

## 1993 Paper 13 Question 12

### Formal Languages and Automata

For each of the following languages over the alphabet  $\{a, b\}$ , say whether or not it is regular. Justify your answers stating clearly any results that you use.

- (a) The set of all strings which are not palindromes (i.e. which are not equal to their own reverse) [4 marks]
- (b) The union of countably many regular languages  $L_1, L_2, L_3, \dots$  [4 marks]
- (c) The set of all strings in which the number of occurrences of the letter  $a$  and the number of occurrences of the letter  $b$  are both divisible by 3 [4 marks]
- (d) The set of all strings which are of the form  $ww$  for some string  $w$  [4 marks]
- (e) The set of all strings such that in each initial substring the number of occurrences of the letter  $a$  and the number of occurrences of the letter  $b$  differ by no more than 2 [4 marks]