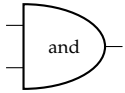


# Reversible Computing

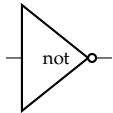
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Last updated: 21 September 2023

## Logical Reversibility



$x_1$	$x_2$	$\wedge$
0	0	0
0	1	0
1	0	0
1	1	1



$x$	$\bar{x}$
0	1
1	0

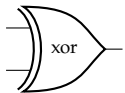
## Landauer's Principle

$$\Delta E \geq kT \ln 2$$

$$k = 1.380649 \times 10^{-23} \text{ JK}^{-1}$$

$$\Delta E \geq (1.380649 \times 10^{-23})(293)(0.693147) \approx 2.8 \times 10^{-21} \text{ J at } 20^\circ \text{C}^1$$

## XOR



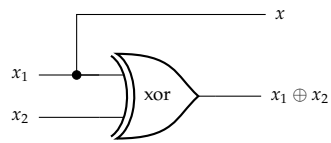
$x_1$	$x_2$	$\wedge$
0	0	0
0	1	1
1	0	1
1	1	0

R. Landauer. Irreversibility and heat generation in the computing process. *IBM Journal of Research and Development*, 5(3):183–191, 1961. doi: 10.1147/rd.53.0183

Charles H. Bennett. The thermodynamics of computation—a review. *International Journal of Theoretical Physics*, 21(12):905–940, Dec 1982. ISSN 1572-9575. doi: 10.1007/BF02084158. URL <https://doi.org/10.1007/BF02084158>

Charles H. Bennett. Notes on landauer's principle, reversible computation and maxwell's demon, 2003

<sup>1</sup> Somewhere in th

*CNOT*

$x_1$	$x_2$	$x_1$	$x_1 \oplus x_2$
0	0	0	0
0	1	0	1
1	0	1	1
1	1	1	0

$x_1 \oplus x_2$  means the same as  $x_1 \vee x_2$ .