

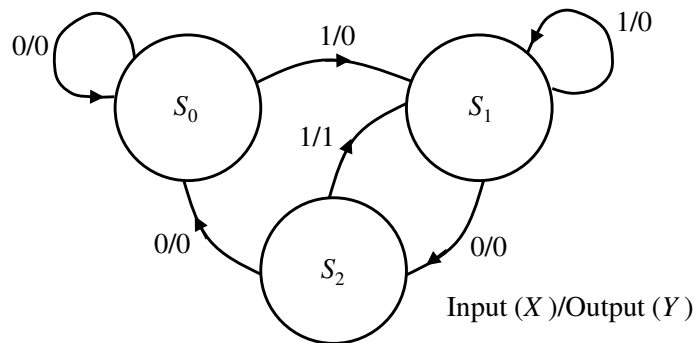
COMPUTER SCIENCE TRIPOS Part IA – 2022 – Paper 2

2 Digital Electronics (ijw24)

- (a) A (fictional) edge-triggered  $UV$  flip-flop has inputs  $U$  and  $V$  and output  $Q$ . Its state-transition table is given by:

Current state ( $Q$ )	Next state ( $Q'$ )			
	$UV = 00$	$01$	$10$	$11$
0	0	1	0	1
1	0	0	0	1

- (i) Draw the state-transition diagram for the  $Q$  output. [3 marks]
- (ii) For an implementation based on a D-type flip-flop, determine the simplified Boolean equation in sum-of-products form for the next-state ( $Q'$ ) logic. [2 marks]
- (b) Consider the following state machine:



- (i) Assuming that the machine starts in state  $S_0$  and that the input data sequence at input ( $X$ ) is appropriately synchronised with the state machine clock, determine the next-state and output sequences for the input sequence 0101011011011. What operation does the machine perform? [5 marks]
- (ii) For an implementation based on two D-type flip-flops (labelled  $A$  and  $B$ ), determine simplified Boolean expressions for the next-state and output combinational logic, assuming the state assignment  $S_0 = 00$ ,  $S_1 = 01$  and  $S_2 = 10$  is used, where a state is labelled  $Q_AQ_B$  in terms of the flip-flop outputs. [4 marks]
- (iii) For an alternative one-hot implementation based on D-type flip-flops, determine expressions for the next-state and output logic. [4 marks]
- (iv) What feature, inherent in the proposed state-machine design, may give rise to problems at the output  $Y$ ? How might this be addressed? [2 marks]