Pre-Tutorial (To be completed by student before attending tutorial session)

1. **Design Turing machine for 1's complement of the binary numbers.**

Solution:

i/p - 0110 ⟶ o/p :- 1001

	0	1	B
→ q_0	$(q_0, 1, R)$	$(q_0, 0, R)$	(q_1, B, R)
q_1	—	—	—

$M = (\{q_0, q_1\}, \{0, 1\}, \{0, 1, B\}, \delta, q_0, B, \{q_1\})$

2. **Design Turing machine for 2's complement of the binary numbers.**

Solution:

i/p 1 - 0101 o/p: 1011

δ	0	1	B
→ q_0	$(q_0, 1, R)$	$(q_0, 0, R)$	(q_1, B, L)
q_1	$(q_2, 1, L)$	$(q_1, 0, L)$	(q_2, B, R)
* q_2	—	—	—

$M = (\{q_0, q_1, q_2\}, \{0, 1\}, \{0, 1, B\}, \delta, q_0, B, \{q_2\})$

esign Turing machine for left shift operation of the binary numbers.

δ	0	1	X	Y	B
$\rightarrow q_0$	(q_1, X, R)	$(q_1, Y, R$	E	E	(q_4, B, R)
q_1	$(q_1, 0, R)$	$(q_1, 1, R)$	E	E	(q_2, B, L)
q_2	$(q_2, 0, L)$	$(q_2, 1, L)$	$(q_3, 0, L)$	$(q_3, 1, L)$	E
q_3	E	E	(q_4, B, R)	(q_4, B, R)	E
$*q_4$	—	—	—	—	—

$M = (\{q_0, q_1, q_2, q_3, q_4\}, \{0, 1\}, \{0, 1, X, Y, B\},$

$\delta, q_0, B, \{q_4\})$

IN-TUTORIAL (To be carried out in presence of faculty in classroom)

1. Design Turing machine for addition of two unary numbers.

Solution:

δ	0	1	B
$\rightarrow q_0$	(q_1, B, R)		
q_1	$(q_1, 0, R)$	$(q_2, 0, R)$	
q_2	$(q_2, 0, R)$		(q_3, B, R)
$* q_3$	—	—	—

$M = (\{q_0, q_1, q_2, q_3\}, \{0\}, \{0, 1, B\}, \delta, q_0, B, \{q_3\})$

2. Design Turing machine for proper subtraction of two unary numbers

Solution:

δ	0	1	B
$\rightarrow q_0$	$(q_0, 0, R)$	$(q_0, 1, R)$	(q_1, B, L)
q_1	(q_2, B, L)	(q_4, B, R)	
q_2	$(q_2, 0, L)$	$(q_2, 1, L)$	(q_3, B, R)
q_3	(q_0, B, R)		
$* q_4$	—	—	—

$M = (\{q_0, q_1, q_2, q_3, q_4\}, \{0, 1\}, \{0, 1, B\}, \delta, q_0, B,$

ign Turing machine for multiplication of two unary numbers

δ	0	1	X	Y	B
$\rightarrow q_0$	(q_1, X, R)				
q_1		$(q_1, 1, R)$			$(q_9, B, R$
q_2		(q_3, B, L)	(q_2, X, L)		(q_2, B, L)
q_3		$(q_3, 1, L)$			(q_4, B, L)
q_4					
q_5		(q_6, X, R)		$(q_0, 1, R)$	$(q_7, 1, L)$
q_6		$(q_6, 1, R)$			(q_2, B, L)
q_7		$(q_7, 1, L)$		$(q_8, 1, L)$	
q_8		$(q_8, 1, L)$			(q_4, B, R)
$* q_9$	—	—	—	—	—

$$M = (\{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9\}, \{0, 1\}, \{0, 1, X, Y, B\}, \delta, q_0, B, \{q_9\})$$

Post-Tutorial (To be carried out by student after attending tutorial session)

1. **Design Turing machine to compute n^2**

Solution:

δ	0	1	X	Y	B
$\rightarrow q_0$		(q_1, x, R)			(q_6, B, R)
q_1		$(q_1, R, 1)$			(q_2, B, L)
q_2		$(q_2, 1, L)(q_3, X, R)$			
q_3		(q_4, X, R)			(q_6, B, L)
q_4		$(q_4, 1, R)$			$(q_5, 1, L)$
q_5		$(q_5, 1, R)$			(q_0, B, R)
$* q_6$					

$$M = (\{q_0, q_1, q_2, q_3, q_4, q_5, q_6\}, \{0, 1\}, \{0, 1, X, Y, B\}, \delta, q_0, B, \{q_6\})$$

uring machine to compute n!

δ	0	1	X	Y	B
$\rightarrow q_0$		(q_1, X, R)			(q_5, B, R)
q_1		$(q_1, 1, R)$			(q_2, B, L)
q_2		(q_3, x, L)	(q_2, x, L)		
q_3		$(q_3, 1, L)$			(q_4, B, R)
q_4			$(q_0, 1, R)$		
$*q_5$	—	—	—	—	—

$M = (\{q_0, q_1, q_2, q_3, q_4, q_5\} \{0,1\}, \{0,1,x,y,B\},$

$\delta, q_0, B, \{q_5\})$

Viva- Questions.

1. **Define a computable function.**

Solution:

A computable function is a function for which there exists an algorithm (or Turing machine) that can produce the correct output for any valid input in a finite number of steps. It operates within the bounds of a well defined procedure, yielding output after processing the input.

(For Evaluator's use only)

Comment of the Evaluator (if Any)	Evaluator's Observation
	Marks Secured: out of **50**
	Full Name of the Evaluator:
	Signature of the Evaluator Date of Evaluation: