

Question		Marks																																																																																																																																																															
1	1	<div>All marks AO2 (apply)</div> <div>5</div> <div><table><thead><tr><th colspan="8">Tape</th><th>Current state</th></tr></thead><tbody><tr><td>...</td><td>0</td><td>#</td><td>1</td><td>0*</td><td>1</td><td>0</td><td>0</td><td>...</td><td>S3</td></tr><tr><td>...</td><td>0</td><td>#</td><td>1*</td><td>0</td><td>1</td><td>0</td><td>0</td><td>...</td><td>S4</td></tr><tr><td>...</td><td>0</td><td>#*</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>...</td><td>S4</td></tr><tr><td>...</td><td>0</td><td>#</td><td>1*</td><td>0</td><td>1</td><td>0</td><td>0</td><td>...</td><td>S0</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0*</td><td>1</td><td>0</td><td>0</td><td>...</td><td>S1</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0</td><td>1*</td><td>0</td><td>0</td><td>...</td><td>S2</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0</td><td>1</td><td>0*</td><td>0</td><td>...</td><td>S2</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0</td><td>1*</td><td>1</td><td>0</td><td>...</td><td>S3</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0*</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S3</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#*</td><td>0</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S4</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#</td><td>0*</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S0</td></tr><tr><td>...</td><td>0</td><td>#</td><td>#*</td><td>0</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S5</td></tr><tr><td>...</td><td>0</td><td>#*</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S5</td></tr><tr><td>...</td><td>0*</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S5</td></tr><tr><td>...</td><td>0</td><td>1*</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>...</td><td>S6</td></tr></tbody></table></div> <div>Mark as follows:</div> <div>1 mark: first row of tape is correct</div> <div>1 mark: current state and read/write head position correct for first row of tape</div> <div>1 mark: second and third rows of tape and current state are correct</div> <div>1 mark: last row of tape is correct</div> <div>1 mark: all other rows of current state are correct and read/write head in correct position for row two onwards</div> <div>A. alternative, unambiguous, ways of representing read/write head position</div> <div>I. inclusion of shaded rows/columns</div>	Tape								Current state	...	0	#	1	0*	1	0	0	...	S3	...	0	#	1*	0	1	0	0	...	S4	...	0	#*	1	0	1	0	0	...	S4	...	0	#	1*	0	1	0	0	...	S0	...	0	#	#	0*	1	0	0	...	S1	...	0	#	#	0	1*	0	0	...	S2	...	0	#	#	0	1	0*	0	...	S2	...	0	#	#	0	1*	1	0	...	S3	...	0	#	#	0*	1	1	0	...	S3	...	0	#	#*	0	1	1	0	...	S4	...	0	#	#	0*	1	1	0	...	S0	...	0	#	#*	0	1	1	0	...	S5	...	0	#*	1	0	1	1	0	...	S5	...	0*	1	1	0	1	1	0	...	S5	...	0	1*	1	0	1	1	0	...	S6
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1	2	<div>Mark is for AO2 (analyse)</div> <div>1</div> <div>Make a copy of a string of 1s;</div> <div>A. double the number of 1s on the tape</div>																																																																																																																																																															
1	3	<div>Mark is for AO2 (analyse)</div> <div>1</div> <div>Moves the read/write head to the start of the (original) string of 1s // moves the read/write head back to where it started from;</div>																																																																																																																																																															
1	4	<div>All marks AO1 (knowledge)</div> <div>2</div> <div>A Turing machine that can execute/simulate the behaviour of any other Turing machine // can compute any computable sequence;</div> <div>Faithfully executes operations on the data precisely as the simulated TM does; (Note: must have idea of same process)</div>																																																																																																																																																															

		<p>Description of/Instructions for TM (and the TM's input) are stored on the (Universal Turing machine's) tape // The UTM acts as an interpreter; A. take any other TM and data as input</p> <p><i>Alternative definition:</i> A UTM, U, is an interpreter that reads the description <M> of any arbitrary Turing machine M;</p> <p>and faithfully executes operations on data D precisely as M does.;</p> <p>The description <M> is written at the beginning of the tape, followed by D.;</p> <p>Max 2 marks</p>	
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Question												Marks
2	1	All marks AO2 (apply)										5
		Tape								Current State		
...			#	0*	0	0	#	...		S0		
...			#		0*	0	#	...		S2		
...			#		0	0*	#	...		S1		
...			#		0		#*	...		S2		
...			#		0	*	#	...		S4		
...			#		0*		#	...		S4		
...			#	*	0		#	...		S4		
...			#*		0		#	...		S4		
...		*	#		0		#	...		S5		
...		1	#*		0		#	...		S7		
...		1	#	*	0		#	...		S0		
...		1	#		0*		#	...		S0		
...		1	#			*	#	...		S2		
...		1	#				#*	...		S2		
...		1	#			*	#	...		S4		
...		1	#		*		#	...		S4		
...		1	#	*			#	...		S4		
...		1	#*				#	...		S4		
...		1*	#				#	...		S5		
...	*	1	#				#	...		S5		
...		1	1*	#			#	...		S7		
Mark as follows:												
1 mark: tape and current state of first row correct.												
1 mark: tape and current state of second and third rows correct.												
1 mark: read/write head correct for first three rows.												
1 mark: tape left of first hash symbol and current state for rows four to ten correct (denoted by blue outline in table above).												
1 mark: tape and current state for last row correct.												
A. any unambiguous way of denoting a blank cell on the tape												
I. position of read/write head when awarding mark points 1, 2, 4 and 5												
Max 4 if any errors												
2	2	All marks AO2 (analyse)										2
When there are no zeros between the two hash symbols on the tape;												
When there is a character other than zero (A. a one) between the two hash symbols on the tape;												
If the machine was not in the start state (S0);												
Max 2												

2	3	<p>All marks AO1 (knowledge)</p> <p>A Turing machine that can execute/simulate the behaviour of any other Turing machine // can compute any computable sequence;</p> <p>Faithfully executes every single operation on the data precisely as the simulated TM would; (Note: must have idea of same process)</p> <p>Description of/Instructions for TM (and the TM's input) are stored on the (Universal Turing machine's) tape // The UTM acts as an interpreter; A. take any other TM and data as input</p> <p>Max 2 marks</p> <p>Alternative definition:</p> <p>A UTM, U, is an interpreter that reads the description of any arbitrary Turing machine M;</p> <p>and faithfully executes operations on data D precisely as M does.;</p> <p>The description is written at the beginning of the tape, followed by D.;</p> <p>Max 2 marks</p>	2
2	4	<p>Mark is for AO1 (understanding)</p> <p>It has an infinite amount of memory; A. the tape is infinitely long</p>	1