

## 2004 Paper 6 Question 2

### Computer Design

The ARM processor allows the second operand to be shifted by an arbitrary amount. In order to improve the performance, a six-stage pipeline is proposed with the following stages:

instruction fetch	decode and register fetch	shift operand 2	execute	memory access	register write back
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- (a) What are control hazards and how could they be resolved in the above pipeline?  
[4 marks]
- (b) What are data hazards and how could they be resolved in the above pipeline?  
[4 marks]
- (c) What are feed-forward paths and where could they be added to the above pipeline to improve performance?  
[6 marks]
- (d) Why might a branch instruction result in pipeline bubbles and how many bubbles will appear in the above pipeline as a result of taking a branch instruction?  
[6 marks]