INST> date-written. <WORDS><END_INST> |
| [3] | <WORDS> | → | ID <WORDS_LR> |
| [4] | <WORDS_LR> | → | ID <WORDS_LR> |
| [5] | | → | ε |
| [6] | <END_INST> | → | .\n |
| [7] | <ENV> | → | environment division<END_INST> configuration section<END_INST> source-computer. <WORDS><END_INST> object-computer. <WORDS><END_INST> |
| [8] | <DATA> | → | data division<END_INST> working-storage section<END_INST> <VAR_LIST> |
| [9] | <VAR_LIST> | → | <VAR_DECL> <VAR_LIST> |
| [10] | | → | ε |
| [11] | <VAR_DECL> | → | <LEVEL> ID pic IMAGE <VAR_DECL_TAIL> |
| [12] | <VAR_DECL_TAIL> | → | value INTEGER<END_INST> |
| [13] | | → | <END_INST> |
| [14] | <LEVEL> | → | INTEGER |
| [15] | <PROC> | → | procedure division<END_INST> ID section<END_INST> <LABELS> end program ID. |
| [16] | <LABELS> | → | <LABEL><END_INST> <INSTRUCTION_LIST> <LABELS_LR> |
| [17] | <LABELS_LR> | → | <LABEL><END_INST> <INSTRUCTION_LIST> <LABELS_LR> |
| [18] | | → | ε |
| [19] | <LABEL> | → | ID |
| [20] | <INSTRUCTION_LIST> | → | <INSTRUCTION> <INSTRUCTION_LIST> |
| [21] | | → | ε |
| [22] | <INSTRUCTION> | → | <ASSIGNATION> |
| [23] | | → | <IF> |
| [24] | | → | <CALL> |
| [25] | | → | <READ> |
| [26] | | → | <WRITE> |
| [27] | | → | stop run<END_INST> |
| [28] | <ASSIGNATION> | → | move <EXPRESSION> to ID<END_INST> |
| [29] | | → | compute ID = <EXPRESSION><END_INST> |
| [30] | | → | add <EXPRESSION> to ID<END_INST> |
| [31] | | → | subtract <EXPRESSION> from ID<END_INST> |
| [32] | | → | multiply <ASSIGN_END><END_INST> |
| [33] | | → | divide <ASSIGN_END><END_INST> |
| [34] | <ASSIGN_END> | → | <EXPRESSION>,<EXPRESSION> giving ID |
| [35] | <EXPRESSION> | → | <EXP_AND> <EXPRESSION_LR> |
| [36] | <EXPRESSION_LR> | → | or <EXP_AND> <EXPRESSION_LR> |
| [37] | | → | ε |
| [38] | <EXP_AND> | → | <EXP_EQUAL> <EXP_AND_LR> |
| [39] | <EXP_AND_LR> | → | and <EXP_EQUAL> <EXP_AND_LR> |

| | | |
|------|-------------------|---|
| [40] | | → ε |
| [41] | <EXP_EQUAL> | → <EXP_ADD> <EXP_EQUAL_LR> |
| [42] | <EXP_EQUAL_LR> | → = <EXP_ADD> |
| [43] | | → < <EXP_ADD> |
| [44] | | → > <EXP_ADD> |
| [45] | | → <= <EXP_ADD> |
| [46] | | → >= <EXP_ADD> |
| [47] | | → ε |
| [48] | <EXP_ADD> | → <EXP_MULT> <EXP_ADD_LR> |
| [49] | <EXP_ADD_LR> | → + <EXP_MULT> <EXP_ADD_LR> |
| [50] | | → - <EXP_MULT> <EXP_ADD_LR> |
| [51] | | → ε |
| [52] | <EXP_MULT> | → <EXP_NOT> <EXP_MULT_LR> |
| [53] | <EXP_MULT_LR> | → * <EXP_NOT> <EXP_MULT_LR> |
| [54] | | → / <EXP_NOT> <EXP_MULT_LR> |
| [55] | | → ε |
| [56] | <EXP_NOT> | → -<EXP_NOT> |
| [57] | | → not <EXP_NOT> |
| [58] | | → <EXP_PARENTHESIS> |
| [59] | <EXP_PARENTHESIS> | → (<EXPRESSION>) |
| [60] | | → <EXP_TERM> |
| [61] | <EXP_TERM> | → ID |
| [62] | | → INTEGER |
| [63] | | → true |
| [64] | | → false |
| [65] | <IF> | → if <EXPRESSION> then <INSTRUCTION_LIST> |
| | | <IF_END> |
| [66] | <IF_END> | → else <INSTRUCTION_LIST> end-if |
| [67] | | → end-if |
| [68] | <CALL> | → perform ID <CALL_TAIL> |
| [69] | <CALL_TAIL> | → until <EXPRESSION><END_INST> |
| [70] | | → <END_INST> |
| [71] | <READ> | → accept ID<END_INST> |
| [72] | <WRITE> | → display <WRITE_TAIL> |
| [73] | <WRITE_TAIL> | → <EXPRESSION><END_INST> |
| [74] | | → STRING<END_INST> |

| Variable | First ¹ | Follow ¹ |
|------------|--------------------|---------------------|
| <PROGRAM> | identification | |
| <IDENT> | identification | environment |
| <WORDS> | ID | . |
| <WORDS_LR> | ID, ε | . |

| | | |
|--------------------|---|--|
| <END_INST> | . | program-id, date-written, environment, configuration, source-computer, object-computer, data, working-storage, INTEGER, ε , ID, move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop |
| <ENV> | environment | data |
| <DATA> | data | procedure |
| <VAR_LIST> | INTEGER, ε | procedure |
| <VAR_DECL> | INTEGER | INTEGER, ε |
| <VAR_DECL_TAIL> | value, . | INTEGER, ε |
| <LEVEL> | INTEGER | ID |
| <PROC> | procedure | |
| <LABELS> | ID | end |
| <LABELS_LR> | ID, ε | end |
| <LABEL> | ID | . |
| <INSTRUCTION_LIST> | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε | ID, ε |
| <INSTRUCTION> | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <ASSIGNATION> | move, compute, add, subtract, multiply, divide | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <ASSIGN_END> | -, not, (, ID, INTEGER, true, false | . |
| <EXPRESSION> | -, not, (, ID, INTEGER, true, false | to, ., from, , , giving,), then |
| <EXPRESSION_LR> | or, ε | to, ., from, , , giving,), then |
| <EXP_AND> | -, not, (, ID, INTEGER, true, false | or, ε |
| <EXP_AND_LR> | and, ε | or, ε |
| <EXP_EQUAL> | -, not, (, ID, INTEGER, true, false | and, ε |
| <EXP_EQUAL_LR> | =, <, >, <=, >=, ε | and, ε |
| <EXP_ADD> | -, not, (, ID, INTEGER, true, false | =, <, >, <=, >=, ε |
| <EXP_ADD_LR> | +, -, ε | =, <, >, <=, >=, ε |
| <EXP_MULT> | -, not, (, ID, INTEGER, true, false | +, -, ε |
| <EXP_MULT_LR> | *, /, ε | +, -, ε |
| <EXP_NOT> | -, not, (, ID, INTEGER, true, false | *, /, ε |
| <EXP_PARENTHESIS> | (, ID, INTEGER, true, false | *, /, ε |
| <EXP_TERM> | ID, INTEGER, true, false | *, /, ε |
| <IF> | if | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <IF_END> | else, end-if | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |

| | | |
|--------------|---|---|
| <CALL> | perform | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <CALL_TAIL> | until, . | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <READ> | accept | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <WRITE> | display | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |
| <WRITE_TAIL> | STRING, -, not, (, ID, INTEGER, true, false | move, compute, add, subtract, multiply, divide, if, perform, accept, display, stop, ε |

| | identification | ID | . | environment | data | INTEGER | value |
|--------------------|----------------|----|----|-------------|------|---------|-------|
| <PROGRAM> | 1 | | | | | | |
| <IDENT> | 2 | | | | | | |
| <WORDS> | | 3 | | | | | |
| <WORDS_LR> | | 4 | 5 | | | | |
| <END_INST> | | | 6 | | | | |
| <ENV> | | | | 7 | | | |
| <DATA> | | | | | 8 | | |
| <VAR_LIST> | | | | | 9 | | 10 |
| <VAR_DECL> | | | | | 11 | | |
| <VAR_DECL_TAIL> | | 13 | | | | | 12 |
| <LEVEL> | | | | | | 14 | |
| <PROC> | | | | | | | |
| <LABELS> | | 16 | | | | | |
| <LABELS_LR> | | 17 | | | | | |
| <LABEL> | | 19 | | | | | |
| <INSTRUCTION_LIST> | | 21 | | | | | |
| <INSTRUCTION> | | | | | | | |
| <ASSIGNATION> | | | | | | | |
| <ASSIGN_END> | | 34 | | | | 34 | |
| <EXPRESSION> | | 35 | | | | 35 | |
| <EXPRESSION_LR> | | | 37 | | | | |
| <EXP_AND> | | 38 | | | | 38 | |
| <EXP_AND_LR> | | | | | | | |
| <EXP_EQUAL> | | 41 | | | | 41 | |
| <EXP_EQUAL_LR> | | | | | | | |
| <EXP_ADD> | | 48 | | | | 48 | |
| <EXP_ADD_LR> | | | | | | | |
| <EXP_MULT> | | 52 | | | | 52 | |
| <EXP_MULT_LR> | | | | | | | |
| <EXP_NOT> | | 56 | | | | 56 | |
| <EXP_PARENTHESIS> | | 59 | | | | 59 | |
| <EXP_TERM> | | 61 | | | | 62 | |
| <IF> | | | | | | | |
| <IF_END> | | | | | | | |
| <CALL> | | | | | | | |
| <CALL_TAIL> | | | | | | | |
| <READ> | | | | | | | |
| <WRITE> | | | | | | | |
| <WRITE_TAIL> | | 73 | | | | 73 | |

| | procedure | move | compute | add | subtract | multiply | divide |
|--------------------|-----------|------|---------|-----|----------|----------|--------|
| <PROGRAM> | | | | | | | |
| <IDENT> | | | | | | | |
| <WORDS> | | | | | | | |
| <WORDS_LR> | | | | | | | |
| <END_INST> | | | | | | | |
| <ENV> | | | | | | | |
| <DATA> | | | | | | | |
| <VAR_LIST> | 10 | | | | | | |
| <VAR_DECL> | | | | | | | |
| <VAR_DECL_TAIL> | | | | | | | |
| <LEVEL> | | | | | | | |
| <PROC> | 15 | | | | | | |
| <LABELS> | | | | | | | |
| <LABELS_LR> | | | | | | | |
| <LABEL> | | | | | | | |
| <INSTRUCTION_LIST> | | 20 | 20 | 20 | 20 | 20 | 20 |
| <INSTRUCTION> | | 22 | 22 | 22 | 22 | 22 | 22 |
| <ASSIGNATION> | | 28 | 29 | 30 | 31 | 32 | 33 |
| <ASSIGN_END> | | | | | | | |
| <EXPRESSION> | | | | | | | |
| <EXPRESSION_LR> | | | | | | | |
| <EXP_AND> | | | | | | | |
| <EXP_AND_LR> | | | | | | | |
| <EXP_EQUAL> | | | | | | | |
| <EXP_EQUAL_LR> | | | | | | | |
| <EXP_ADD> | | | | | | | |
| <EXP_ADD_LR> | | | | | | | |
| <EXP_MULT> | | | | | | | |
| <EXP_MULT_LR> | | | | | | | |
| <EXP_NOT> | | | | | | | |
| <EXP_PARENTHESIS> | | | | | | | |
| <EXP_TERM> | | | | | | | |
| <IF> | | | | | | | |
| <IF_END> | | | | | | | |
| <CALL> | | | | | | | |
| <CALL_TAIL> | | | | | | | |
| <READ> | | | | | | | |
| <WRITE> | | | | | | | |
| <WRITE_TAIL> | | | | | | | |

| | perform | accept | display | stop | - | not | (| true | false |
|--------------------|---------|--------|---------|------|----|-----|----|------|-------|
| <PROGRAM> | | | | | | | | | |
| <IDENT> | | | | | | | | | |
| <WORDS> | | | | | | | | | |
| <WORDS_LR> | | | | | | | | | |
| <END_INST> | | | | | | | | | |
| <ENV> | | | | | | | | | |
| <DATA> | | | | | | | | | |
| <VAR_LIST> | | | | | | | | | |
| <VAR_DECL> | | | | | | | | | |
| <VAR_DECL_TAIL> | | | | | | | | | |
| <LEVEL> | | | | | | | | | |
| <PROC> | | | | | | | | | |
| <LABELS> | | | | | | | | | |
| <LABELS_LR> | | | | | | | | | |
| <LABEL> | | | | | | | | | |
| <INSTRUCTION_LIST> | 20 | 20 | 20 | 20 | | | | | |
| <INSTRUCTION> | 24 | 25 | 26 | 27 | | | | | |
| <ASSIGNATION> | | | | | | | | | |
| <ASSIGN_END> | | | | | | 34 | 34 | 34 | 34 |
| <EXPRESSION> | | | | | | 35 | 35 | 35 | 35 |
| <EXPRESSION_LR> | | | | | | | | | |
| <EXP_AND> | | | | | | 38 | 38 | 38 | 38 |
| <EXP_AND_LR> | | | | | | | | | |
| <EXP_EQUAL> | | | | | | 41 | 41 | 41 | 41 |
| <EXP_EQUAL_LR> | | | | | | | | | |
| <EXP_ADD> | | | | | | 48 | 48 | 48 | 48 |
| <EXP_ADD_LR> | | | | | | 50 | | | |
| <EXP_MULT> | | | | | | 52 | 52 | 52 | 52 |
| <EXP_MULT_LR> | | | | | | 55 | | | |
| <EXP_NOT> | | | | | | 56 | 57 | 58 | 58 |
| <EXP_PARENTHESIS> | | | | | | | 59 | 60 | 60 |
| <EXP_TERM> | | | | | | | | 63 | 64 |
| <IF> | | | | | | | | | |
| <IF_END> | | | | | | | | | |
| <CALL> | 68 | | | | | | | | |
| <CALL_TAIL> | | | | | | | | | |
| <READ> | | 71 | | | | | | | |
| <WRITE> | | | 72 | | | | | | |
| <WRITE_TAIL> | | | | | 73 | 73 | 73 | 73 | 73 |

| | | | | | | | | | | | | | | |
|--------------------|----|-----|----|----|----|----|----|----|----|----|------|--------|---|-------|
| | or | and | = | < | > | <= | >= | * | / | if | else | end-if | + | until |
| <PROGRAM> | | | | | | | | | | | | | | |
| <IDENT> | | | | | | | | | | | | | | |
| <WORDS> | | | | | | | | | | | | | | |
| <WORDS_LR> | | | | | | | | | | | | | | |
| <END_INST> | | | | | | | | | | | | | | |
| <ENV> | | | | | | | | | | | | | | |
| <DATA> | | | | | | | | | | | | | | |
| <VAR_LIST> | | | | | | | | | | | | | | |
| <VAR_DECL> | | | | | | | | | | | | | | |
| <VAR_DECL_TAIL> | | | | | | | | | | | | | | |
| <LEVEL> | | | | | | | | | | | | | | |
| <PROC> | | | | | | | | | | | | | | |
| <LABELS> | | | | | | | | | | | | | | |
| <LABELS_LR> | | | | | | | | | | | | | | |
| <LABEL> | | | | | | | | | | | | | | |
| <INSTRUCTION_LIST> | | | | | | | | | | | | | | 20 |
| <INSTRUCTION> | | | | | | | | | | | | | | 23 |
| <ASSIGNATION> | | | | | | | | | | | | | | |
| <ASSIGN_END> | | | | | | | | | | | | | | |
| <EXPRESSION> | | | | | | | | | | | | | | |
| <EXPRESSION_LR> | 36 | | | | | | | | | | | | | |
| <EXP_AND> | | | | | | | | | | | | | | |
| <EXP_AND_LR> | 40 | 39 | | | | | | | | | | | | |
| <EXP_EQUAL> | | | | | | | | | | | | | | |
| <EXP_EQUAL_LR> | | 47 | 42 | 43 | 44 | 45 | 46 | | | | | | | |
| <EXP_ADD> | | | | | | | | | | | | | | |
| <EXP_ADD_LR> | | | 51 | 51 | 51 | 51 | 51 | | | | | | | 49 |
| <EXP_MULT> | | | | | | | | | | | | | | |
| <EXP_MULT_LR> | | | | | | | | 53 | 54 | | | | | 55 |
| <EXP_NOT> | | | | | | | | | | | | | | |
| <EXP_PARENTHESIS> | | | | | | | | | | | | | | |
| <EXP_TERM> | | | | | | | | | | | | | | |
| <IF> | | | | | | | | | | 65 | | | | |
| <IF_END> | | | | | | | | | | | 66 | 67 | | |
| <CALL> | | | | | | | | | | | | | | |
| <CALL_TAIL> | | | | | | | | | | | | | | 69 |
| <READ> | | | | | | | | | | | | | | |
| <WRITE> | | | | | | | | | | | | | | |
| <WRITE_TAIL> | | | | | | | | | | | | | | |

| | | | | | | | | |
|--------------------|-------|--------|----|----|------|--------|----|------|
| <PROGRAM> | until | STRING | , | to | from | giving |) | then |
| <IDENT> | | | | | | | | |
| <WORDS> | | | | | | | | |
| <WORDS_LR> | | | | | | | | |
| <END_INST> | | | | | | | | |
| <ENV> | | | | | | | | |
| <DATA> | | | | | | | | |
| <VAR_LIST> | | | | | | | | |
| <VAR_DECL> | | | | | | | | |
| <VAR_DECL_TAIL> | | | | | | | | |
| <LEVEL> | | | | | | | | |
| <PROC> | | | | | | | | |
| <LABELS> | | | | | | | | |
| <LABELS_LR> | | | | | | | | |
| <LABEL> | | | | | | | | |
| <INSTRUCTION_LIST> | | | | | | | | |
| <INSTRUCTION> | | | | | | | | |
| <ASSIGNATION> | | | | | | | | |
| <ASSIGN_END> | | | | | | | | |
| <EXPRESSION> | | | | | | | | |
| <EXPRESSION_LR> | | | 37 | 37 | 37 | 37 | 37 | 37 |
| <EXP_AND> | | | | | | | | |
| <EXP_AND_LR> | | | | | | | | |
| <EXP_EQUAL> | | | | | | | | |
| <EXP_EQUAL_LR> | | | | | | | | |
| <EXP_ADD> | | | | | | | | |
| <EXP_ADD_LR> | | | | | | | | |
| <EXP_MULT> | | | | | | | | |
| <EXP_MULT_LR> | | | | | | | | |
| <EXP_NOT> | | | | | | | | |
| <EXP_PARENTHESIS> | | | | | | | | |
| <EXP_TERM> | | | | | | | | |
| <IF> | | | | | | | | |
| <IF_END> | | | | | | | | |
| <CALL> | | | | | | | | |
| <CALL_TAIL> | 69 | | | | | | | |
| <READ> | | | | | | | | |
| <WRITE> | | | | | | | | |
| <WRITE_TAIL> | | 74 | | | | | | |