# 1998 Paper 10 Question 2

## Modula-3

Compare and contrast the Modula-3 procedures `VAL` and `LOOPHOLE`. [4 marks]

Apart from two incomplete statements, the program below constitutes a solution to the Eight-Queens problem and counts the number of ways in which 8 Queens may be placed on a chess board such that no queen is under attack from any other.

Suggest suitable right-hand sides for the incomplete assignments. [8 marks]

Explain how the program works giving particular attention to all uses of the `LOOPHOLE` procedure. [8 marks]

```
UNSAFE MODULE EightQueens EXPORTS Main;

IMPORT IO, Fmt;

TYPE
  Row = SET OF [0..7];

VAR
  count : CARDINAL := 0;

PROCEDURE try (left, above, right : Row) =
  VAR
    poss, place, l, r : Row;
  BEGIN
    IF above = Row{0..7} THEN
      INC(count)
    ELSE
      poss := Row{0..7} - left - above - right;
      WHILE  poss # Row{} DO
        place := poss * LOOPHOLE(-LOOPHOLE(poss, INTEGER), Row);
        l :=
        r :=
        try(l, above+place, r);
        poss := poss - place
      END
    END
  END try;

BEGIN
  try(Row{}, Row{}, Row{});
  IO.Put ("There are " & Fmt.Int(count) & " solutions\n")
END EightQueens.
```