

INTRODUCTION TO **QUANTUM COMPUTING**

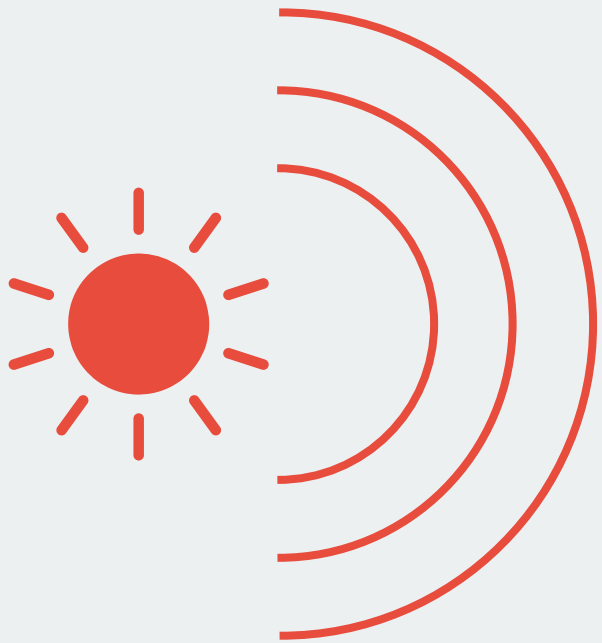
Matija Pretnar

Faculty of Mathematics and Physics
University of Ljubljana

QUANTUM

COMPUTING



























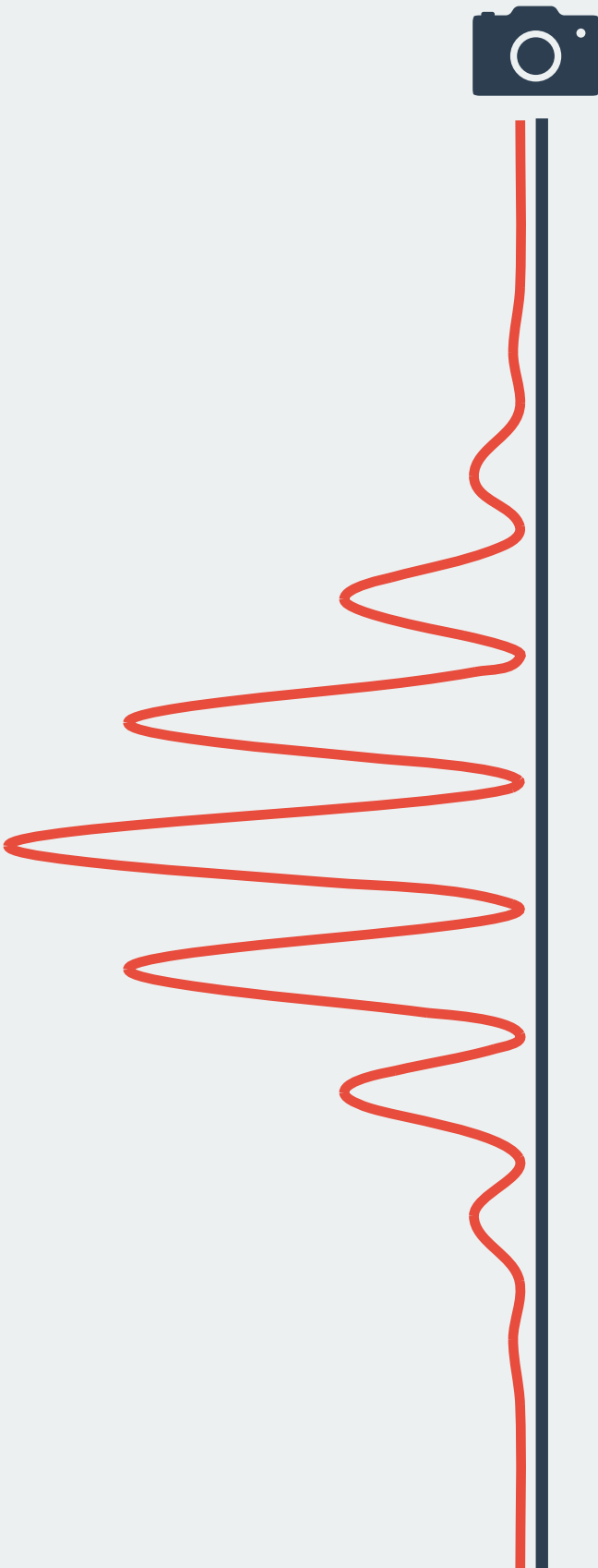


























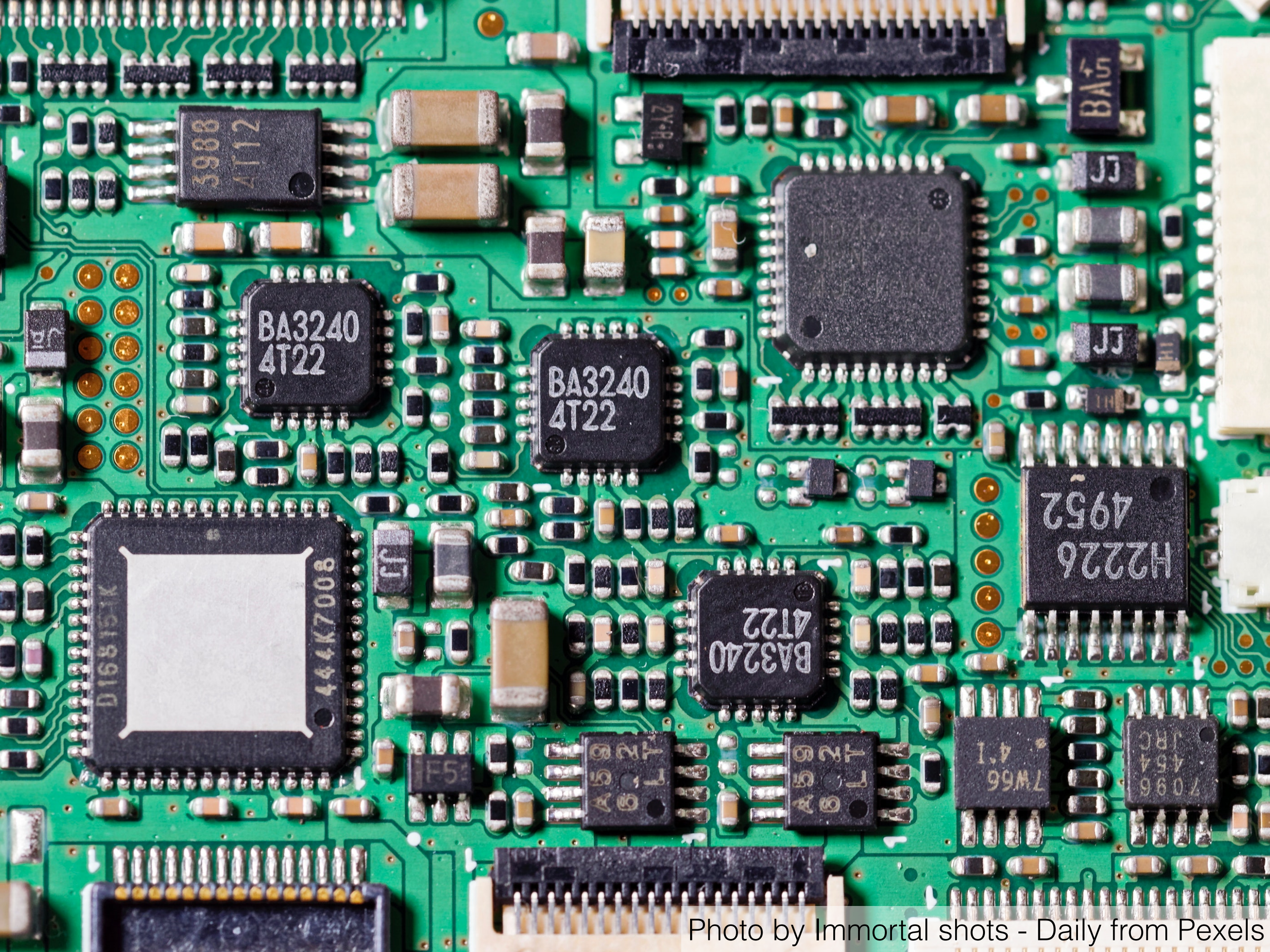


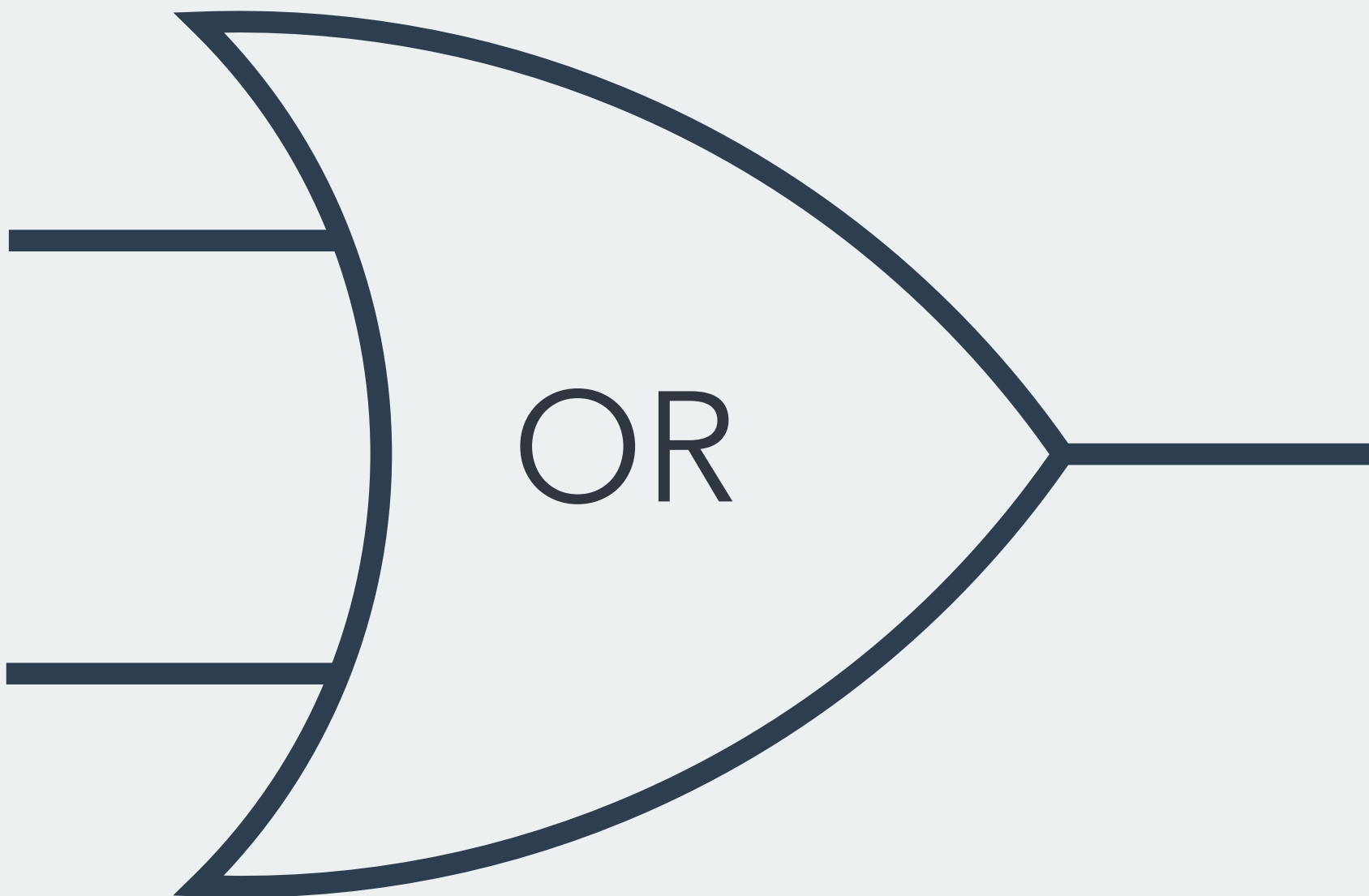
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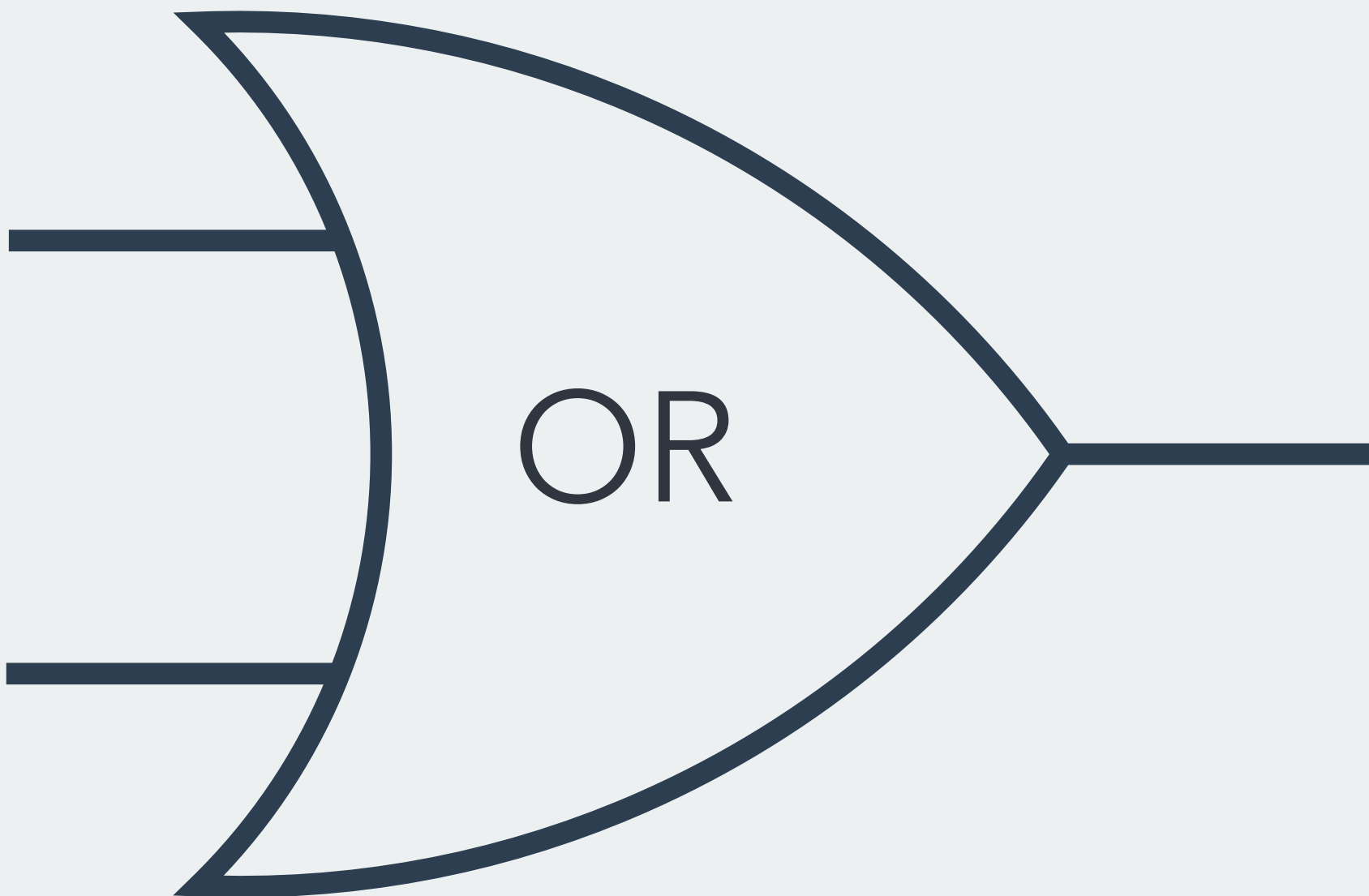
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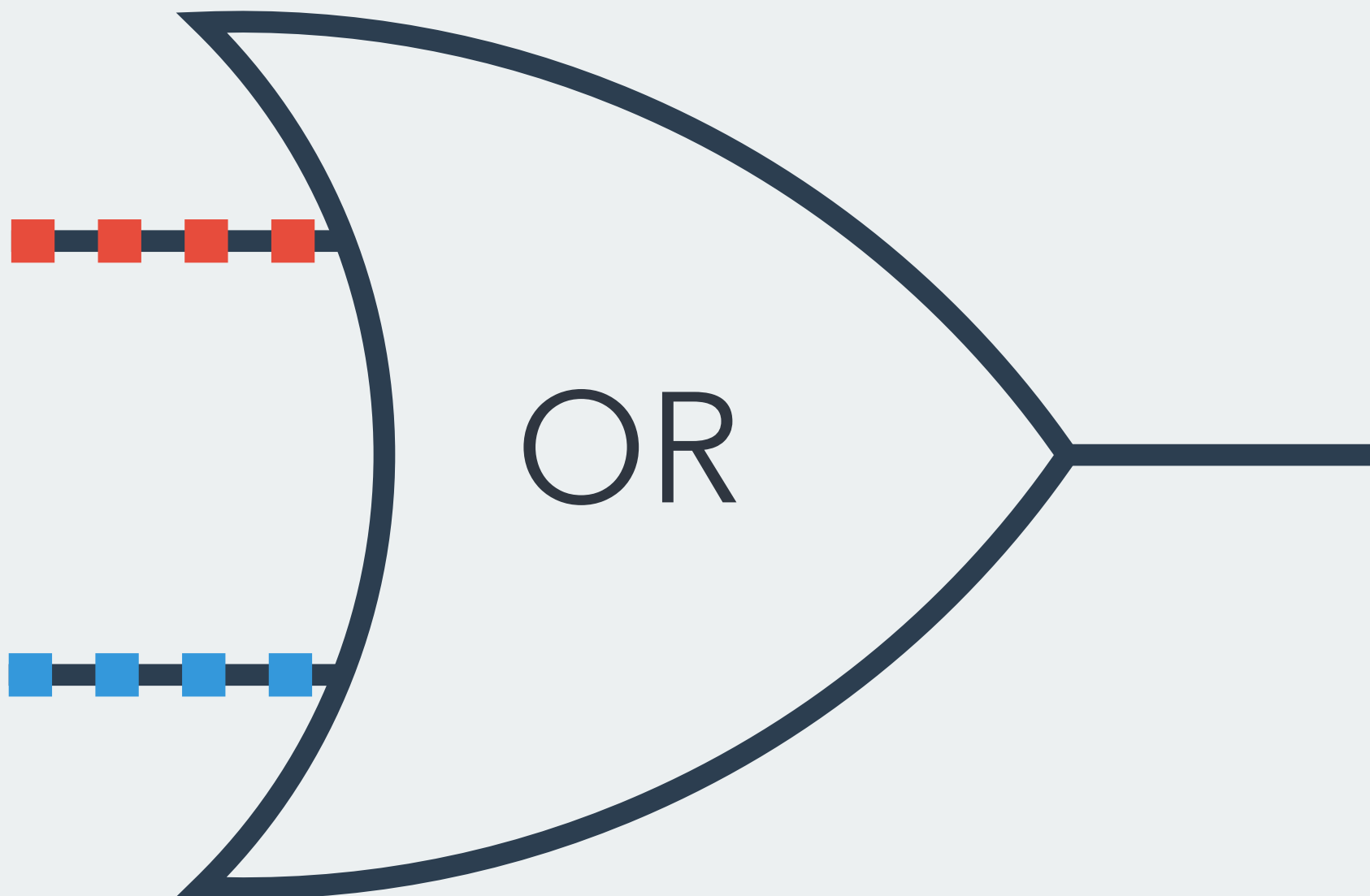
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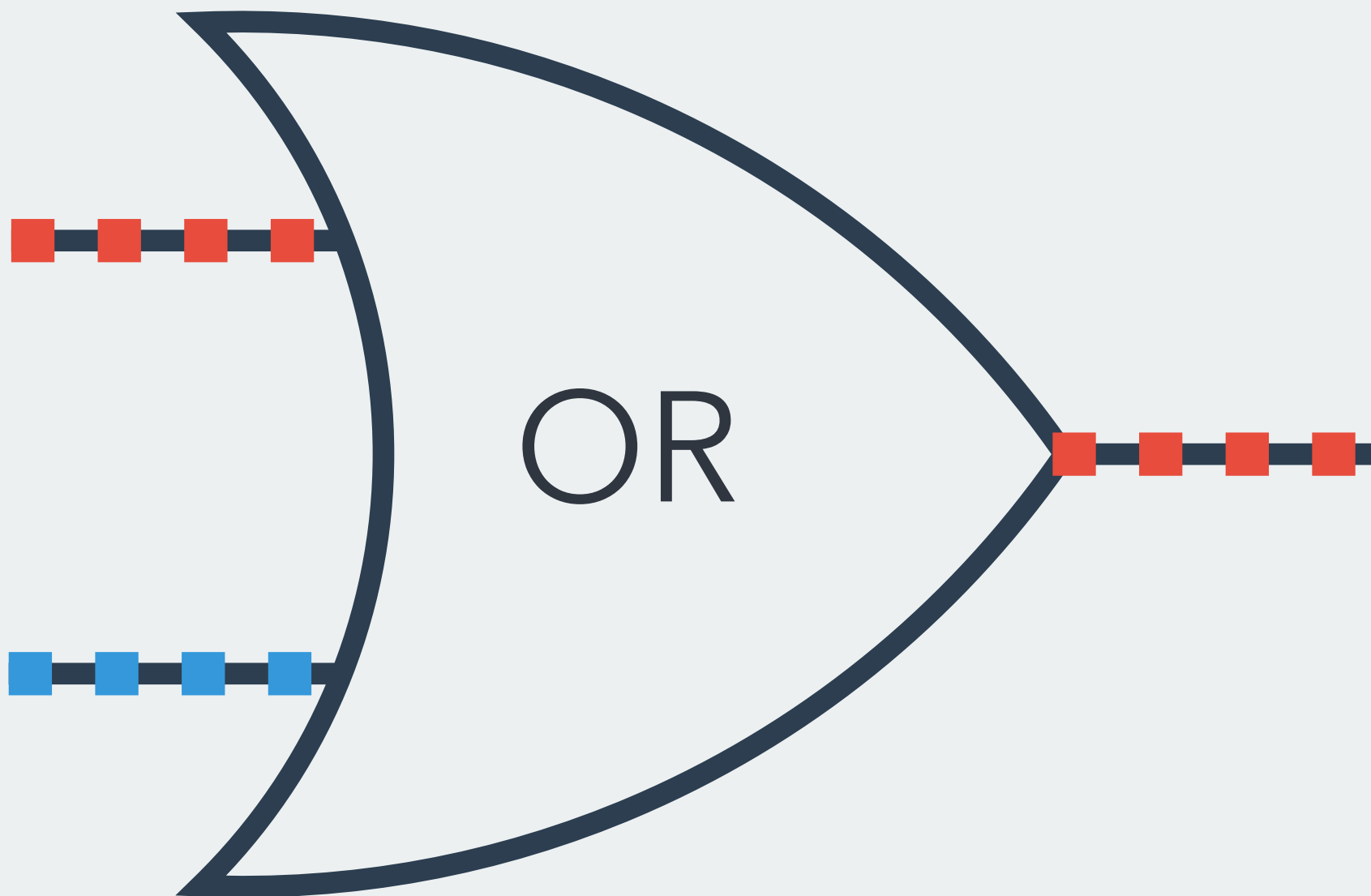
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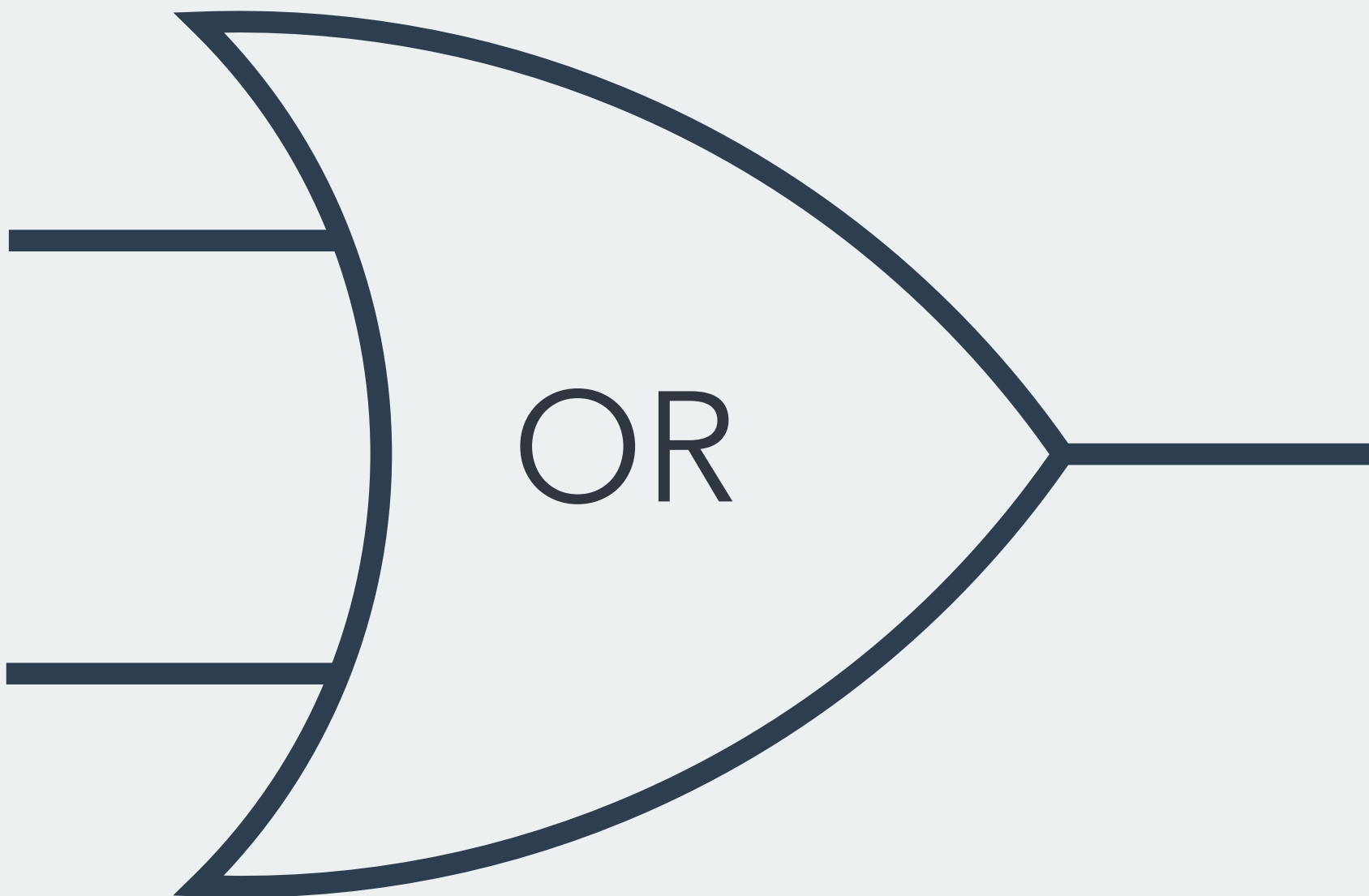


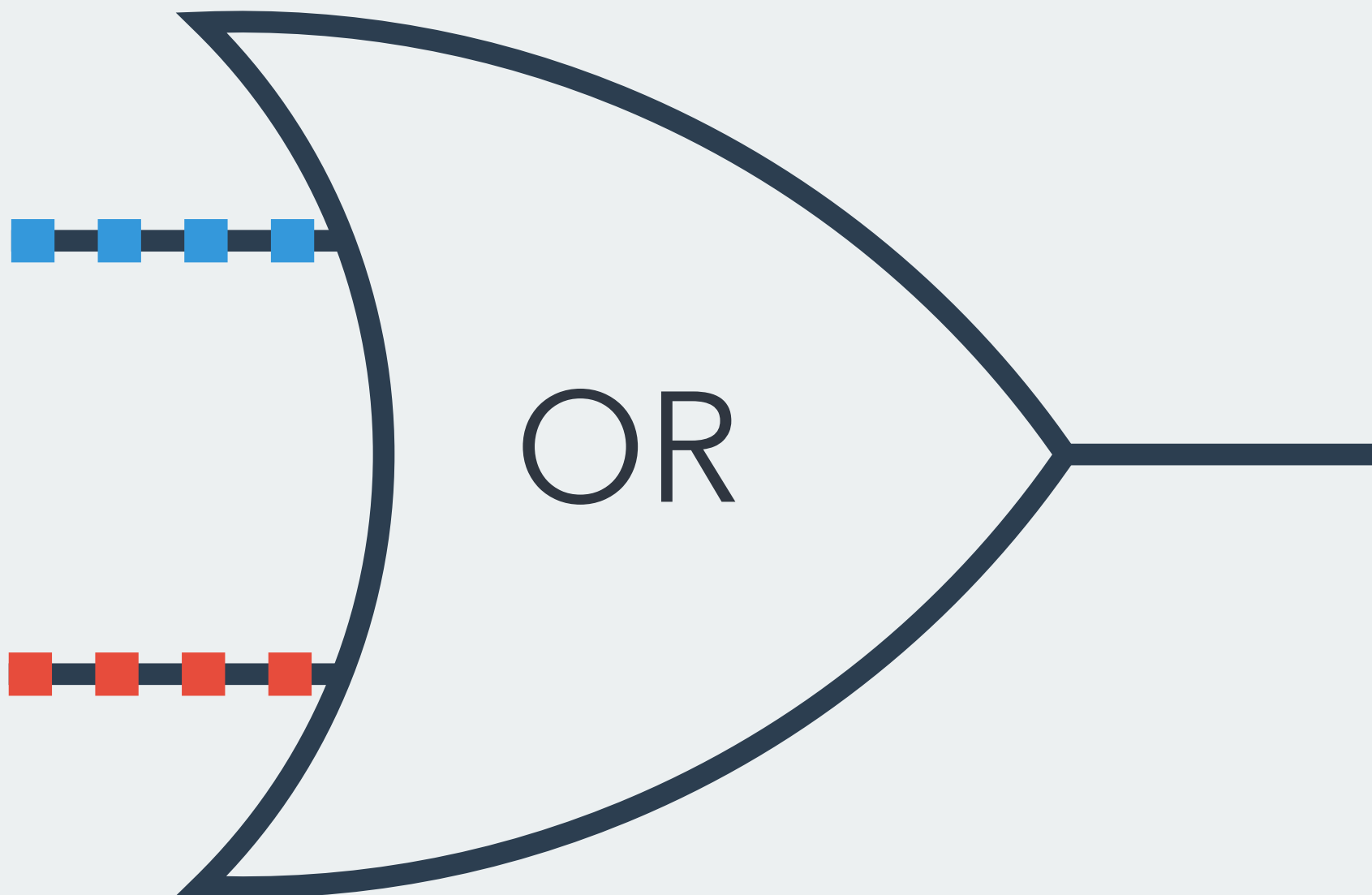


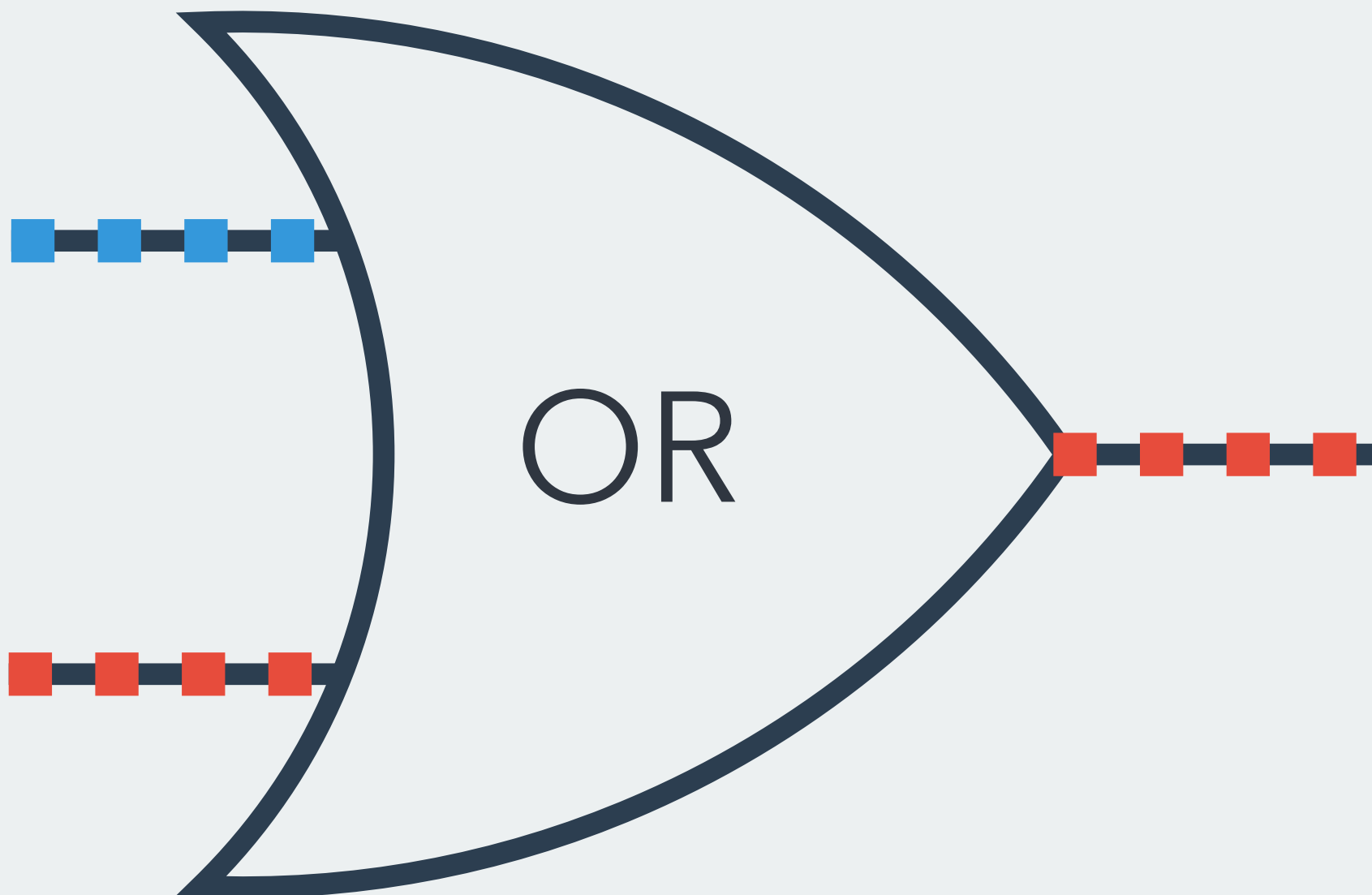


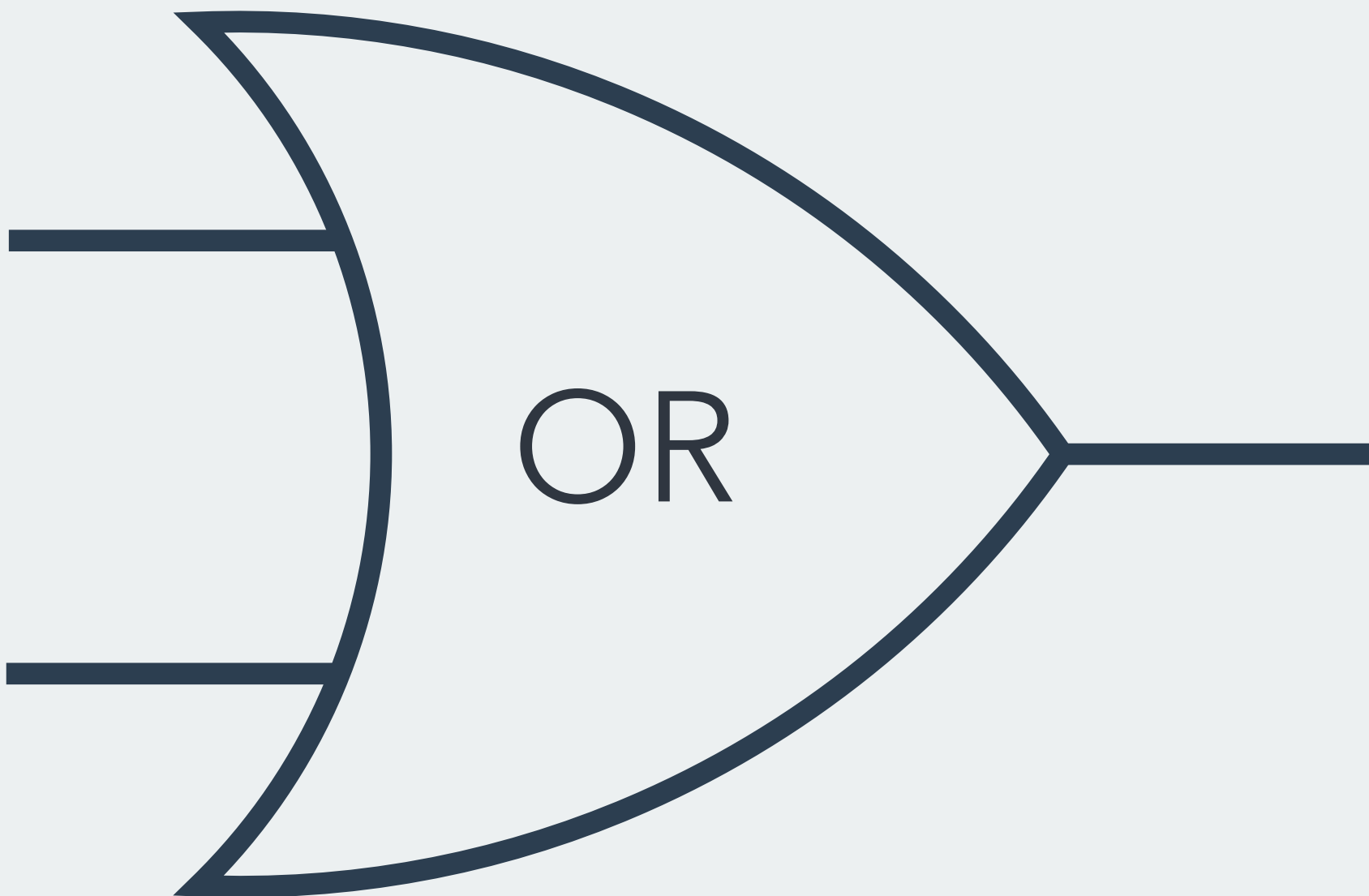


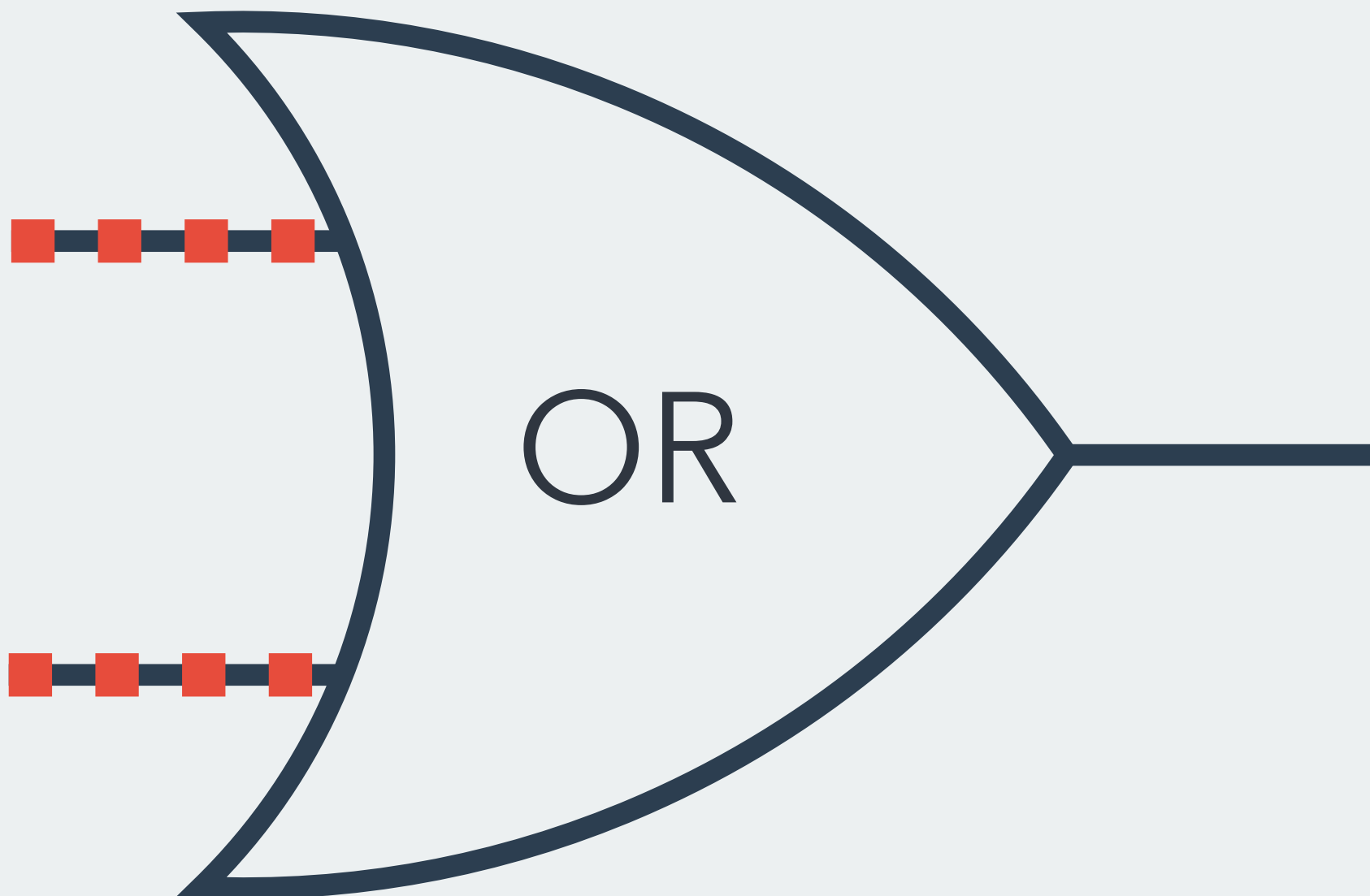


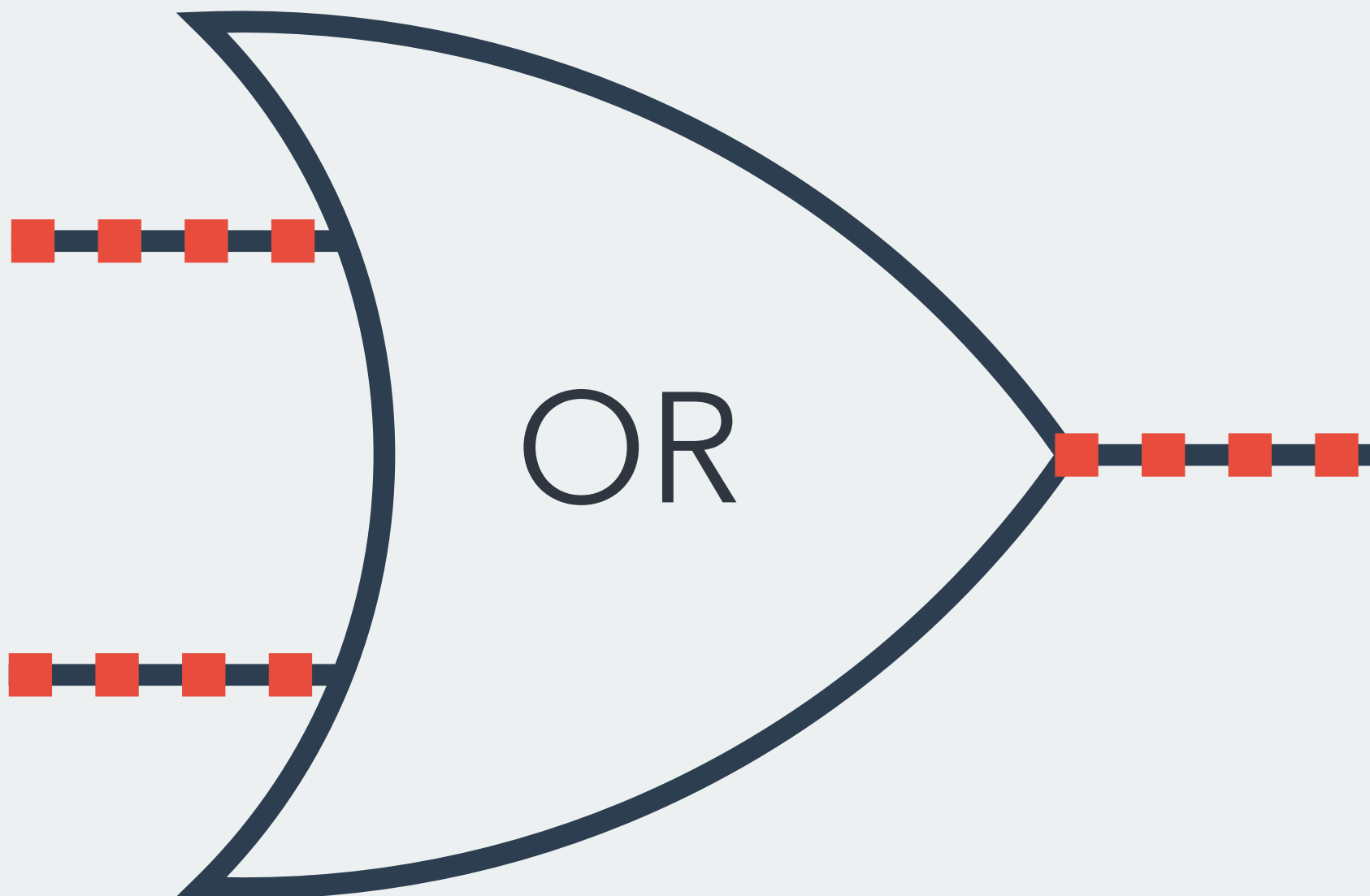


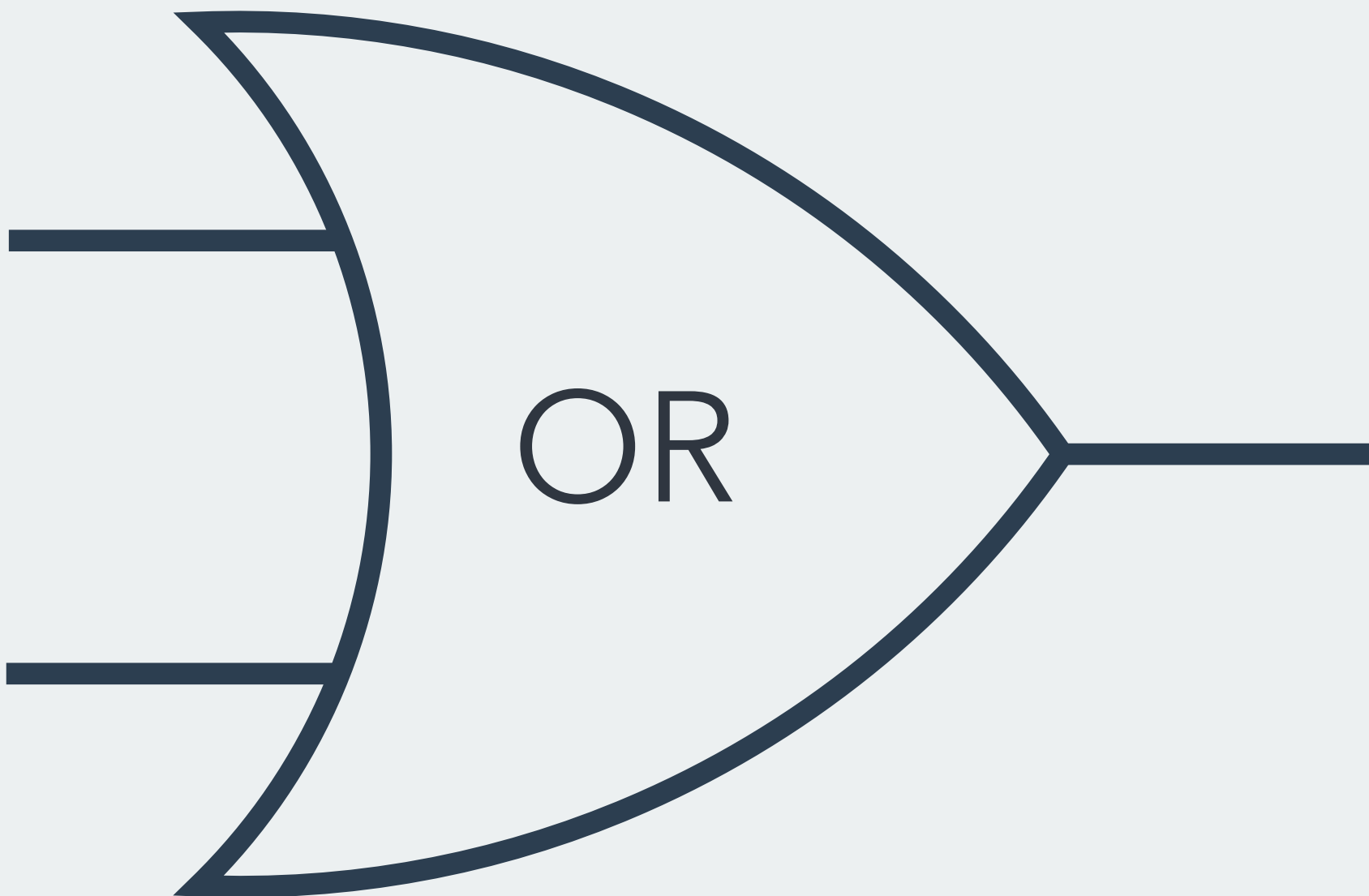


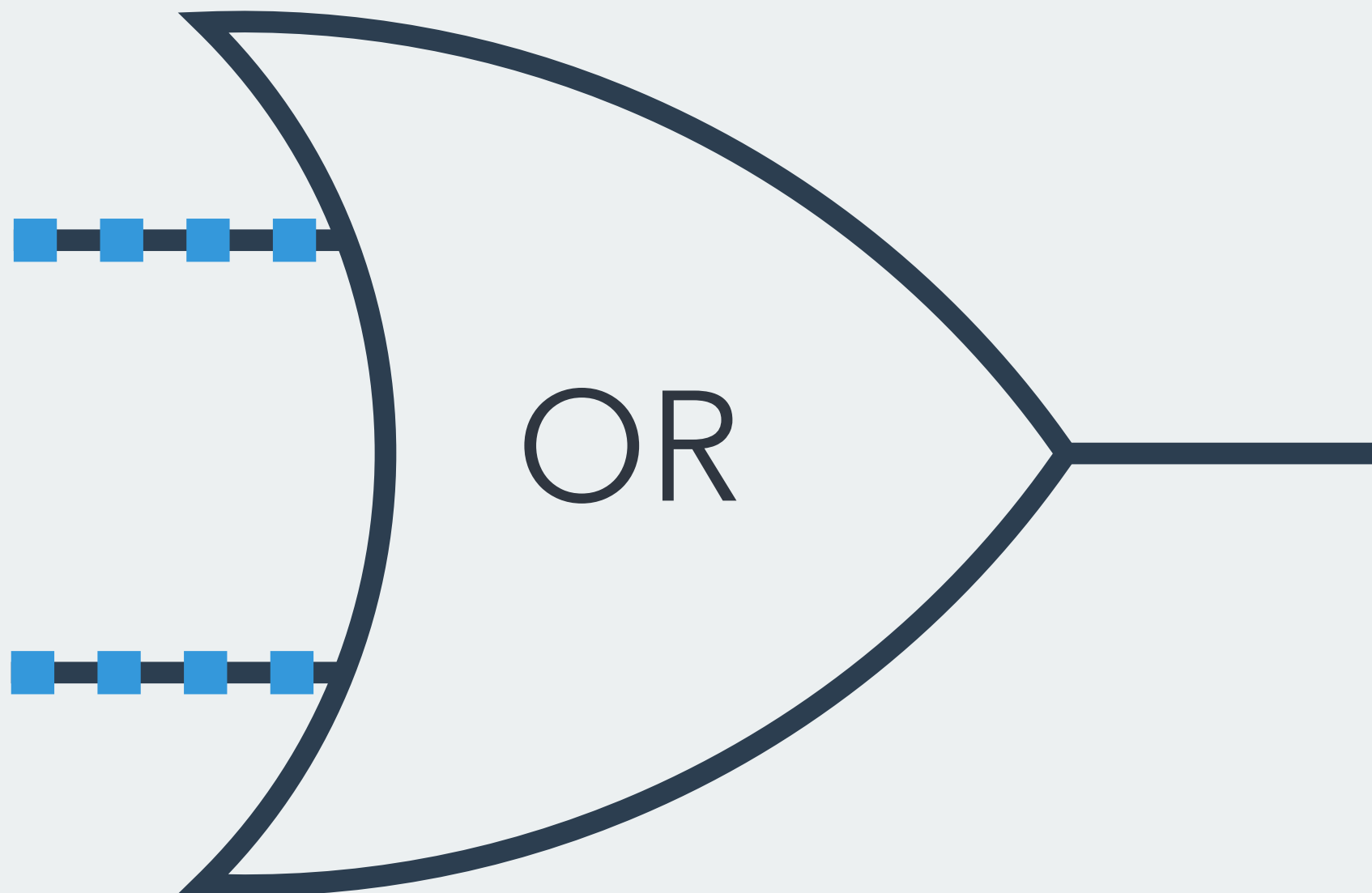


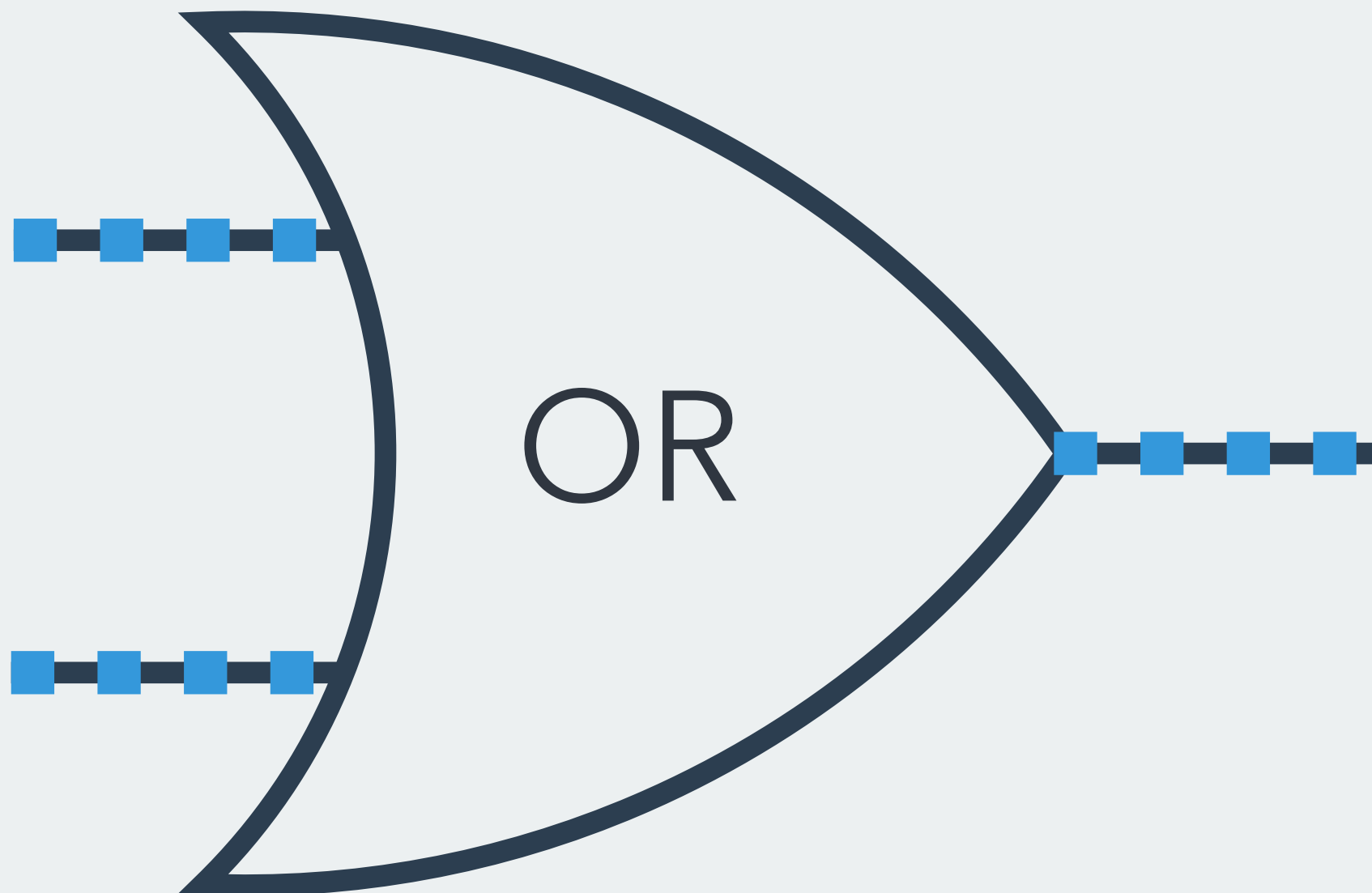


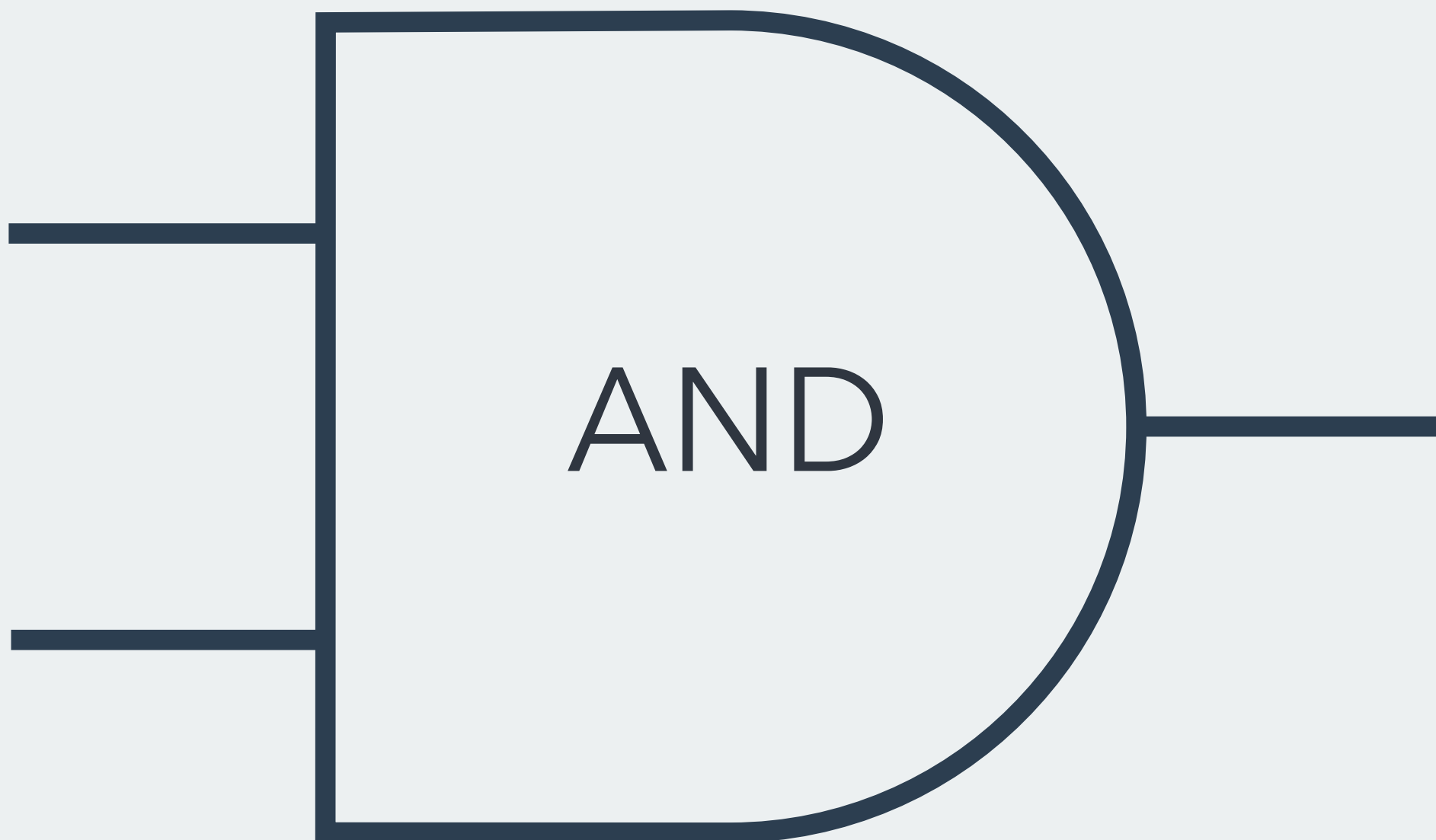


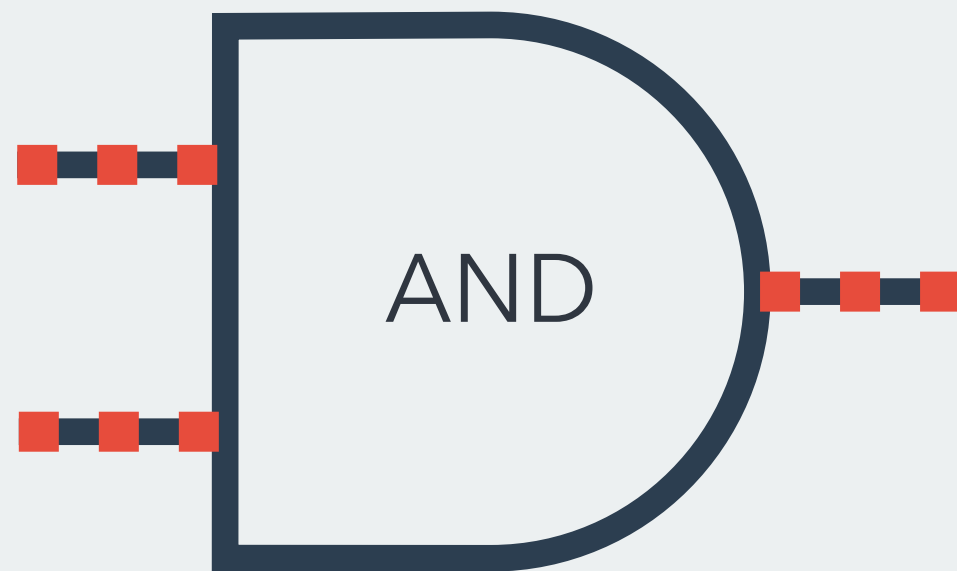
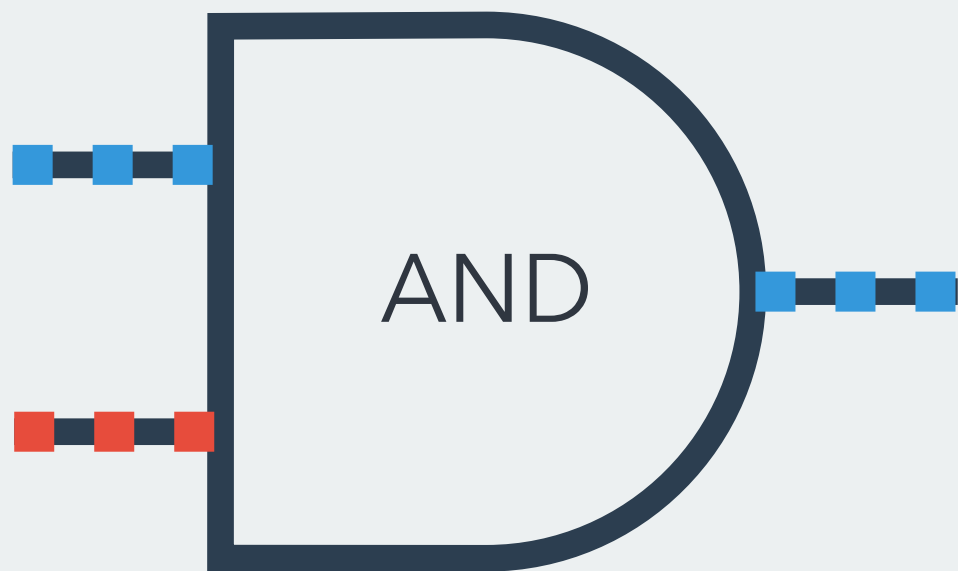
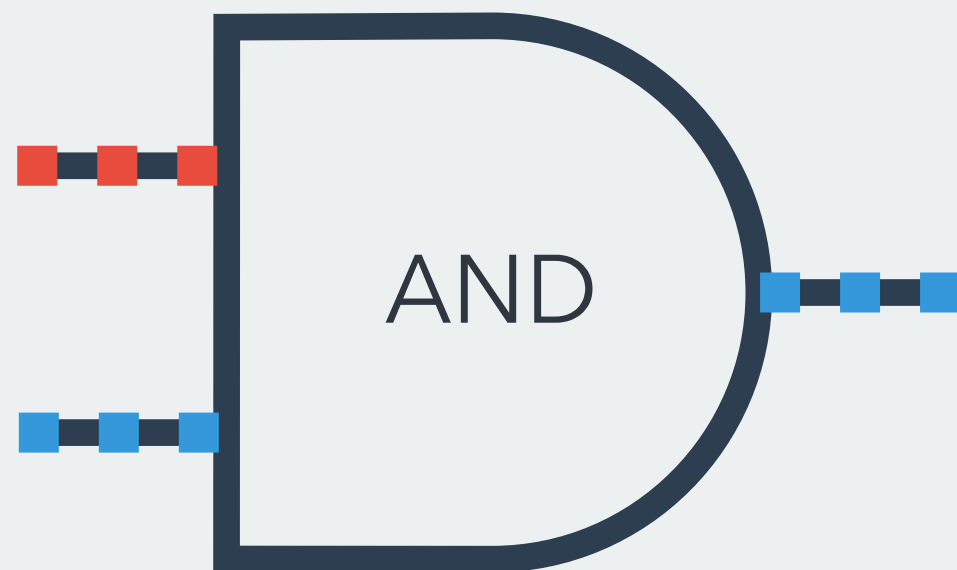
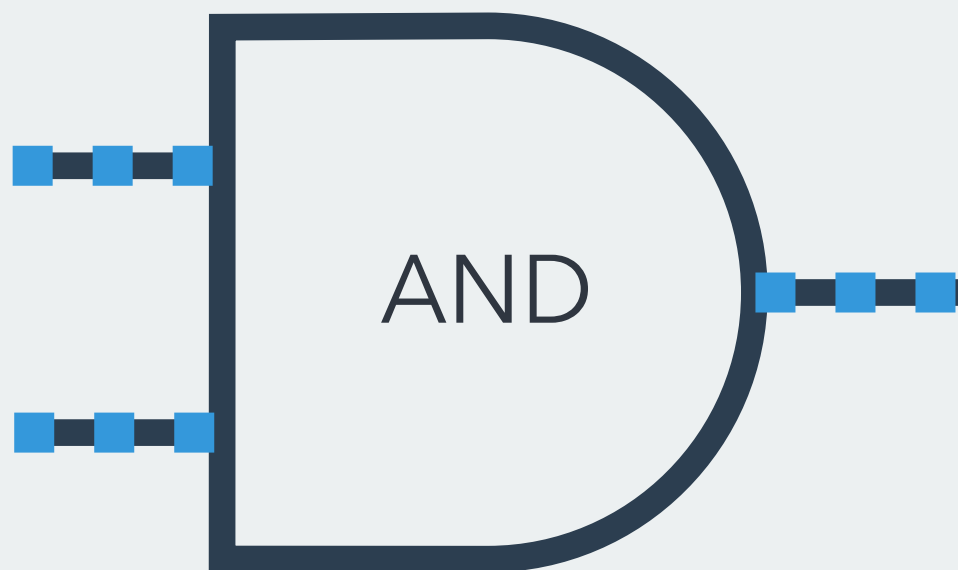


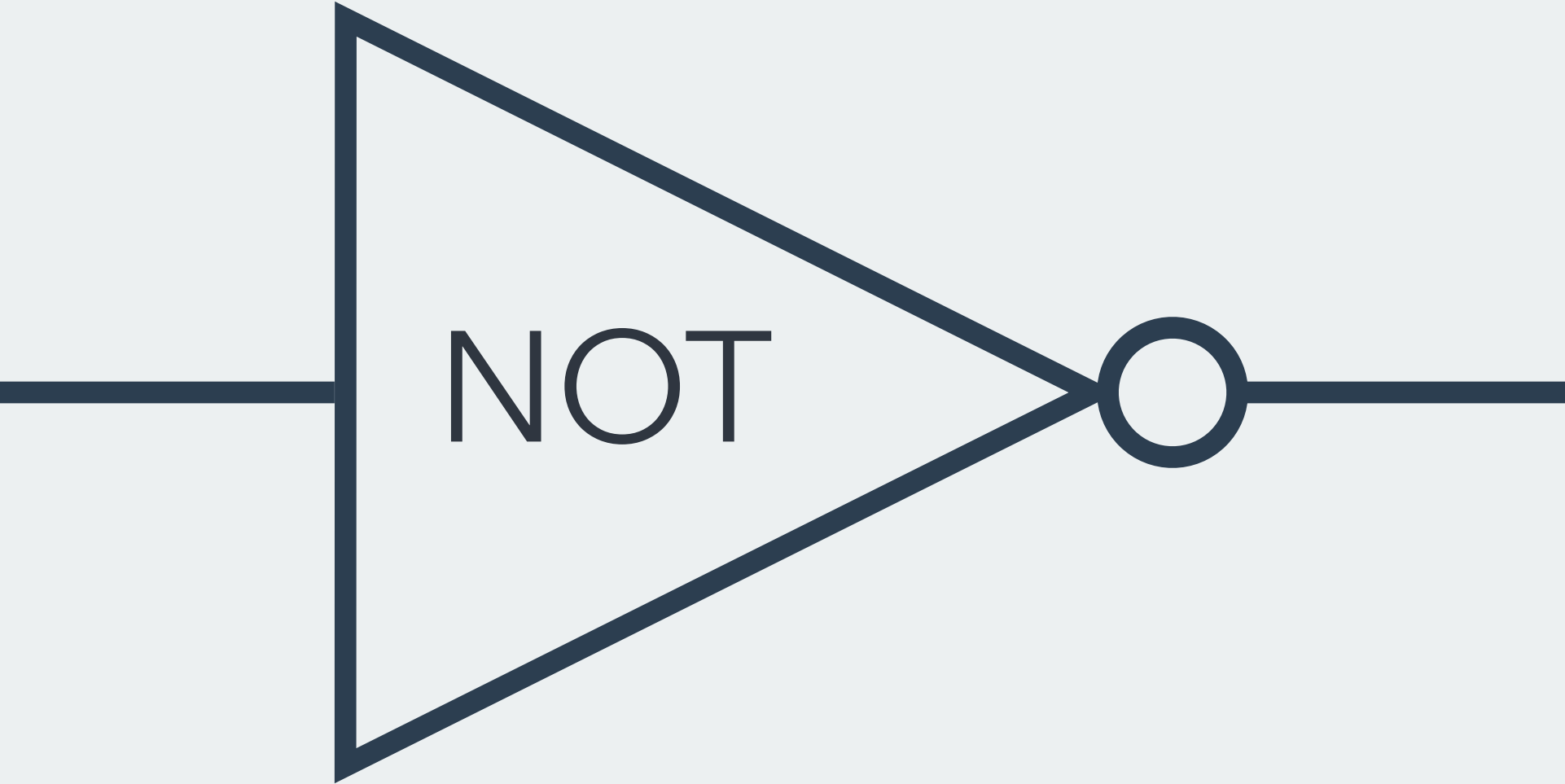


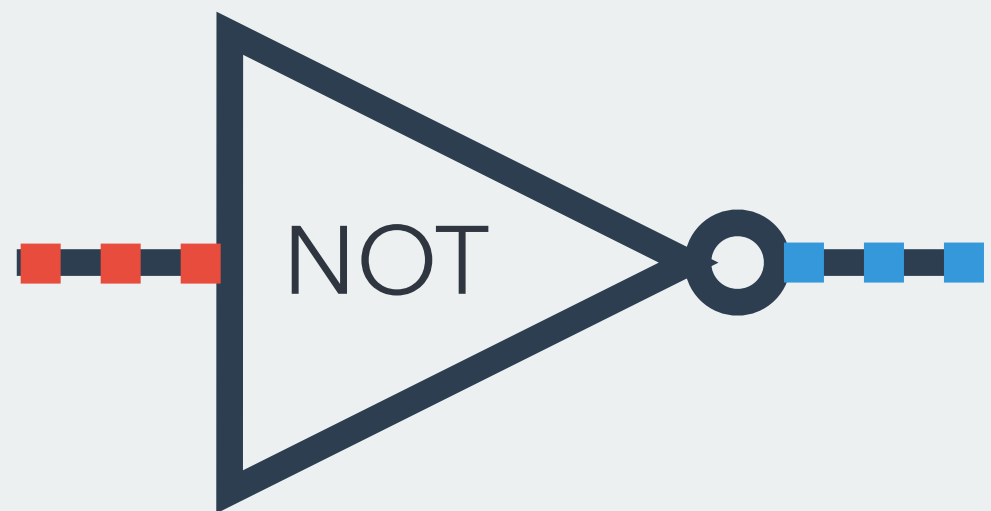
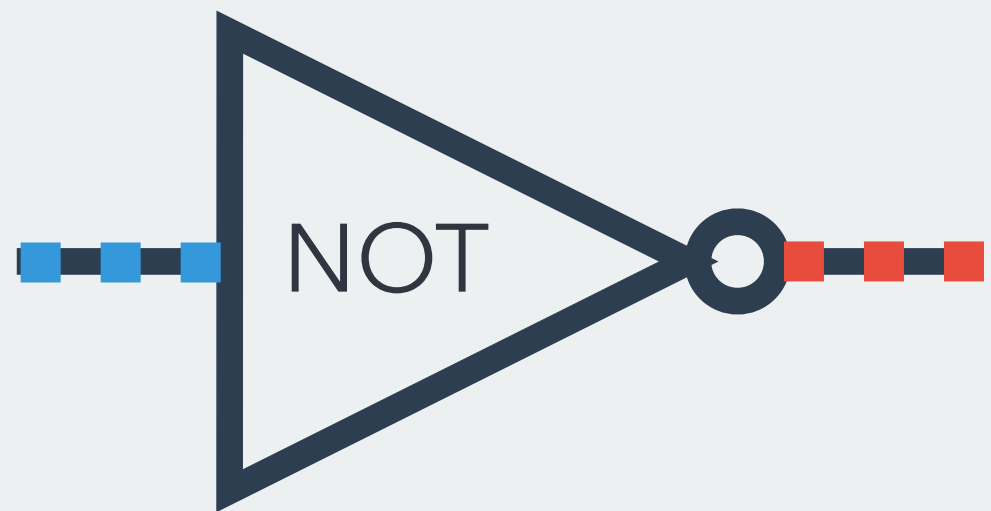


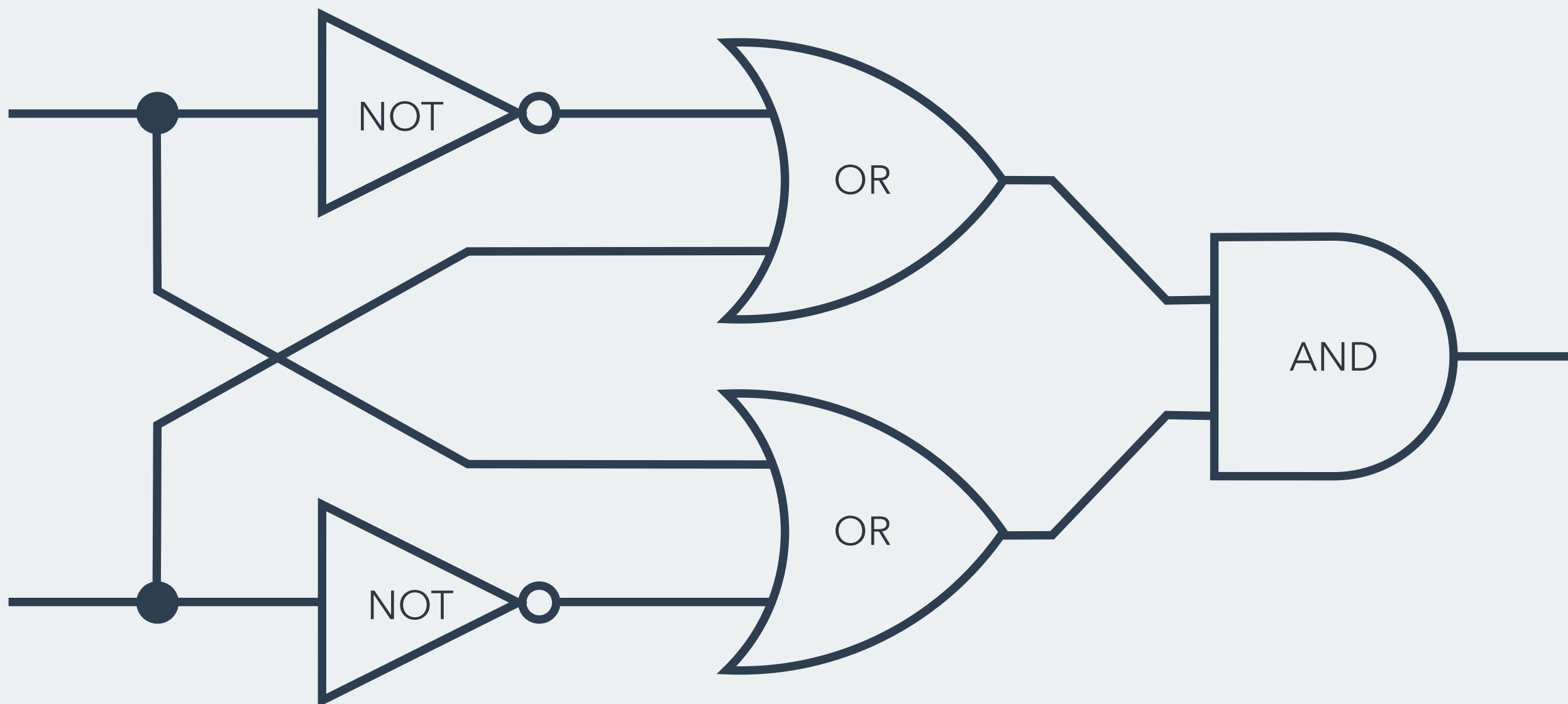


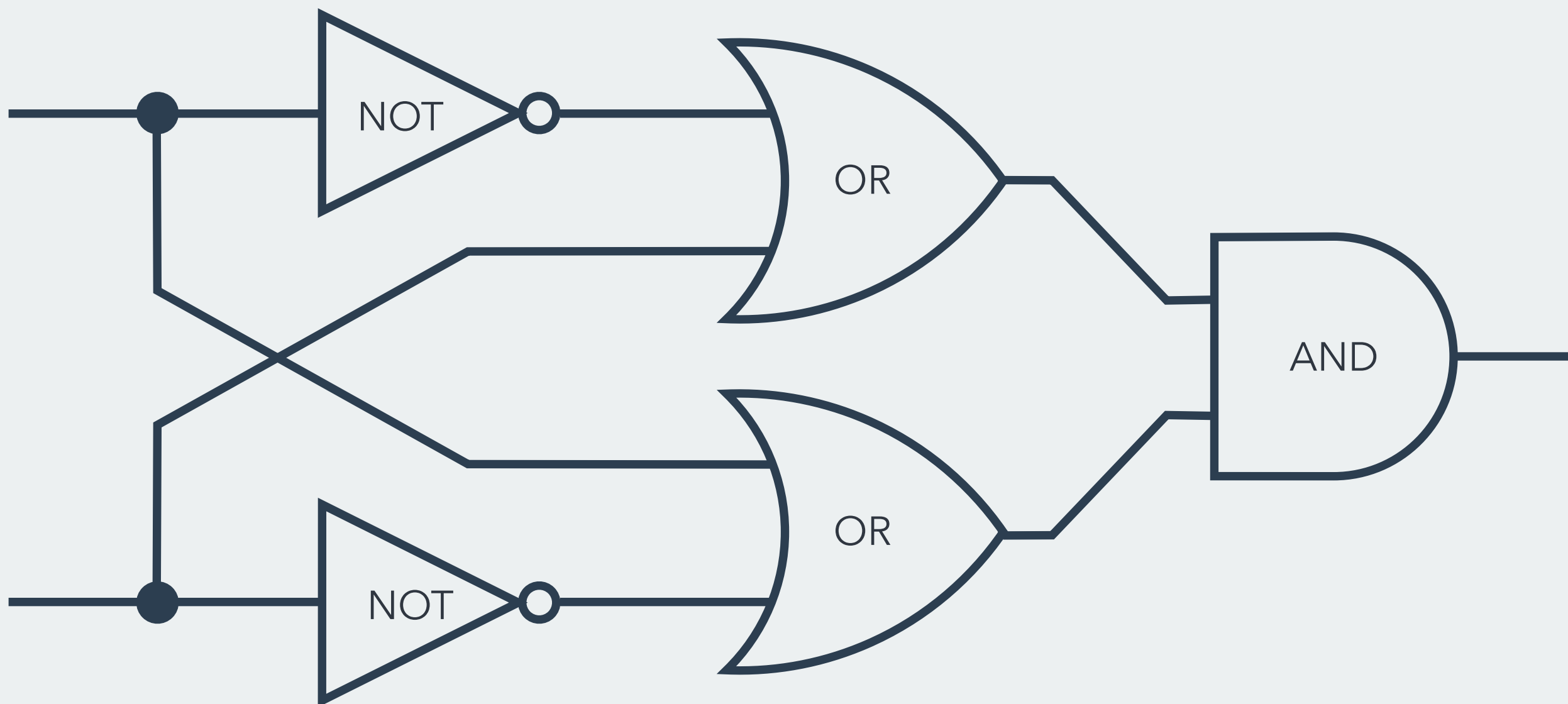


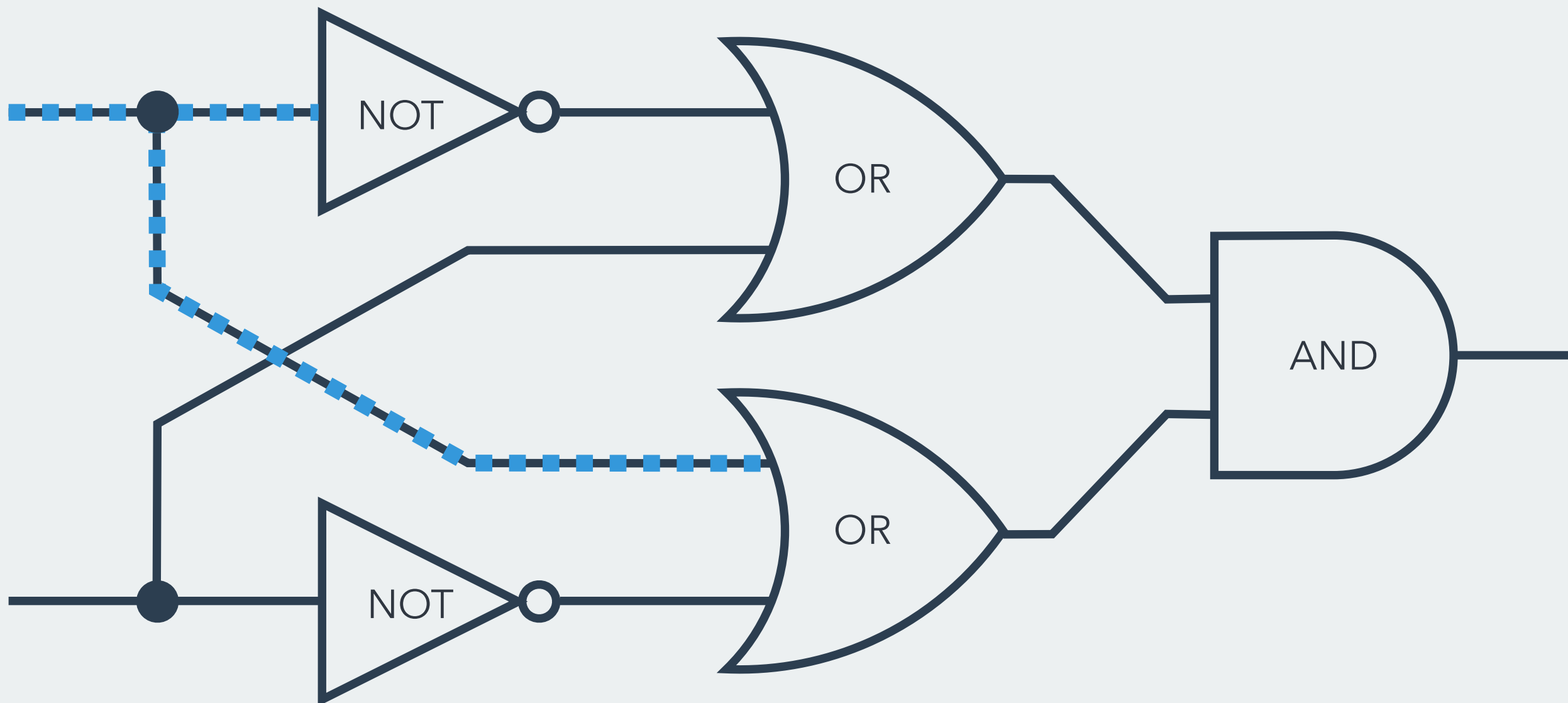


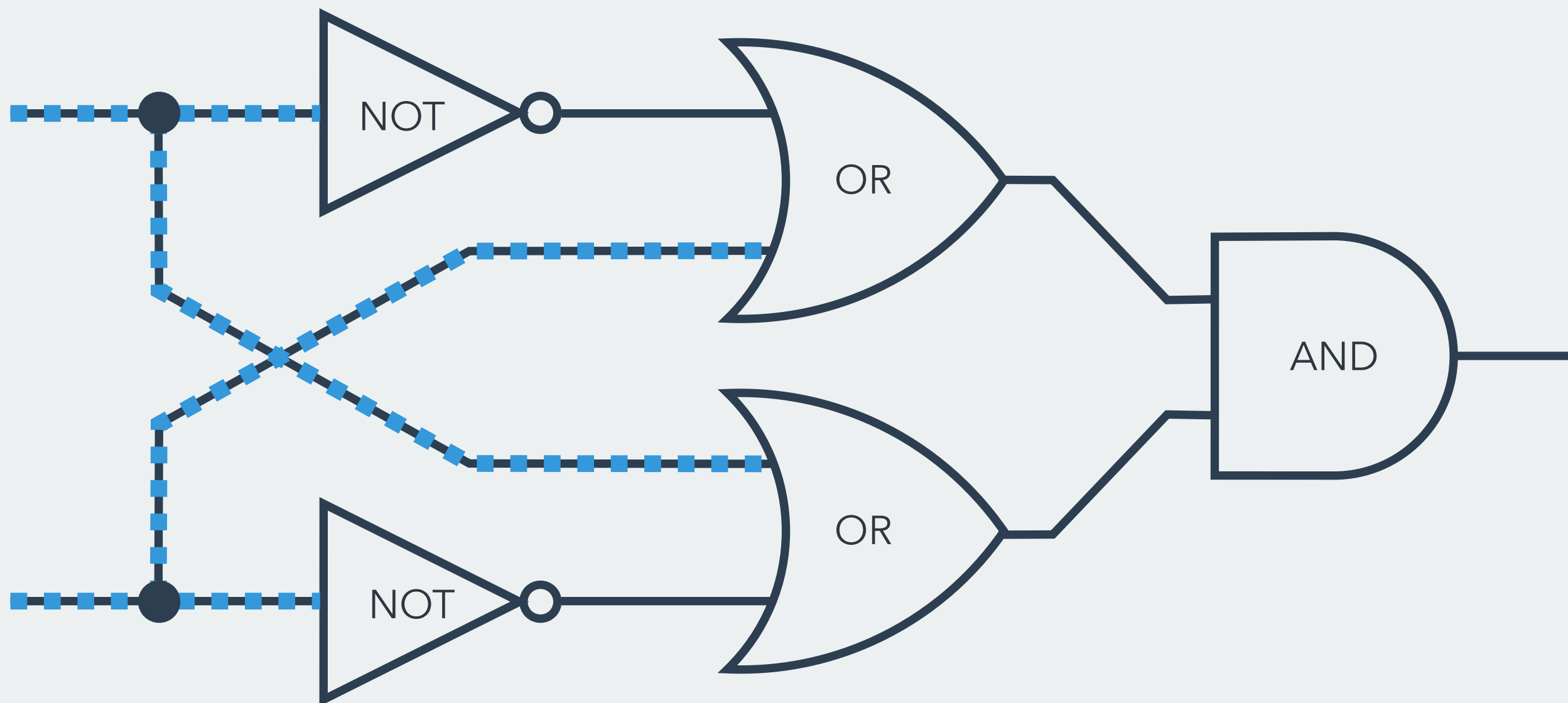


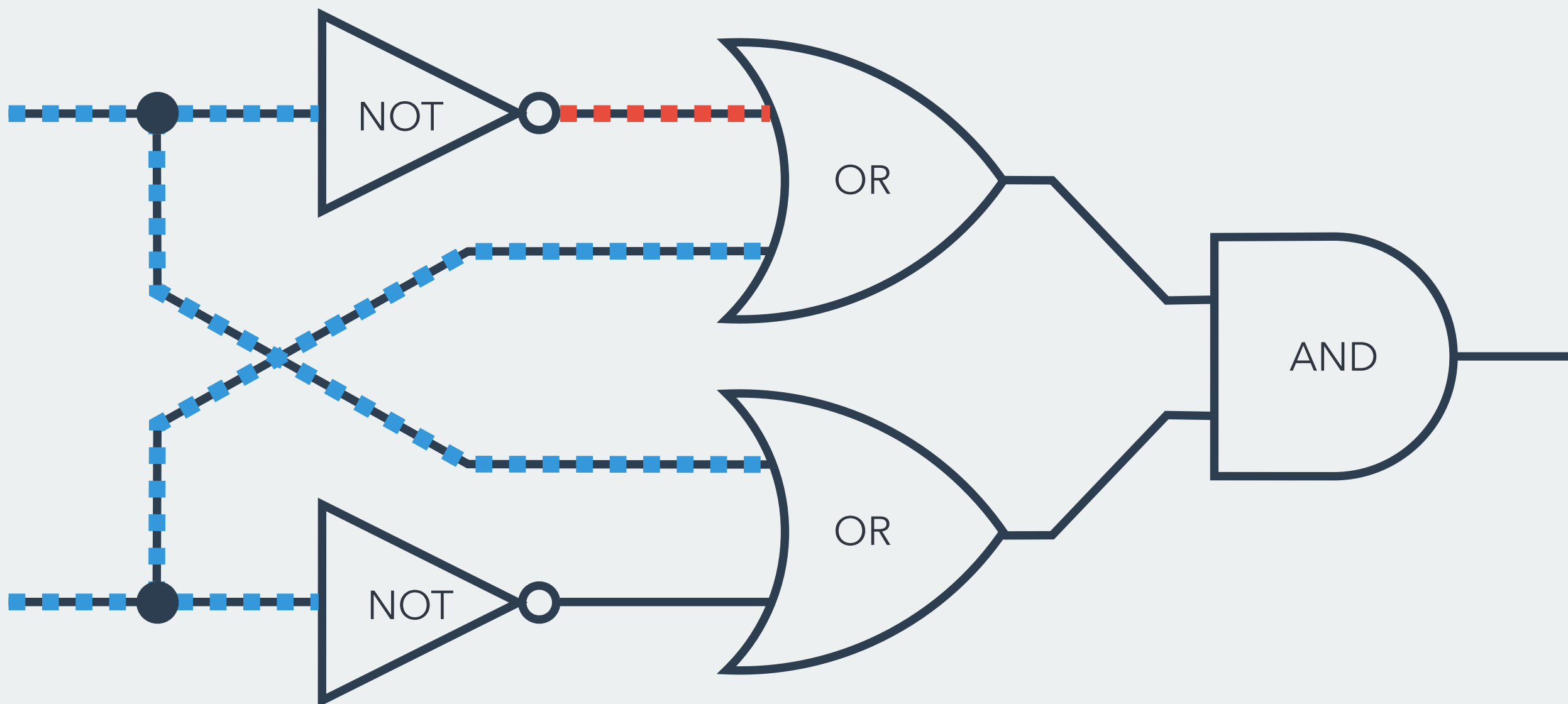


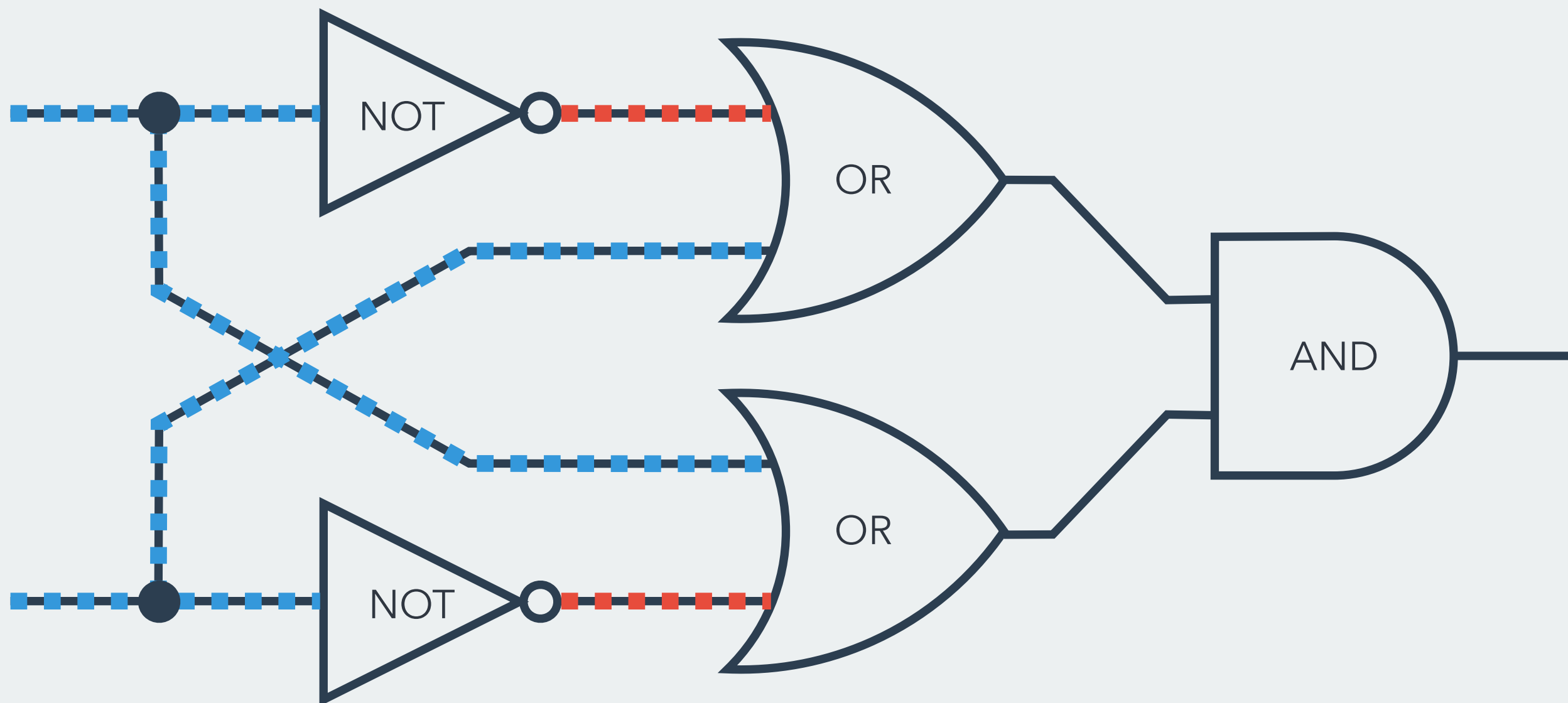


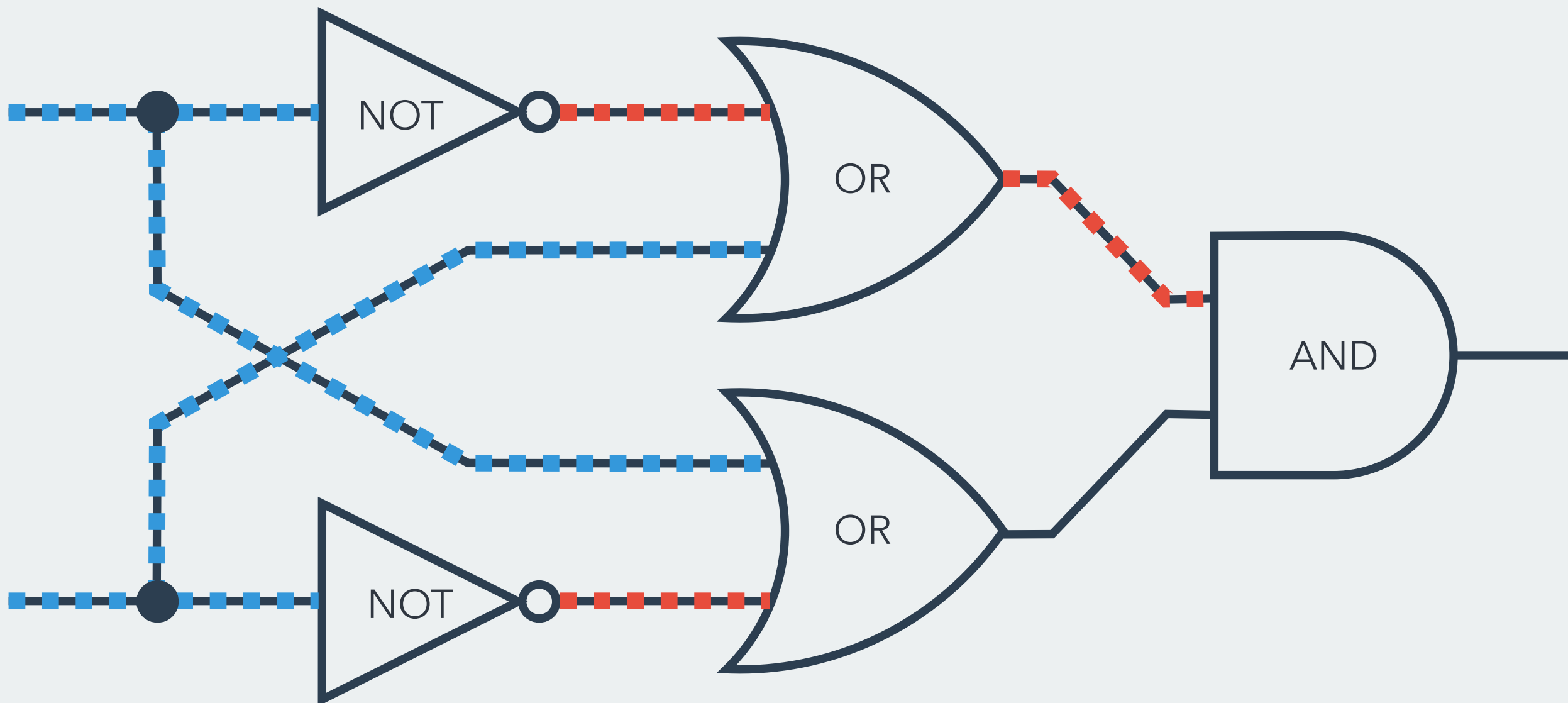


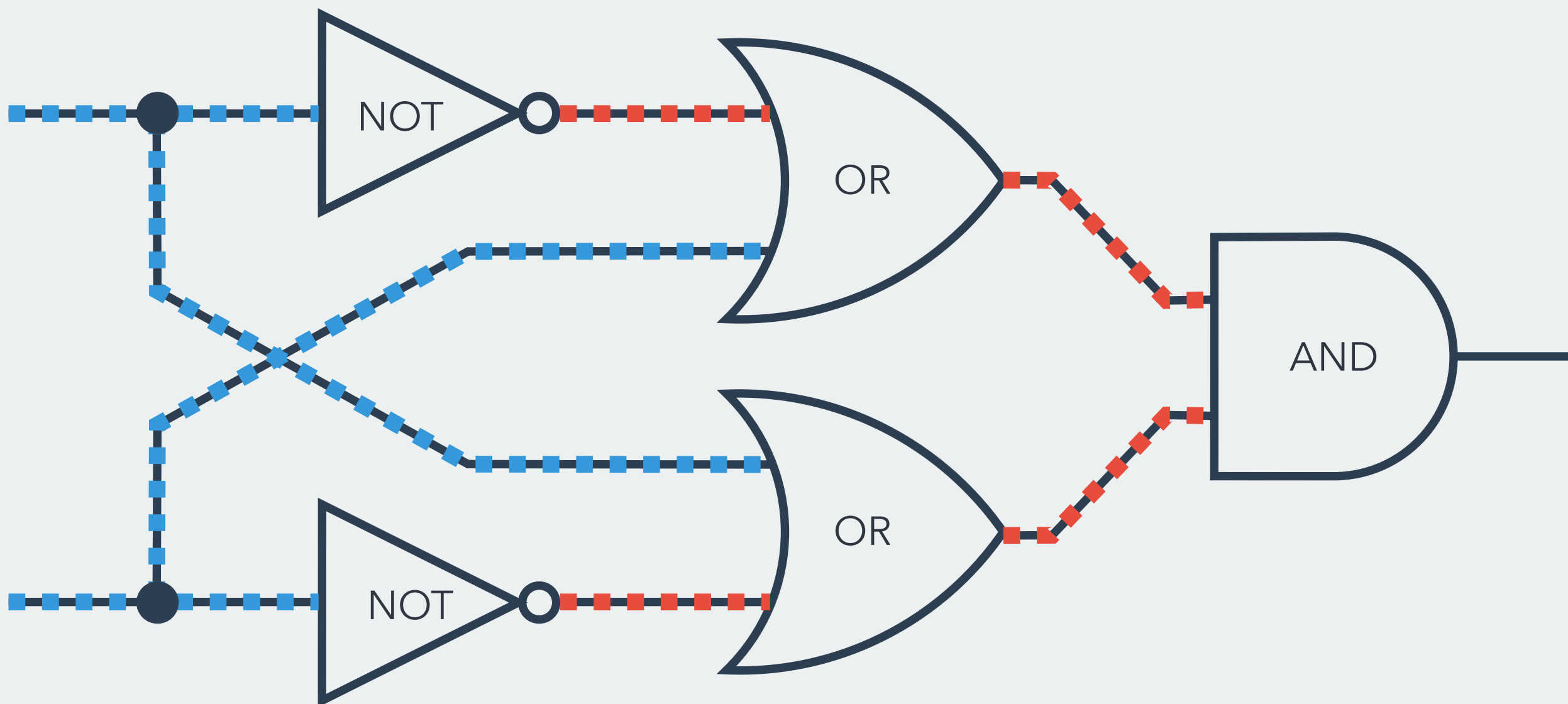


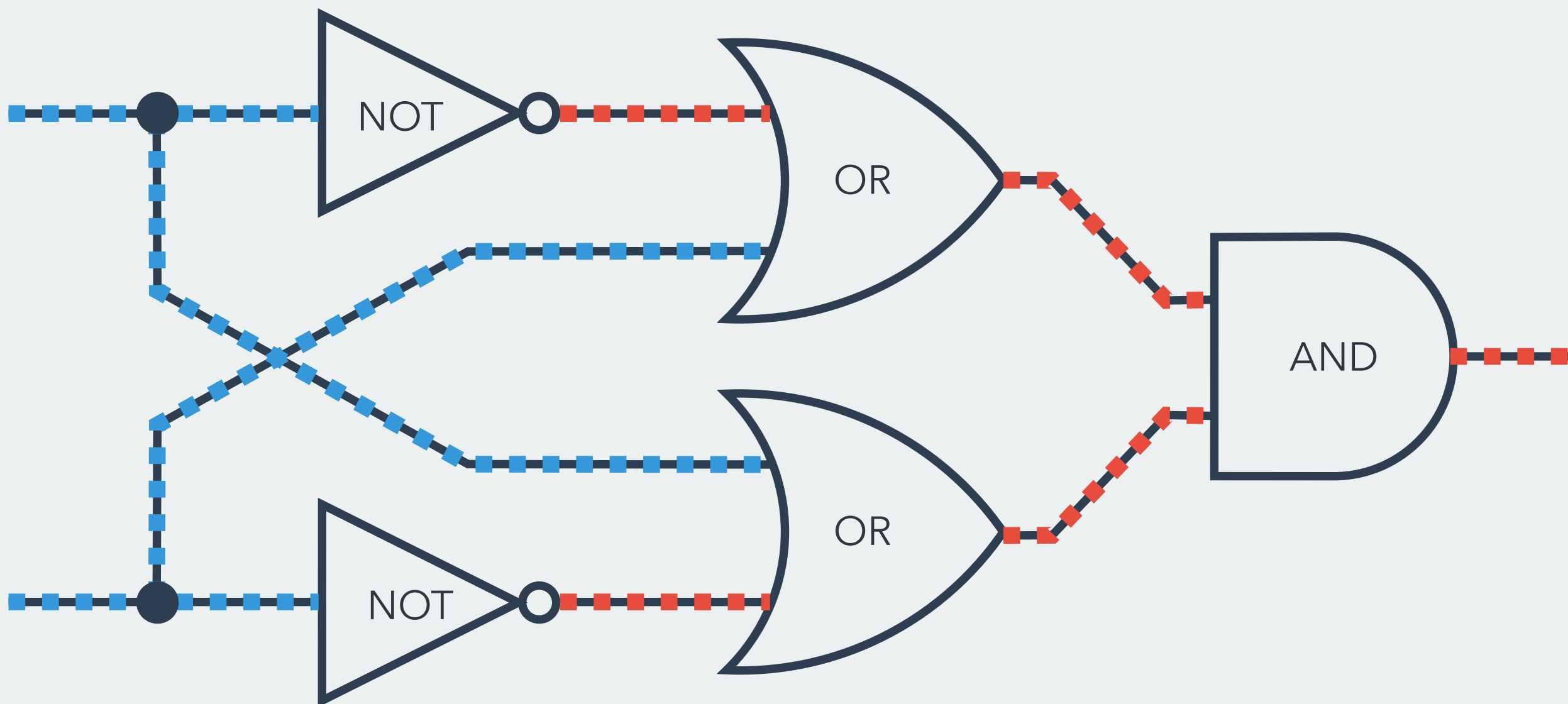


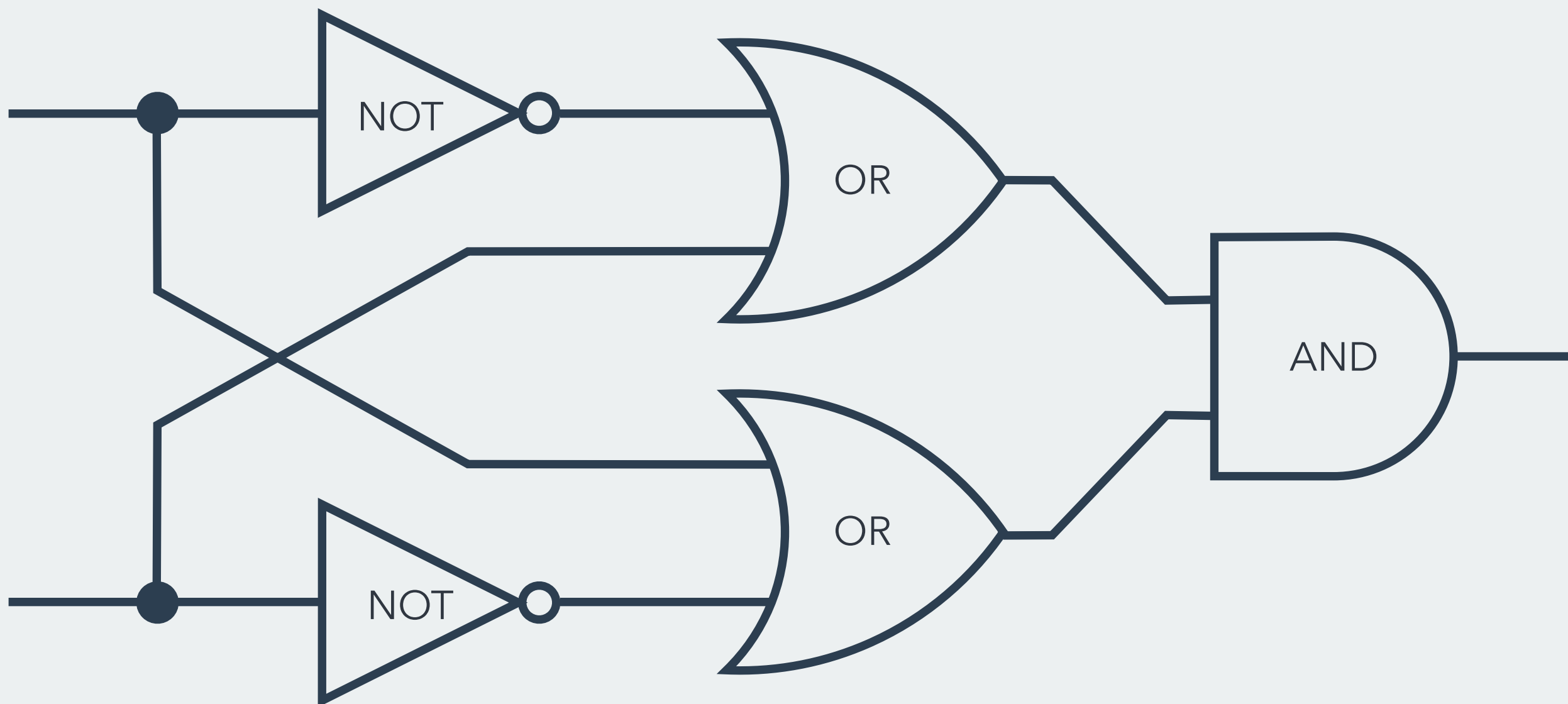


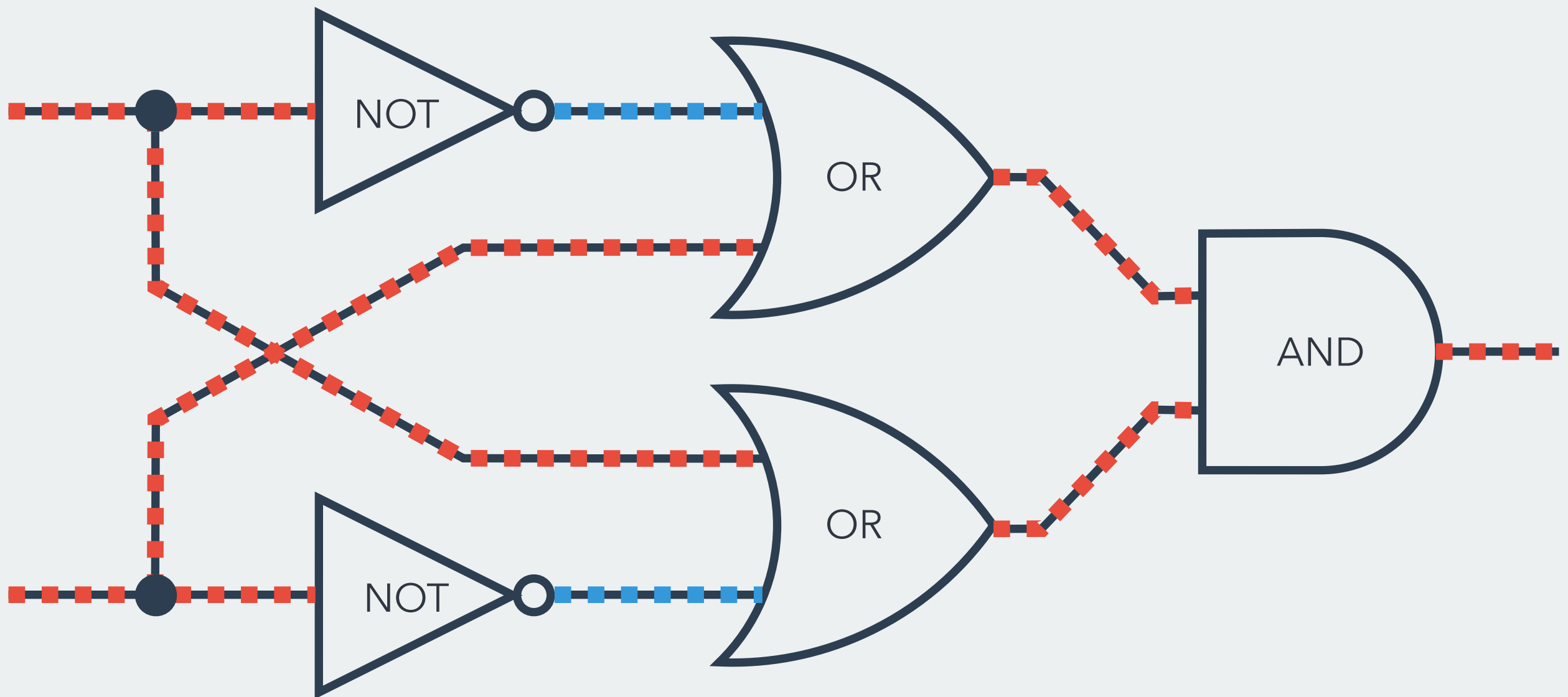


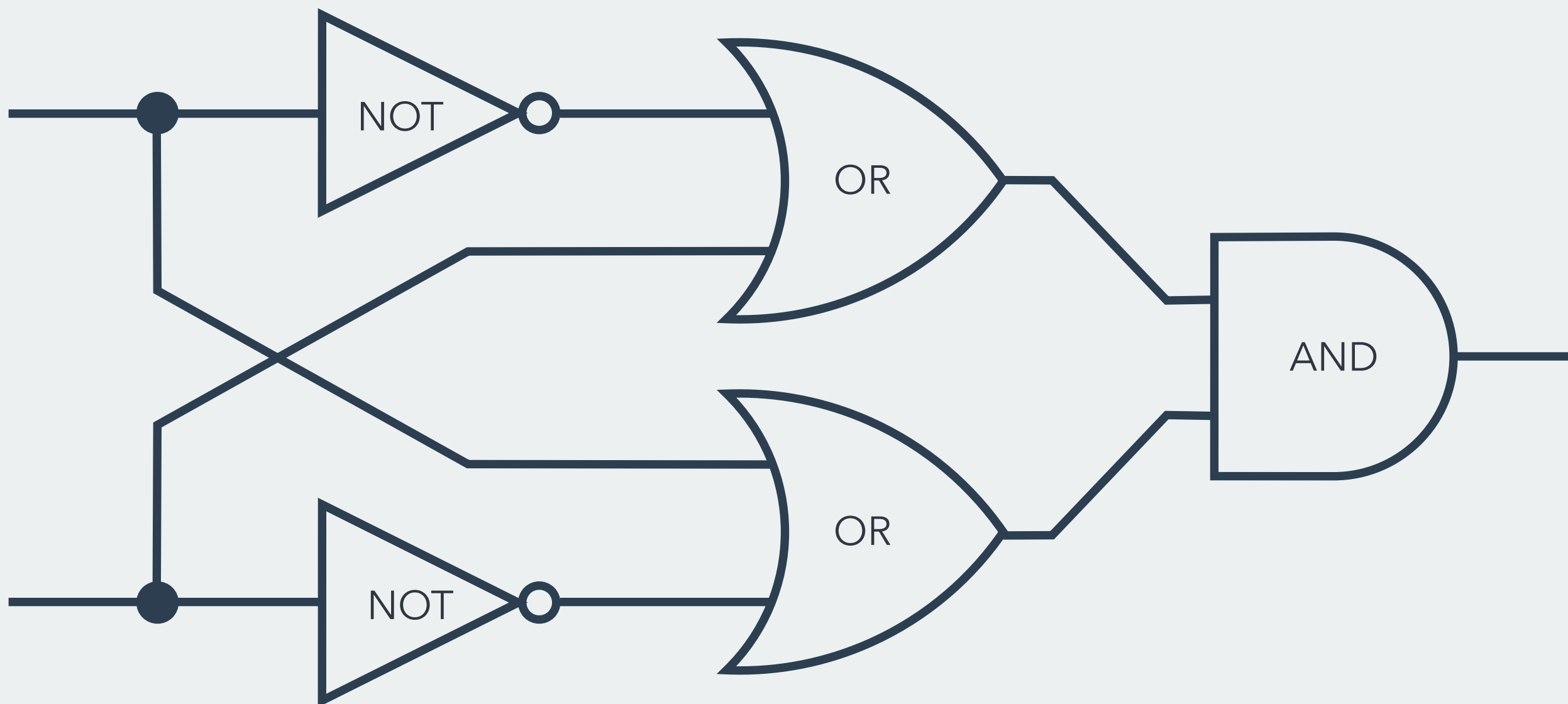


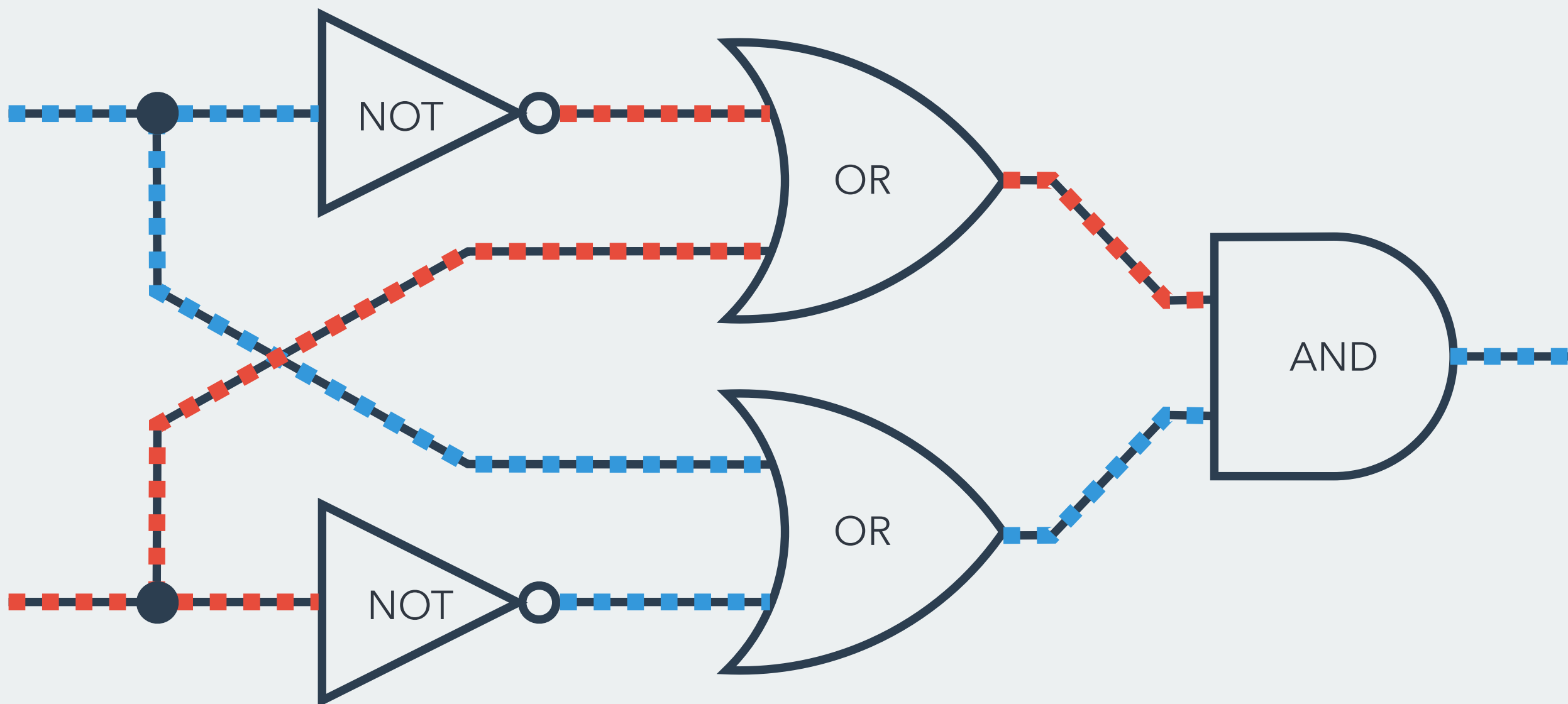


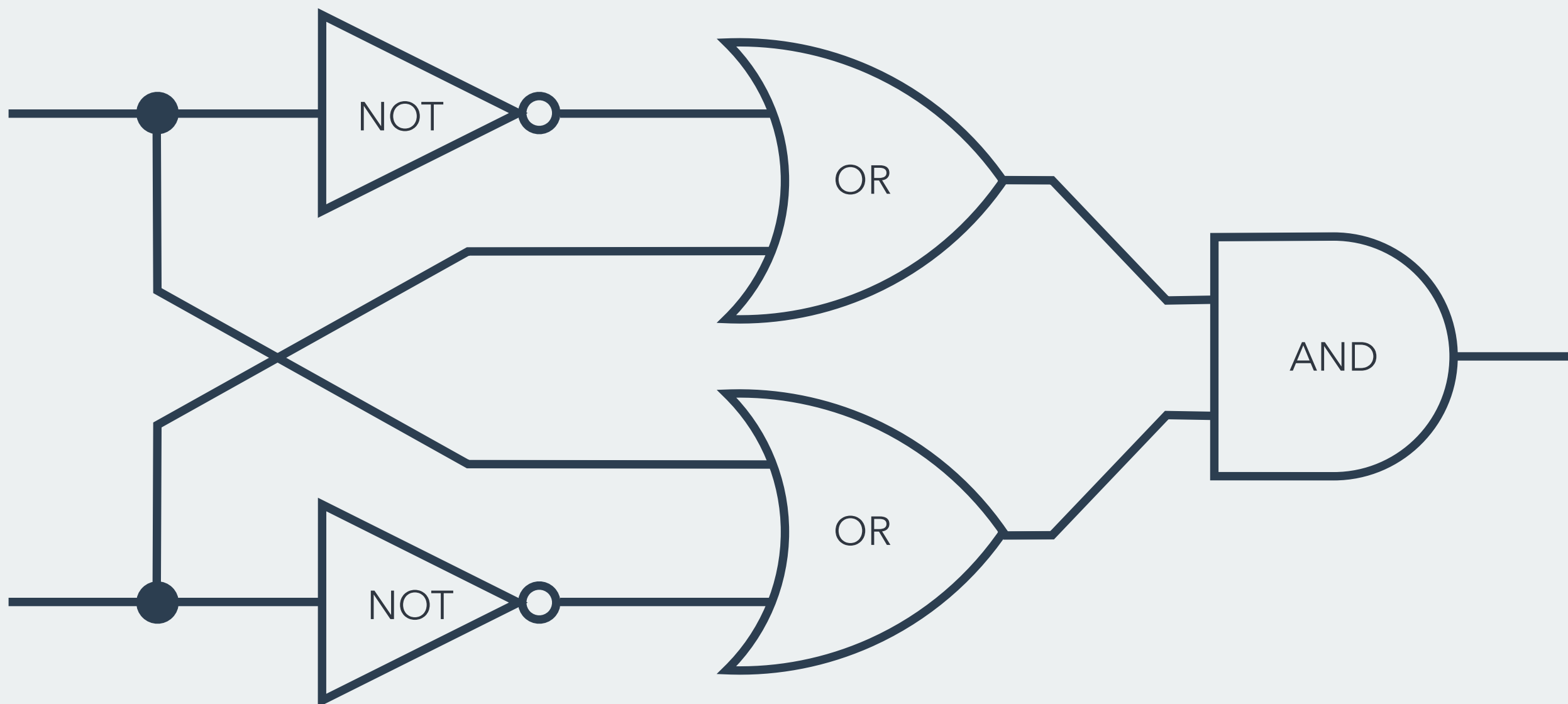


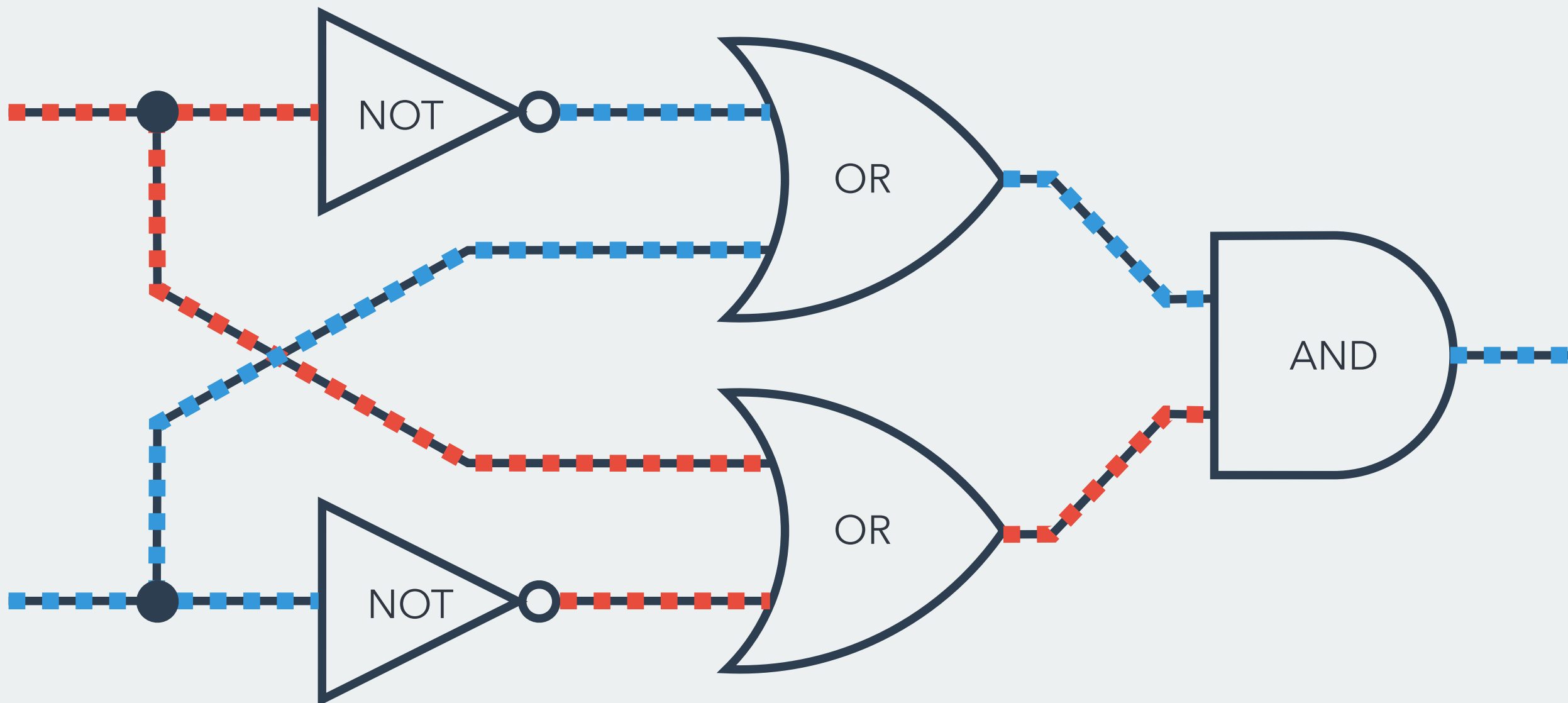


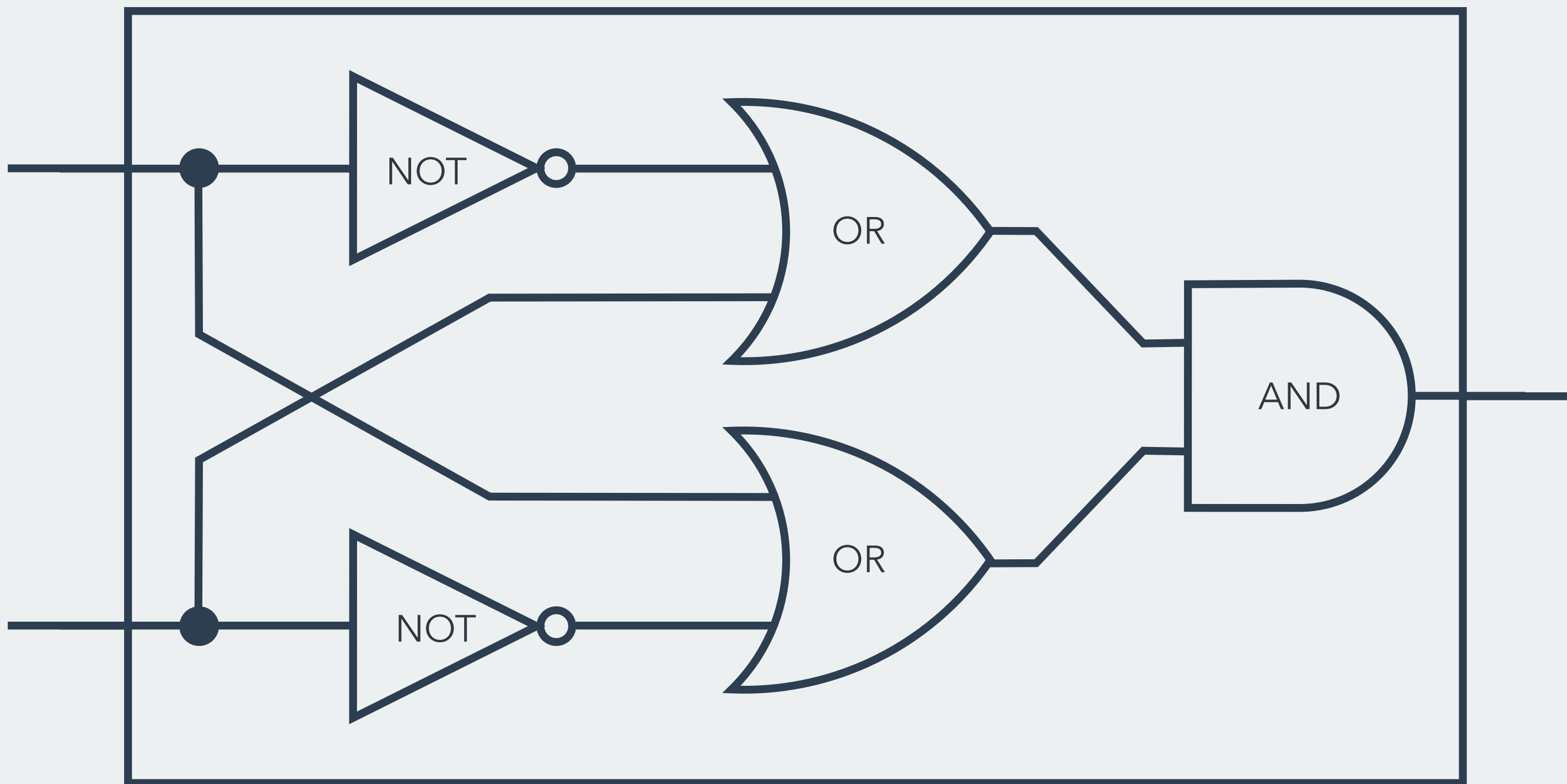


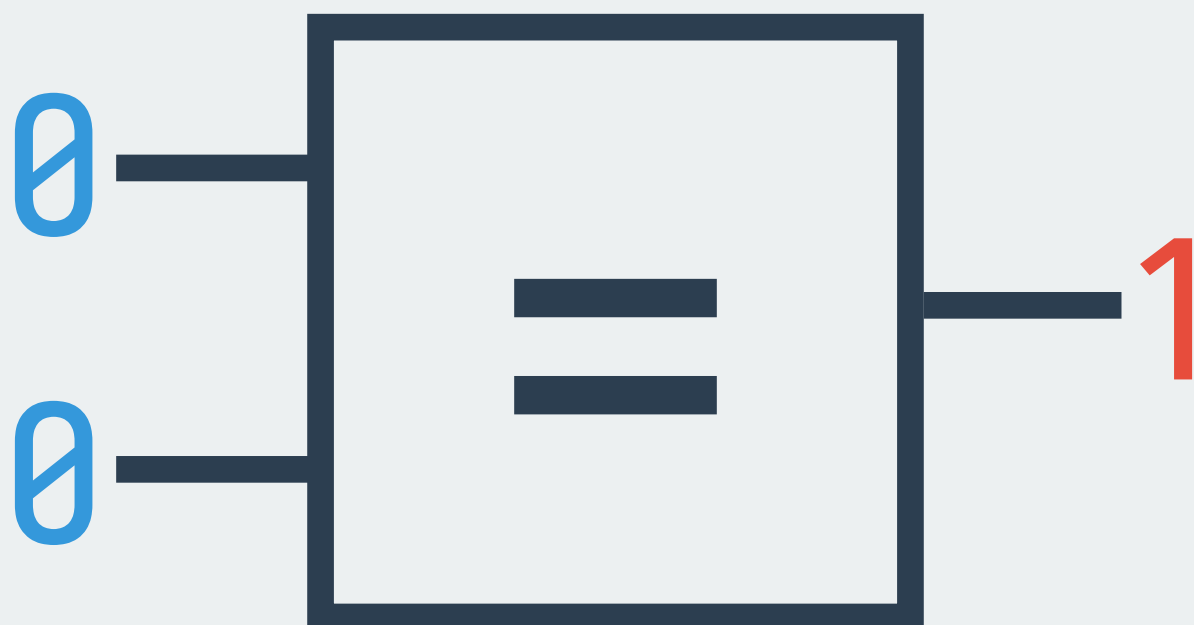


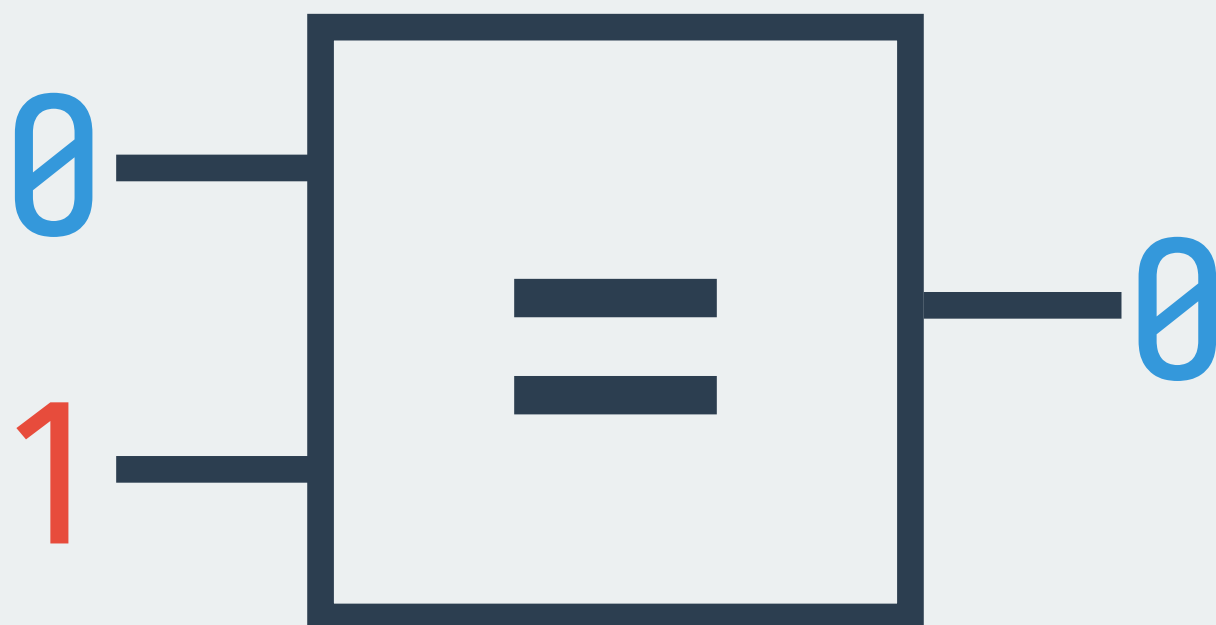




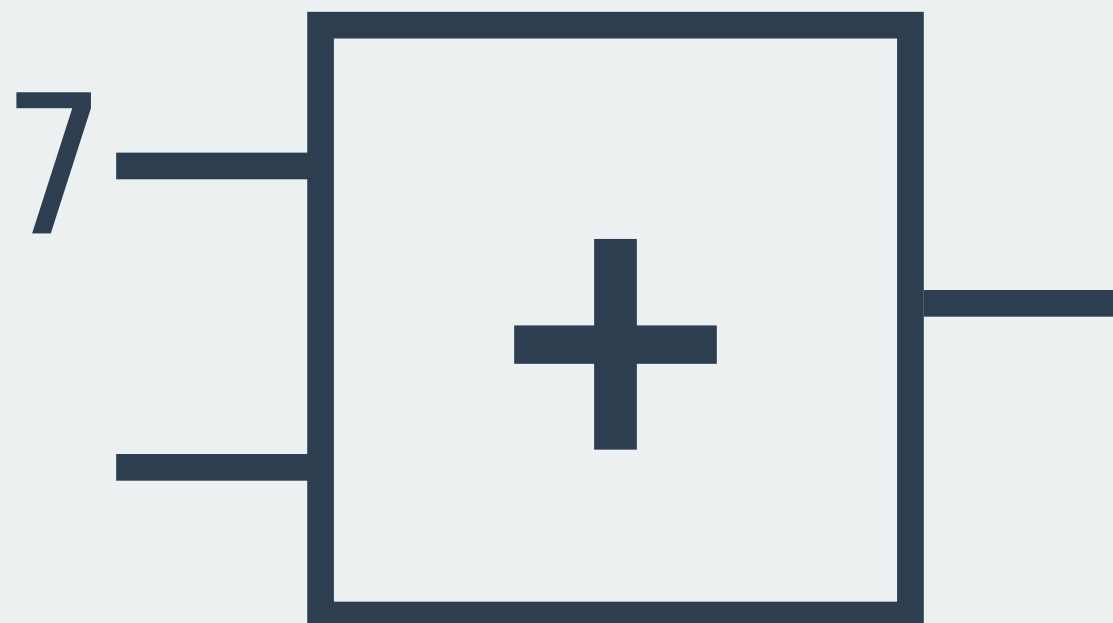


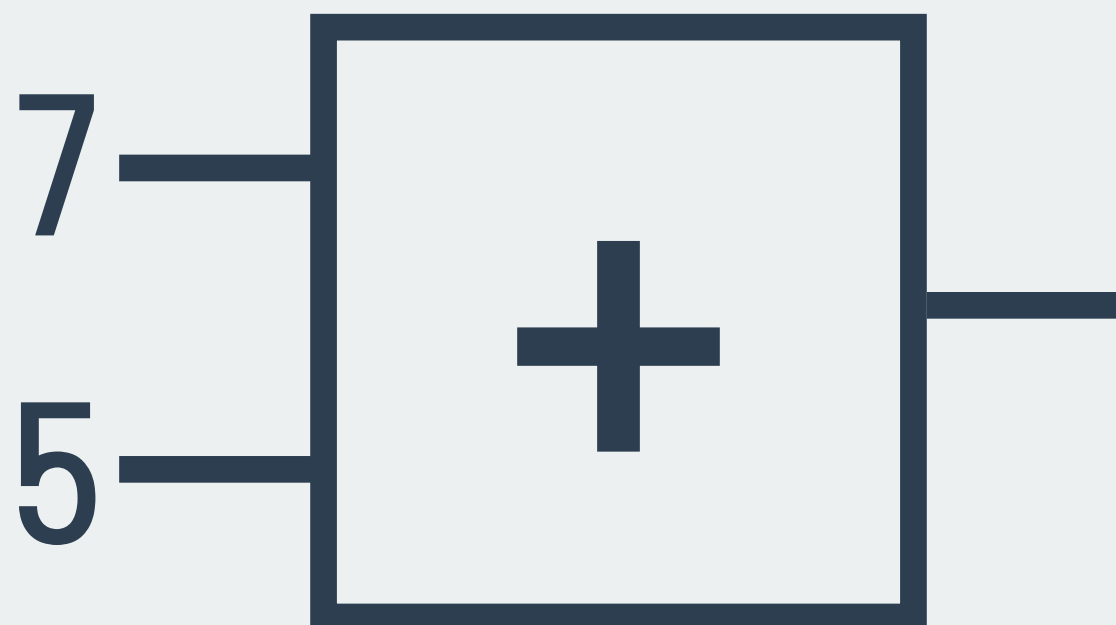














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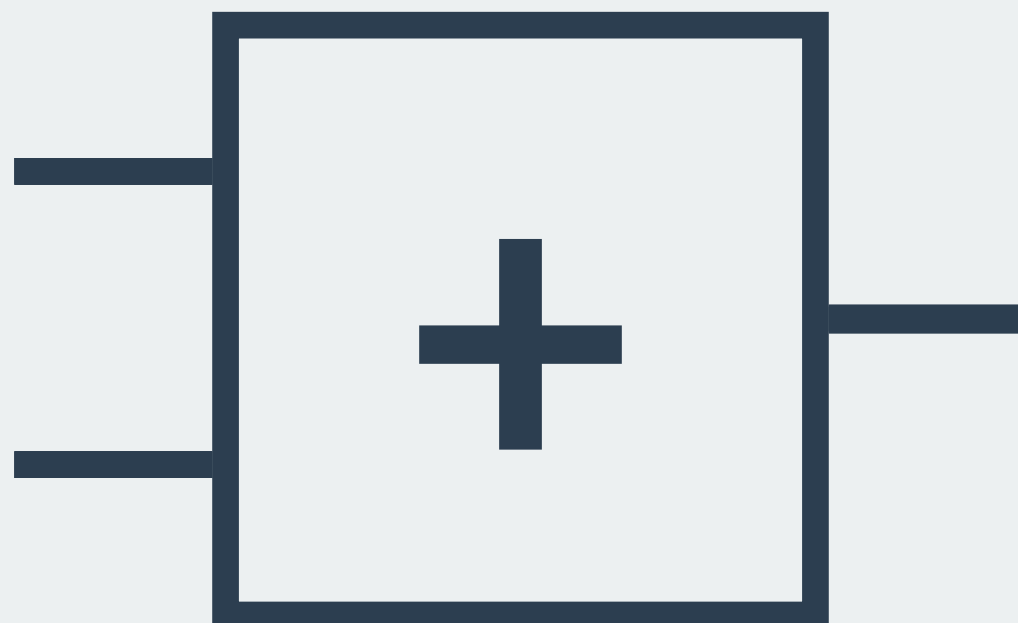
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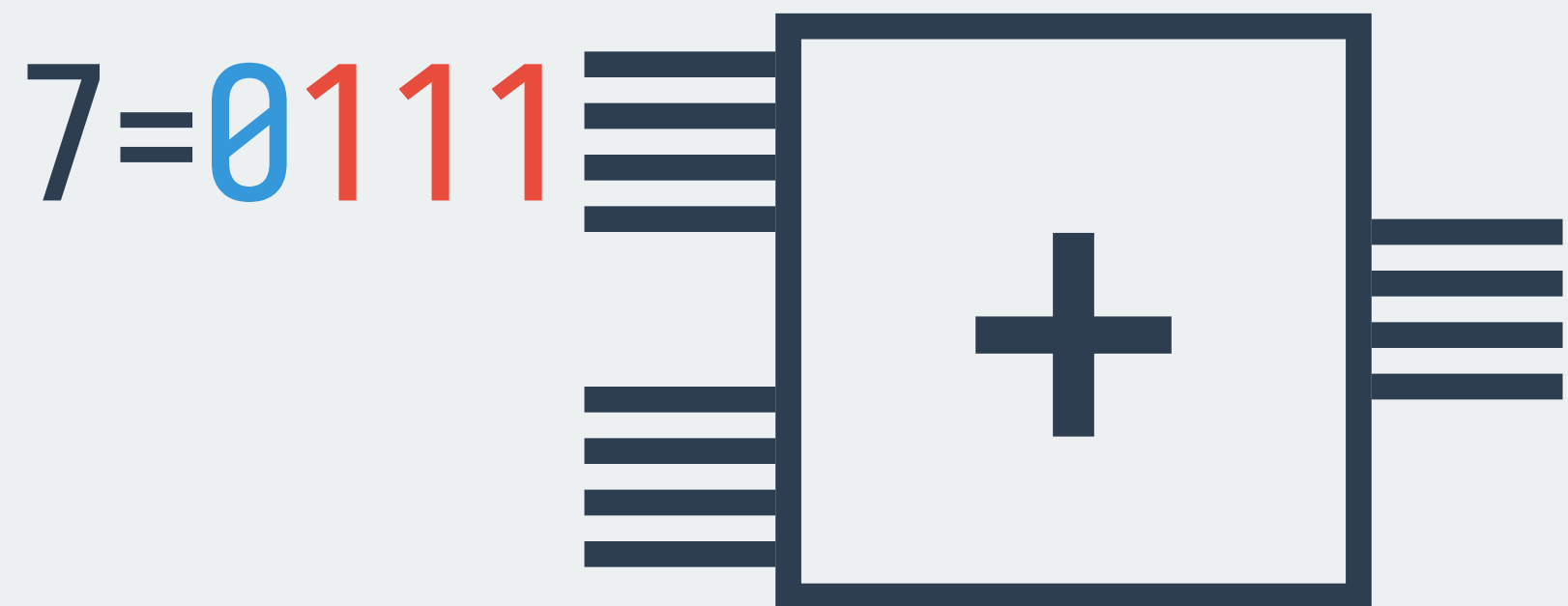
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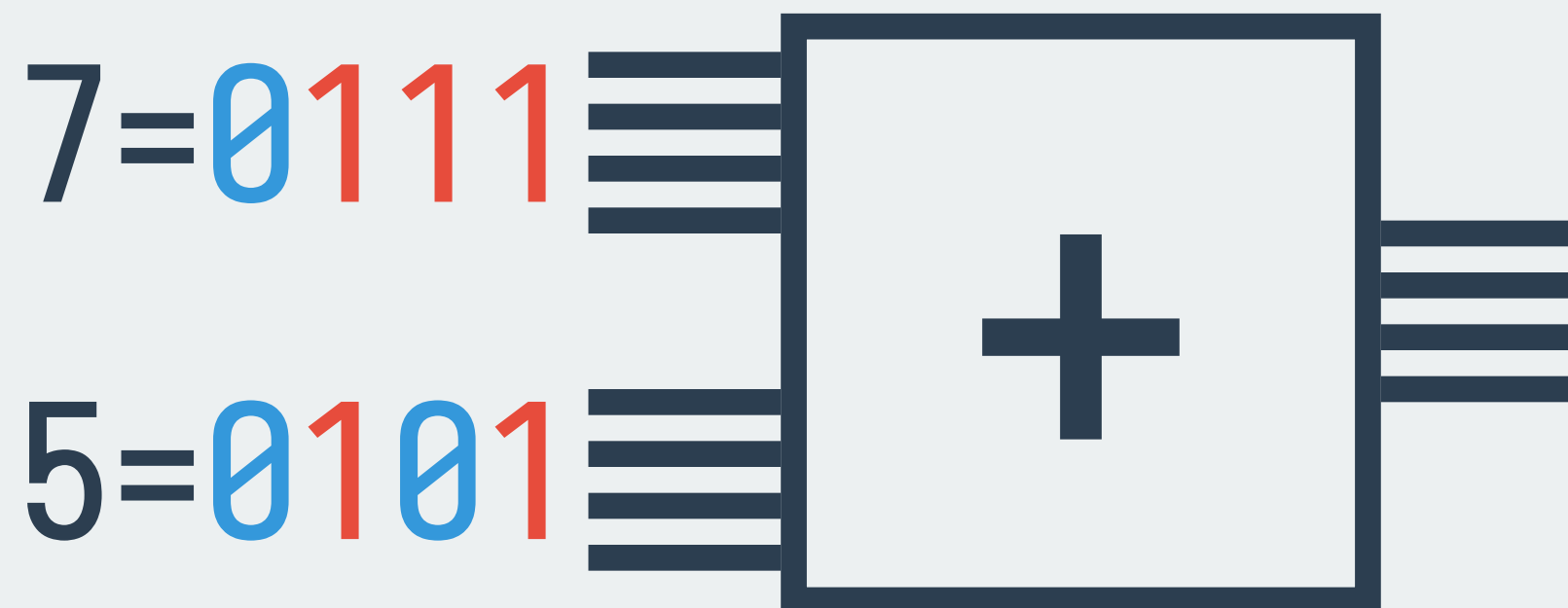
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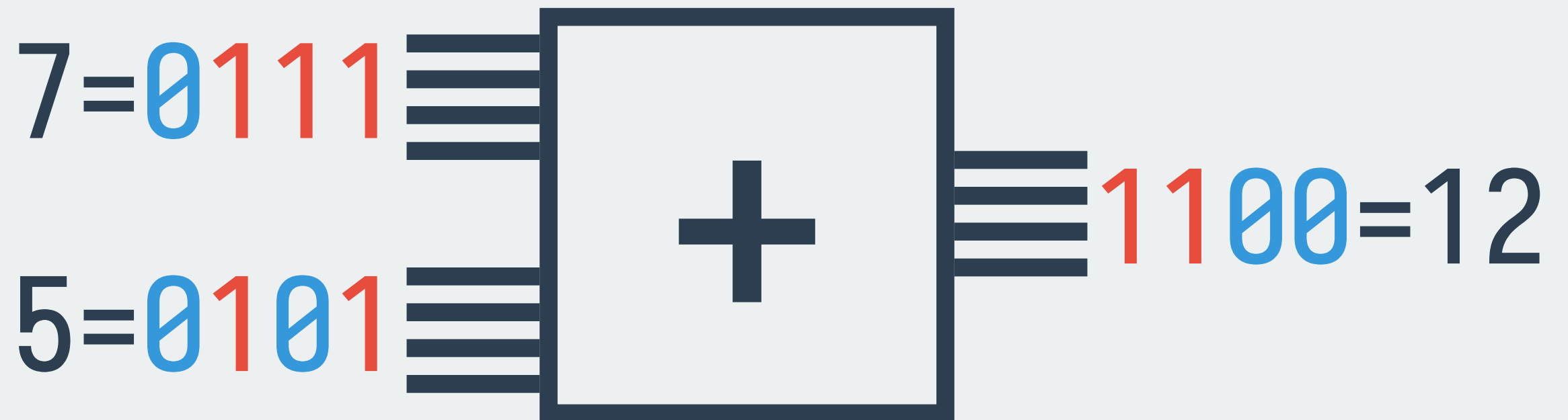
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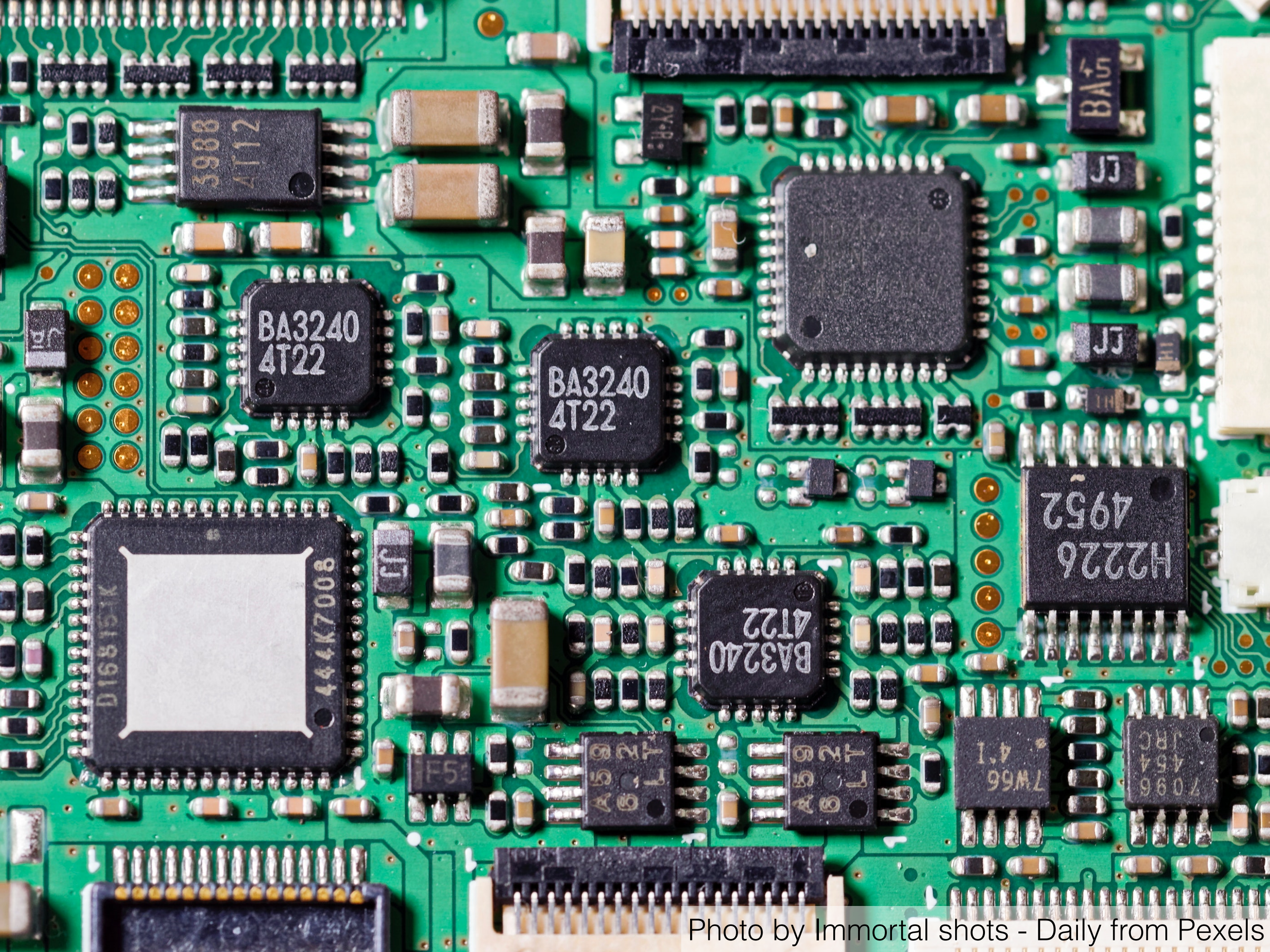












QUANTUM

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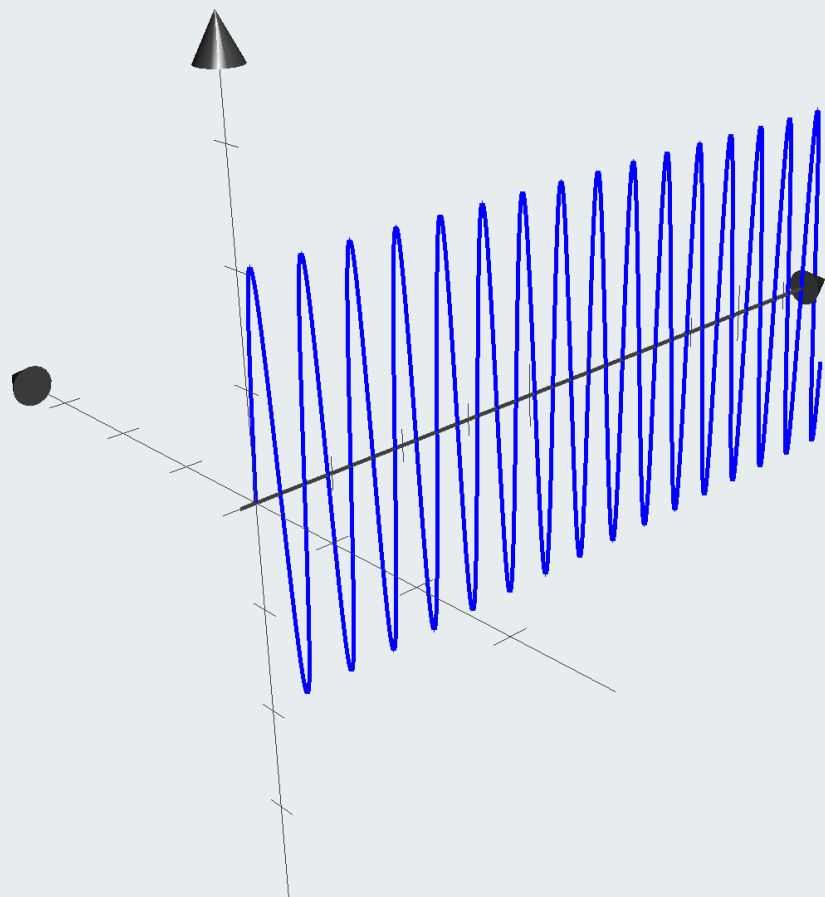
QUANTUM COMPUTING

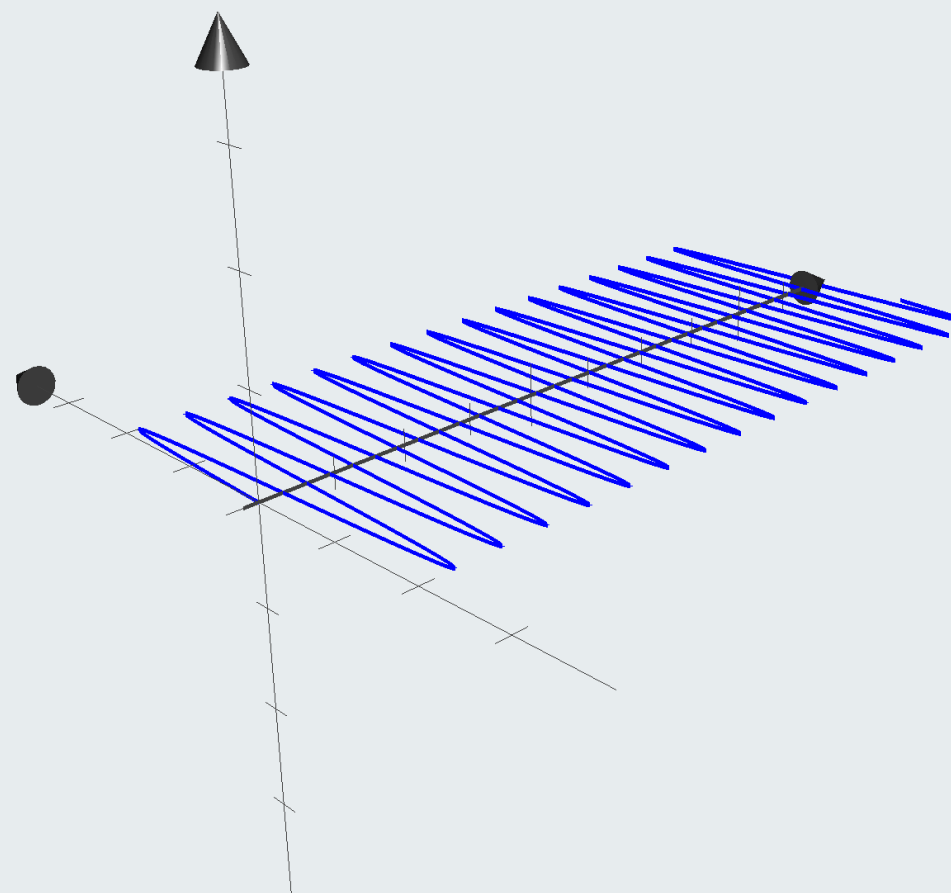
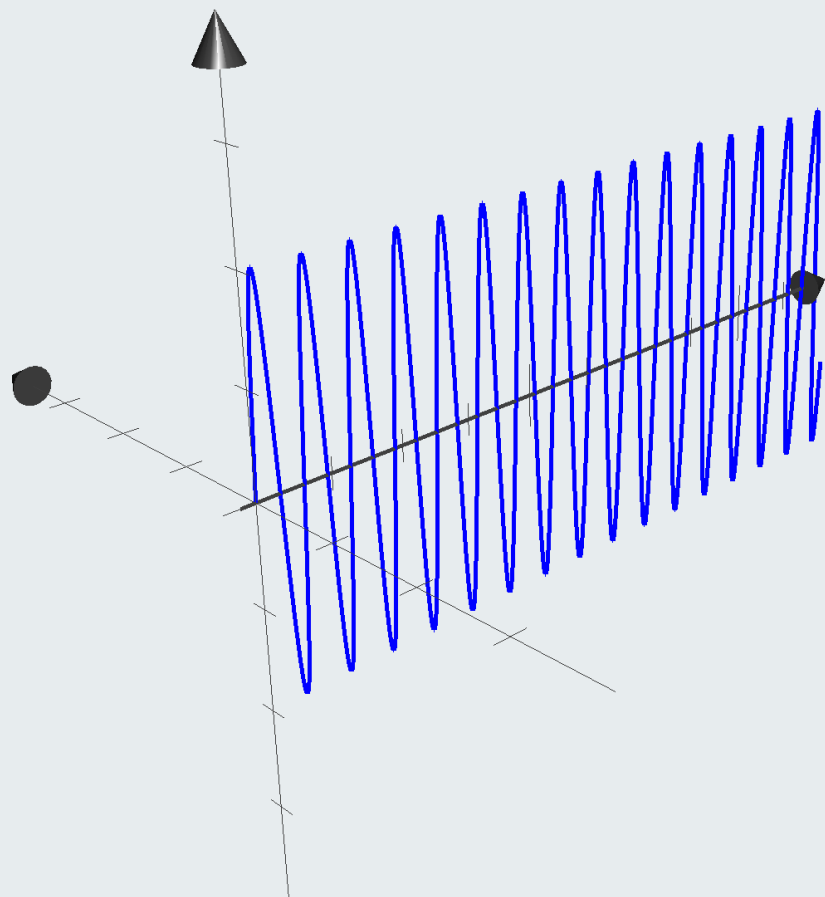


Quantum Optics Lab Olomouc

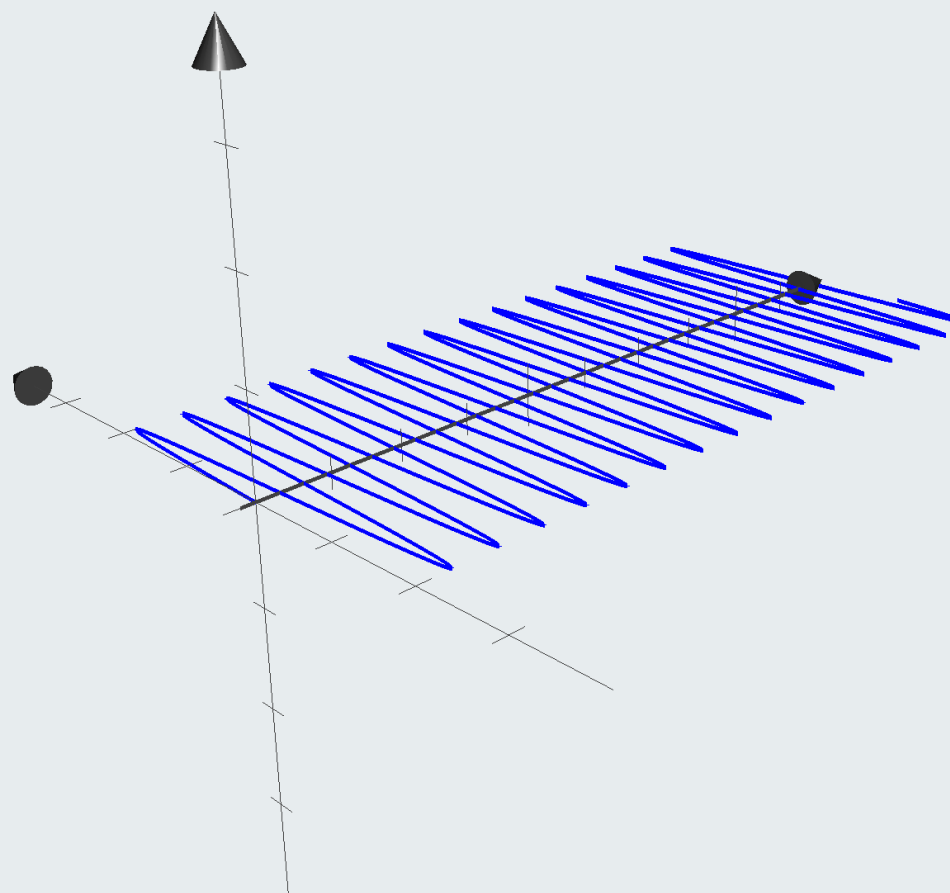
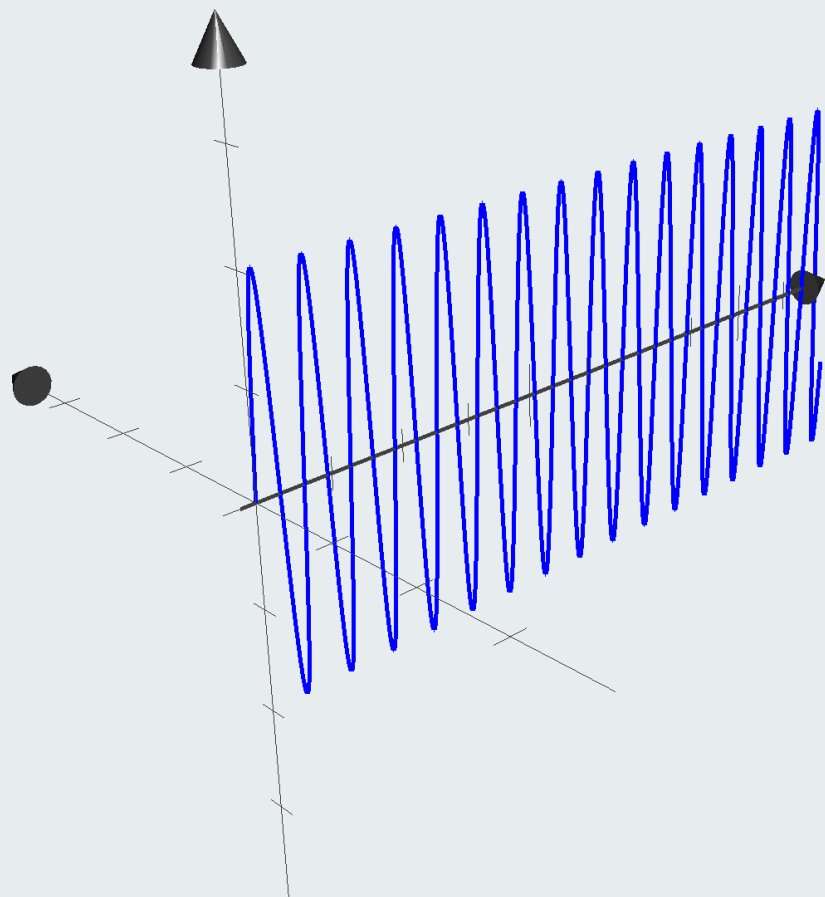
LIGHT **POLARIZATION**

DEMO

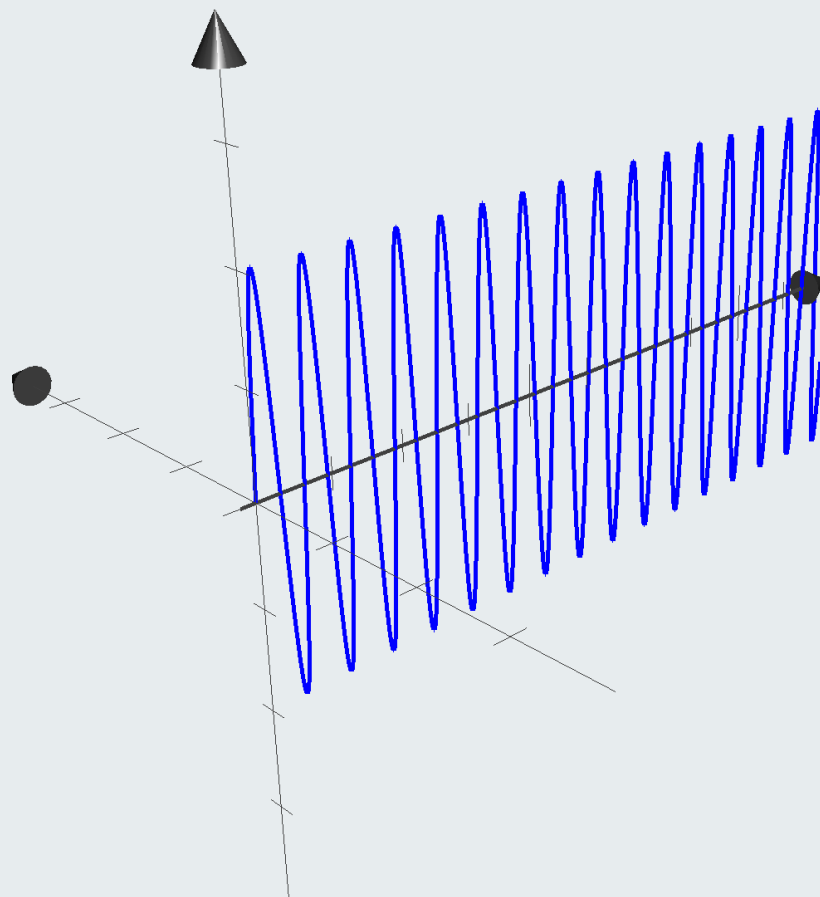




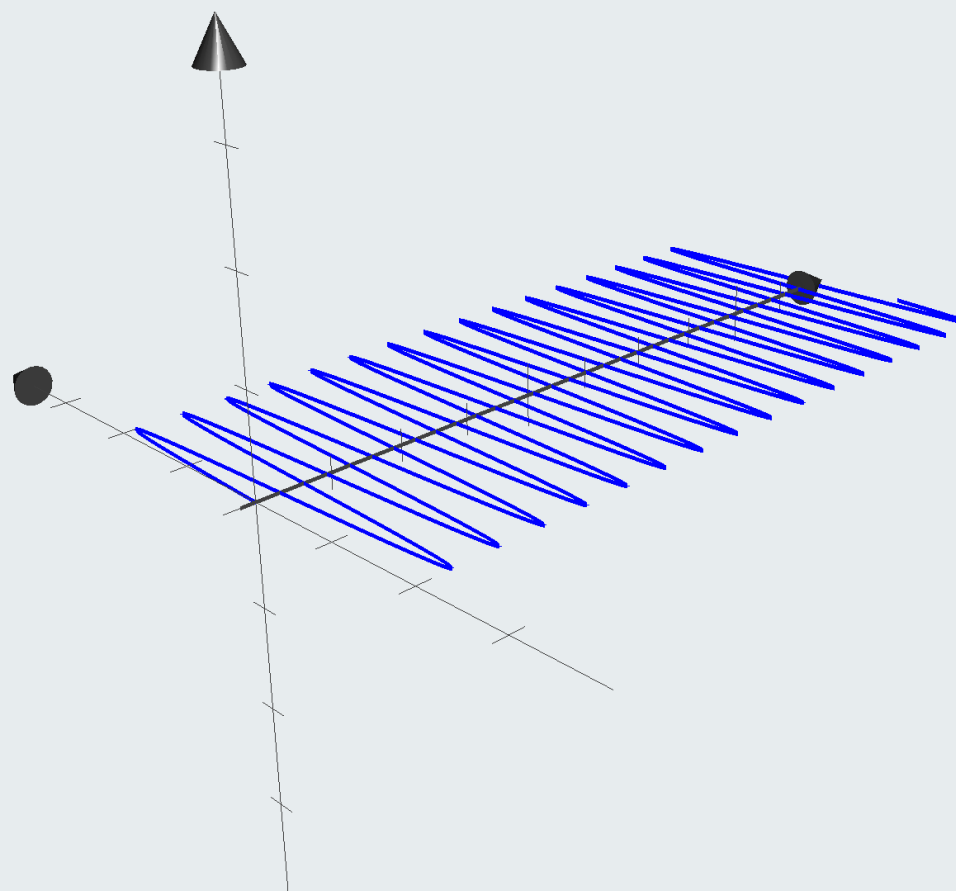
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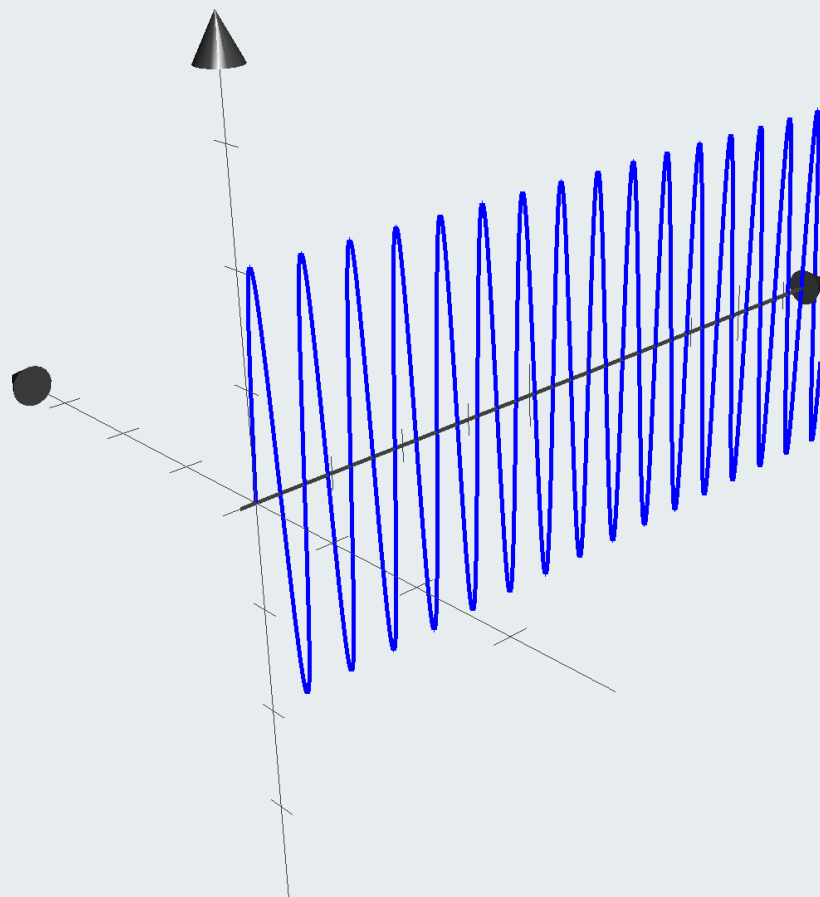
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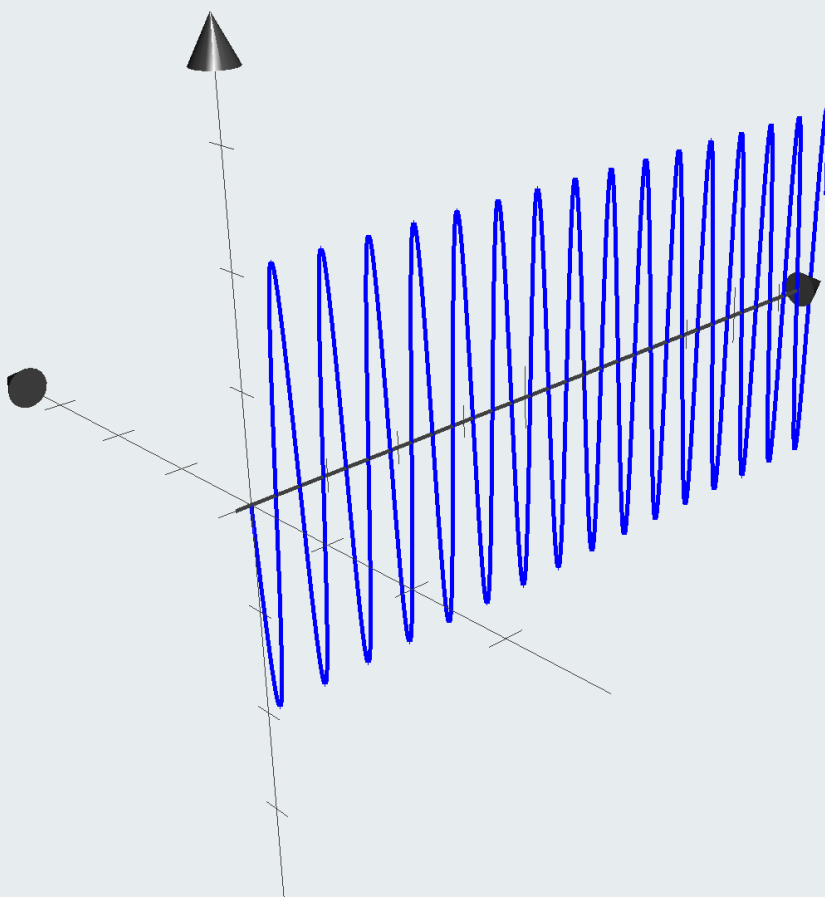
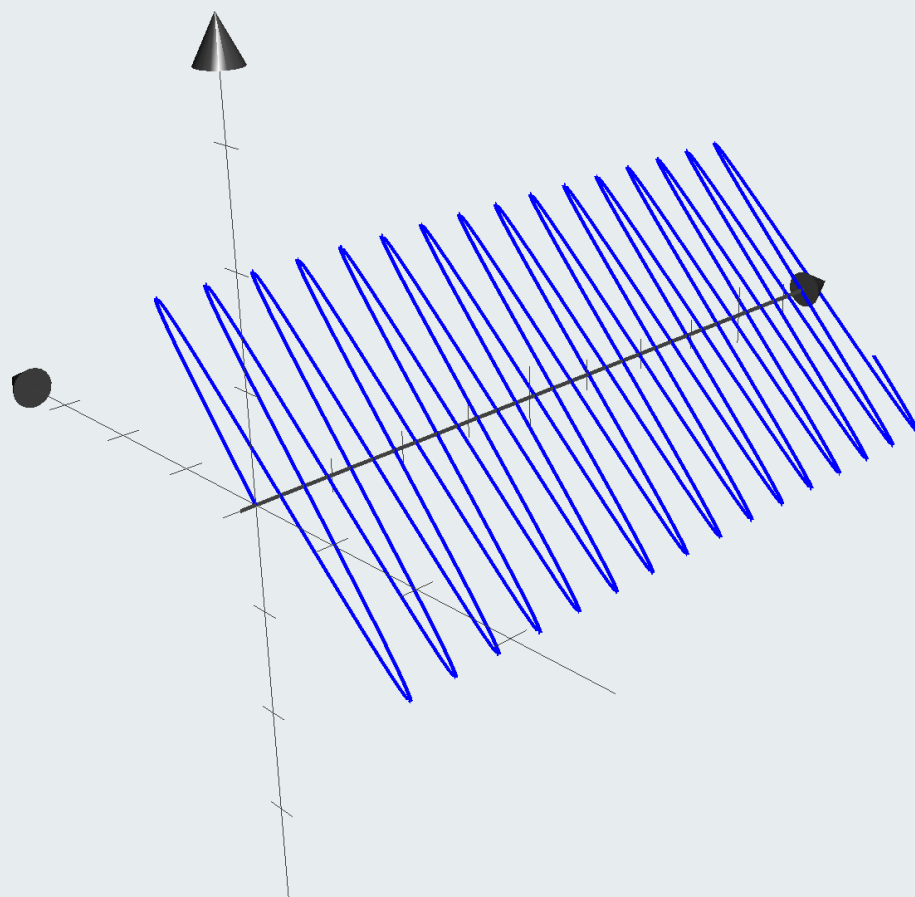
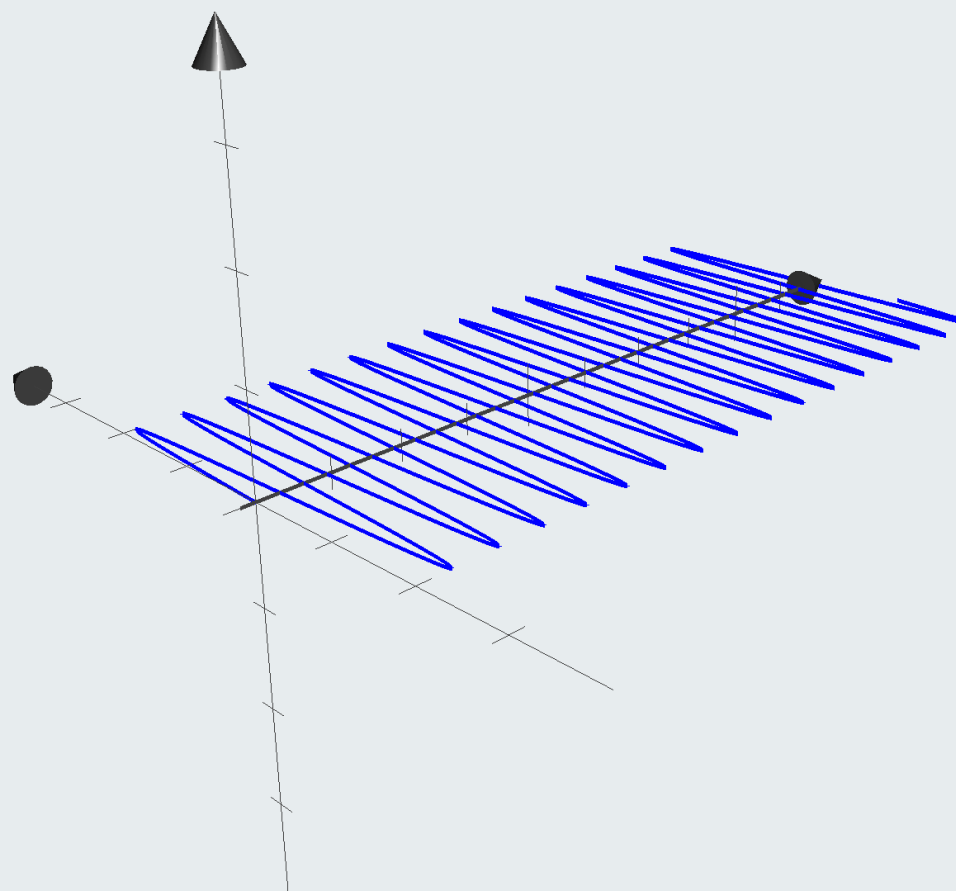
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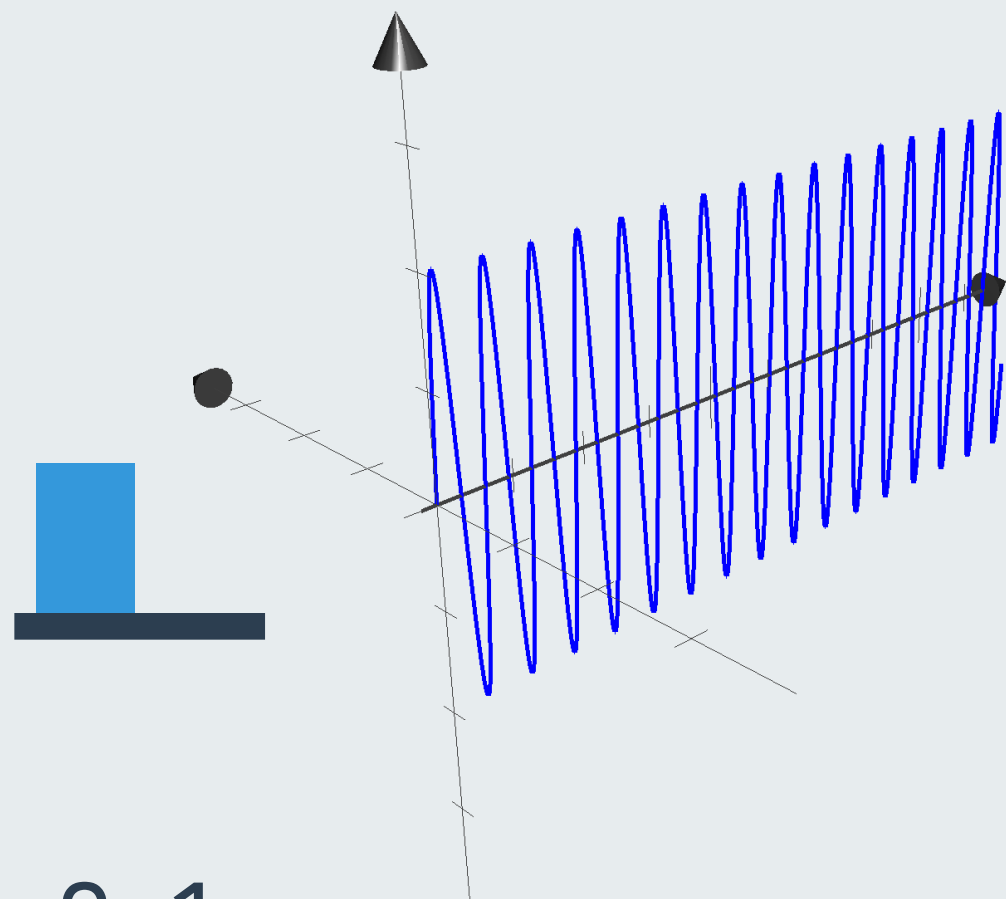


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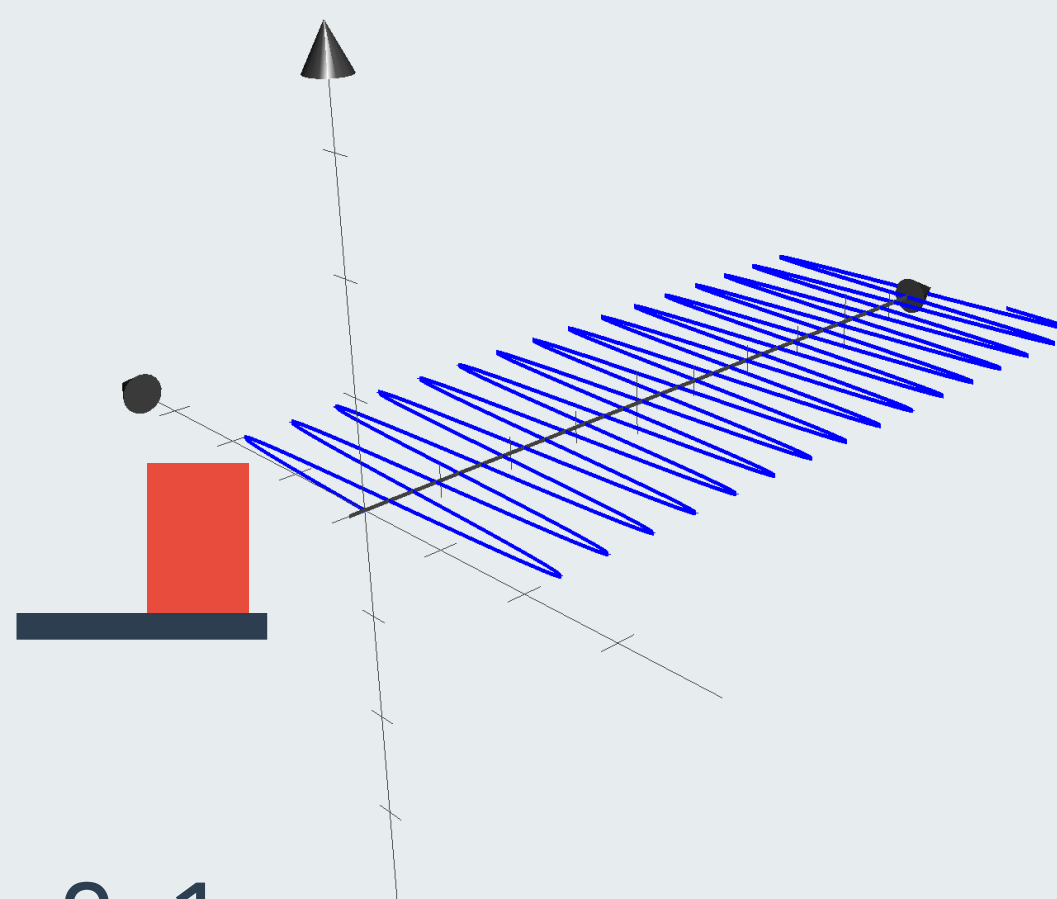


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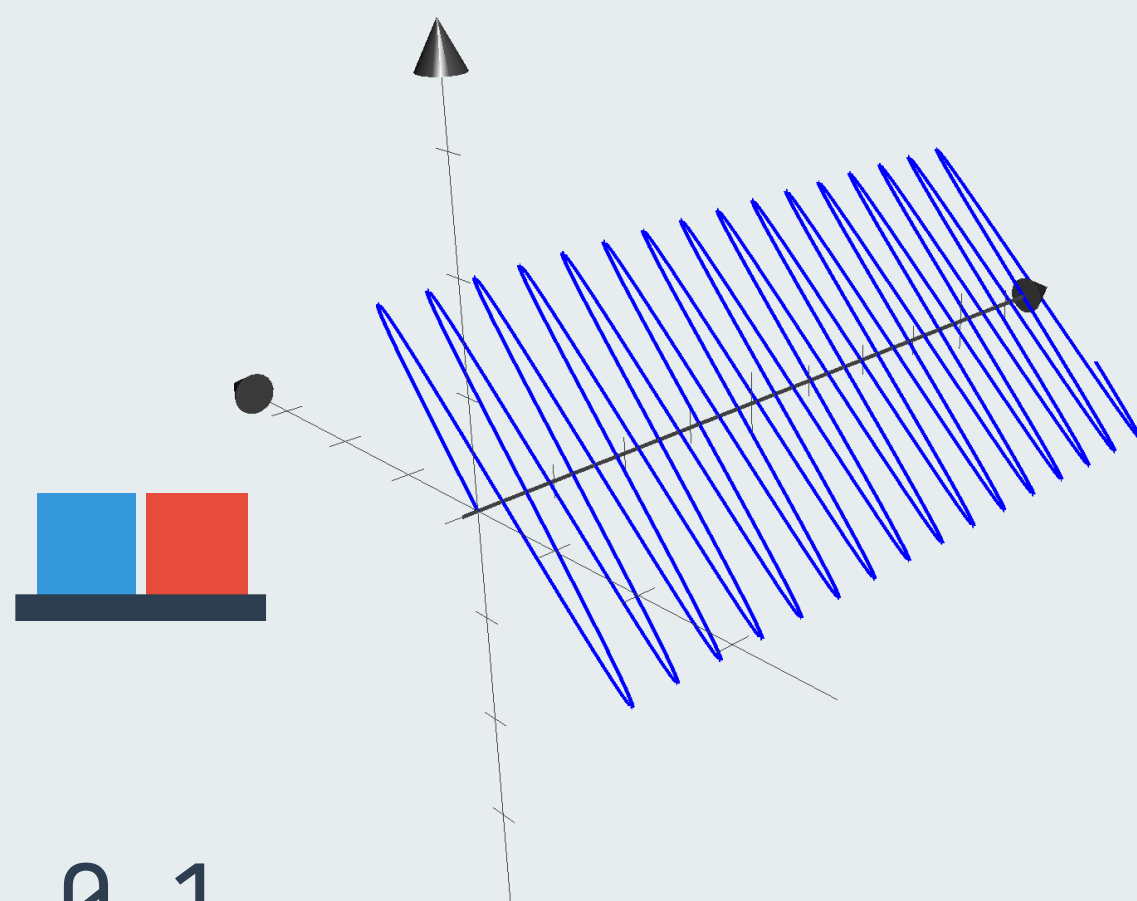




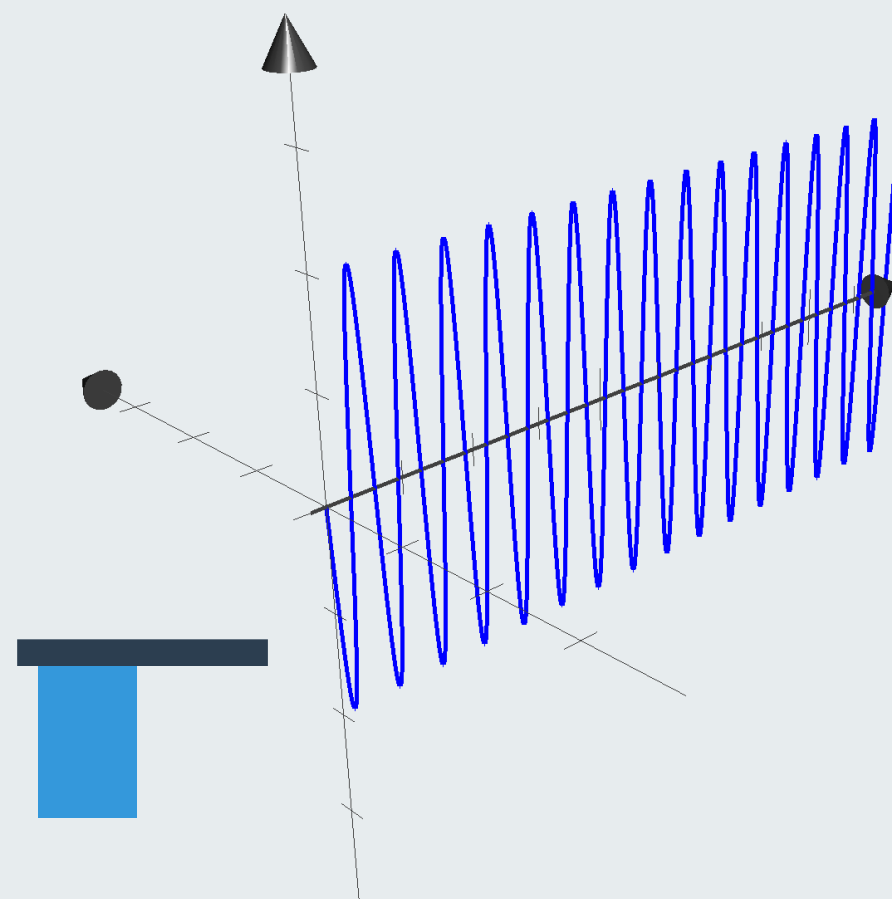
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θ 1



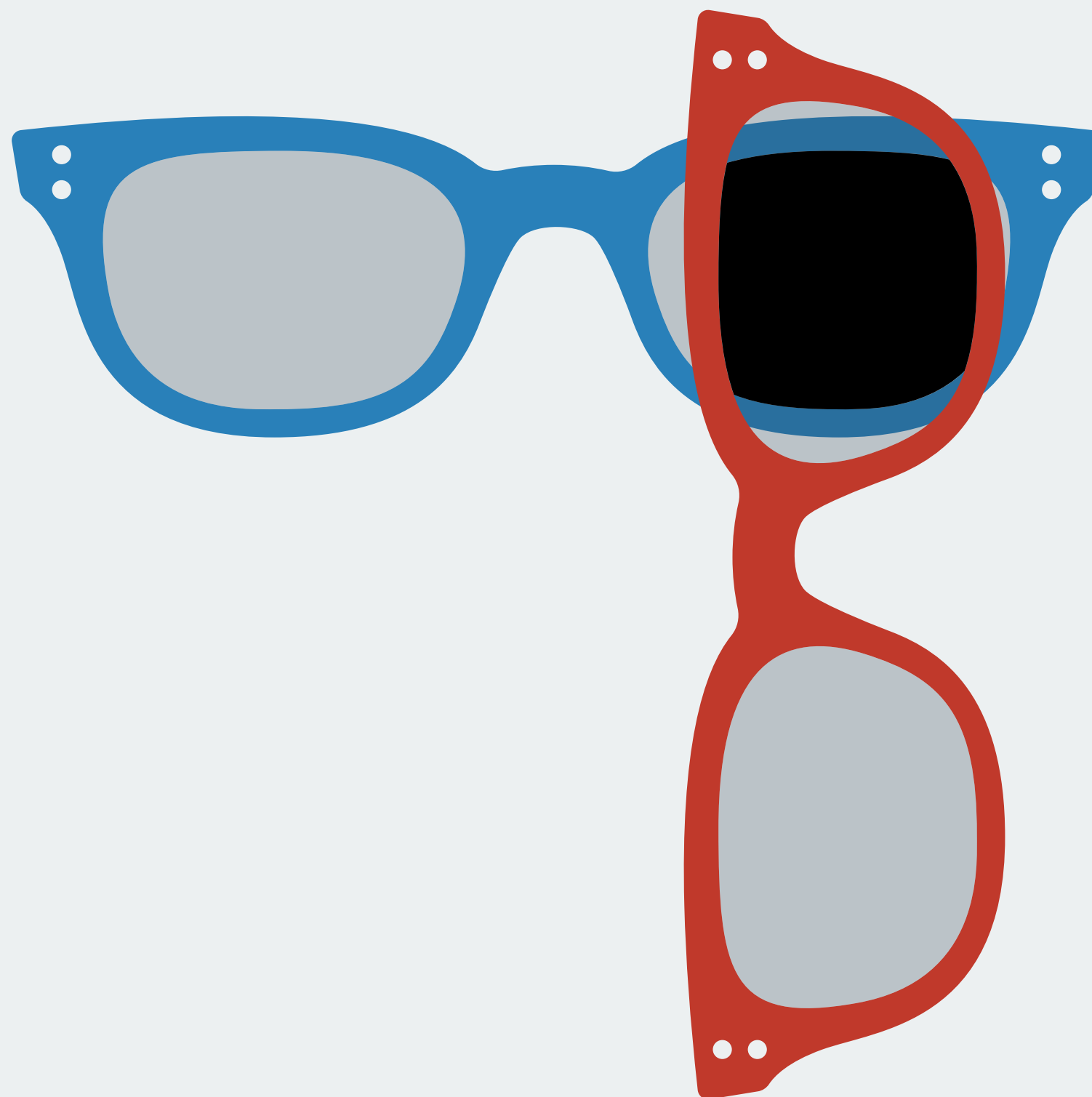
θ 1



θ 1

DEMO



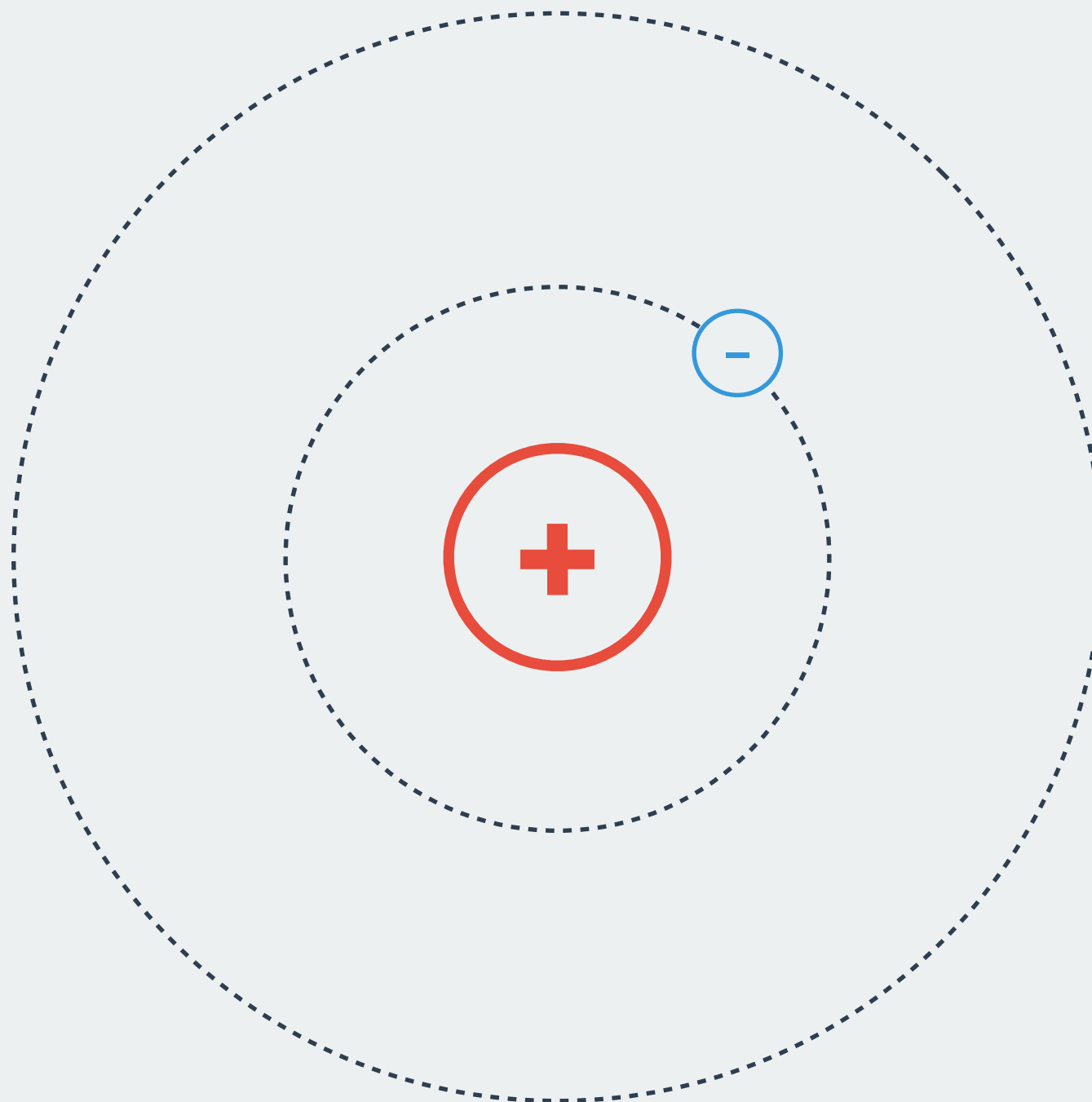


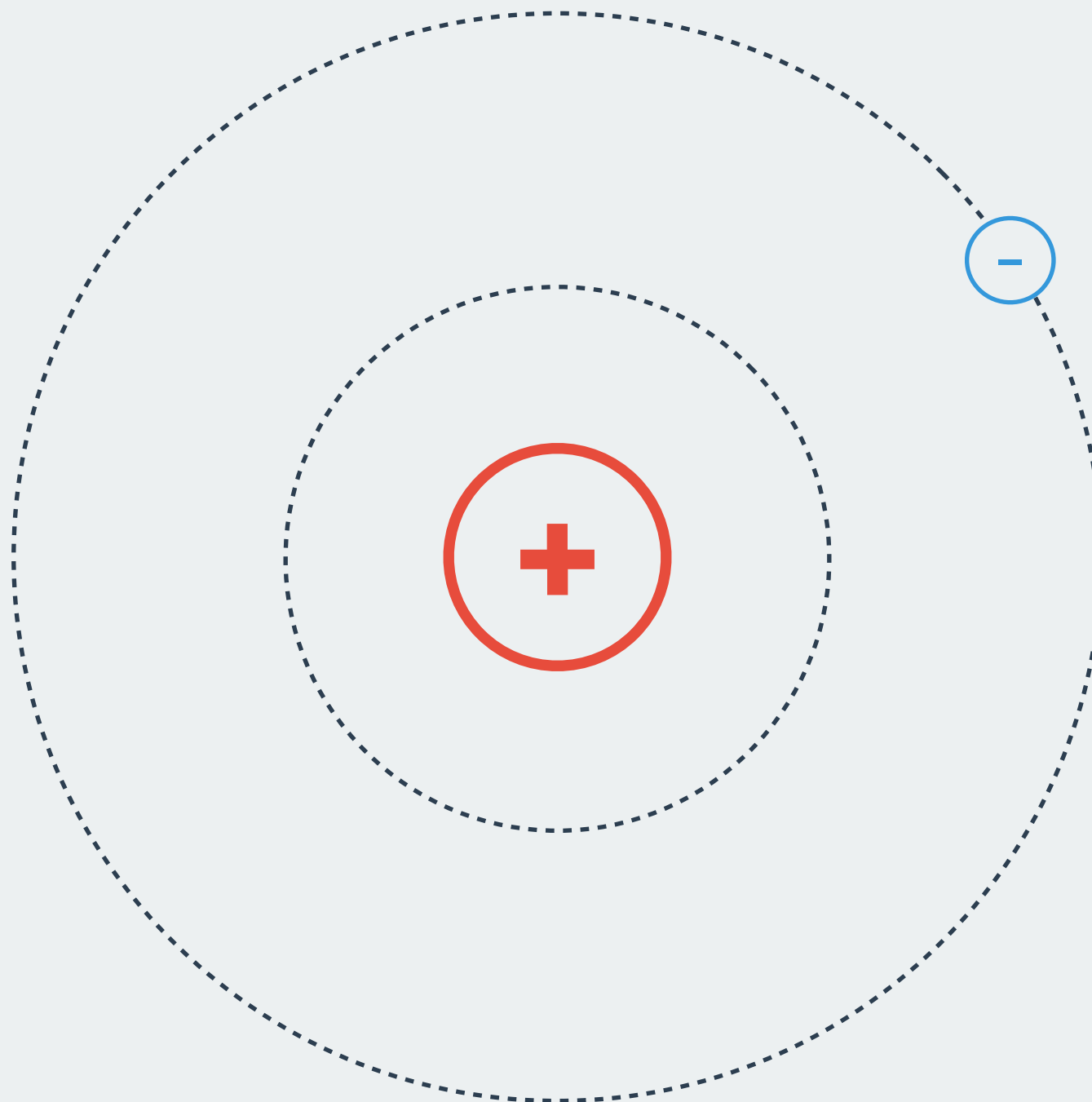


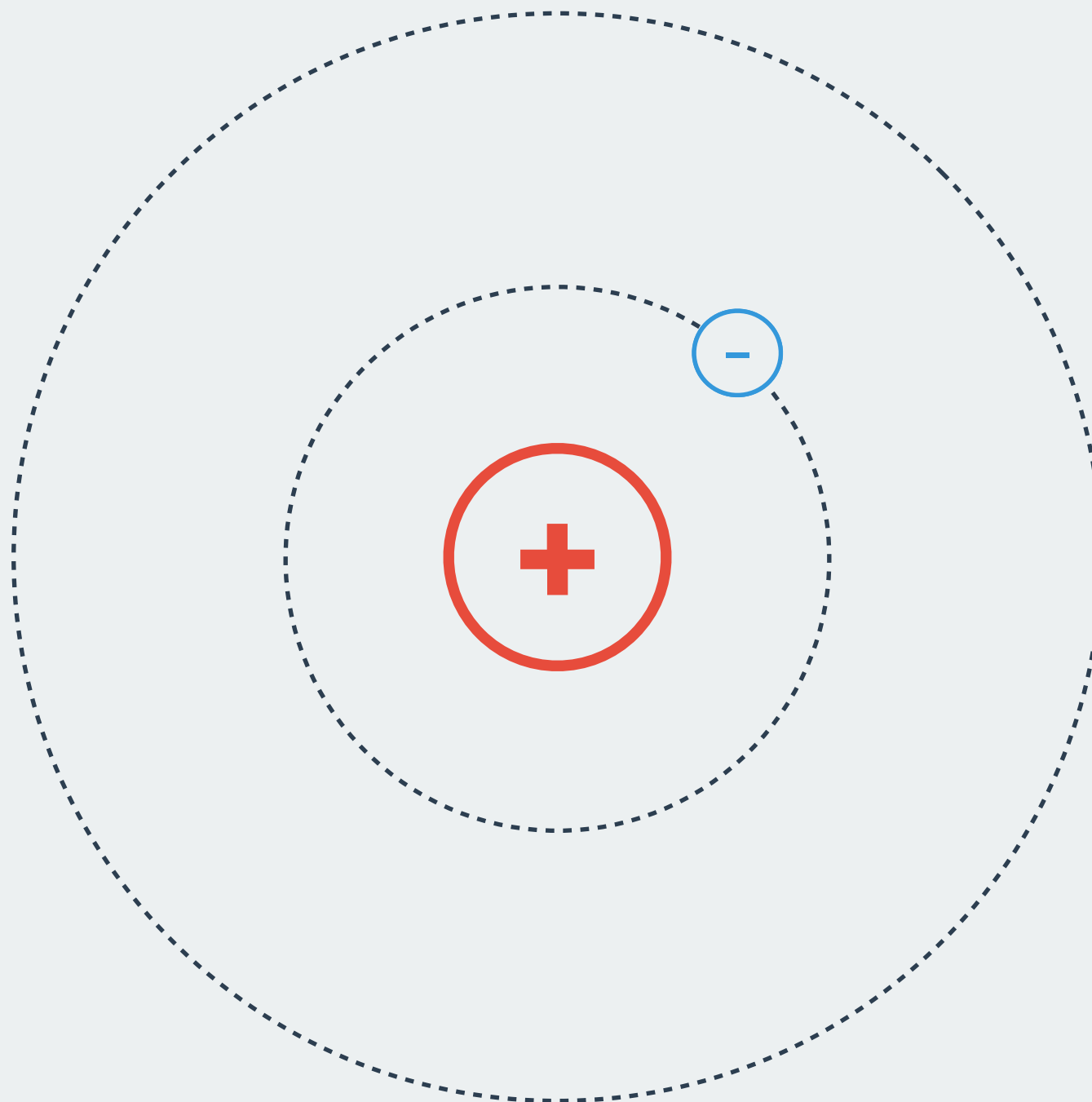
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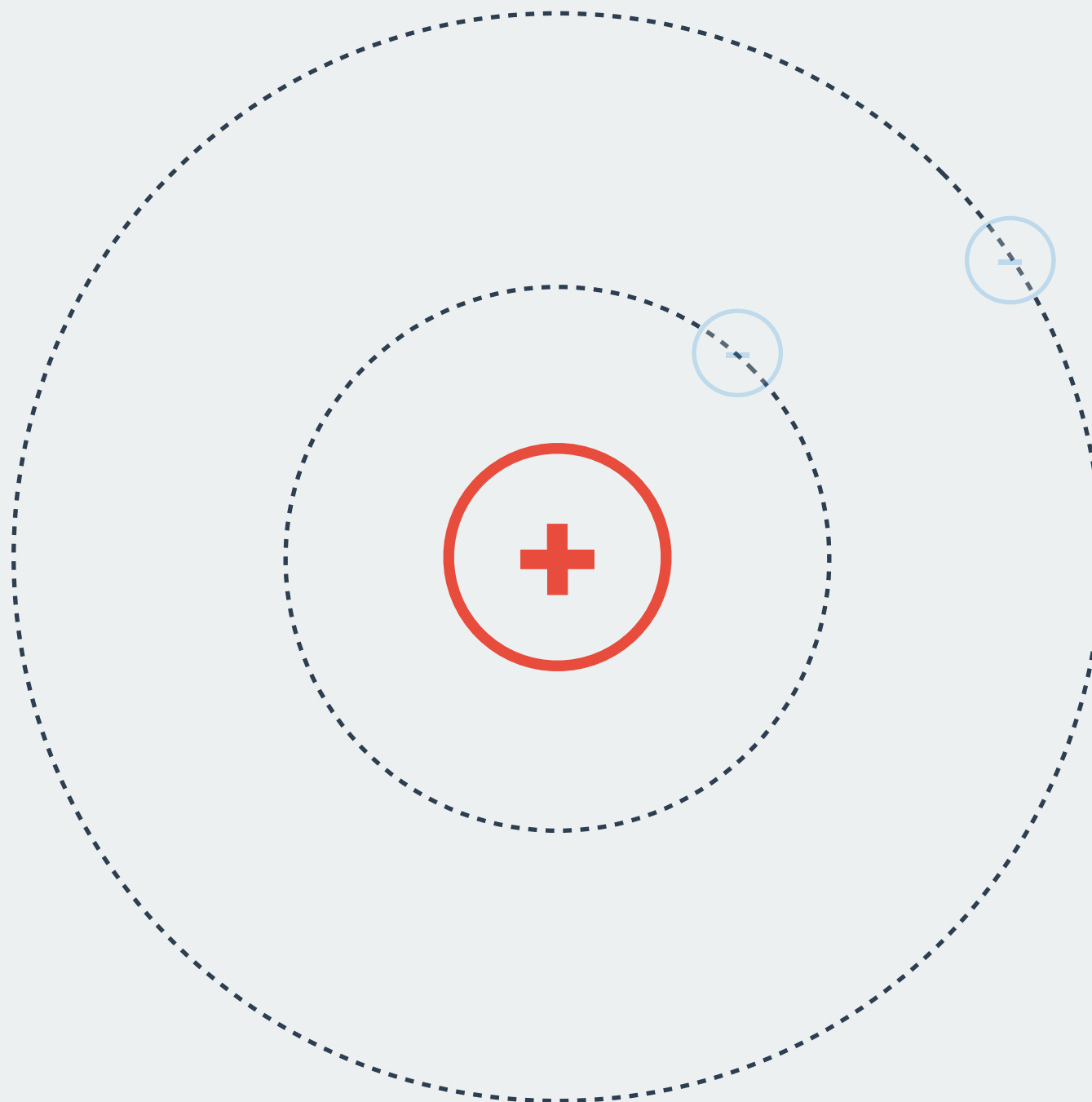


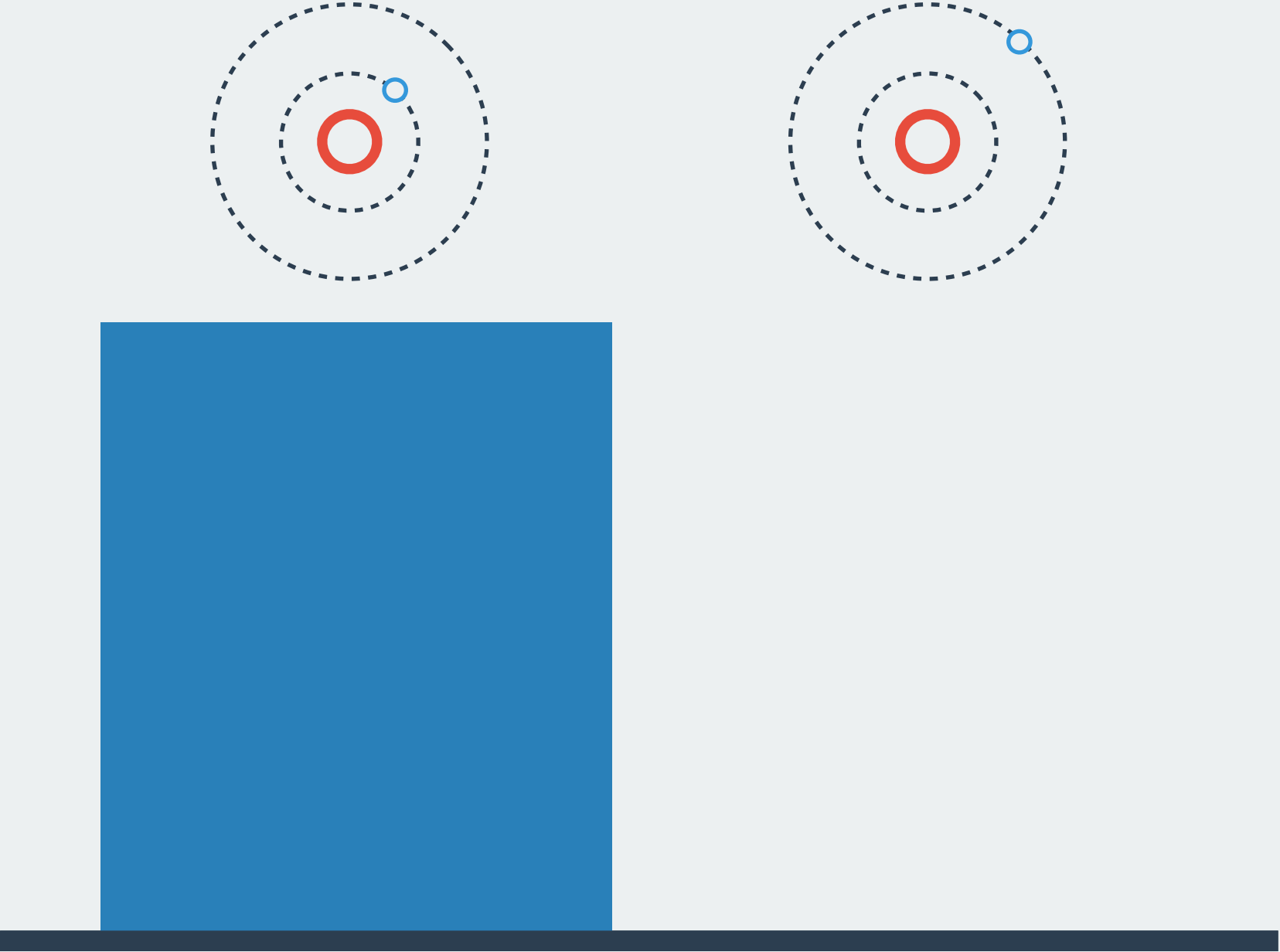
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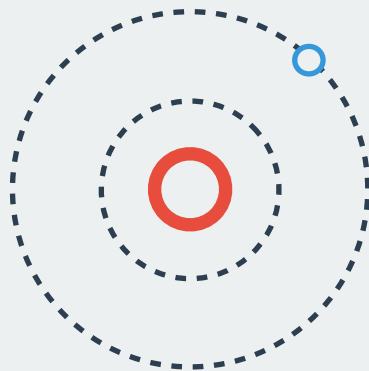
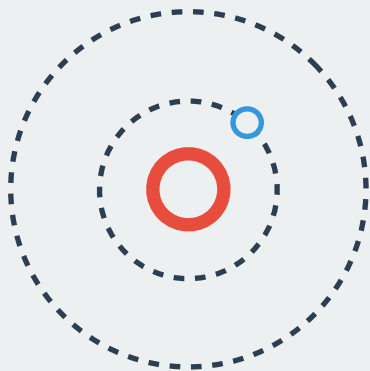


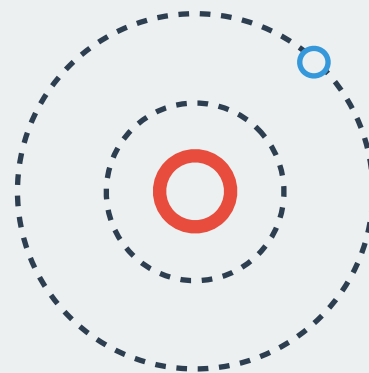
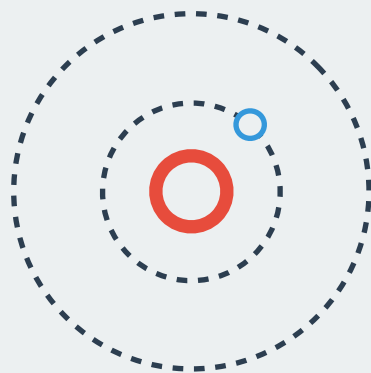


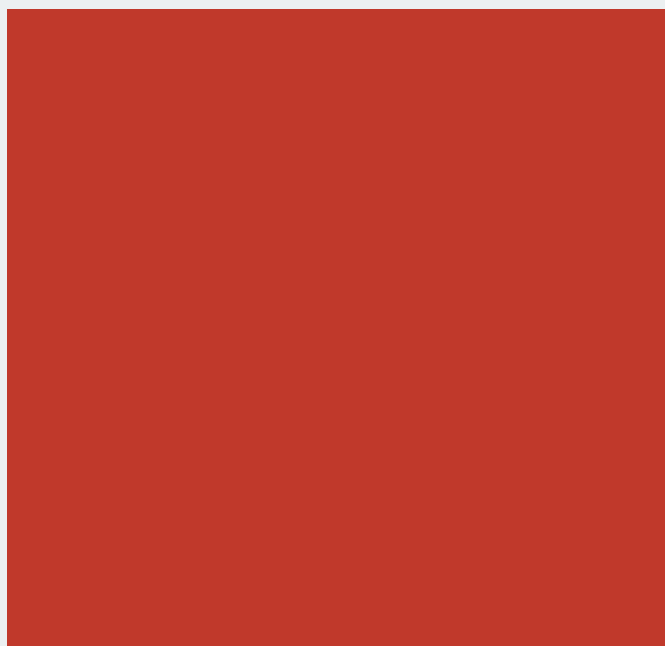
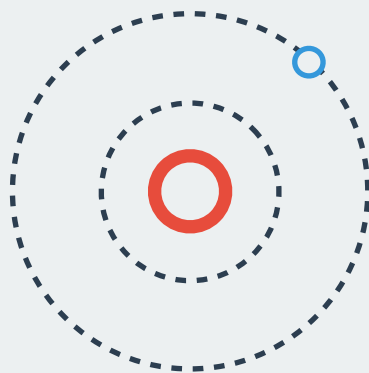
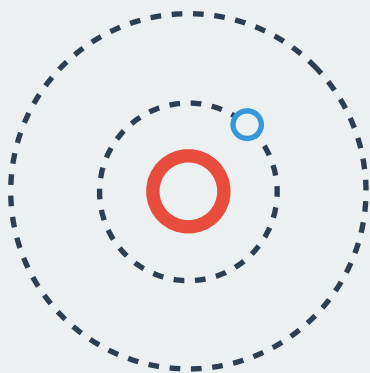


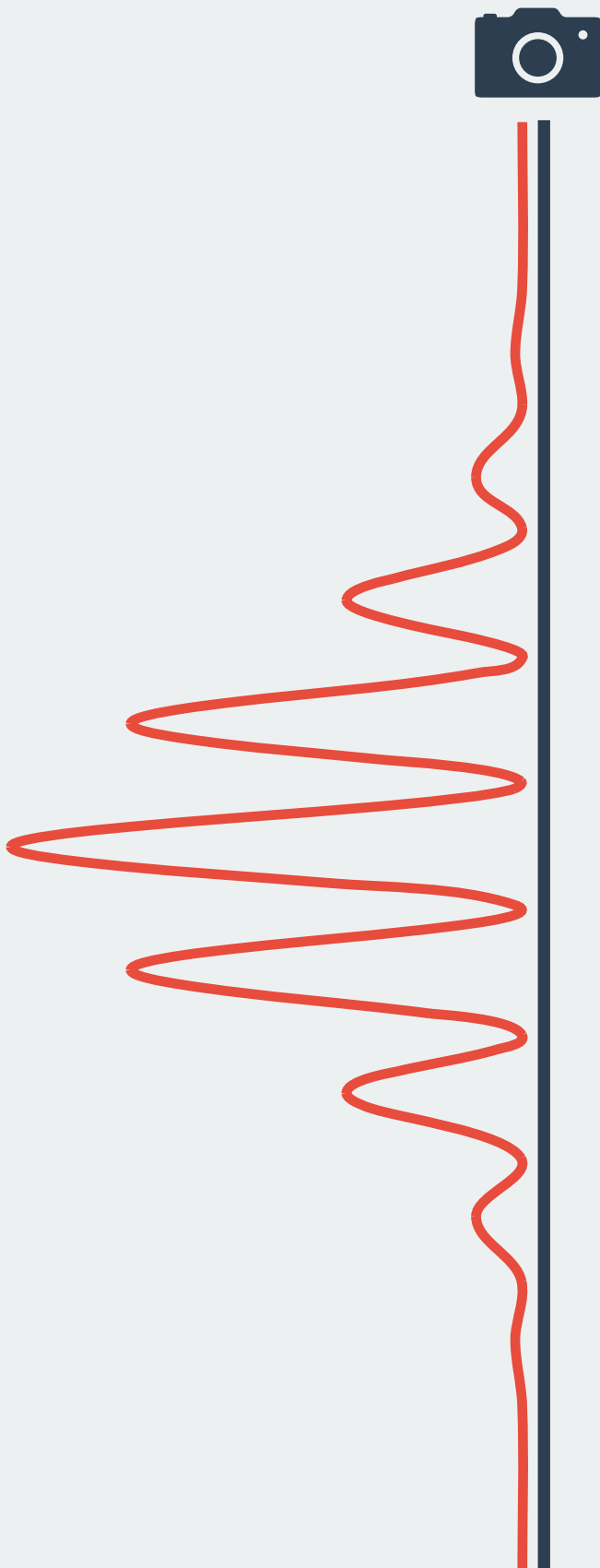


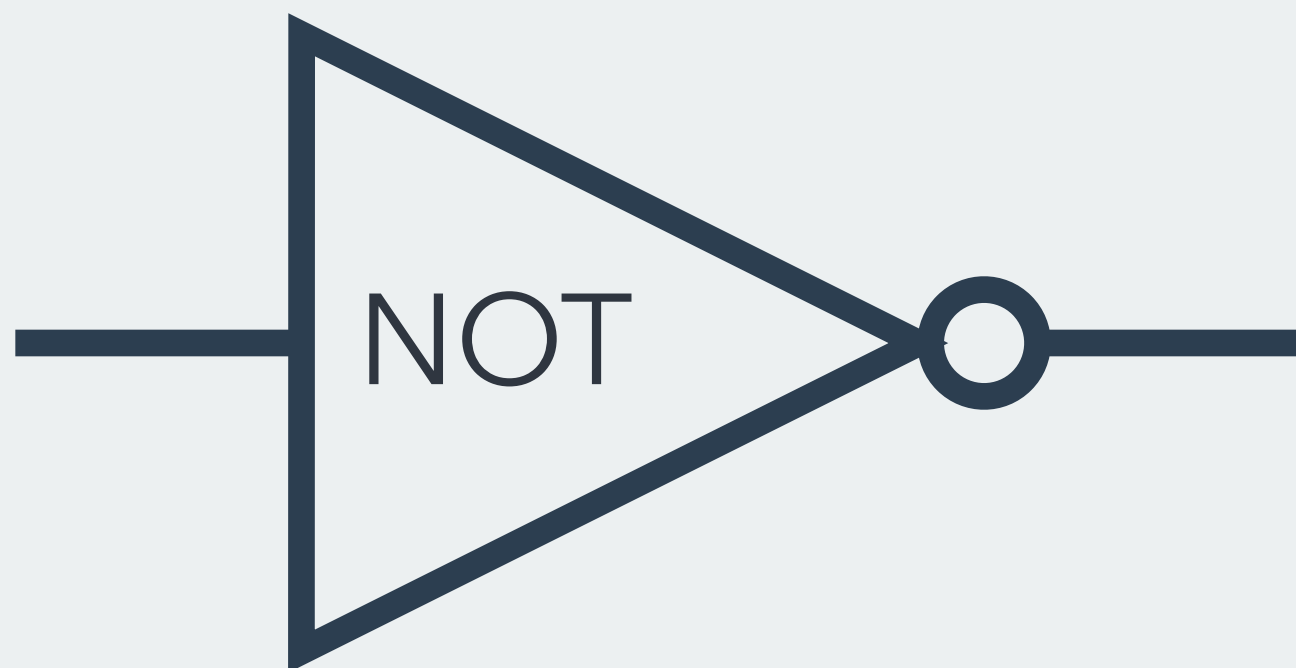


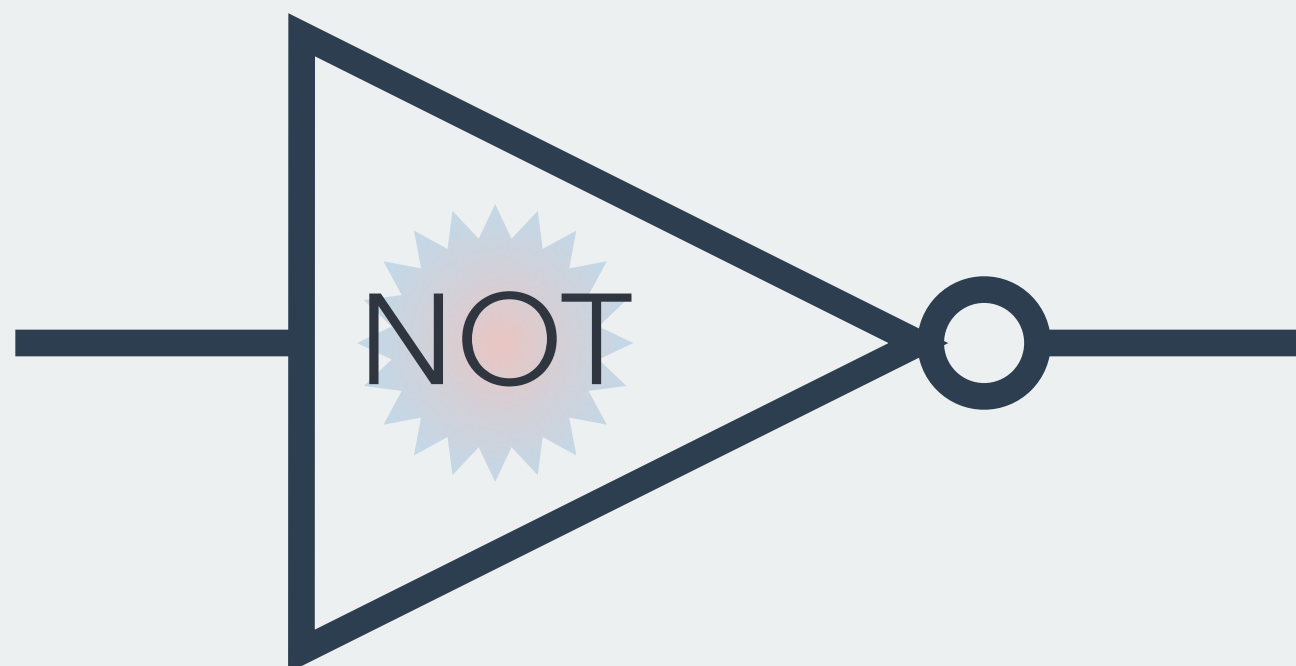




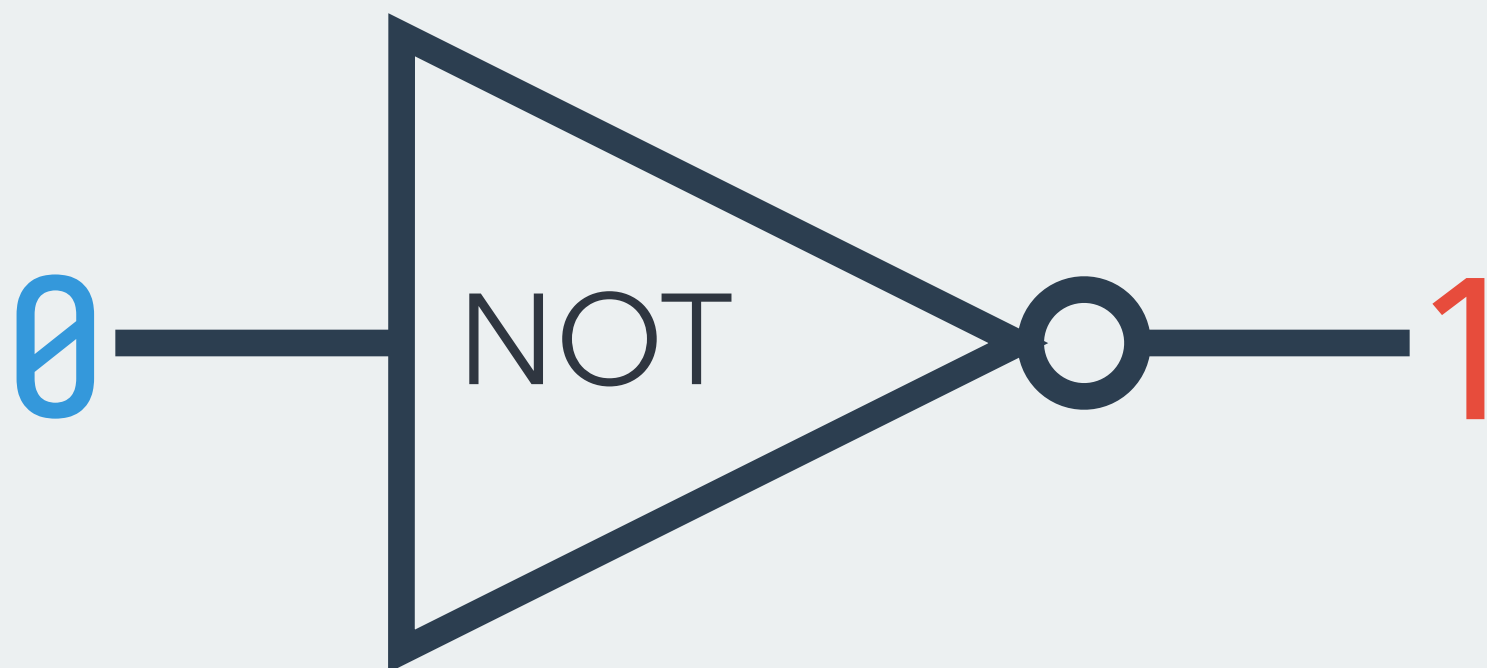


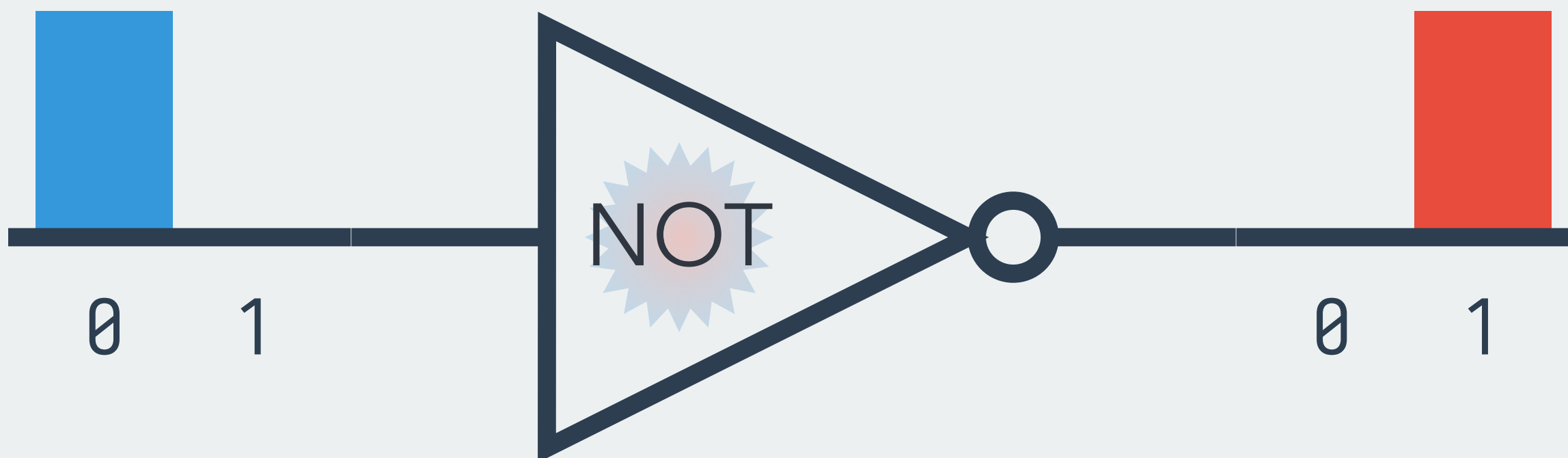


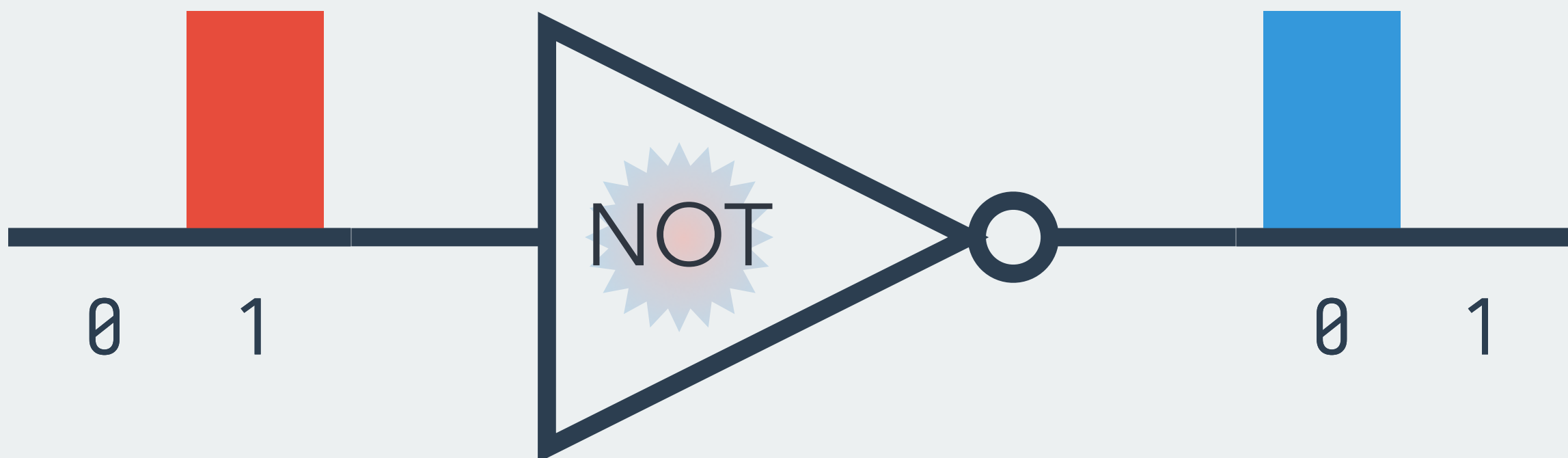


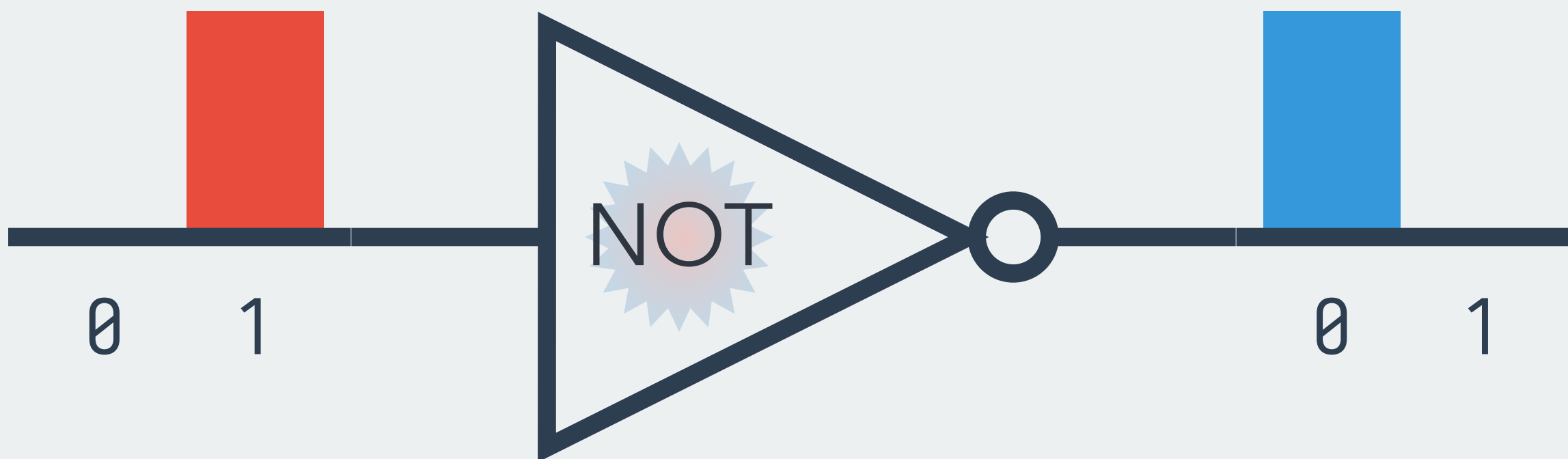


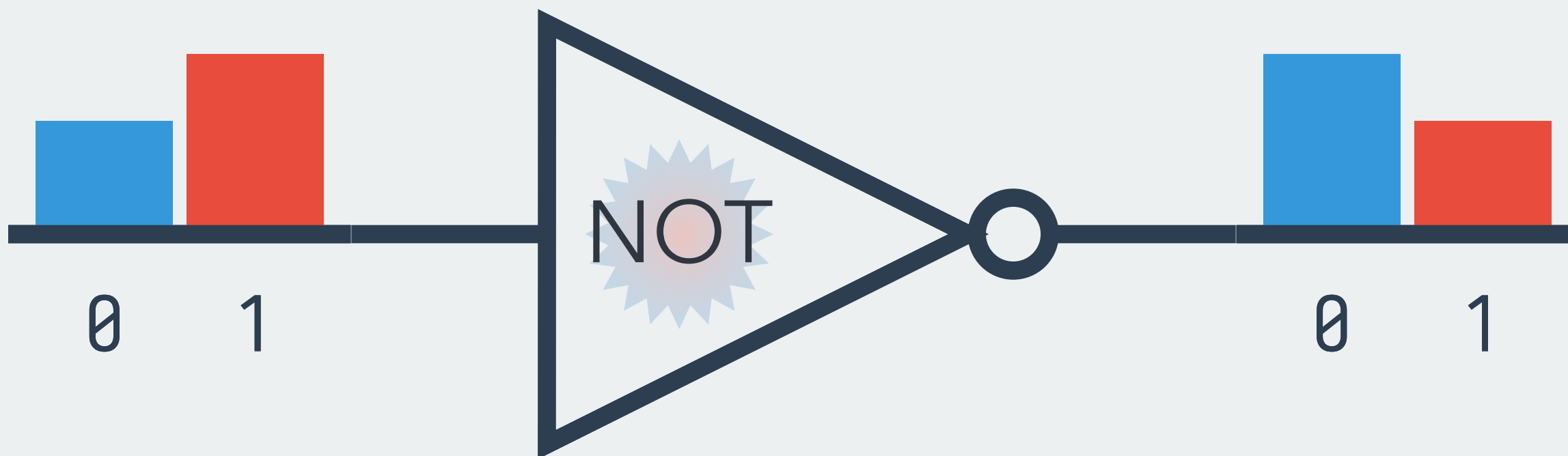
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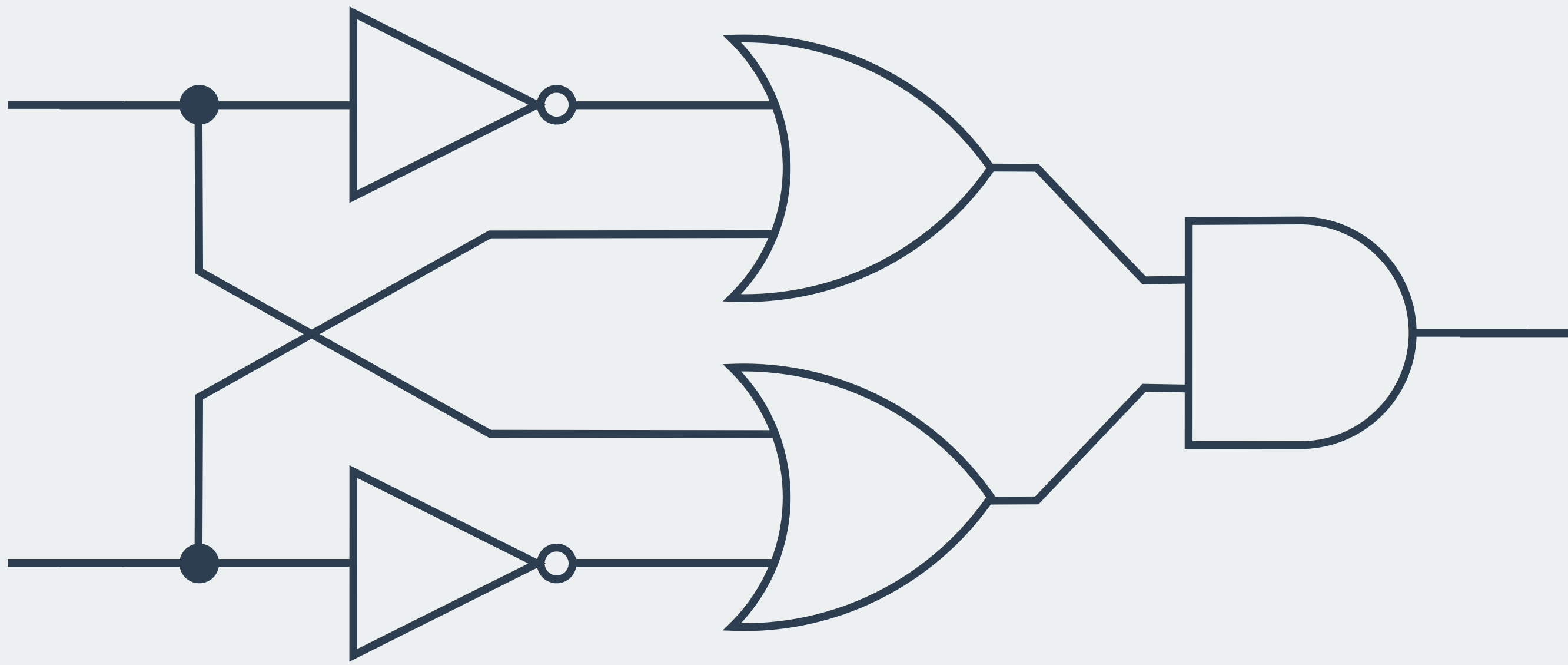


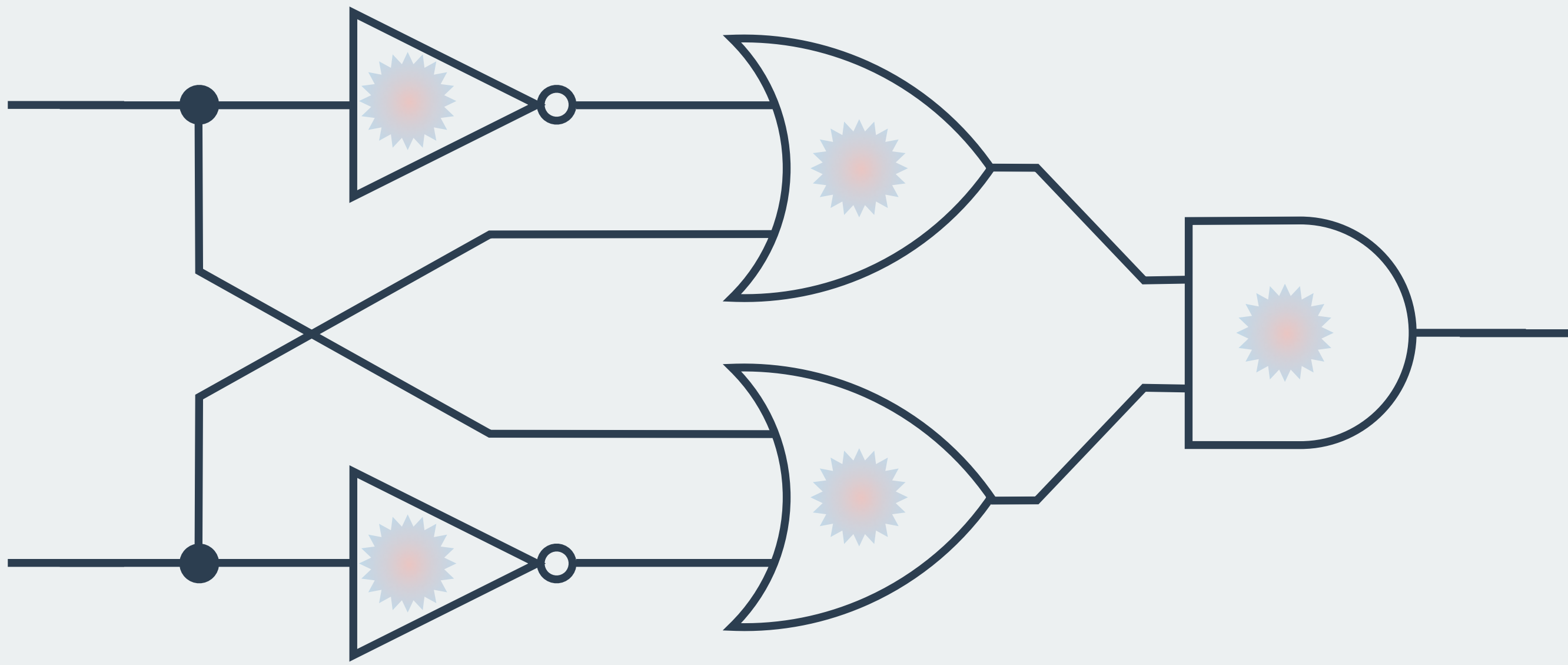


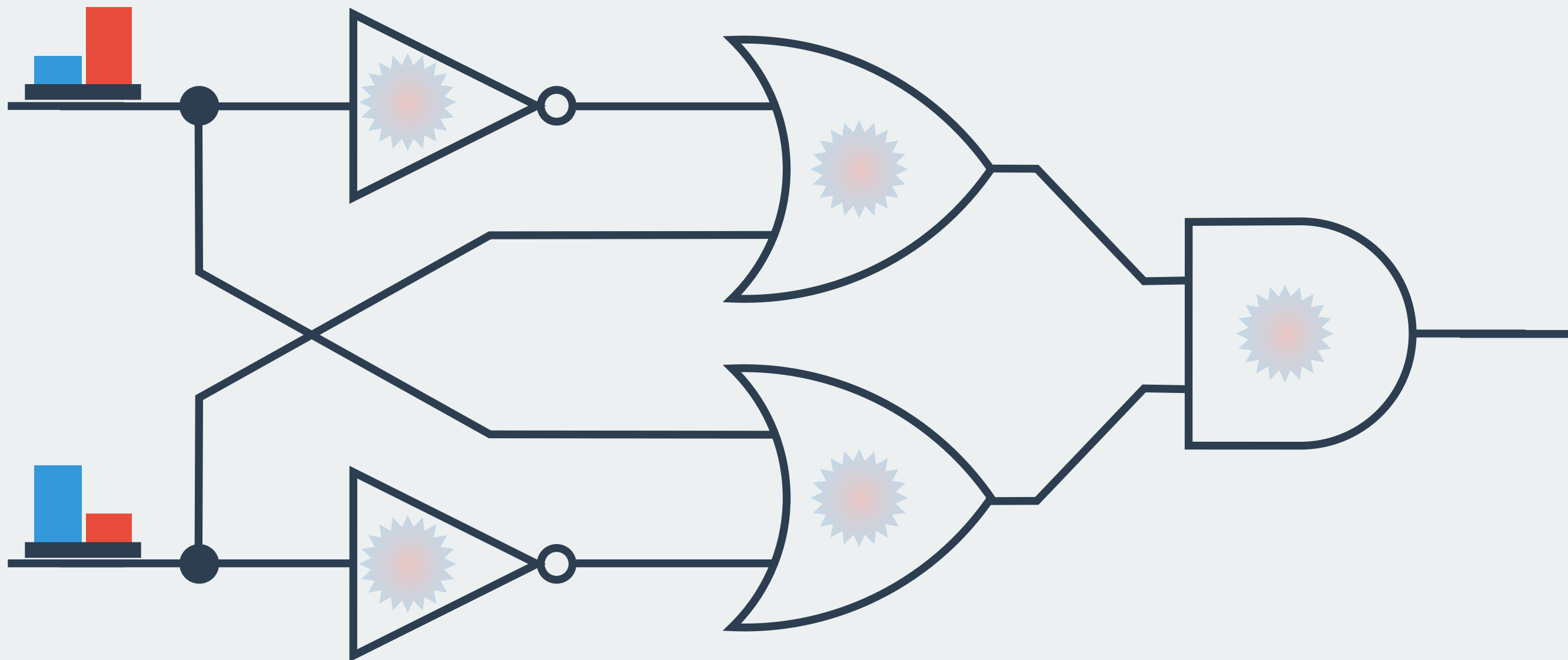


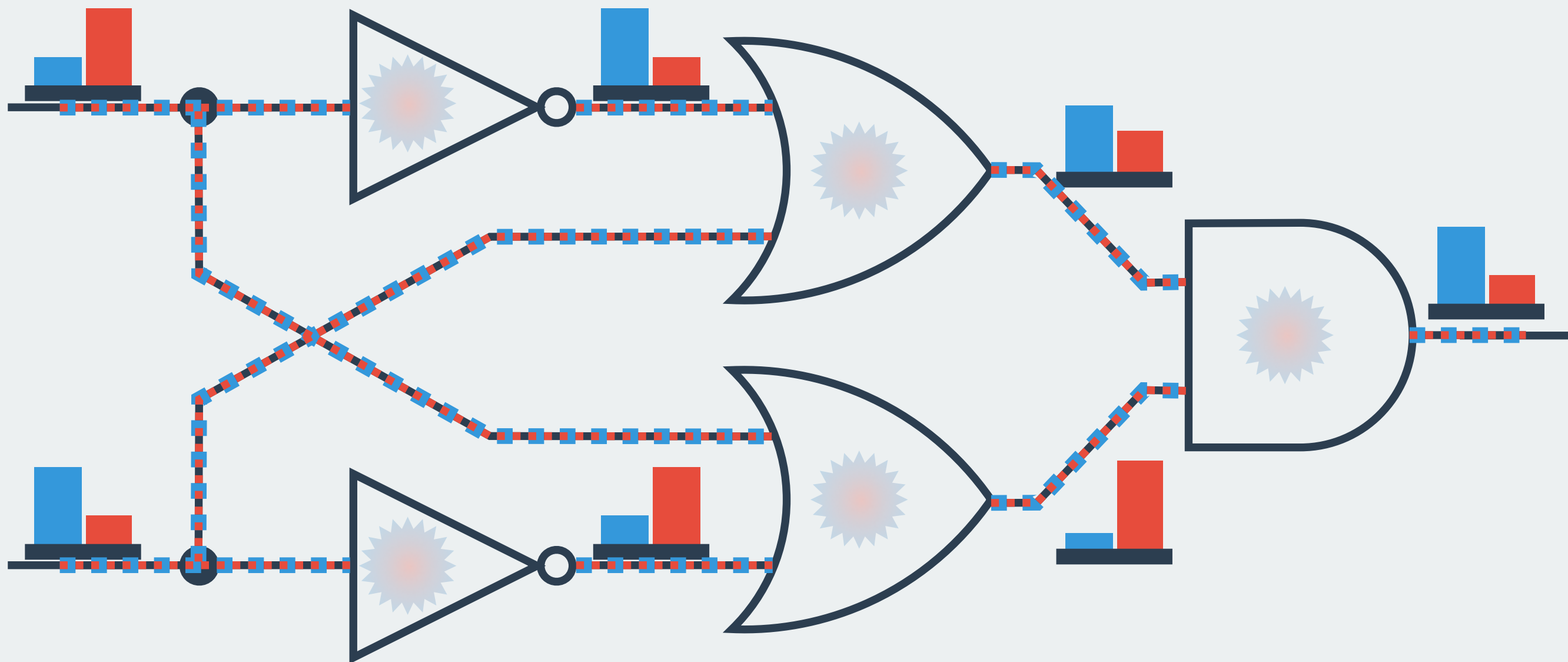










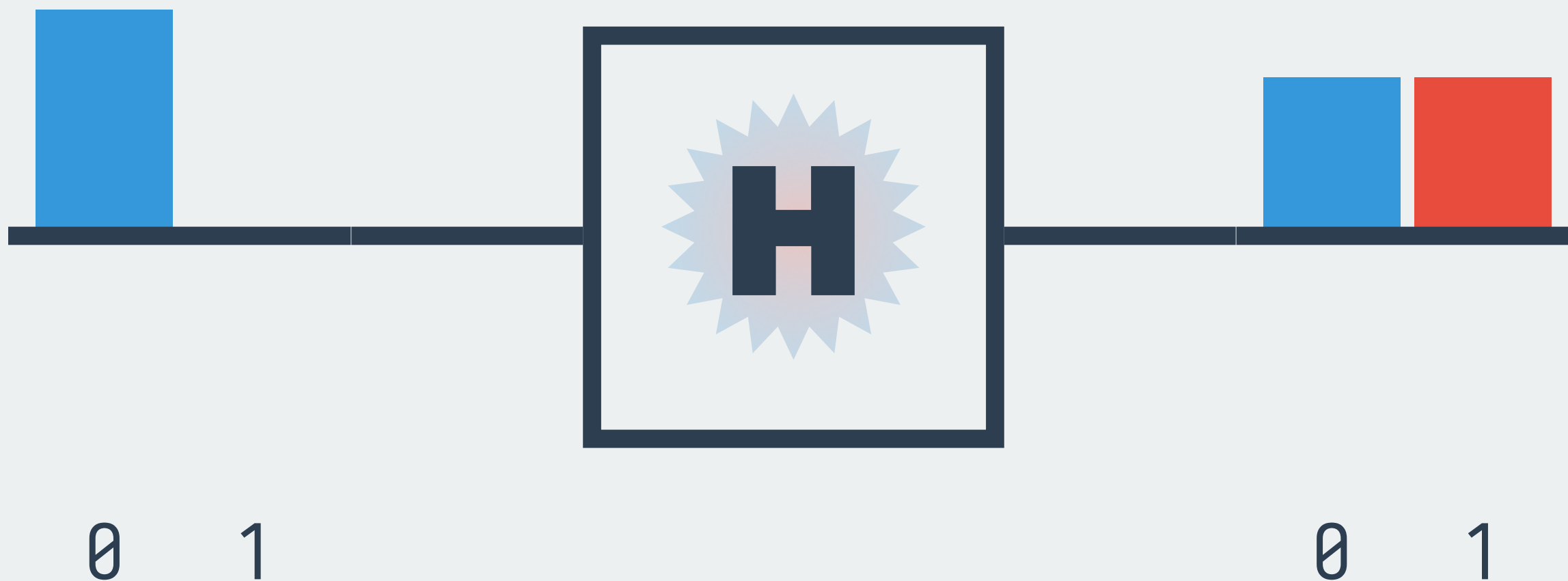


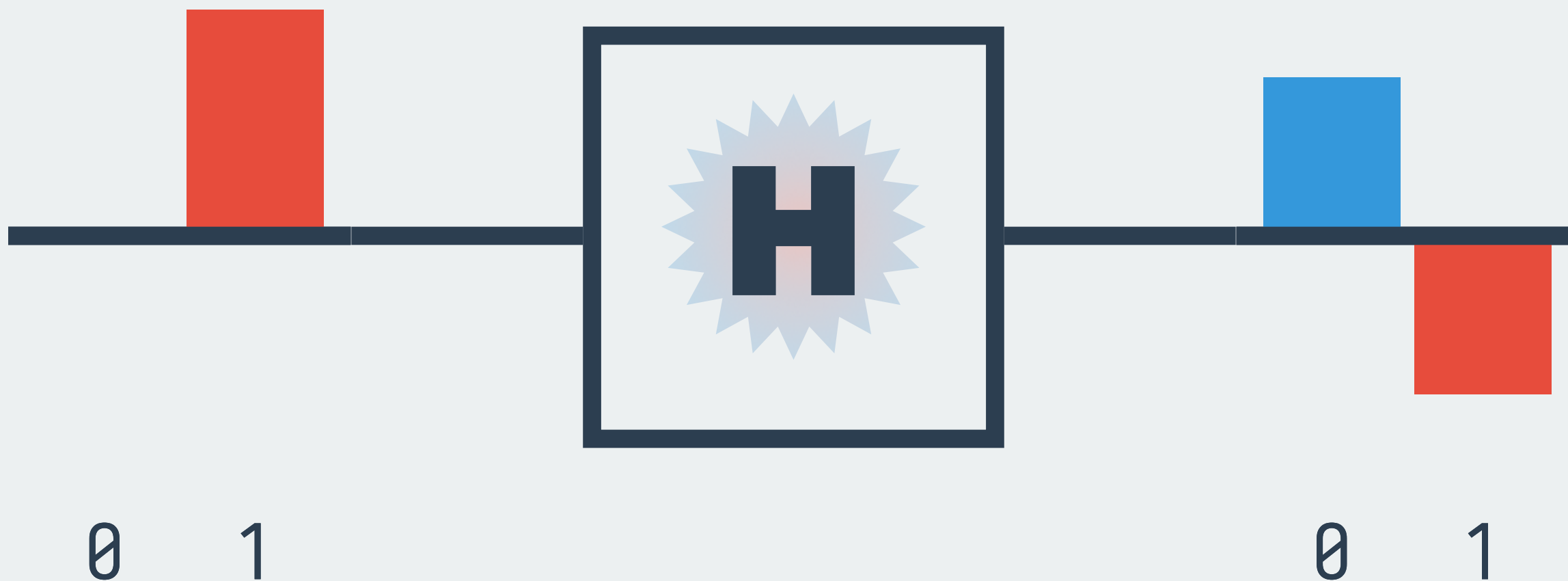


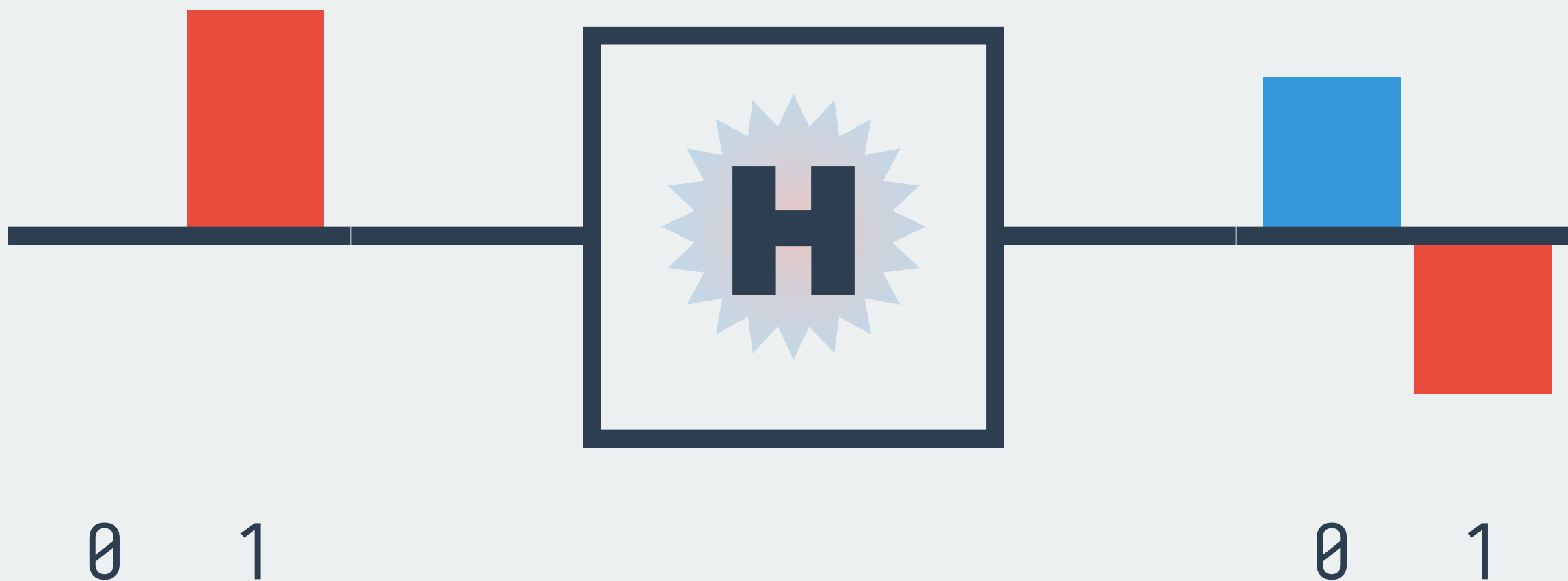


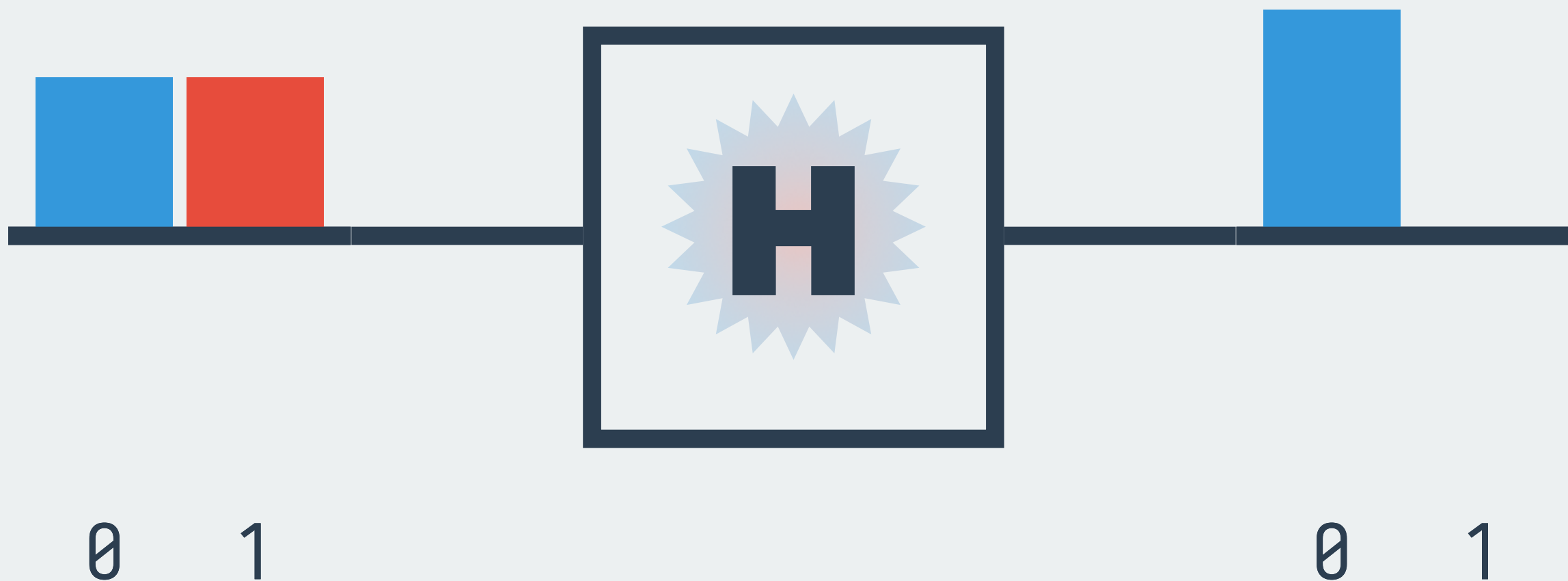
Jacques Hadamard

DEMO

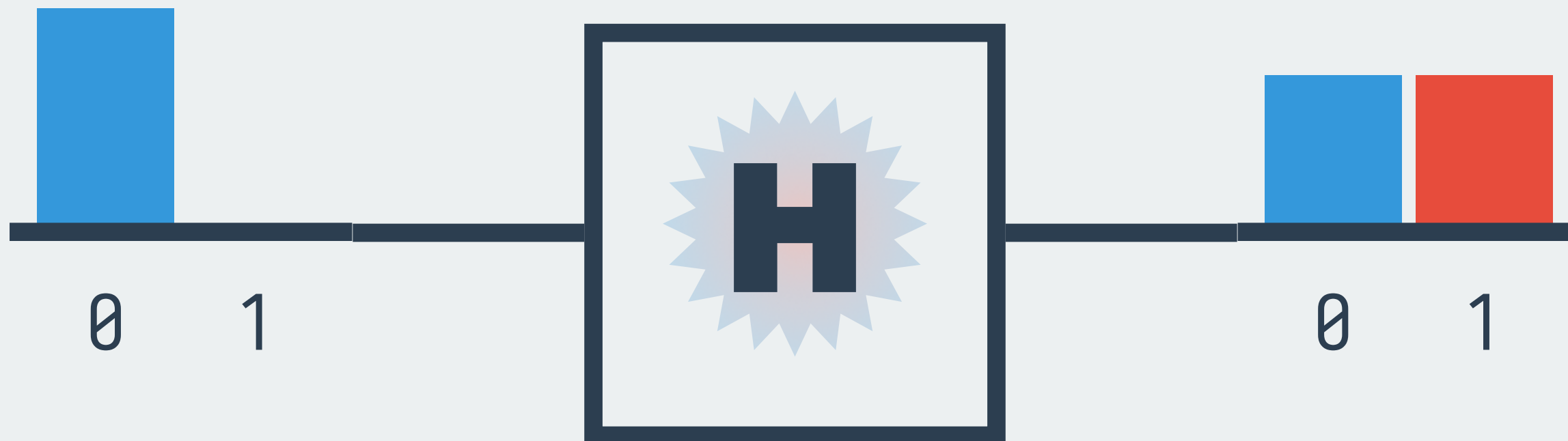


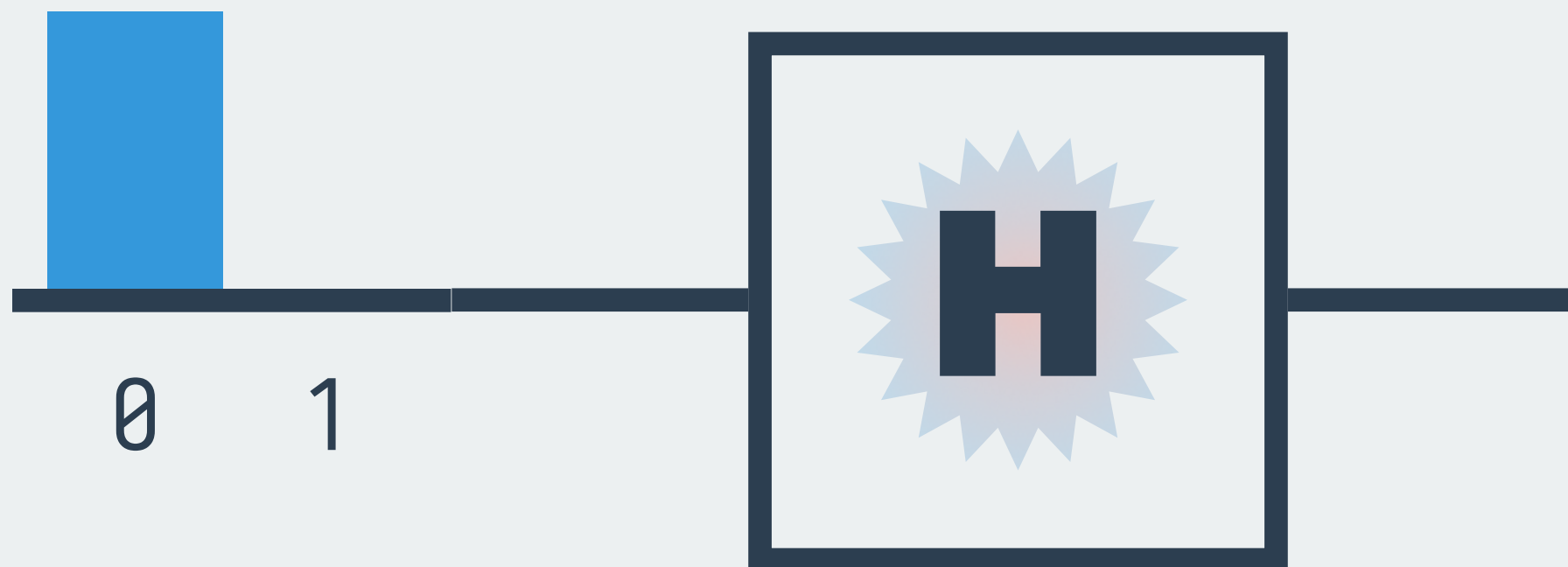
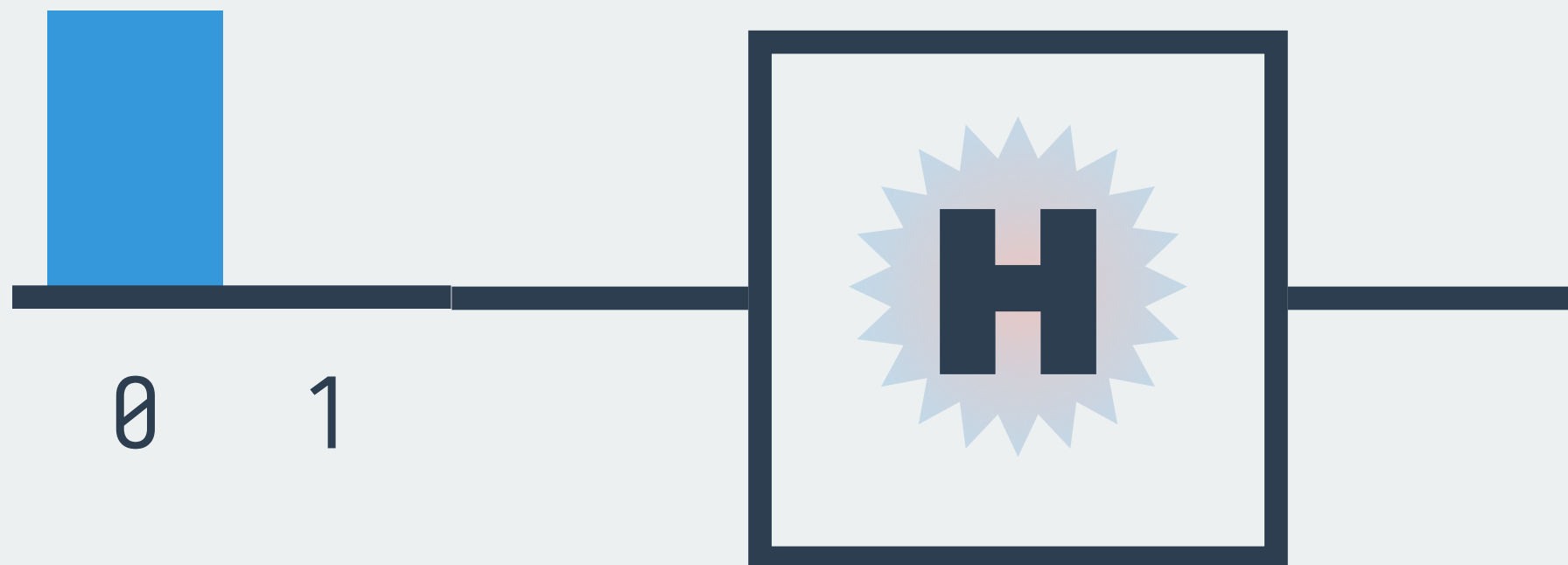


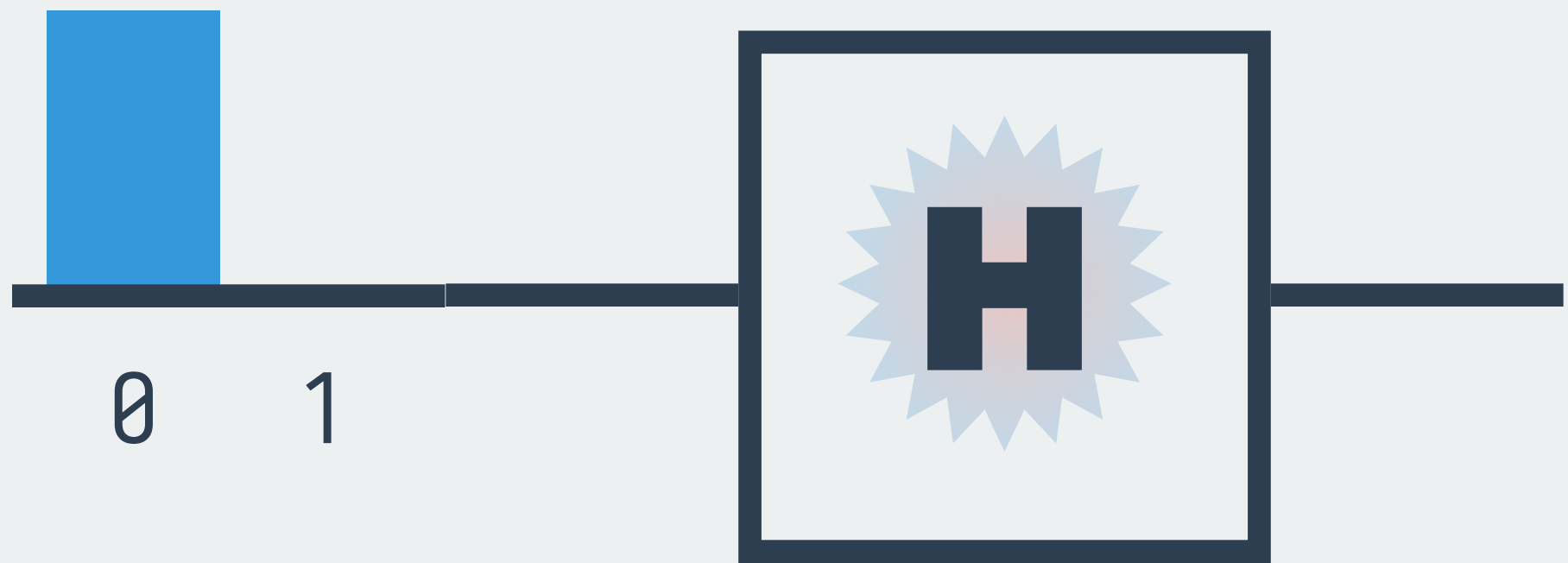
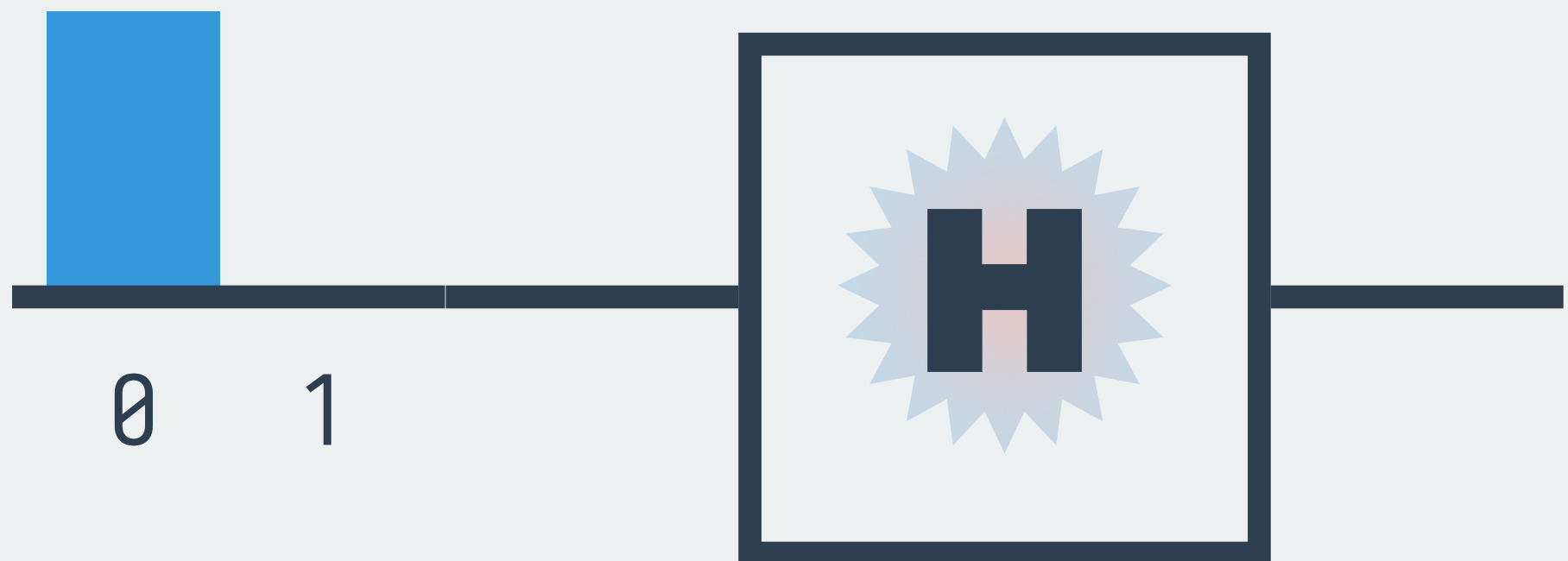
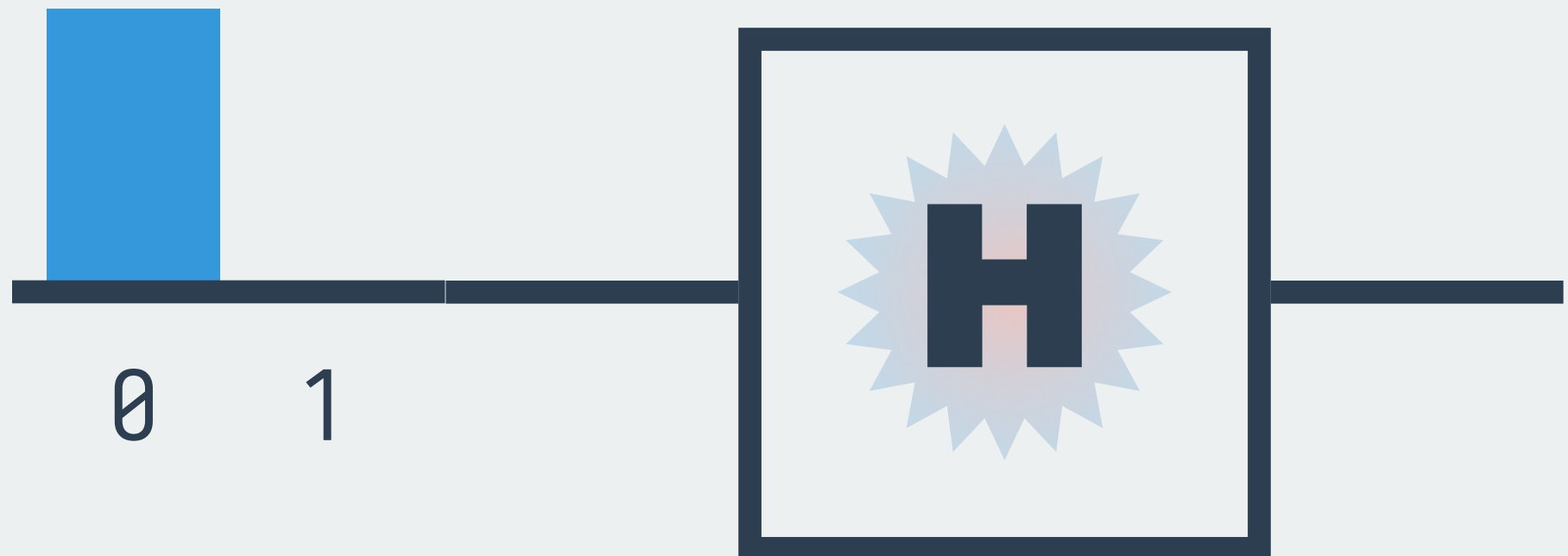


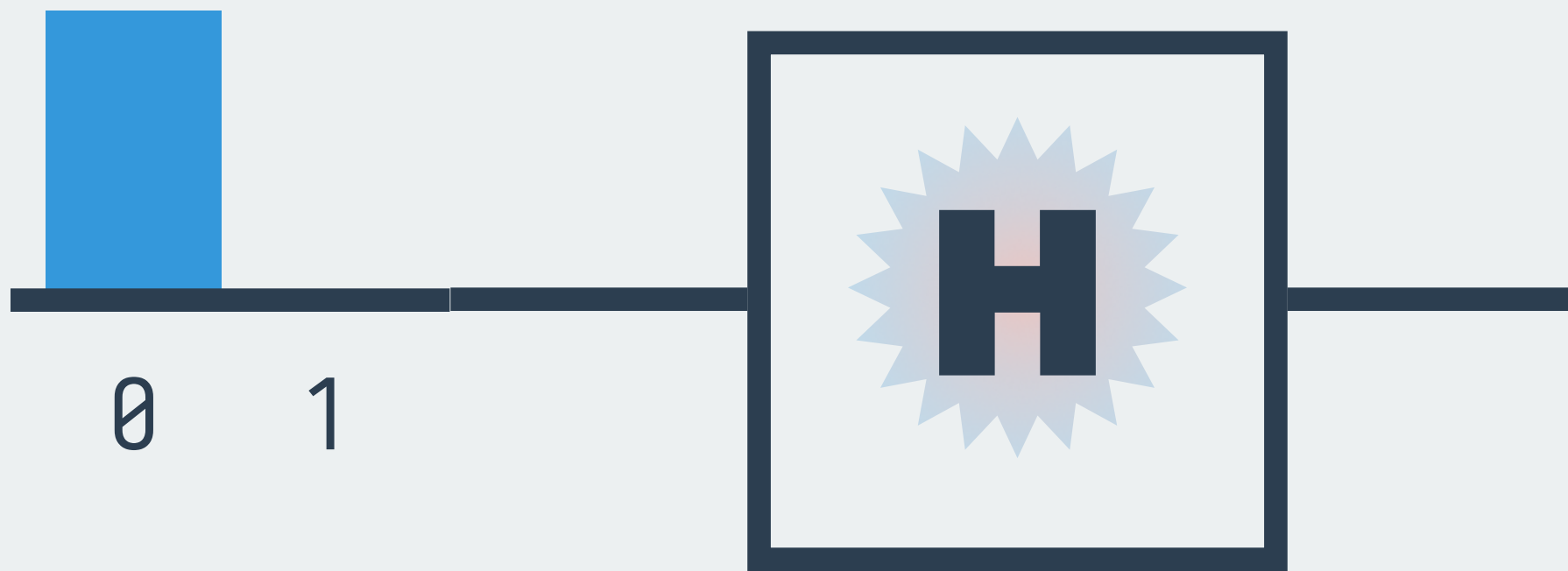
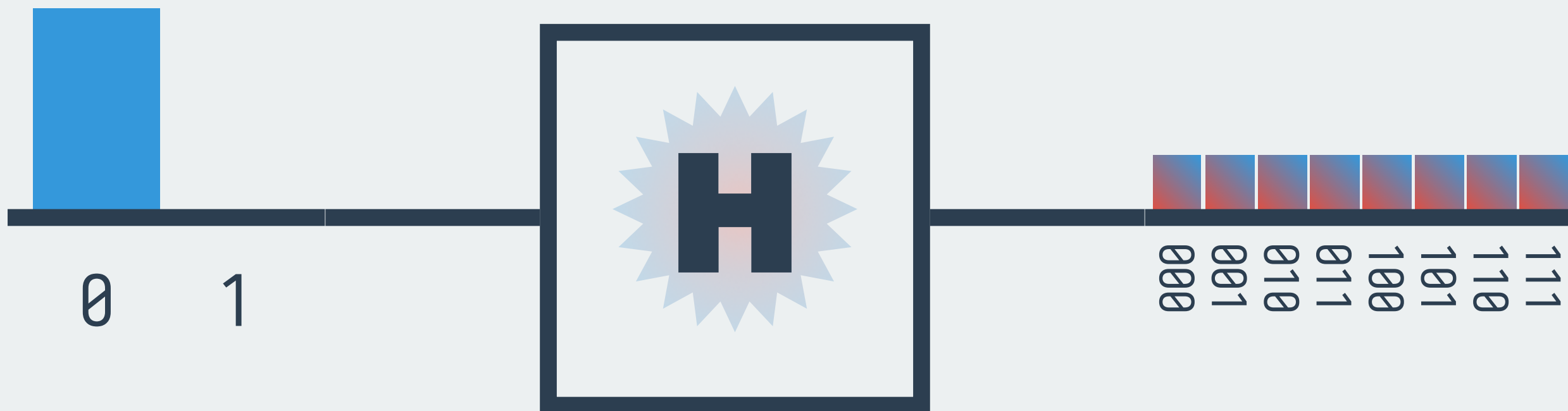
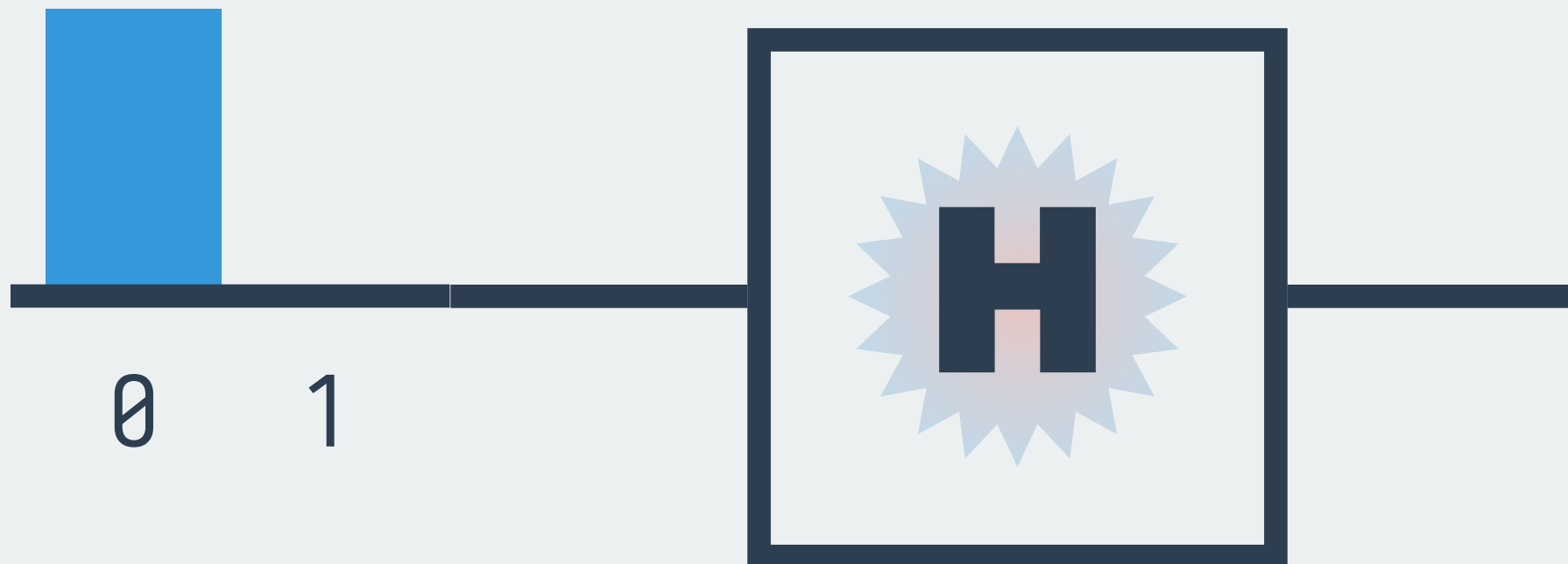


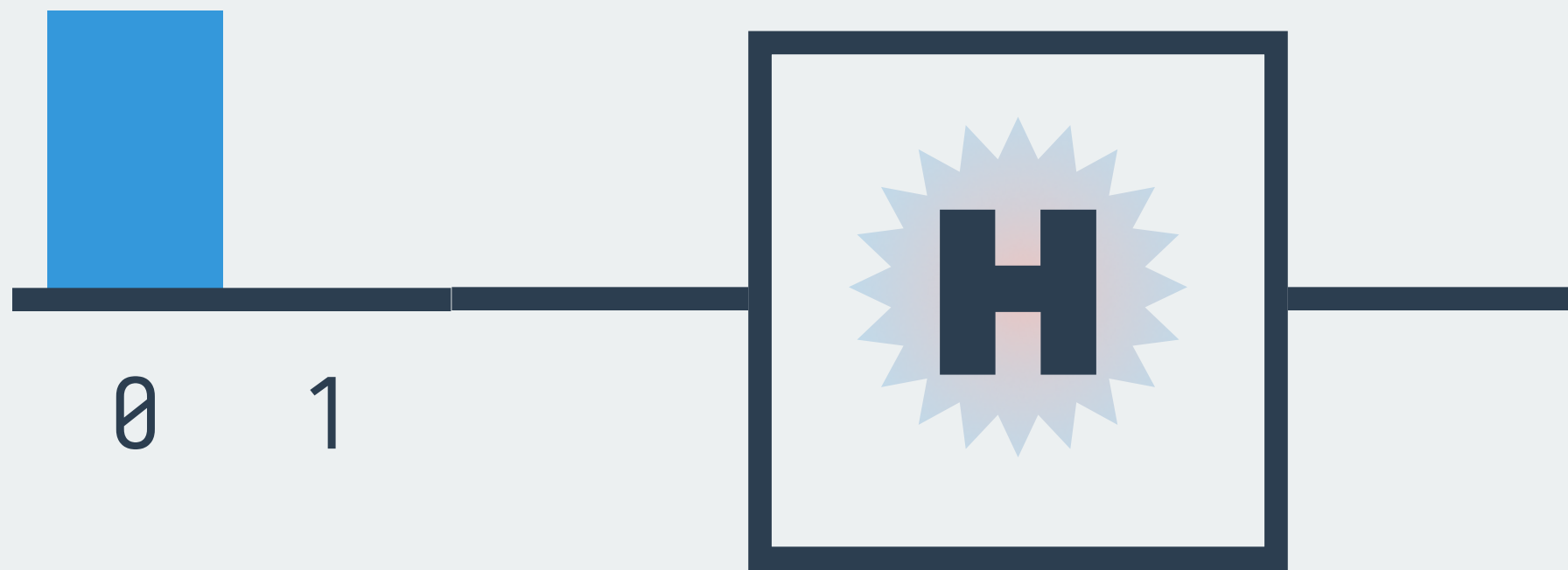
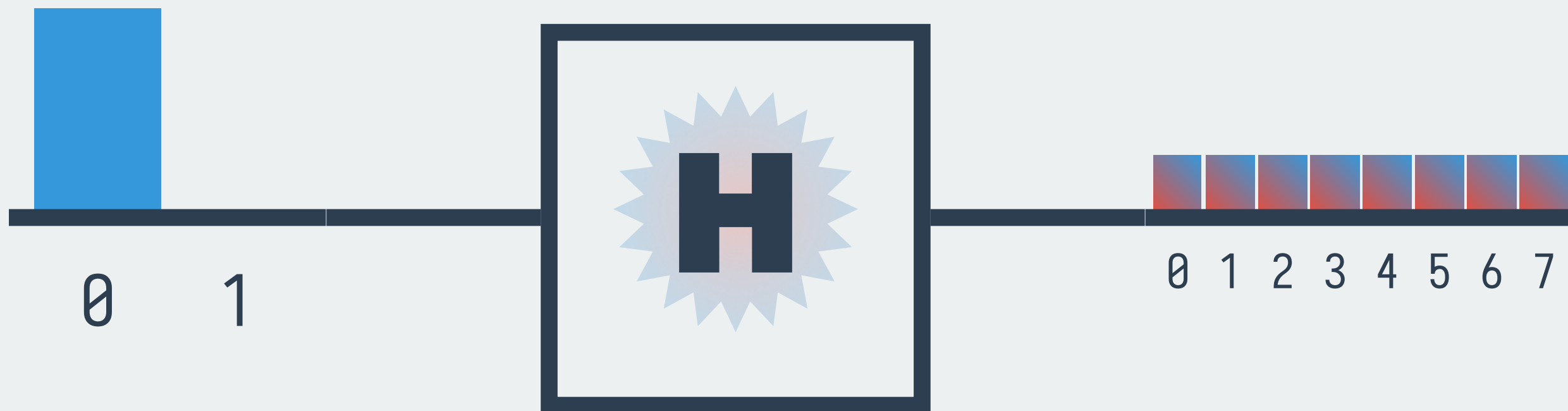
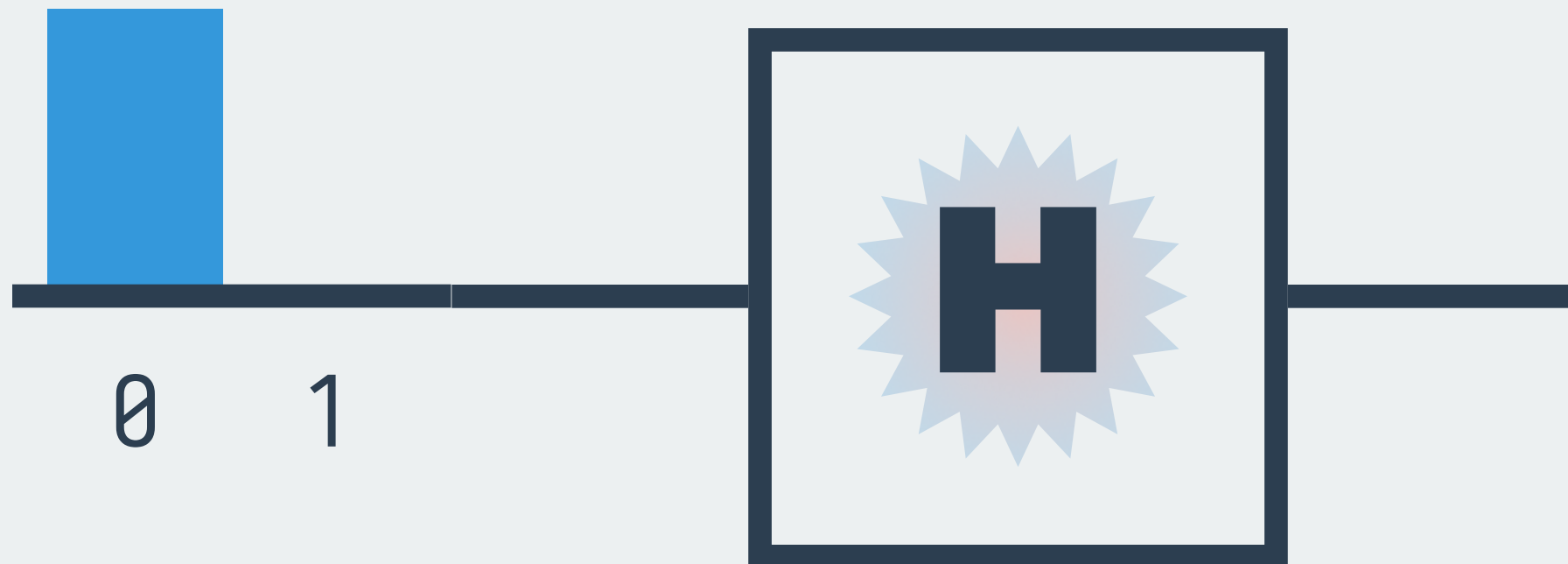
NAIVE APPROACH





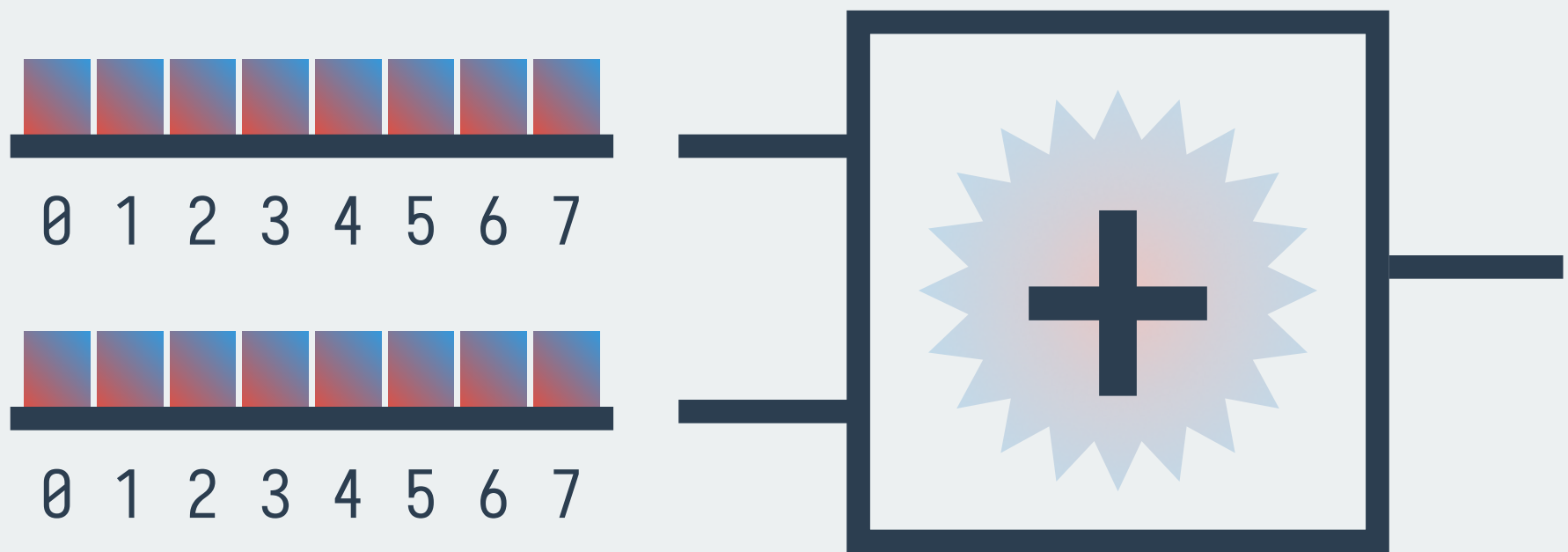


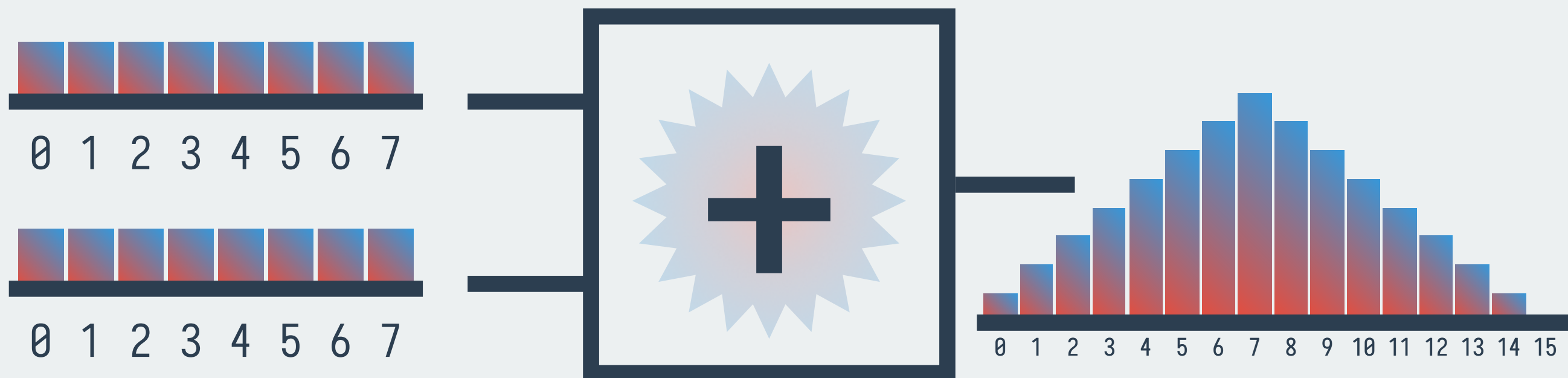


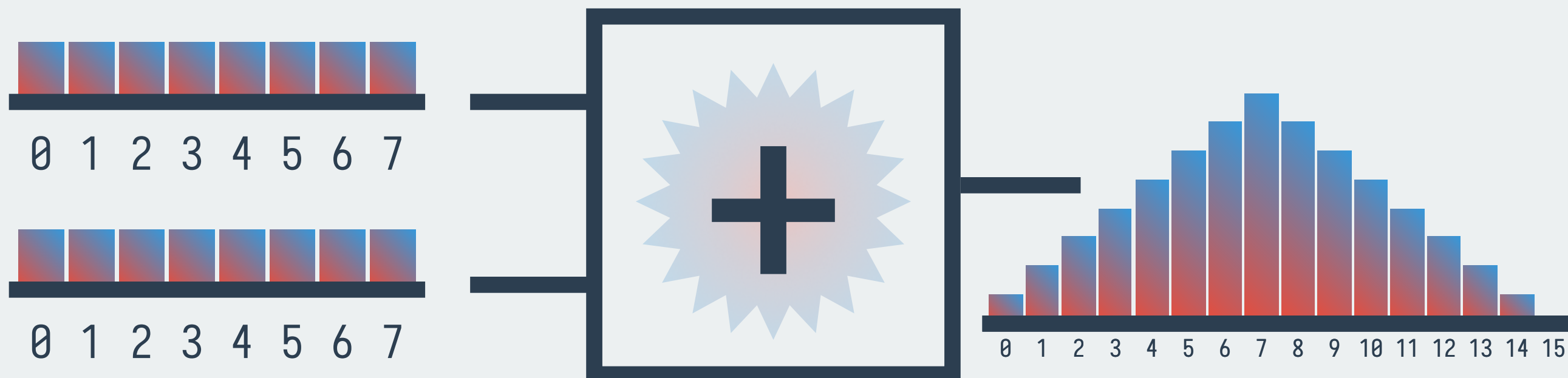












BUT...

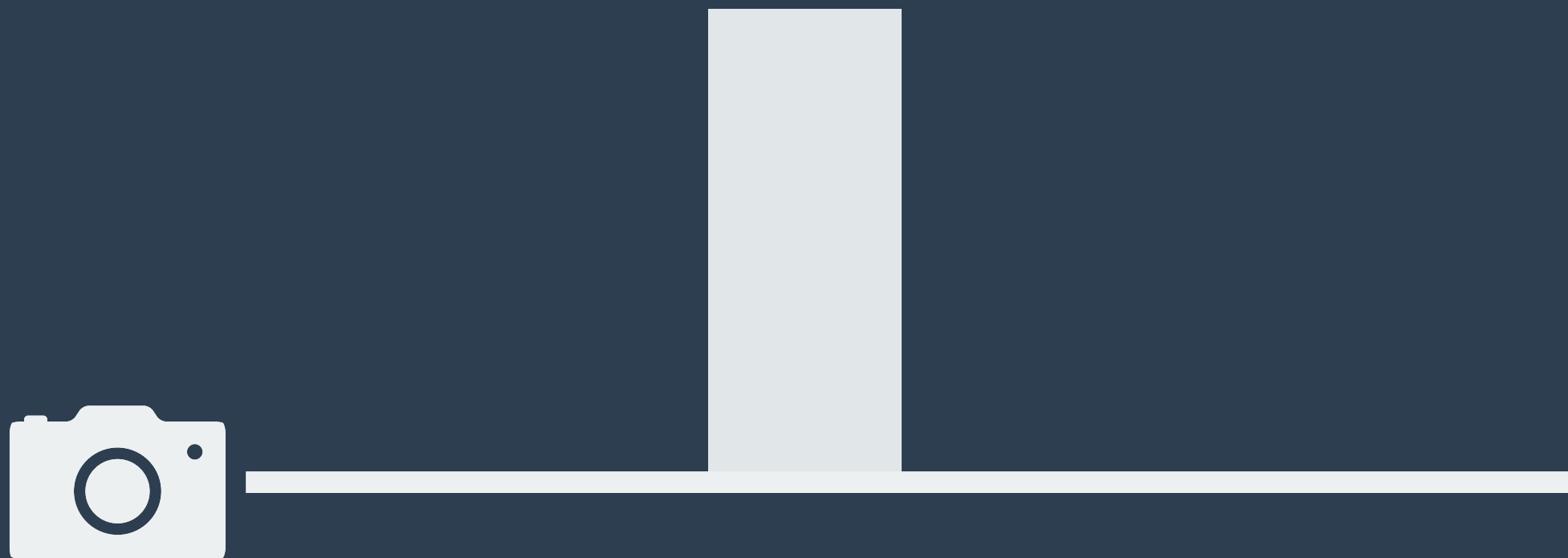




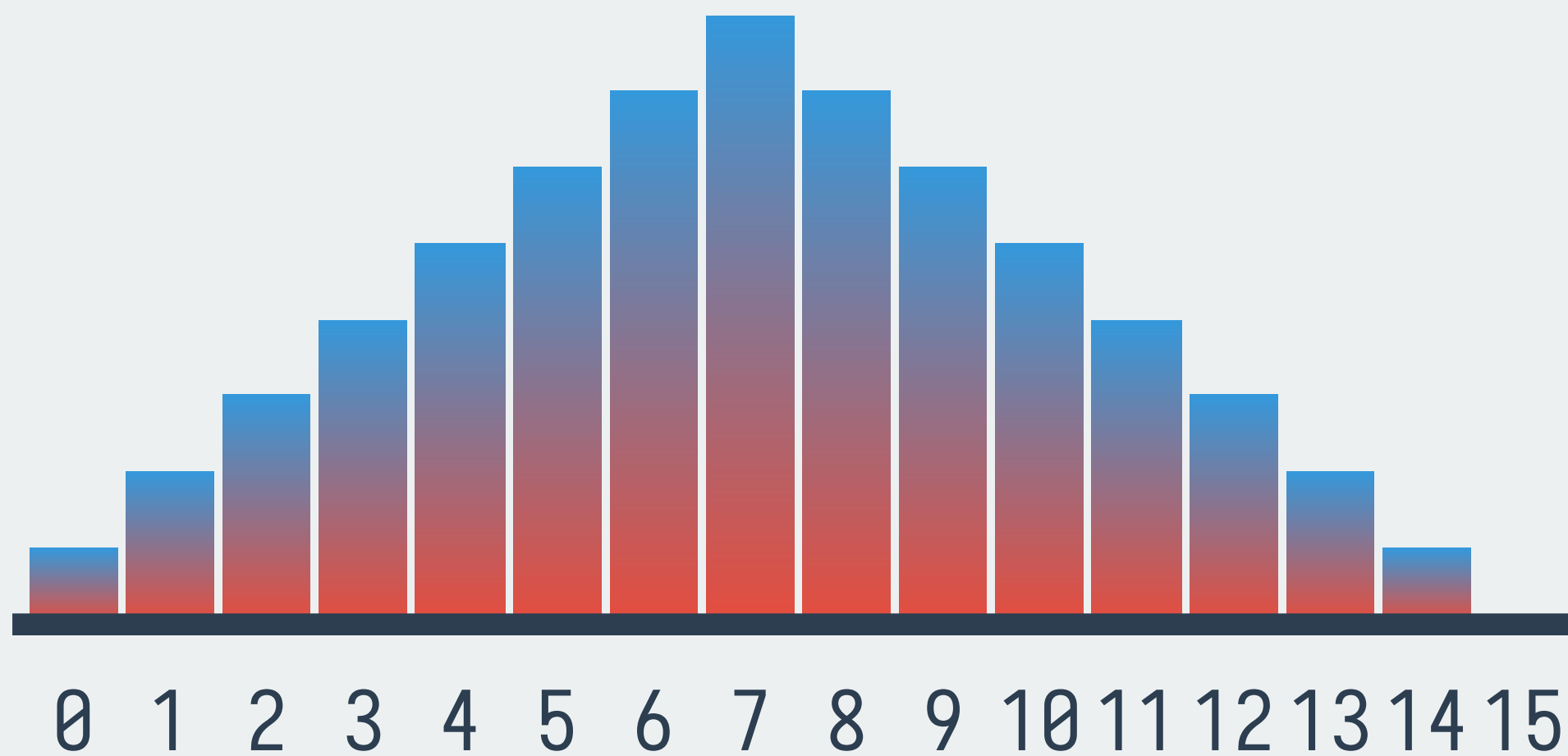
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COLLAPSE

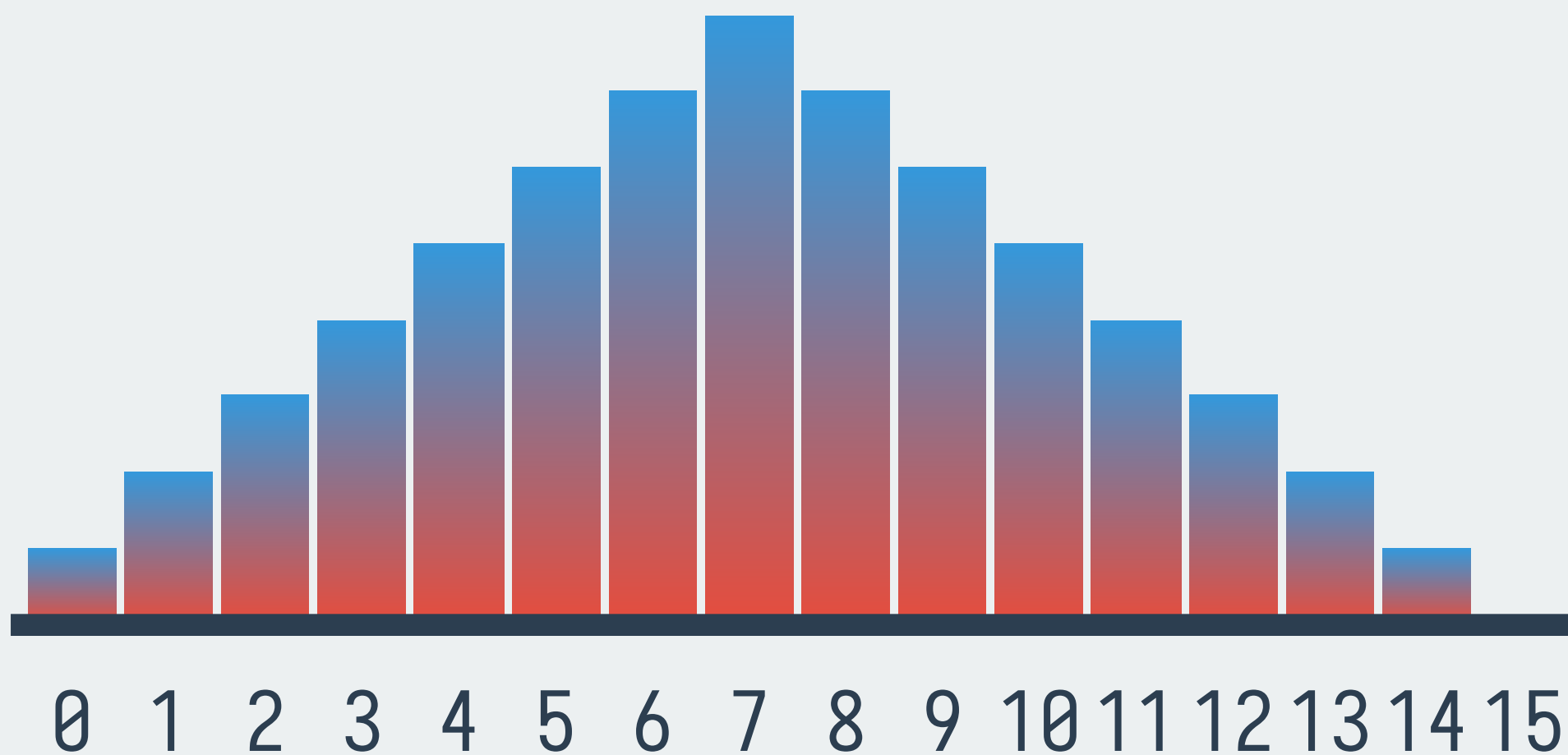


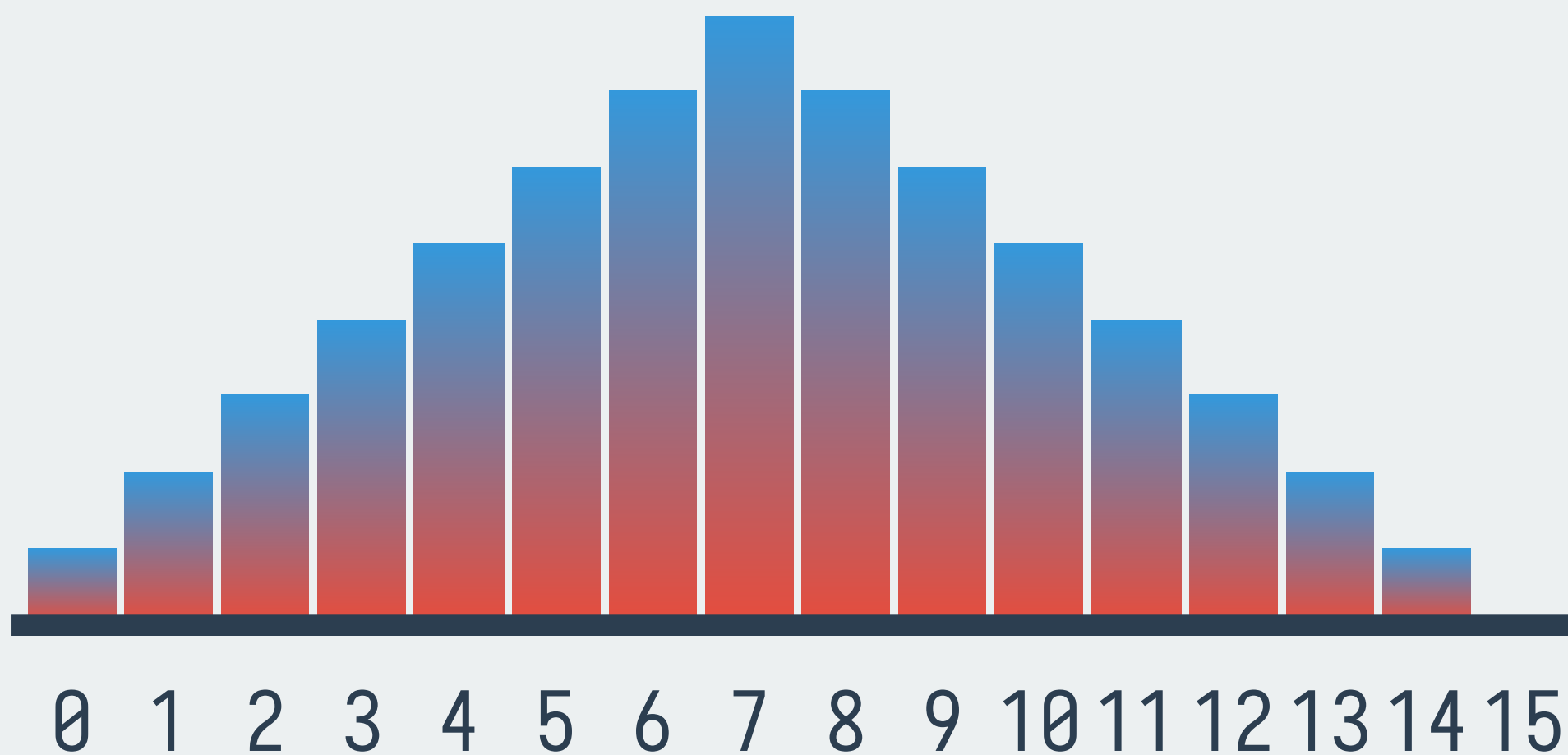
QUANTUM **COLLAPSE**

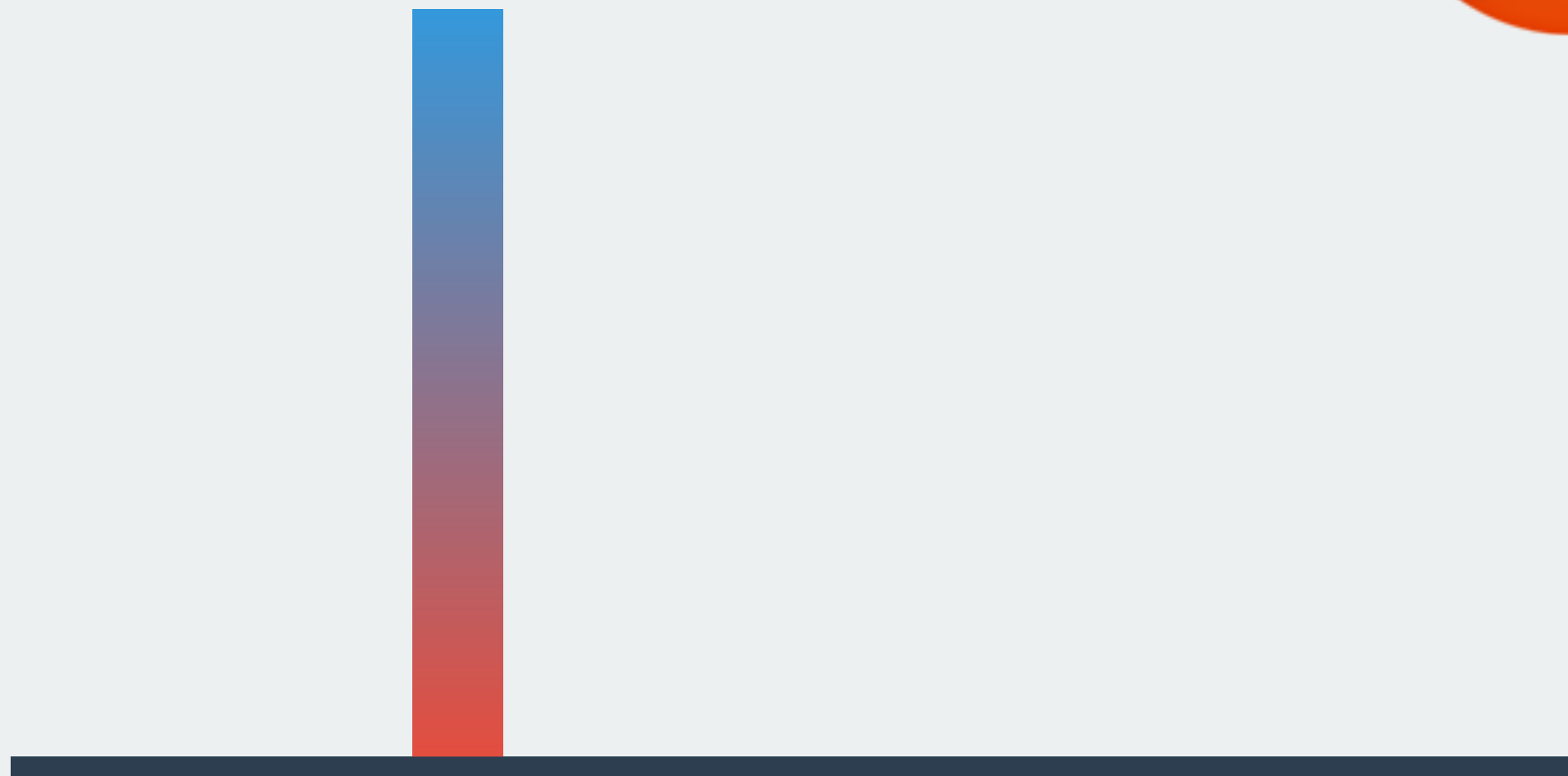


QUANTUM **COLLAPSE**



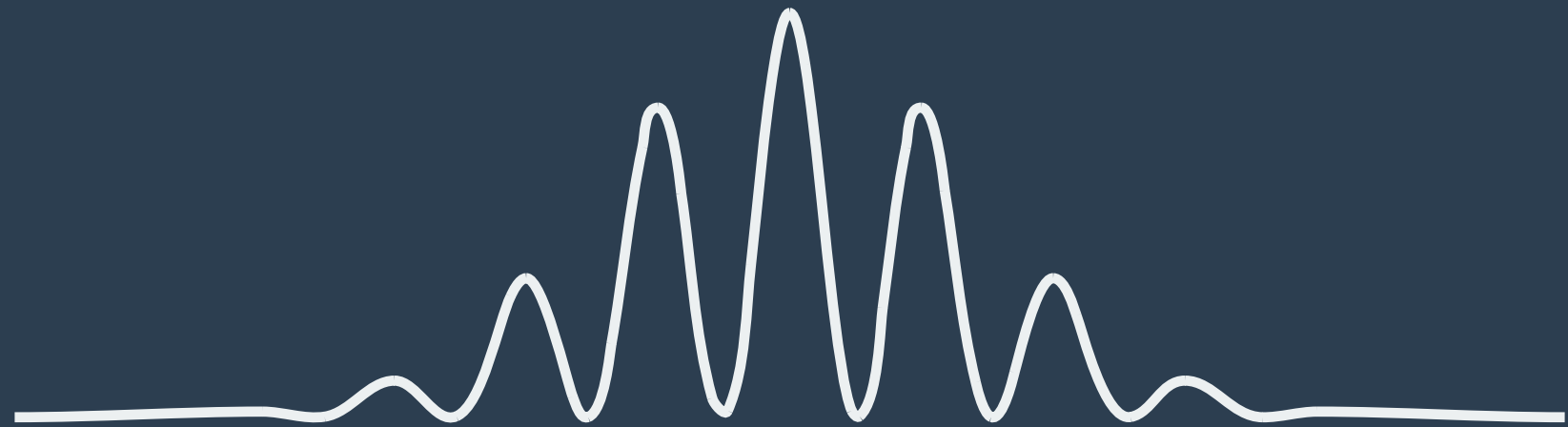






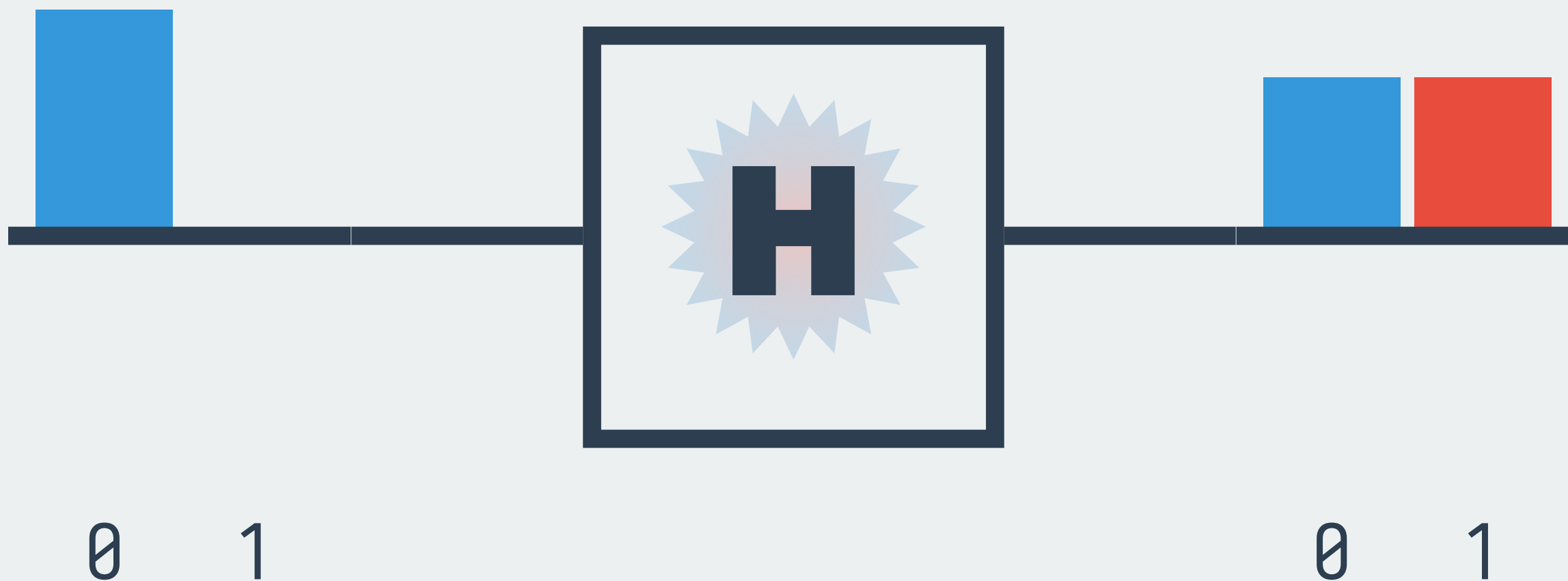
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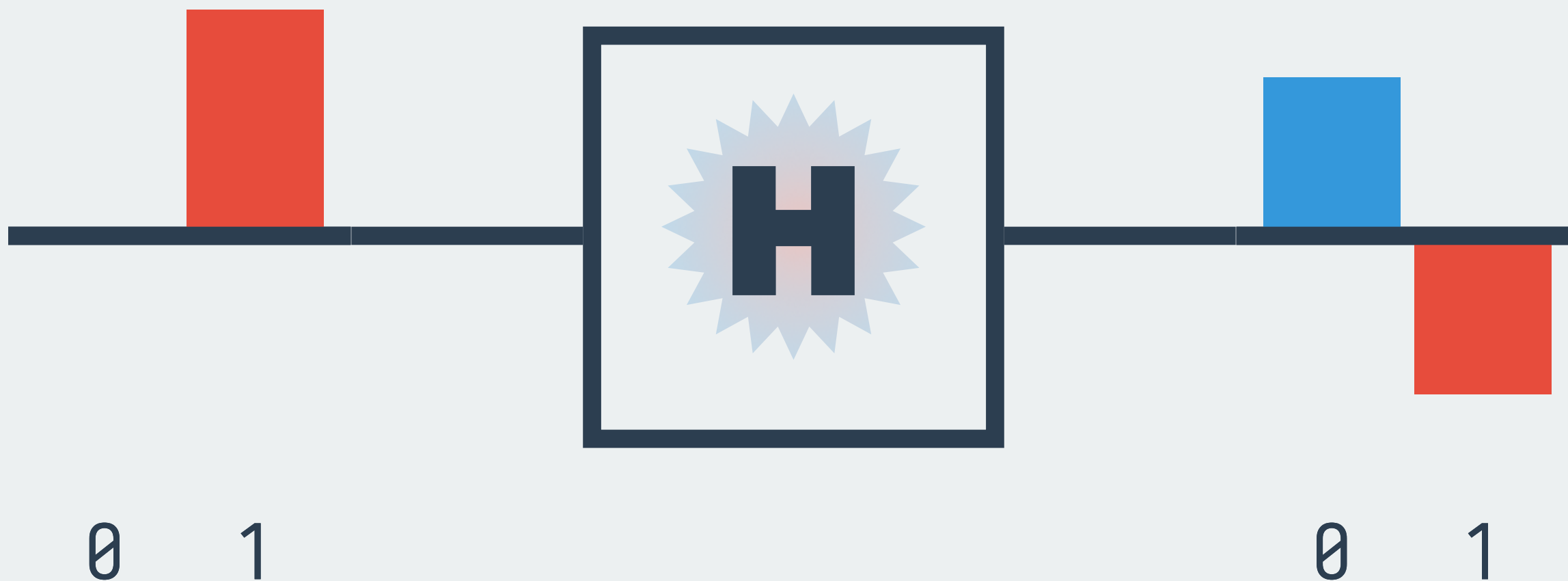


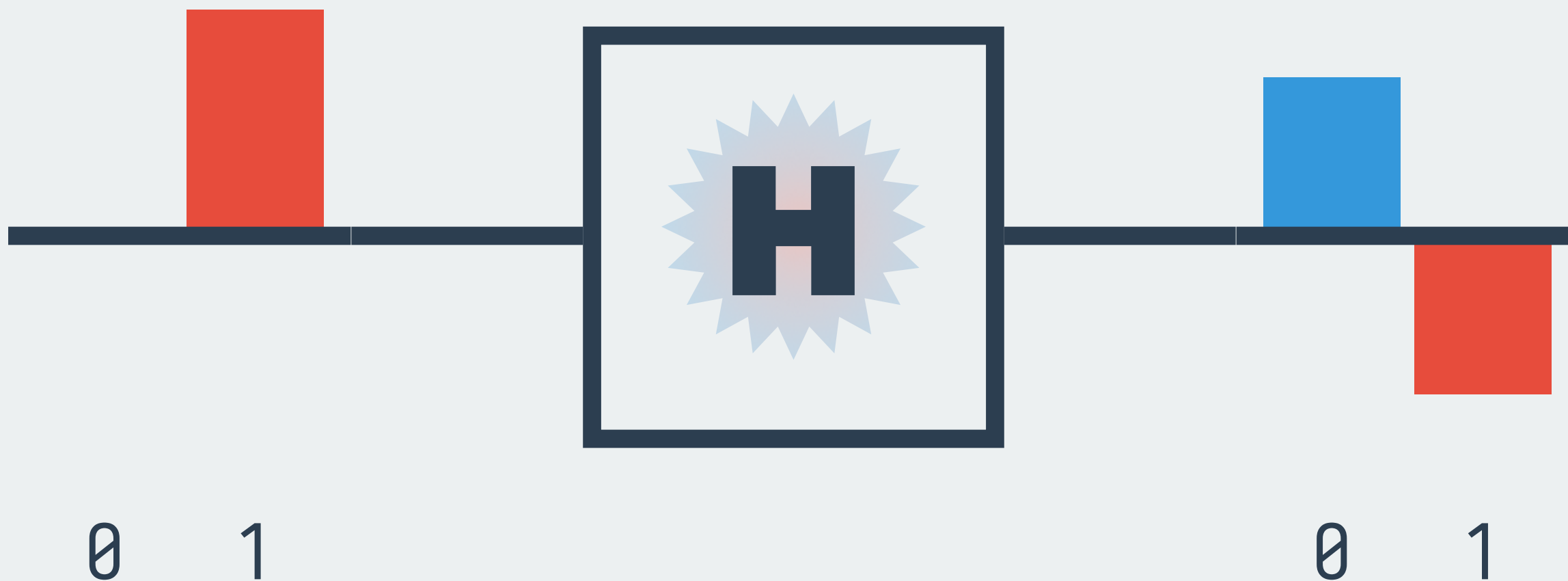


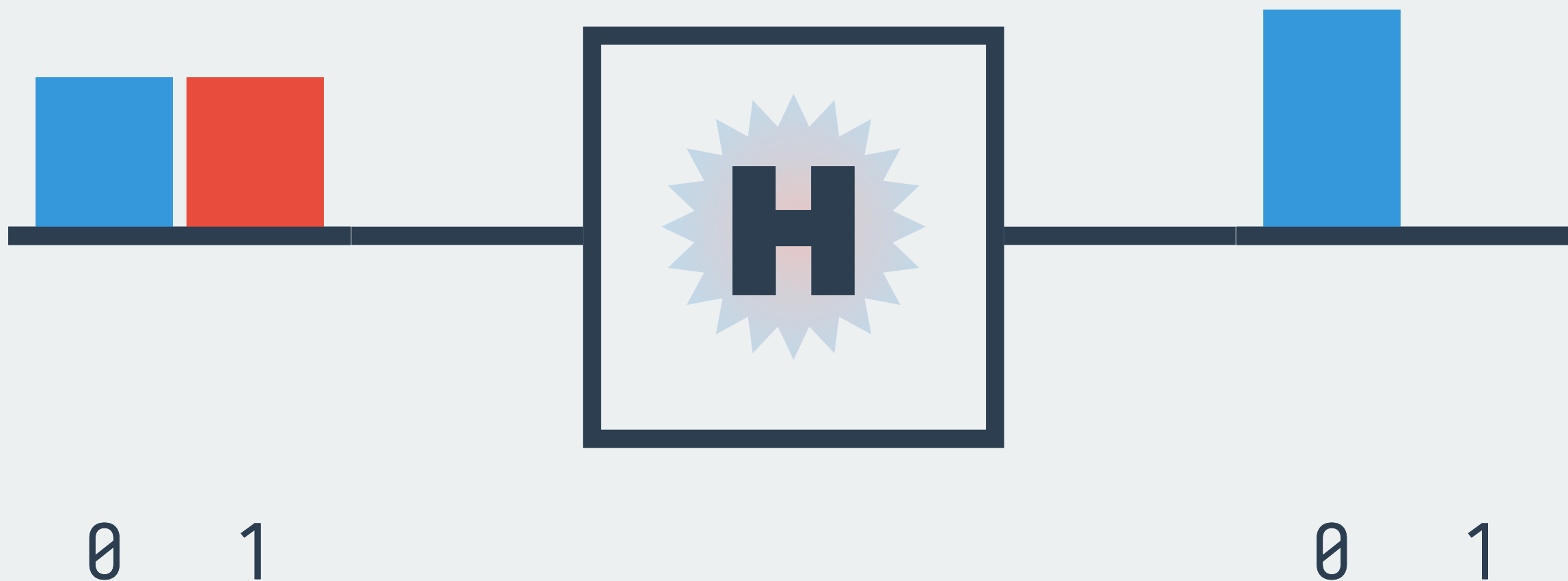
INTERFERENCE







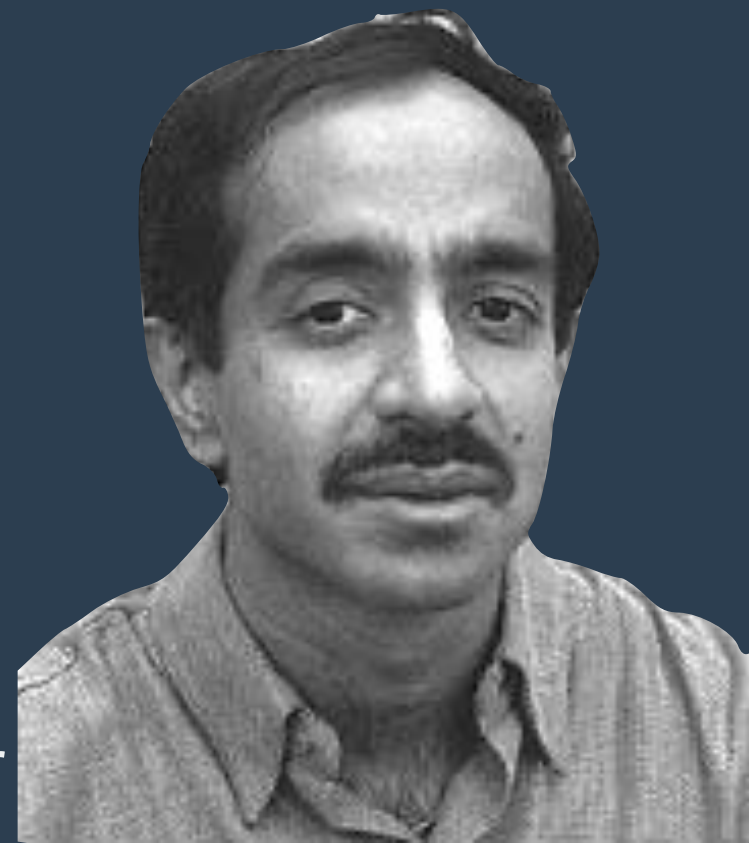


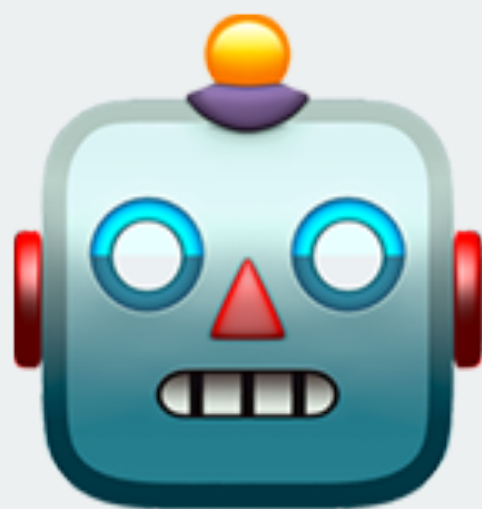


GROVER'S ALGORITHM

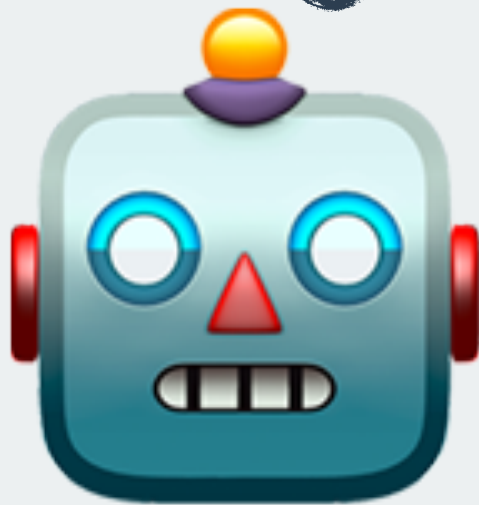
GROVER'S ALGORITHM

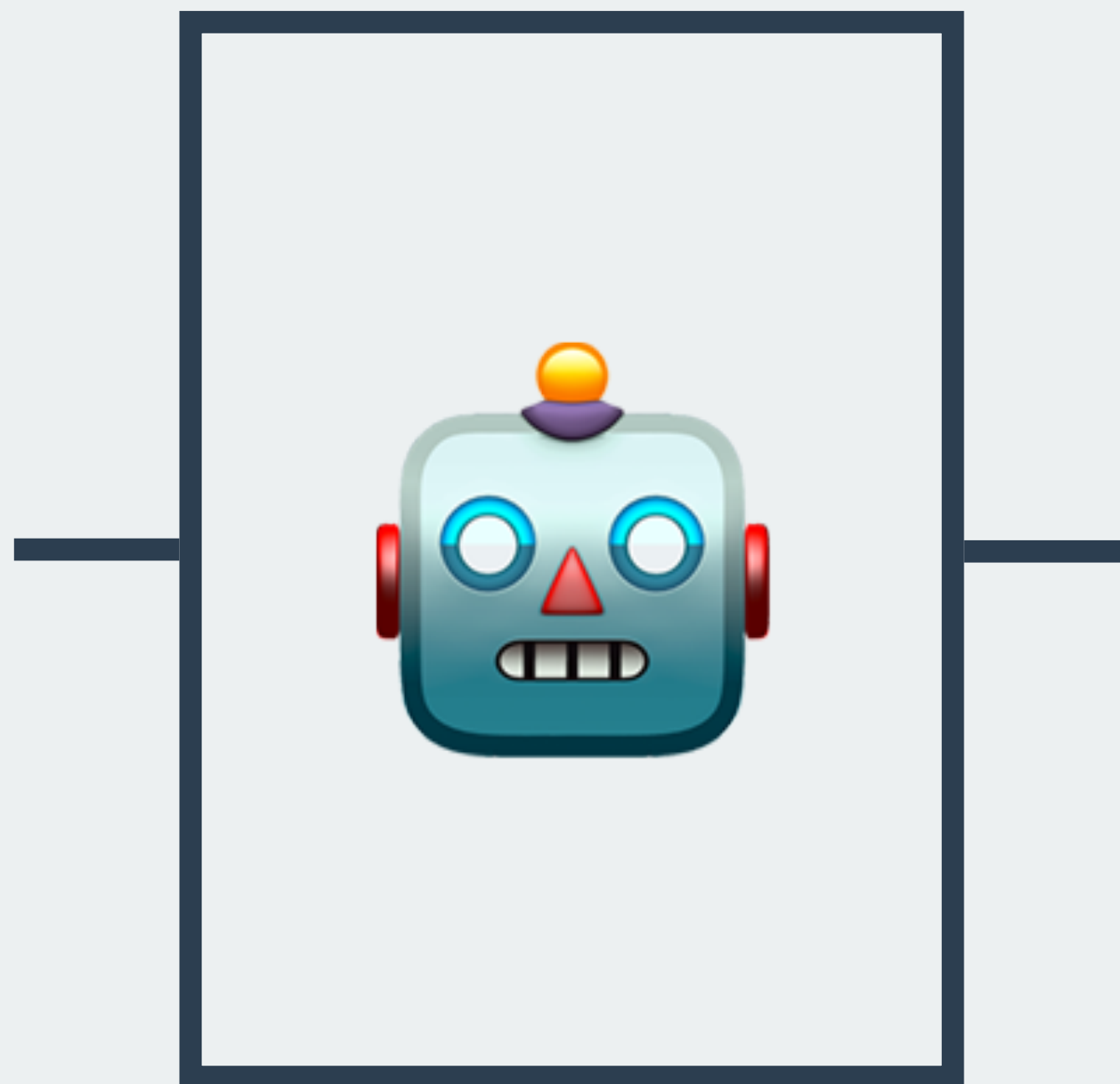
Lov Grover



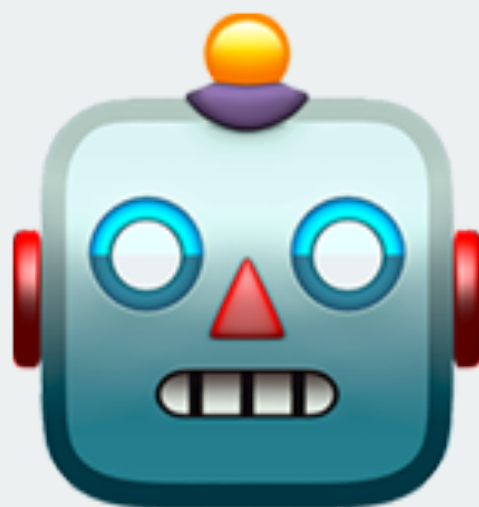


is **x** a
proper divisor of
15?

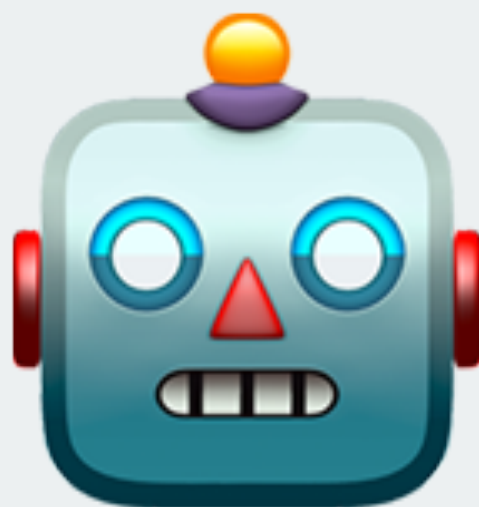




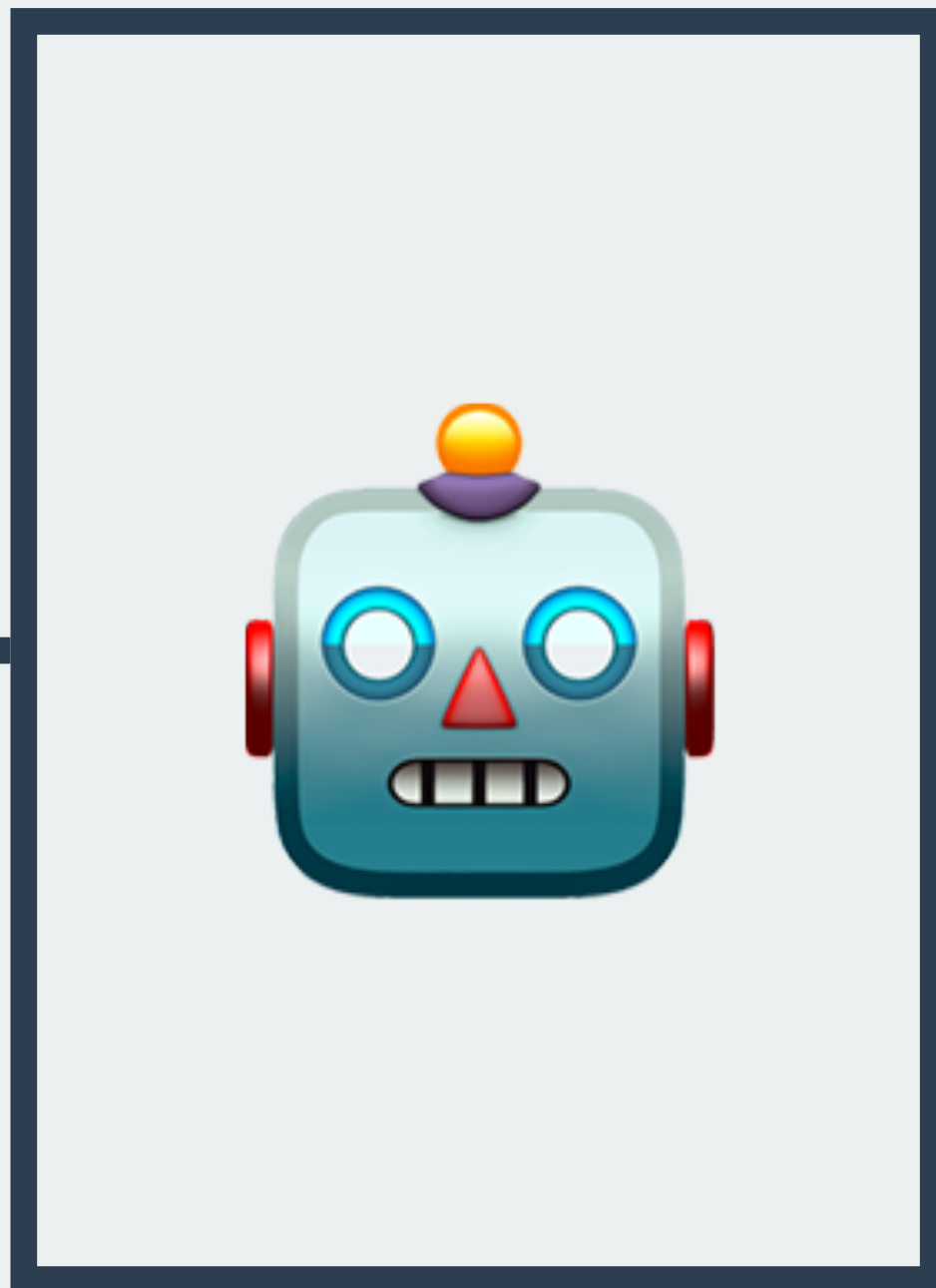
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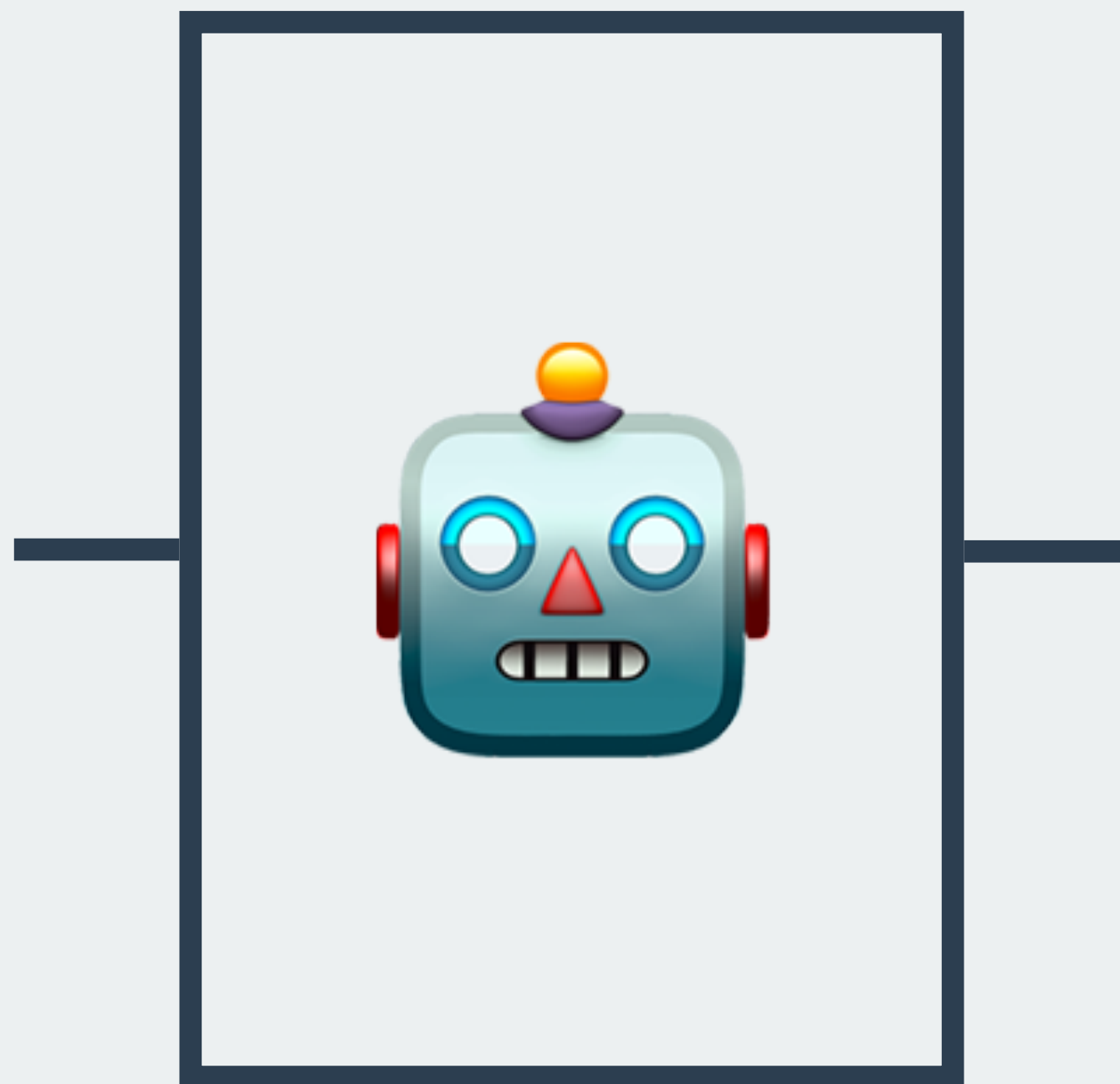
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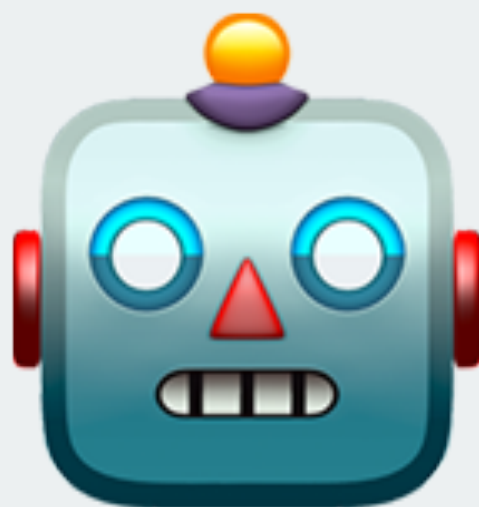
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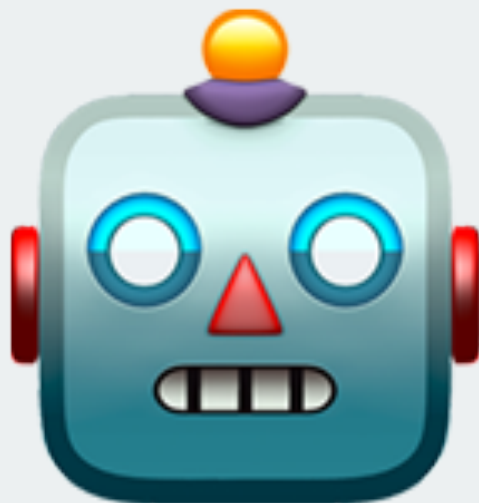
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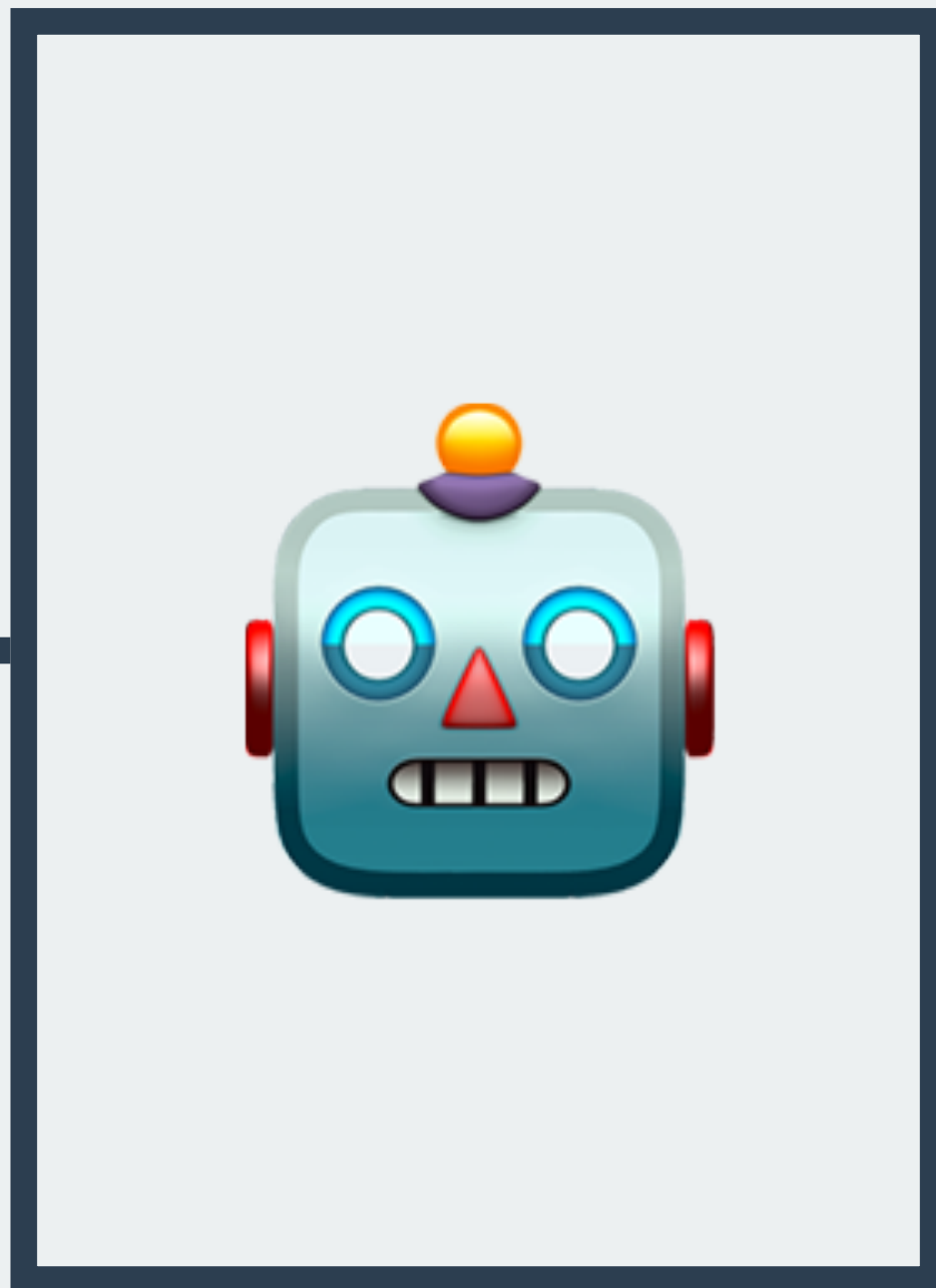
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5

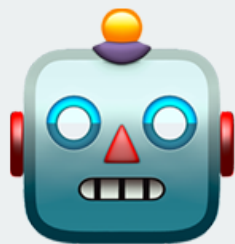


5



1

0 1 2 3 4 5 6 7



0

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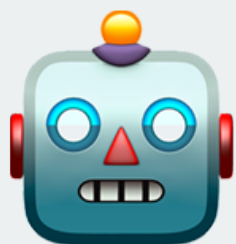
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7



0

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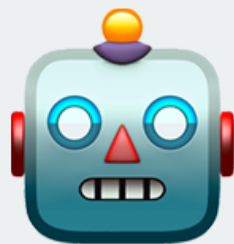
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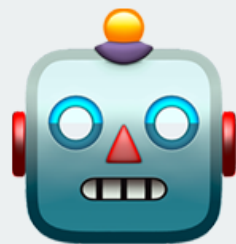
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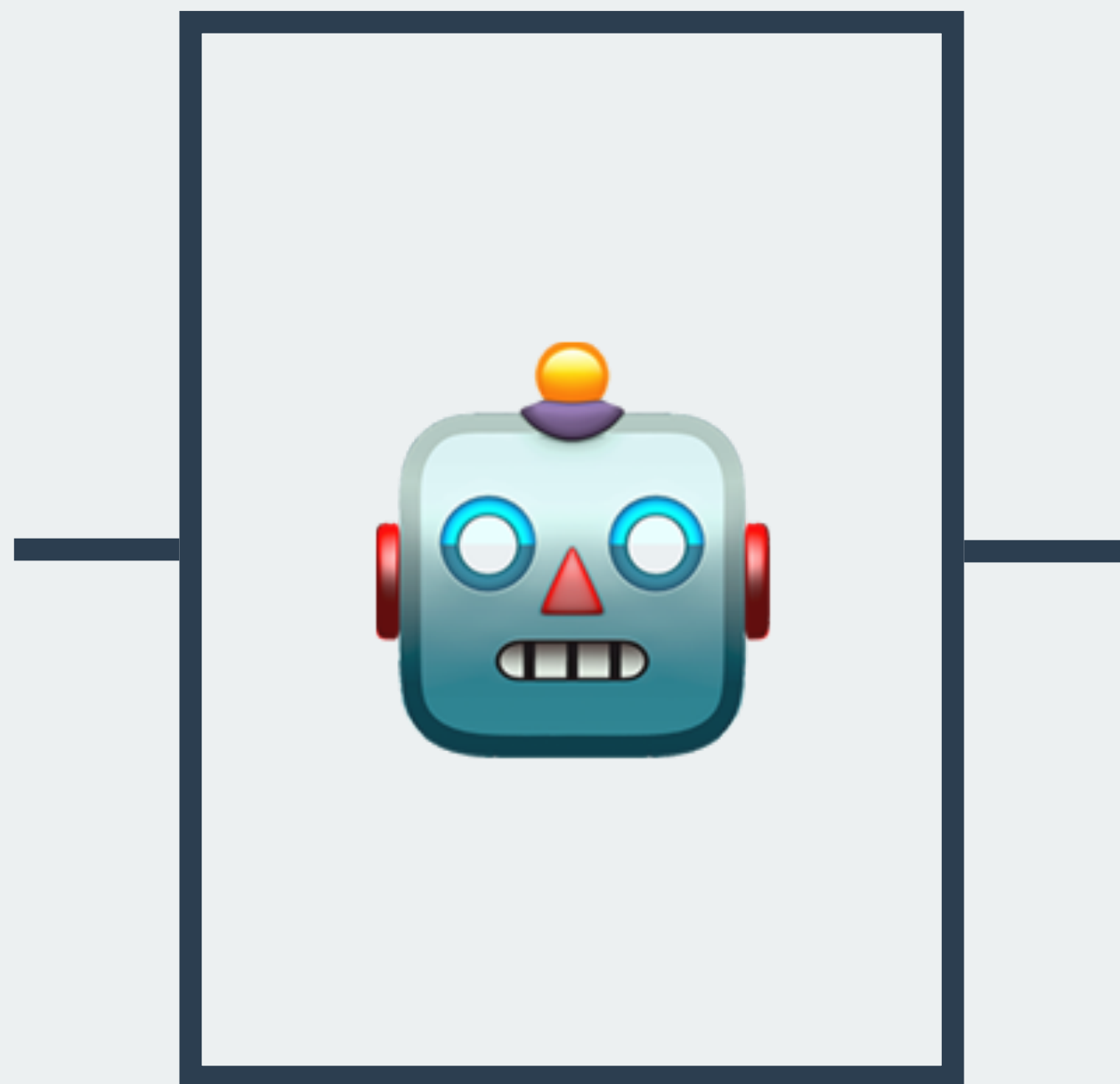


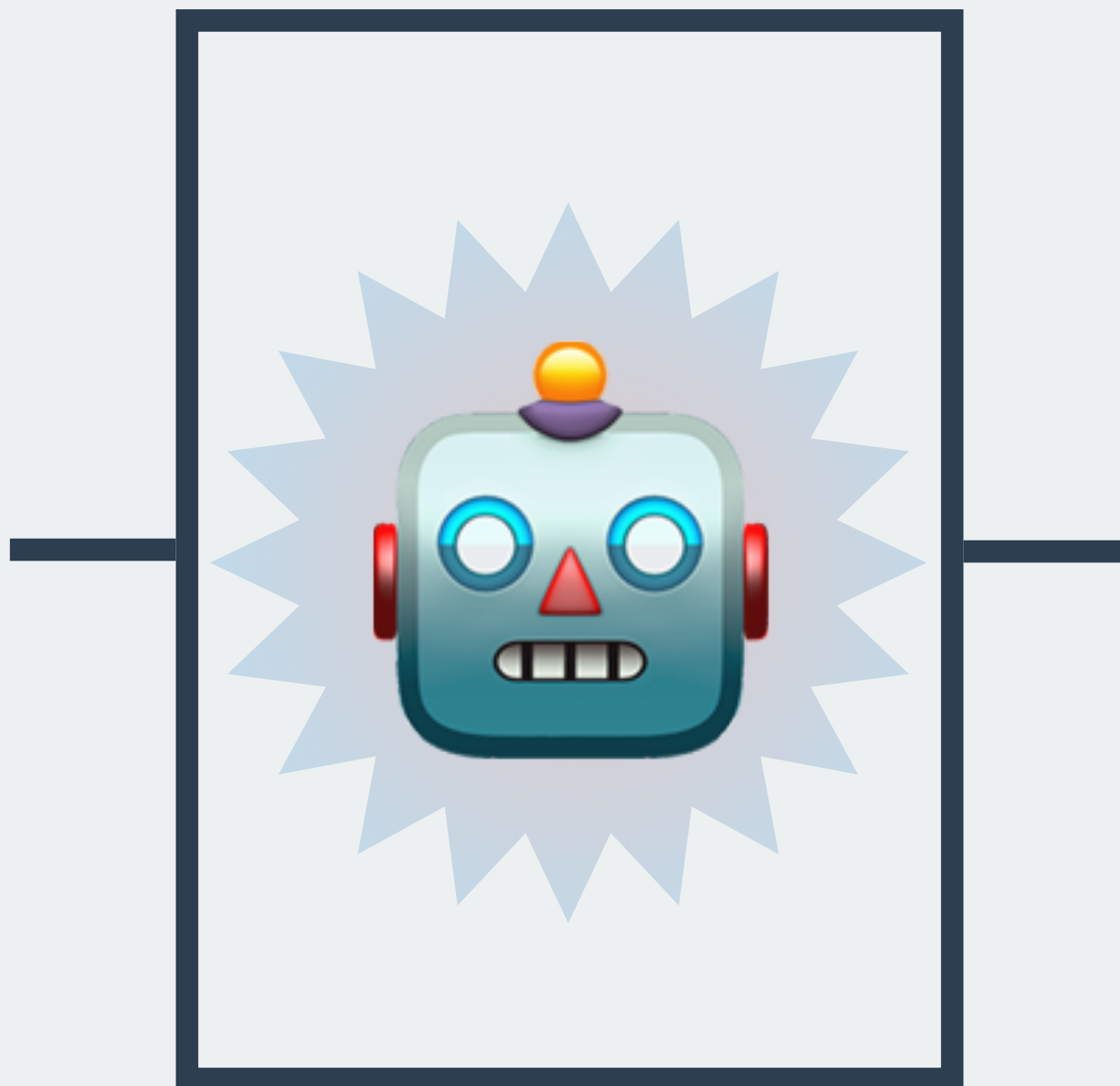
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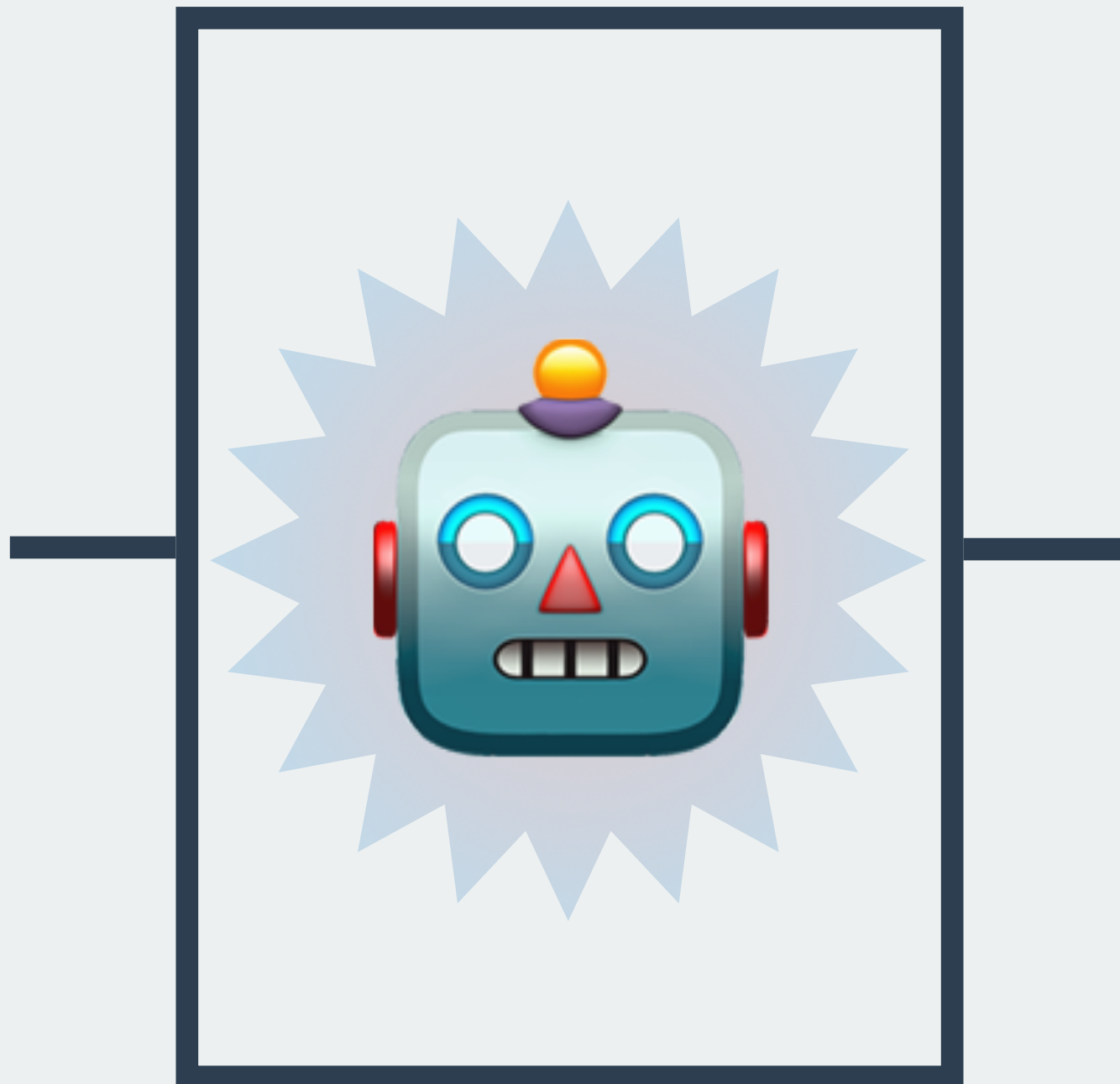
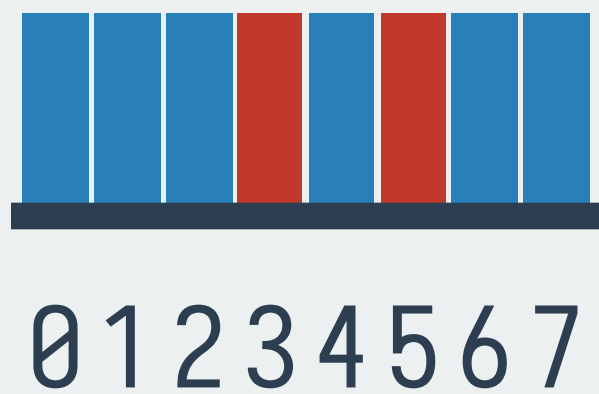


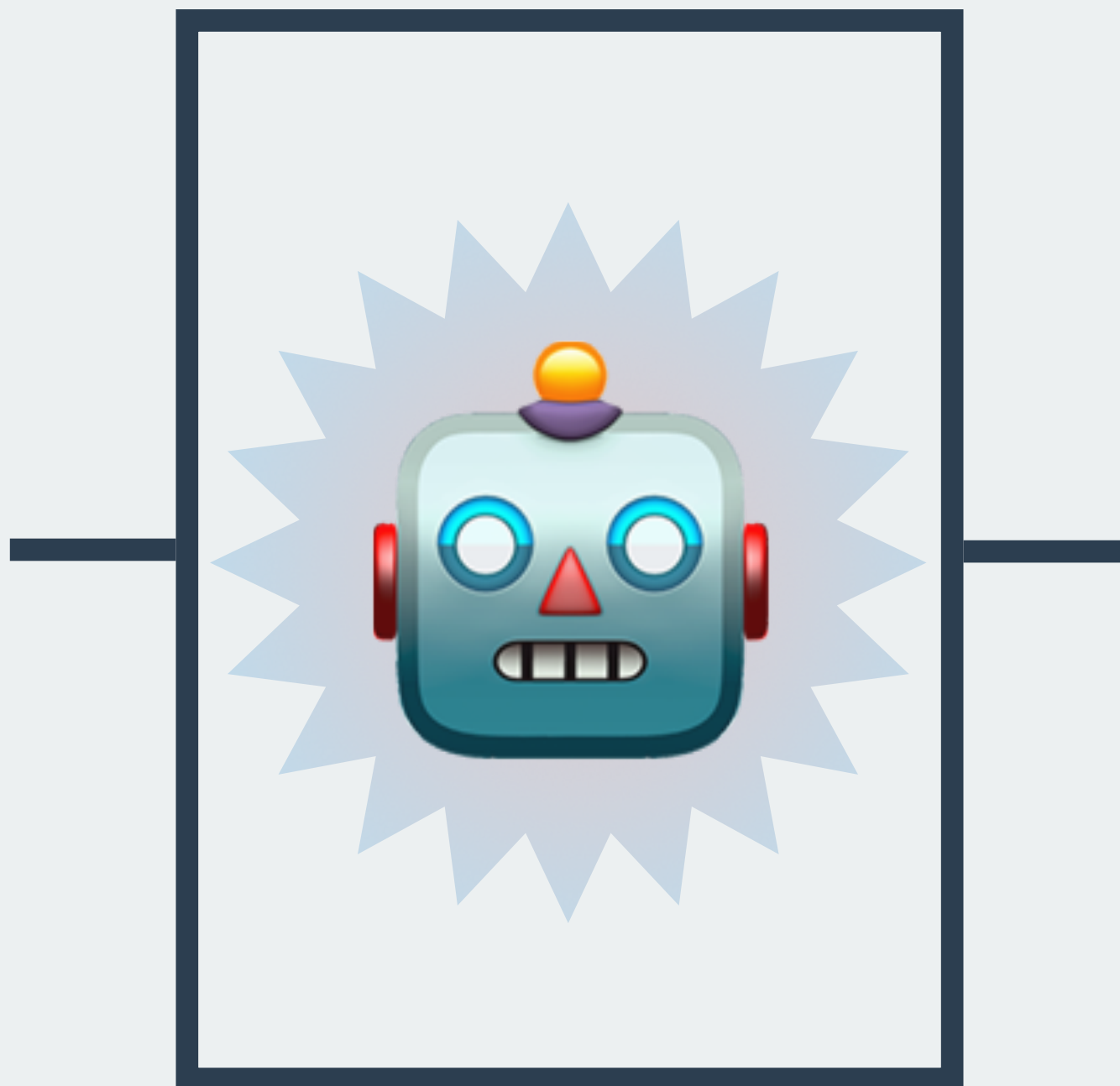
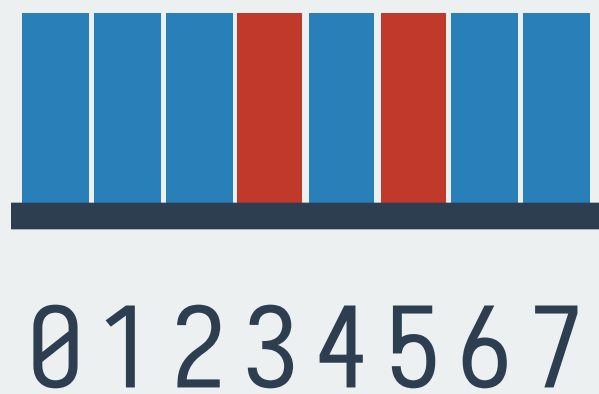
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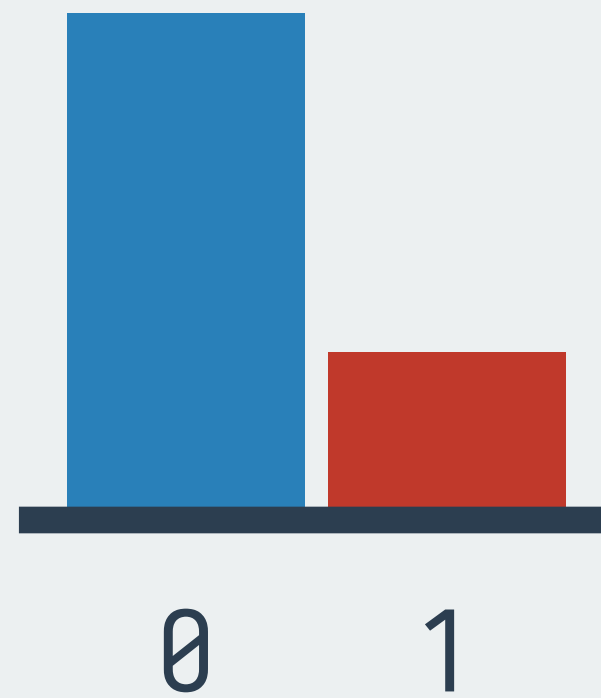
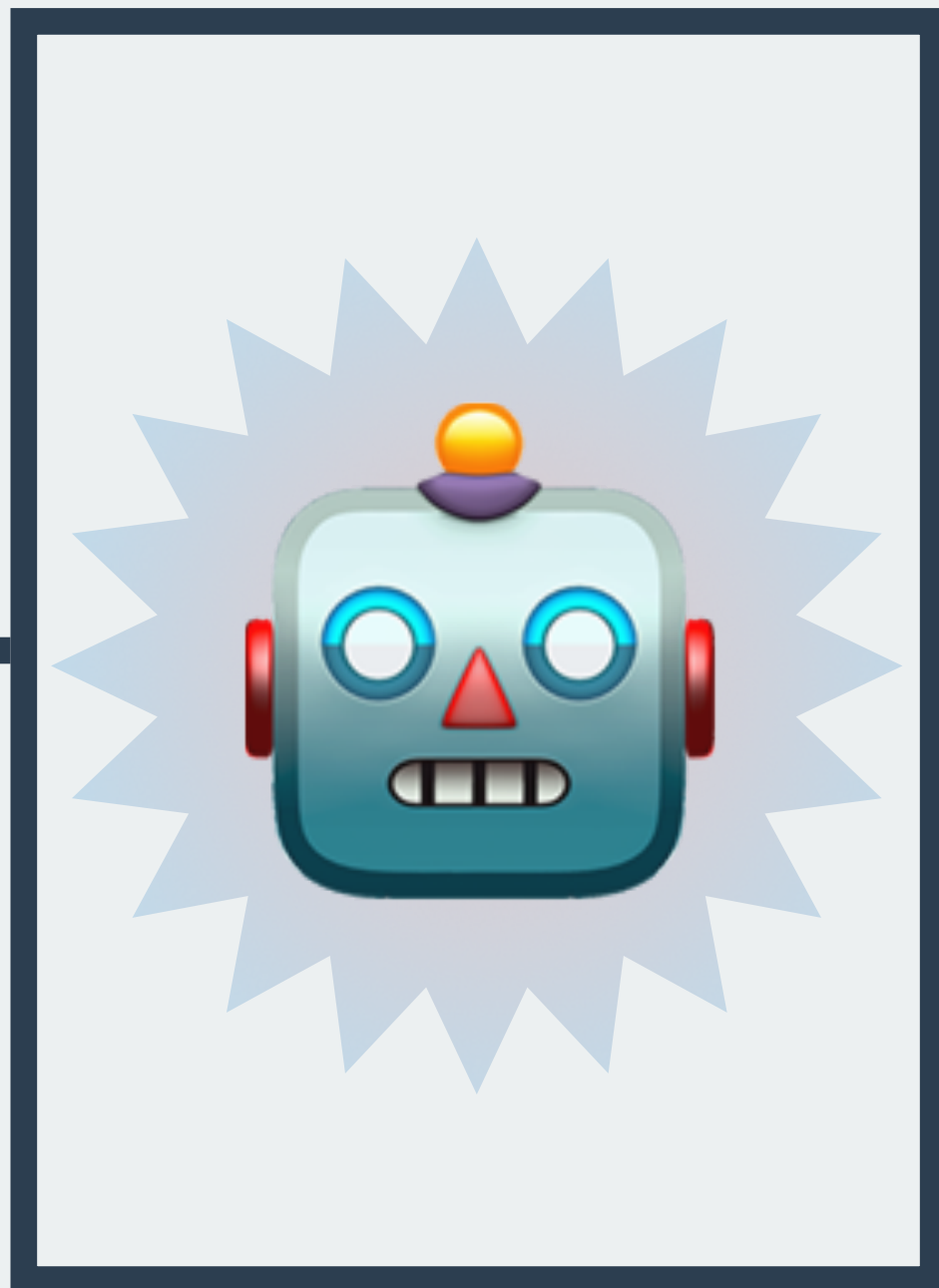
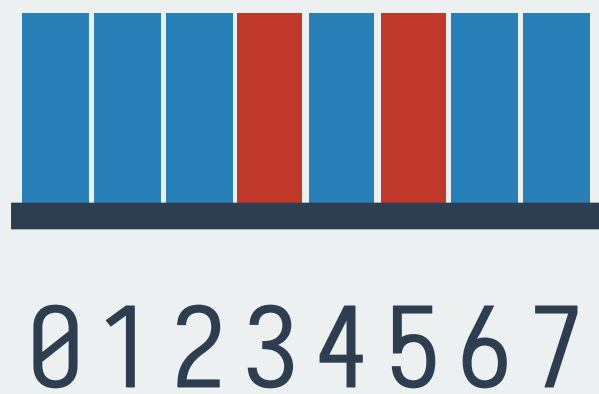
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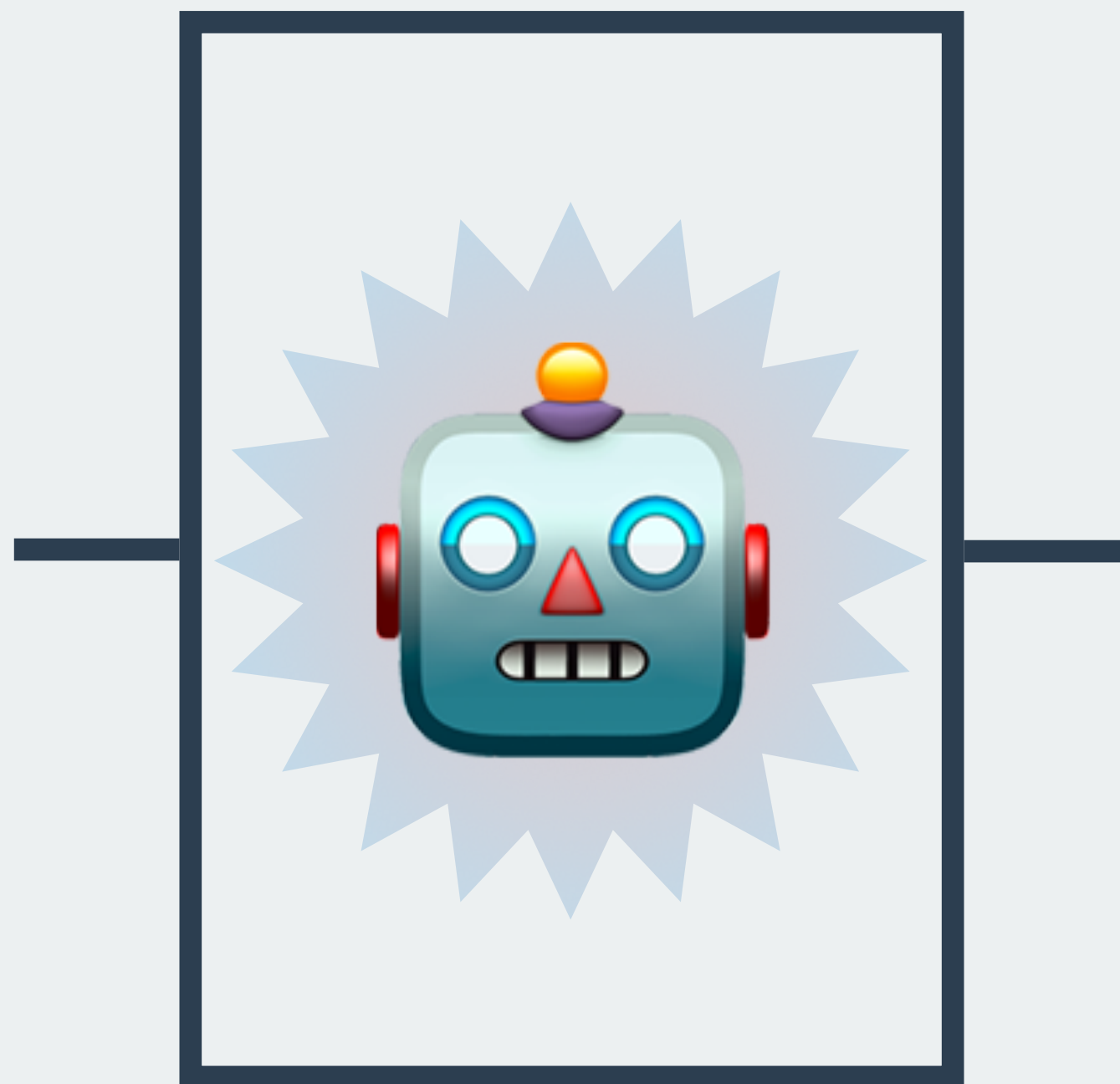


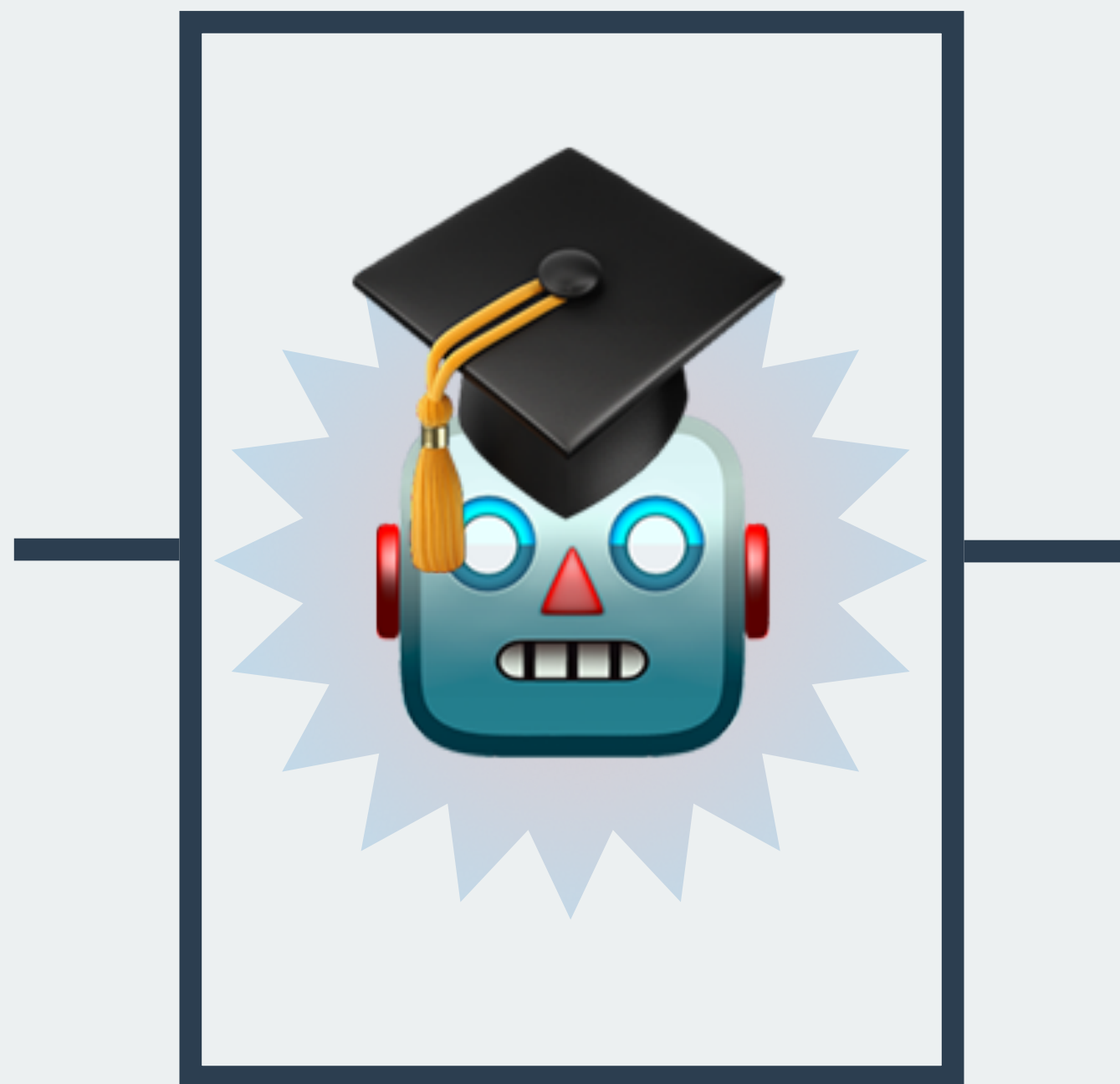


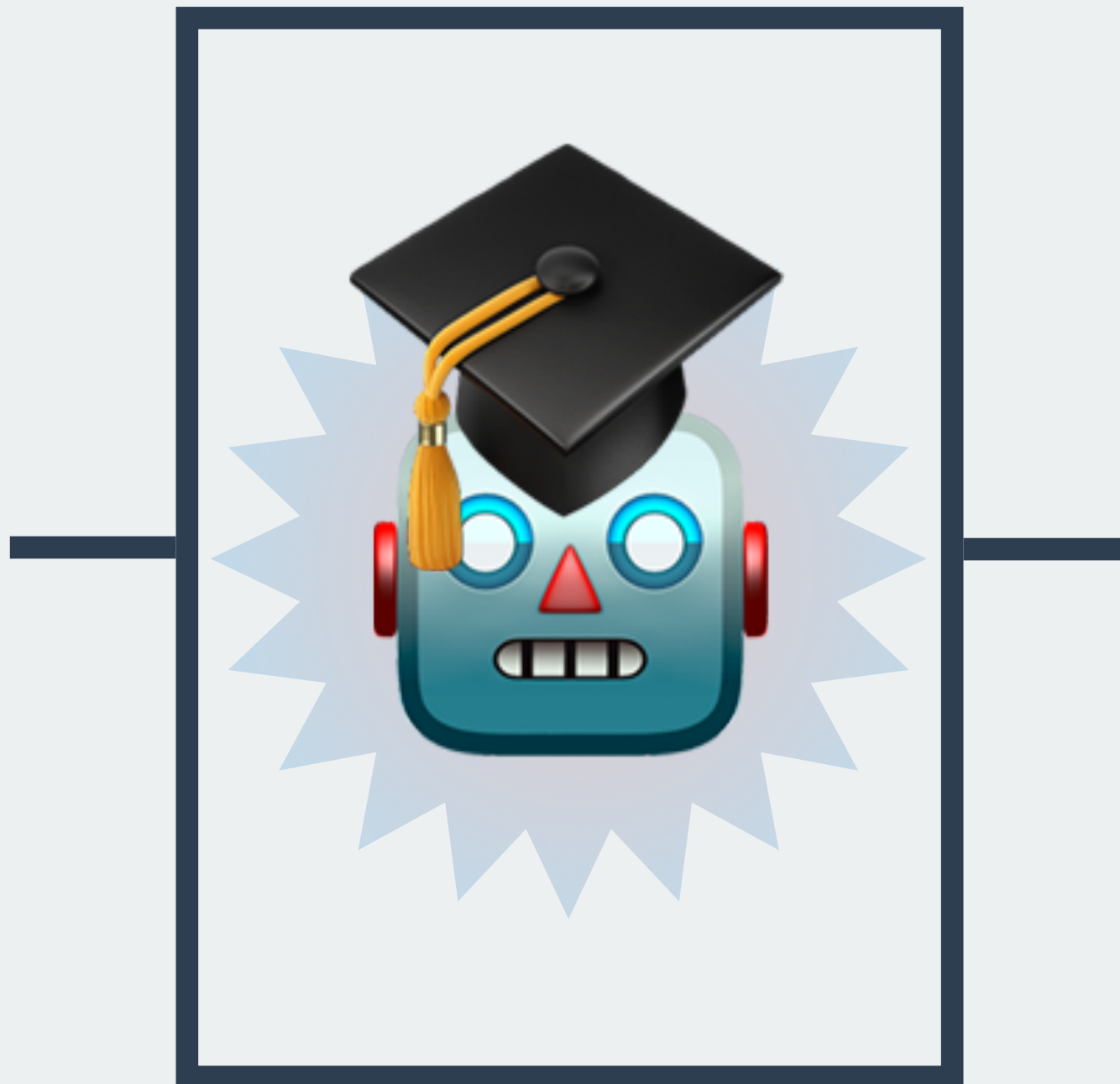
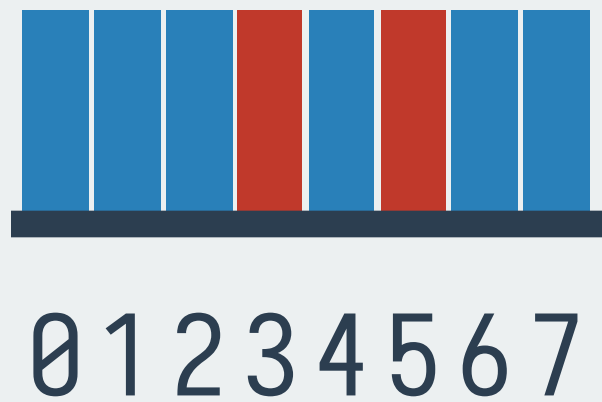


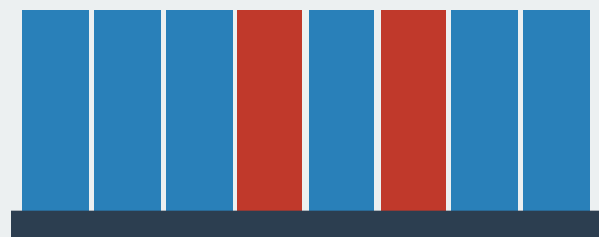




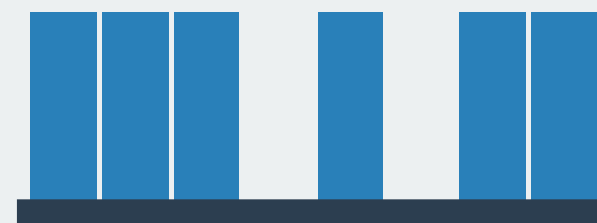
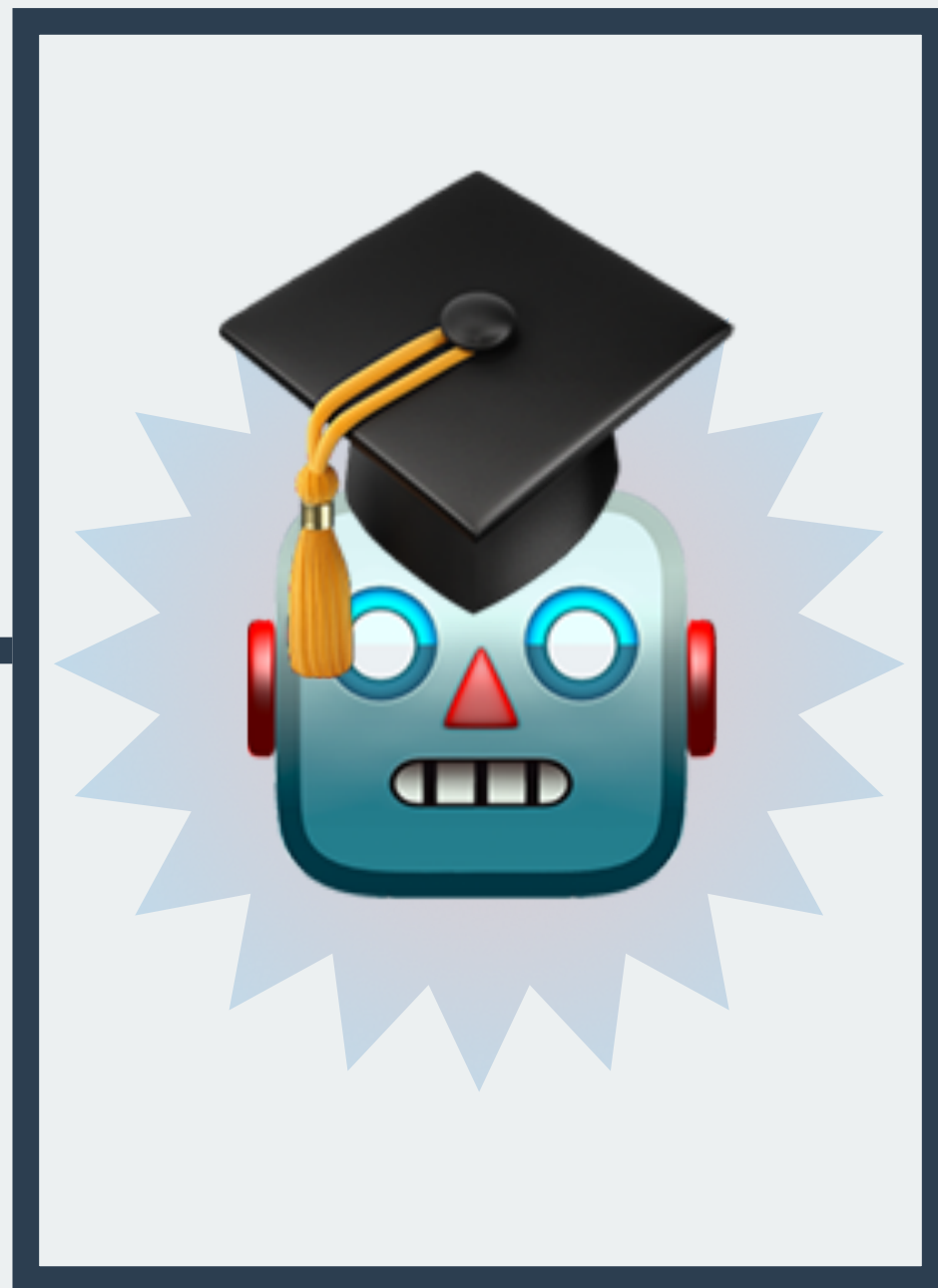




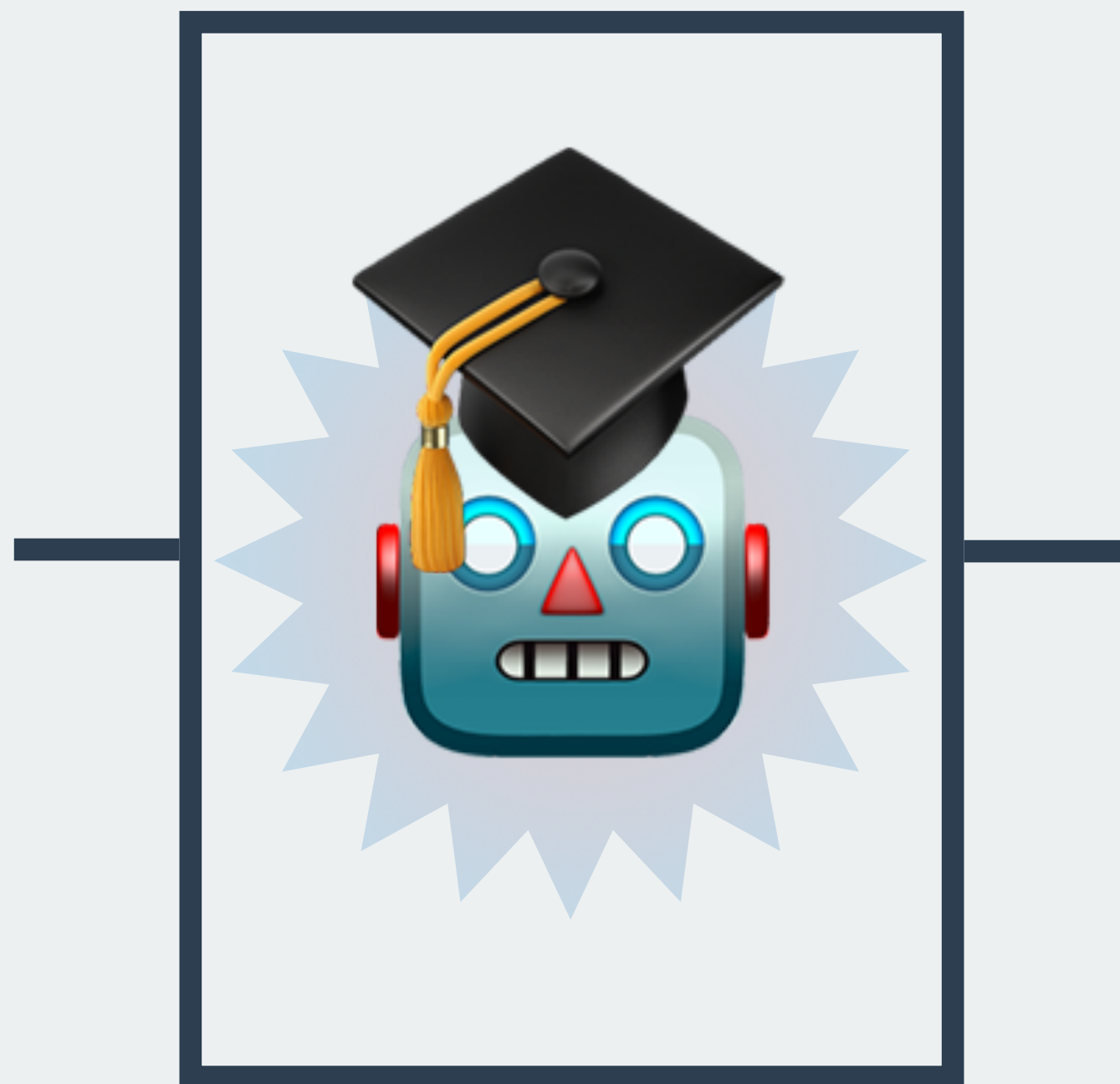


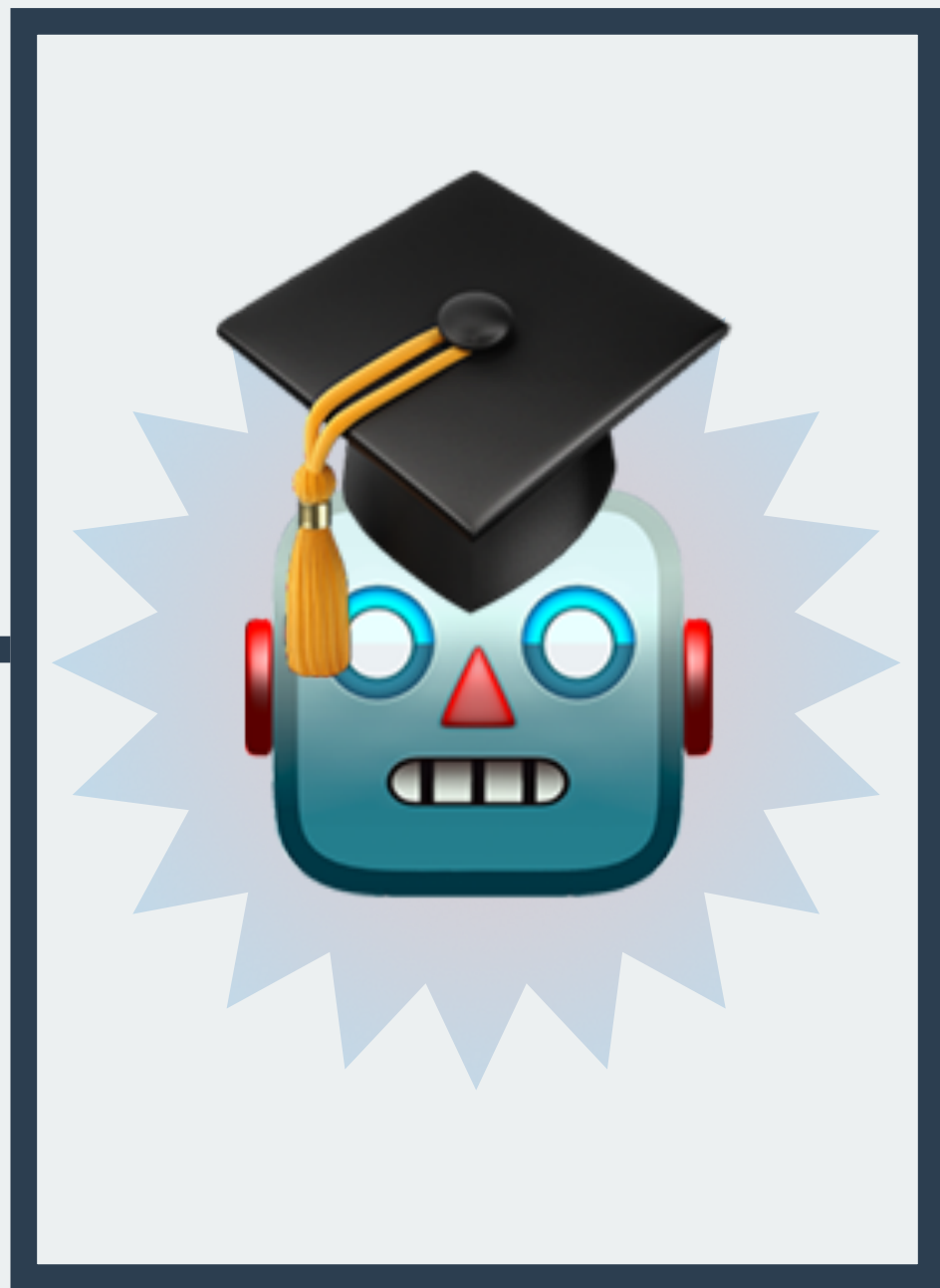
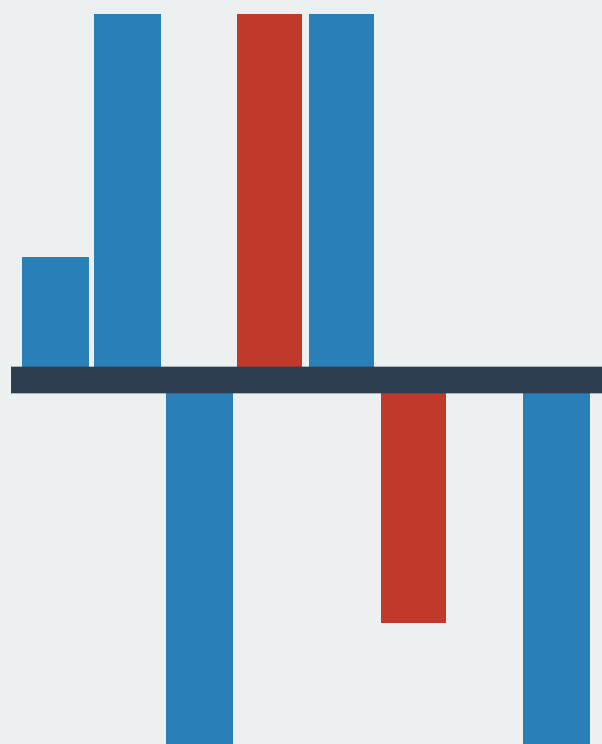


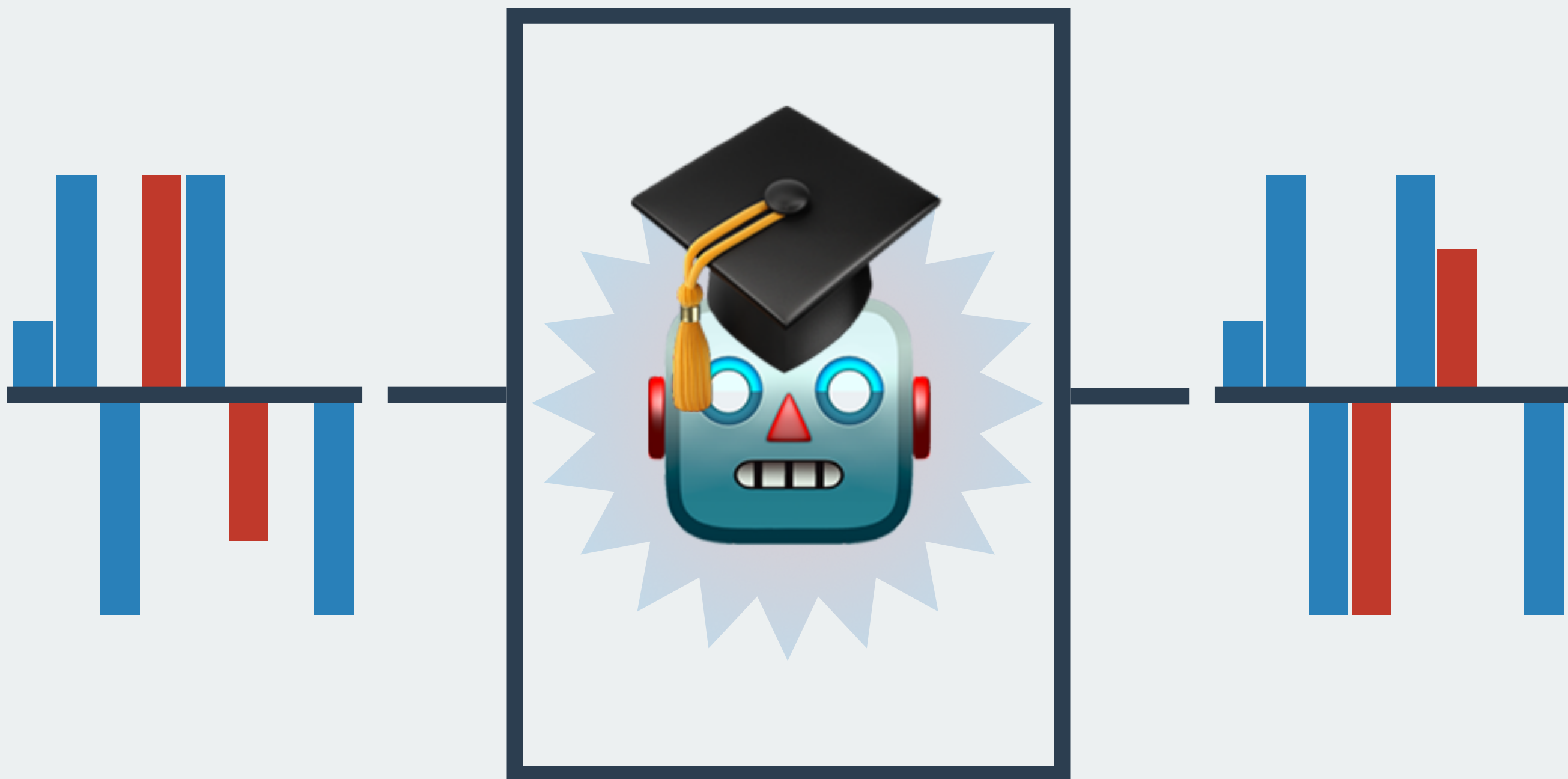
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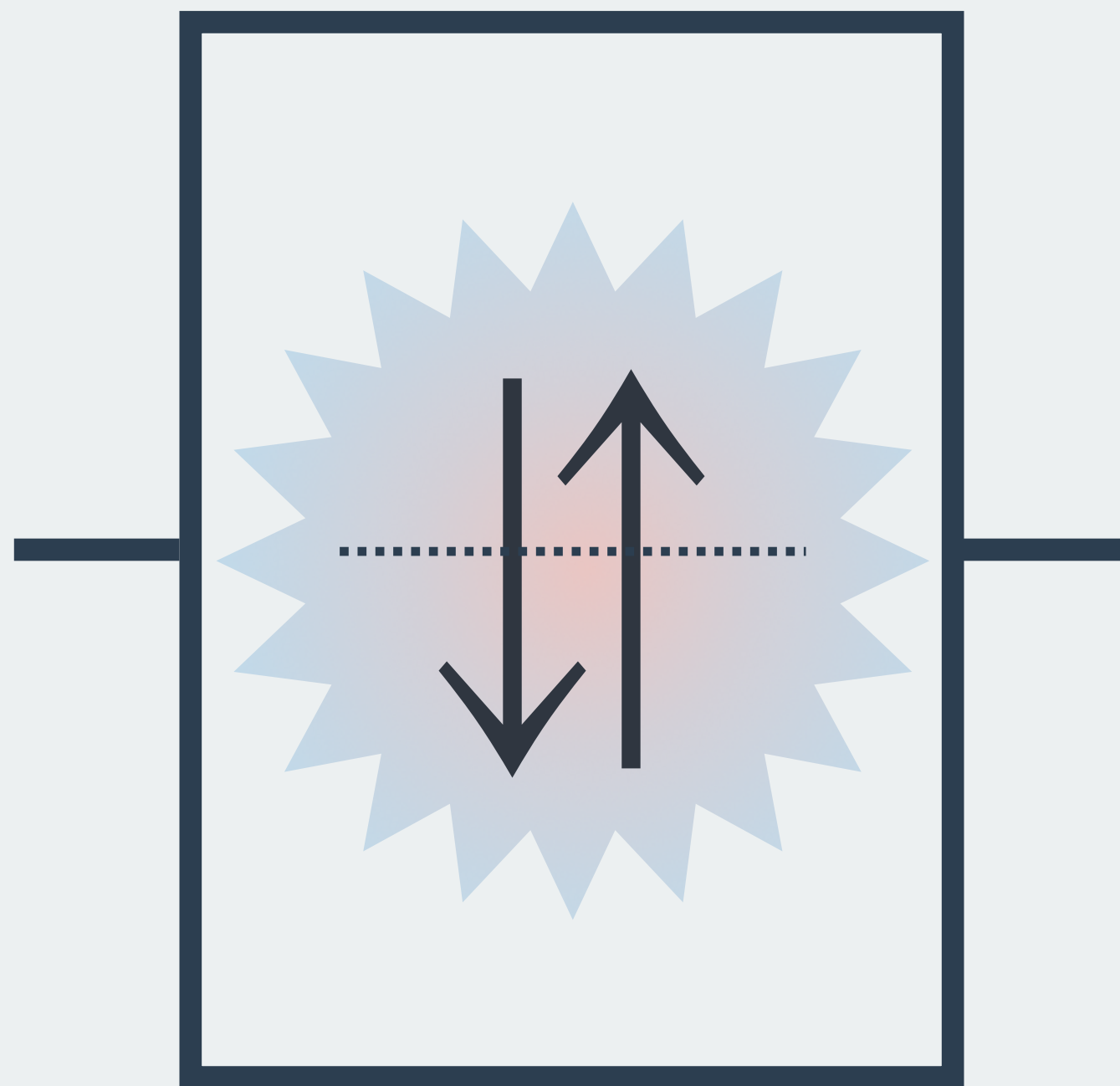


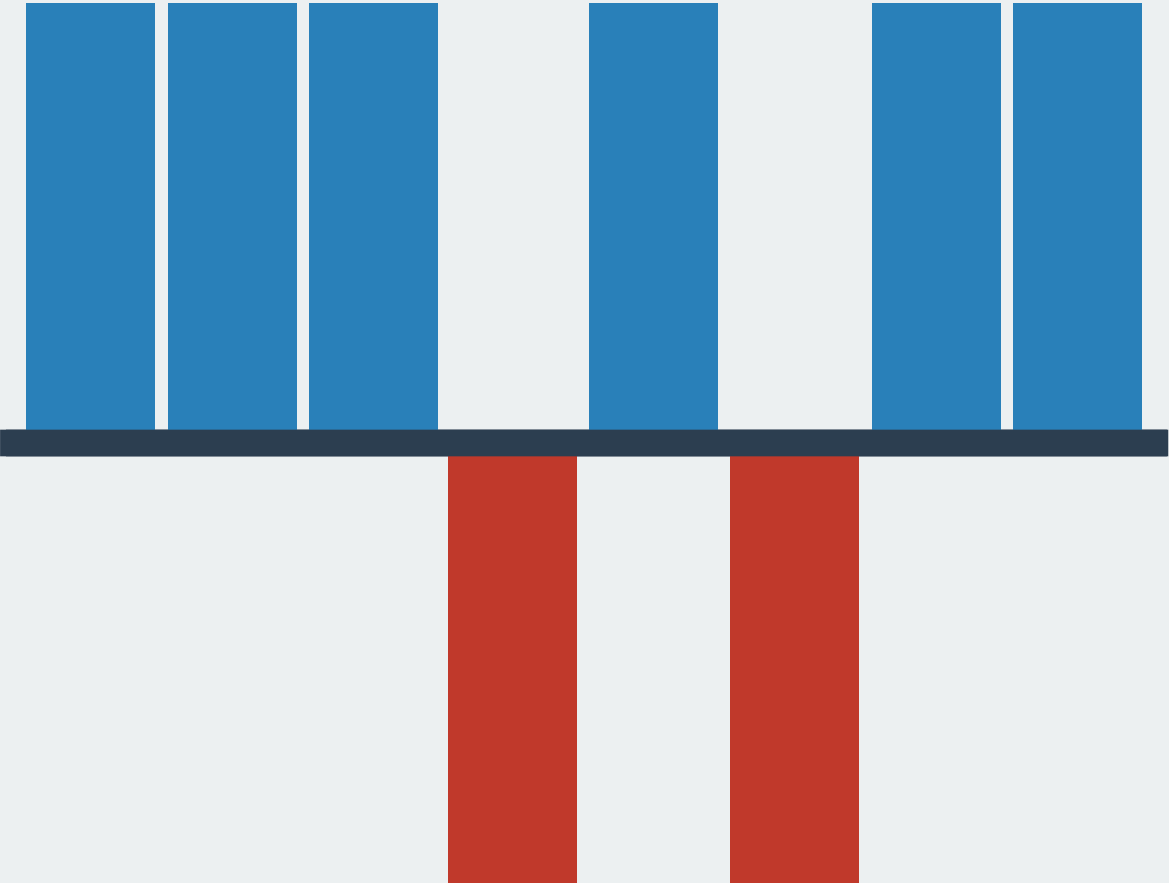
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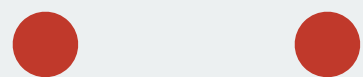
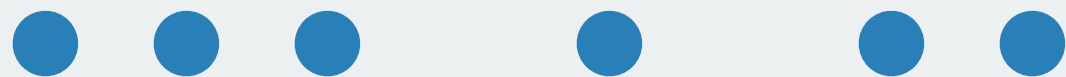


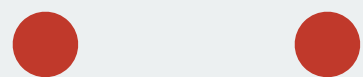
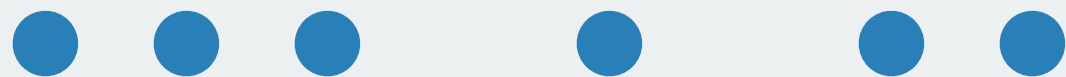


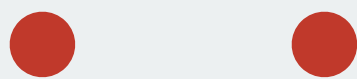
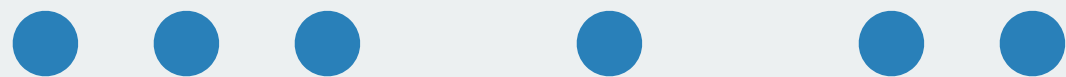


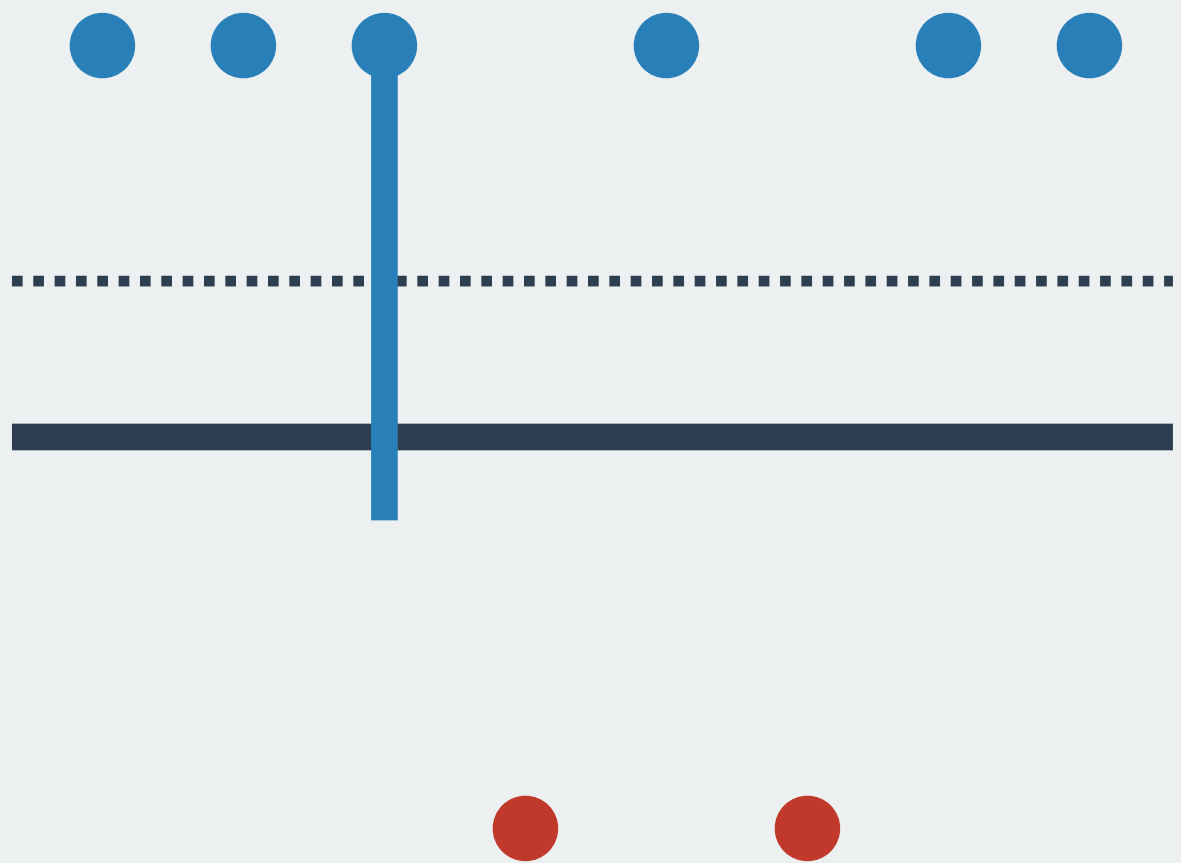


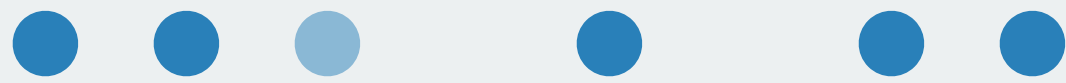


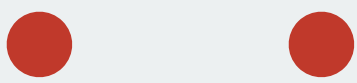
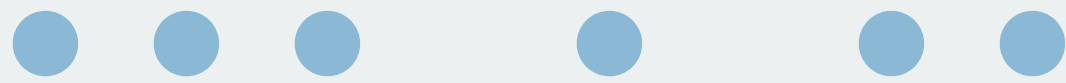


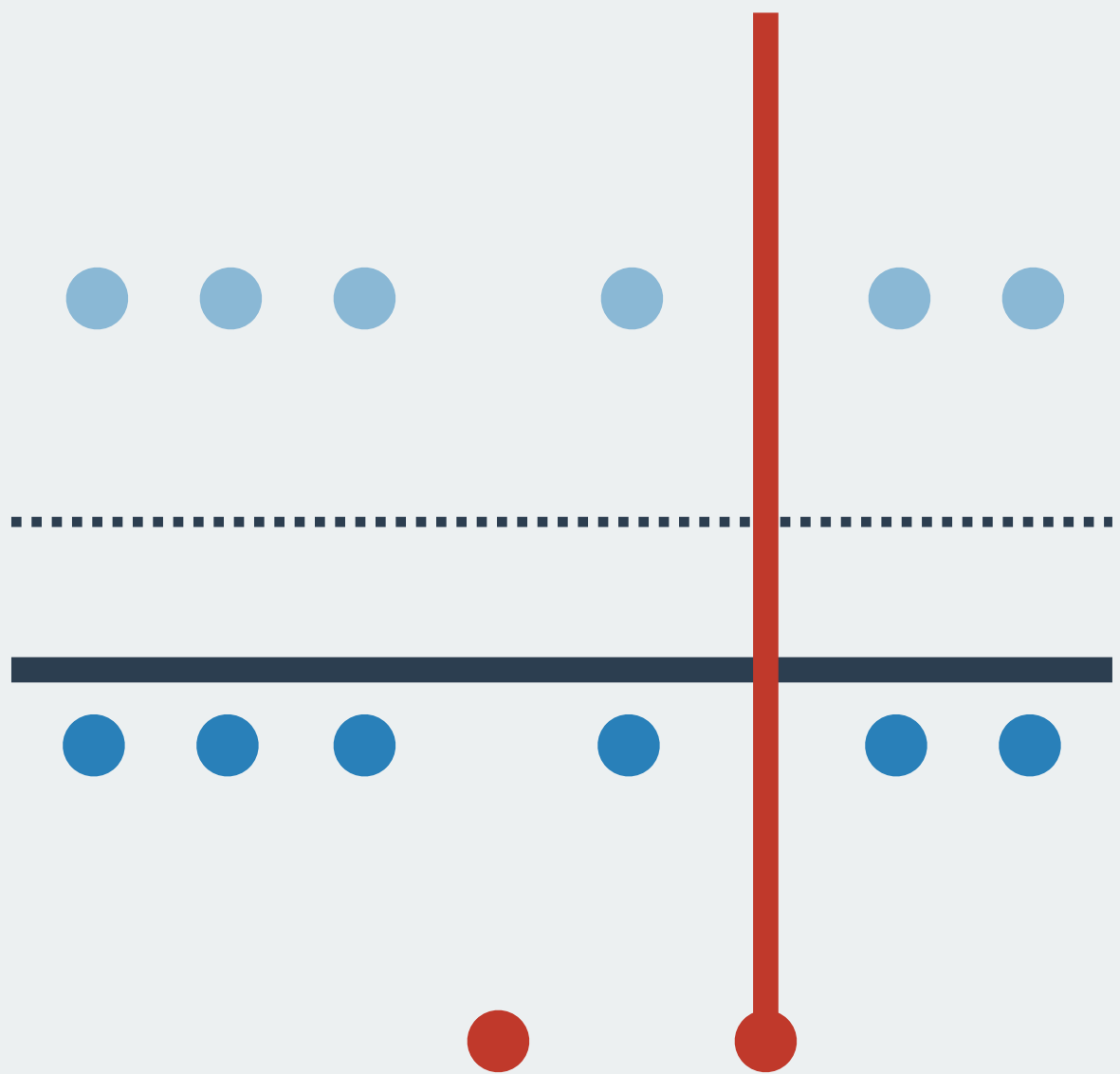


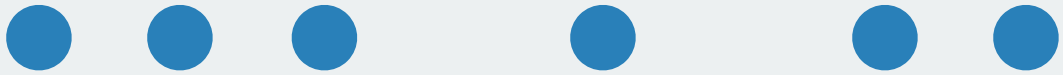
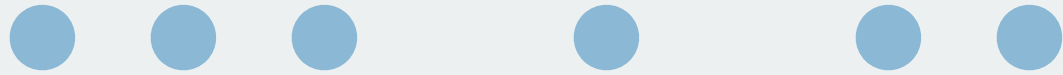


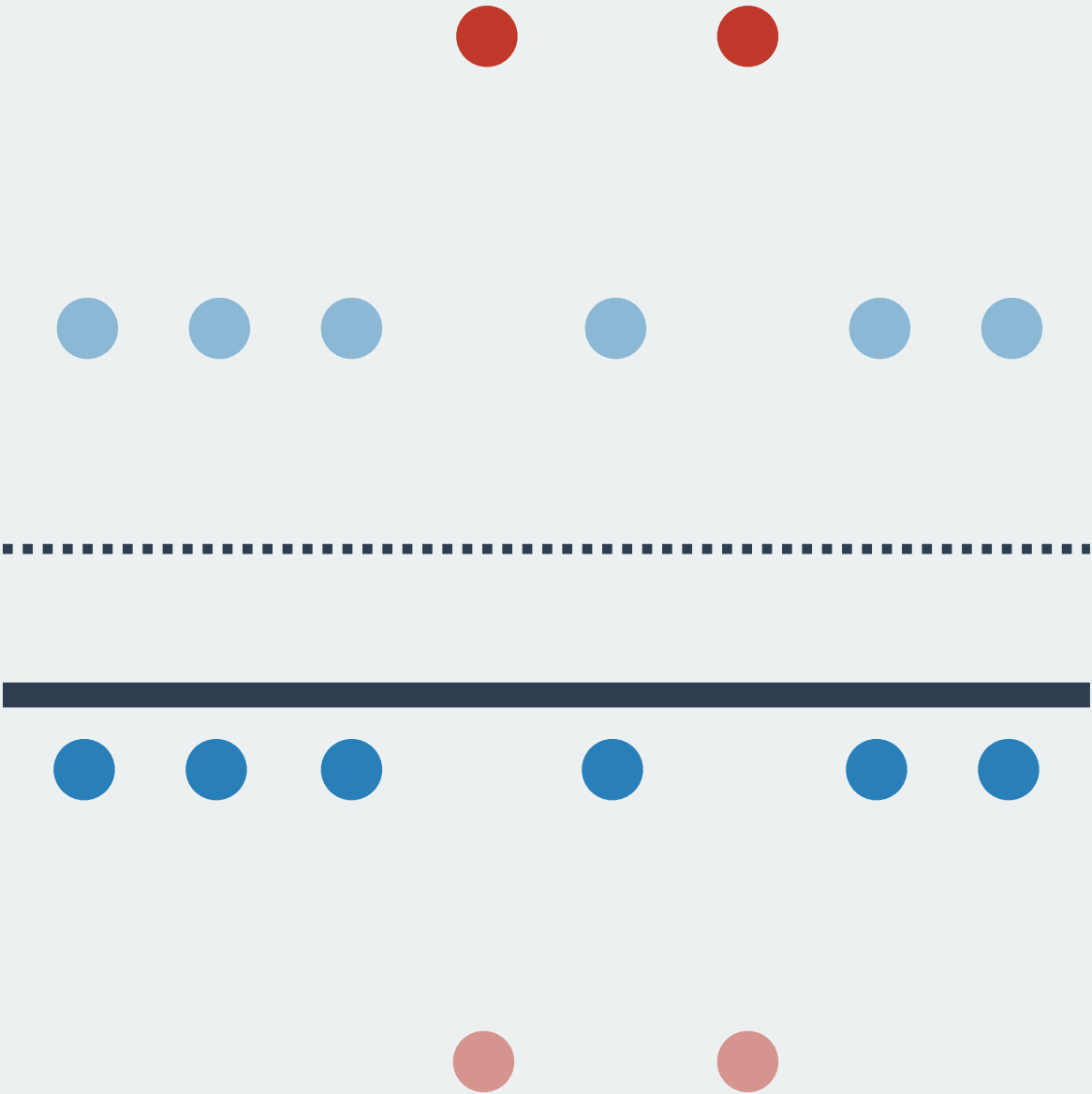


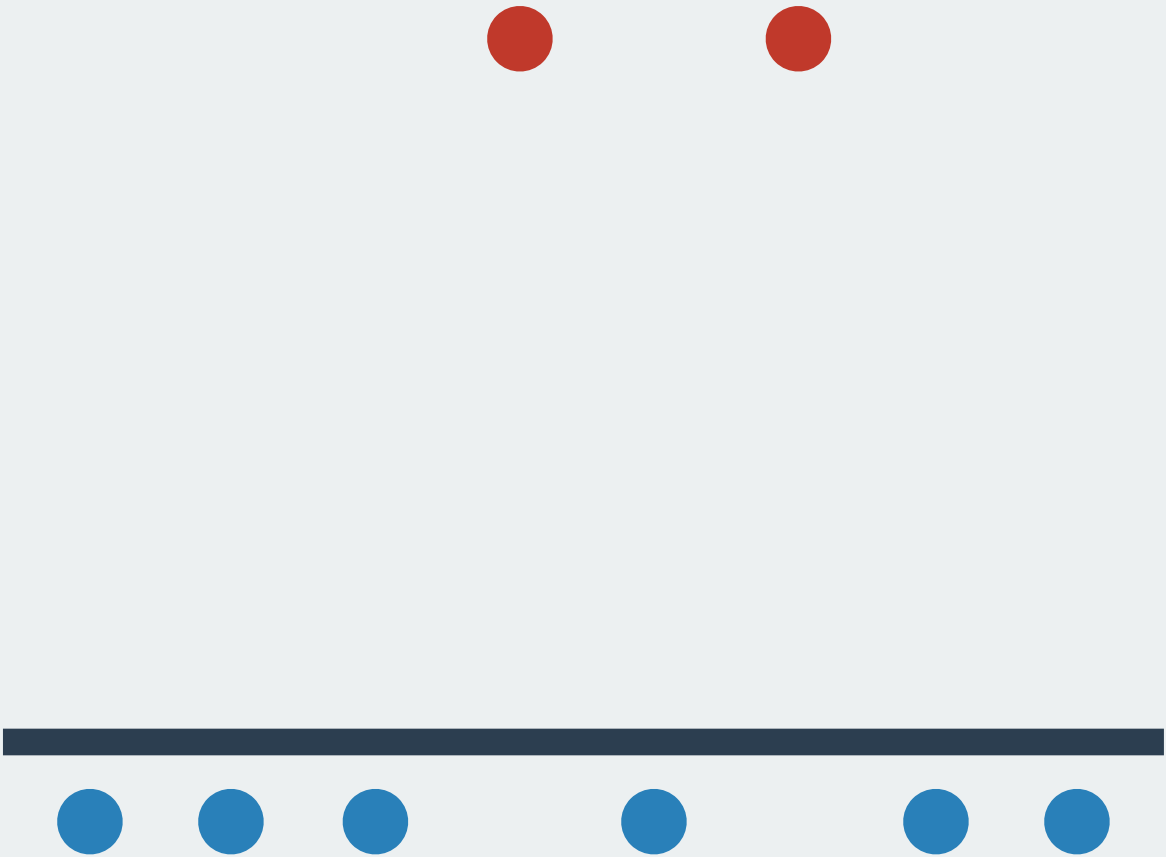


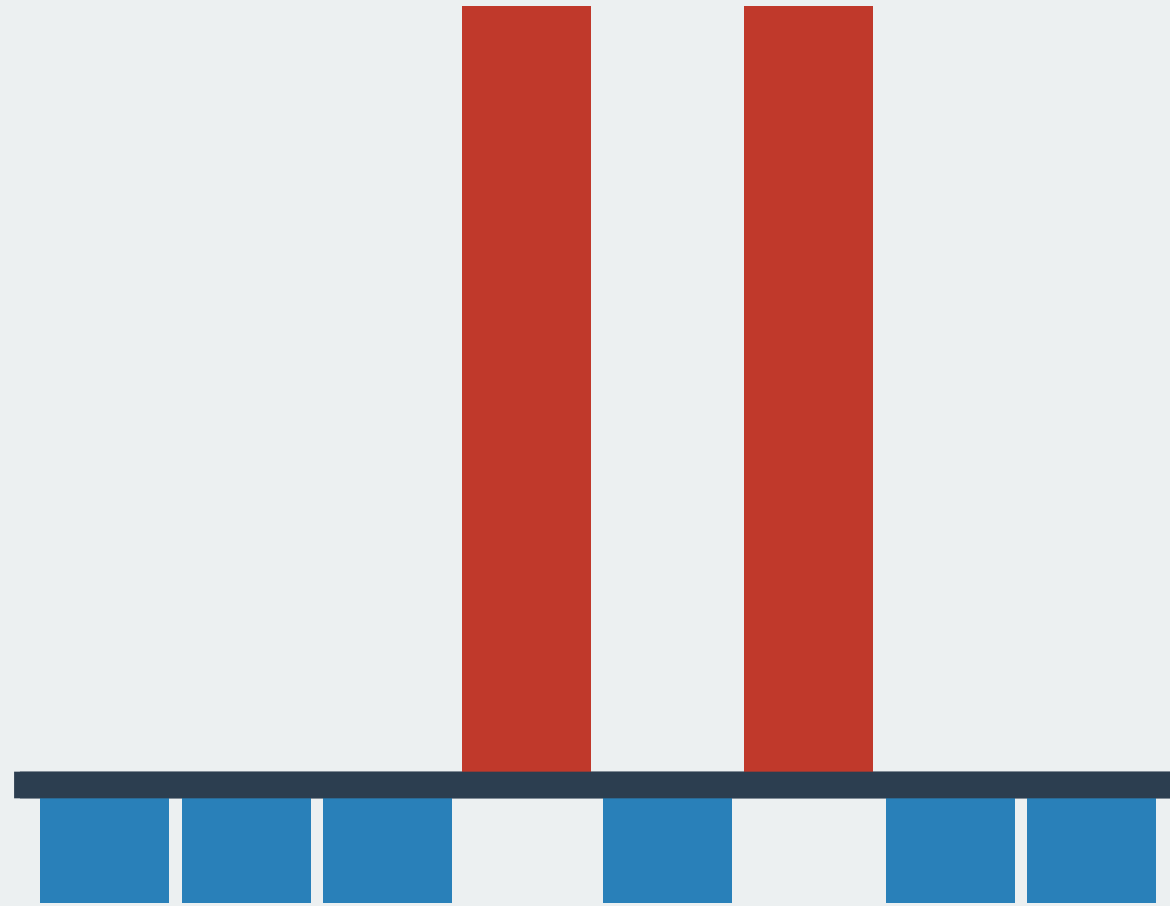


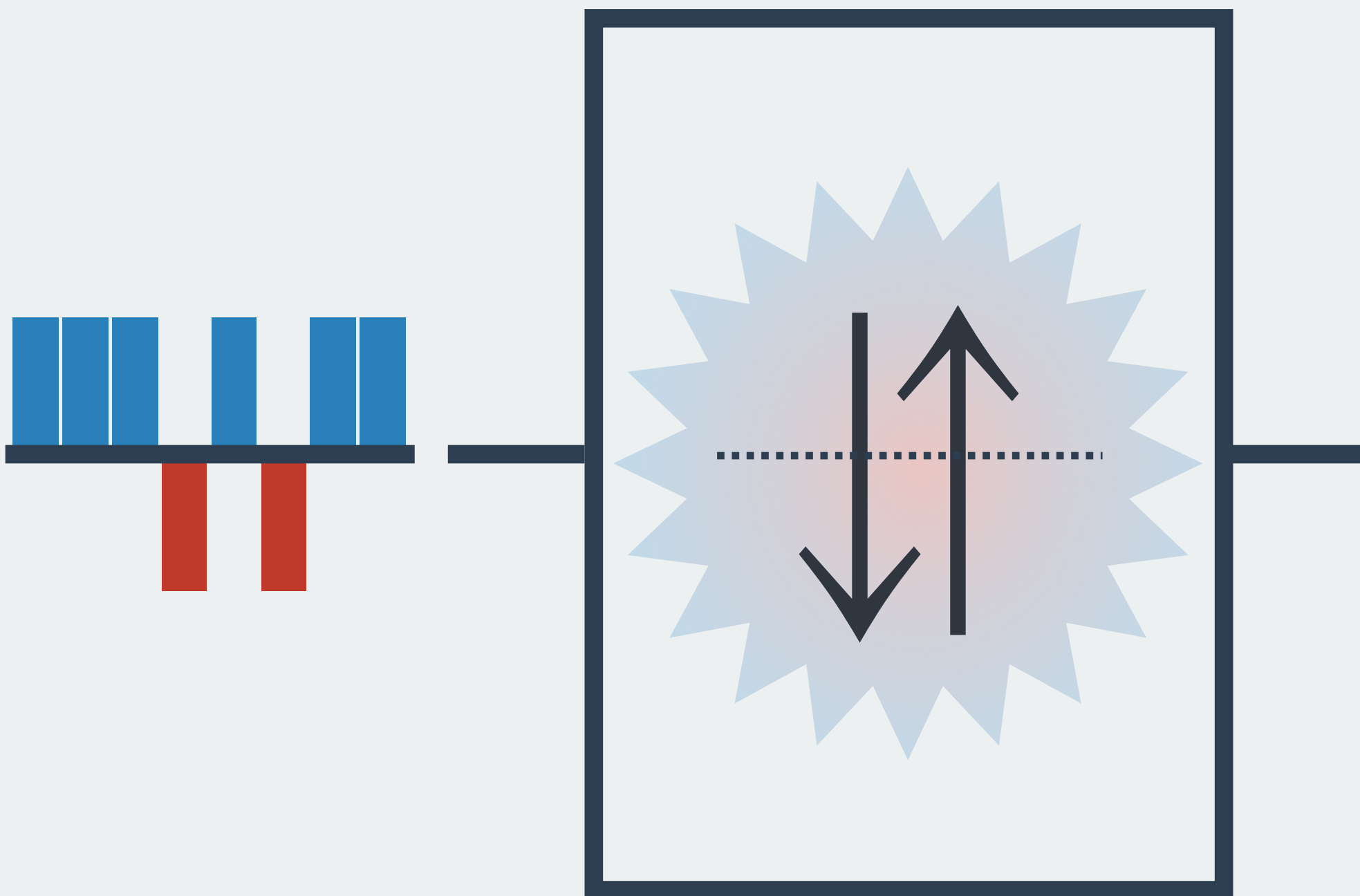


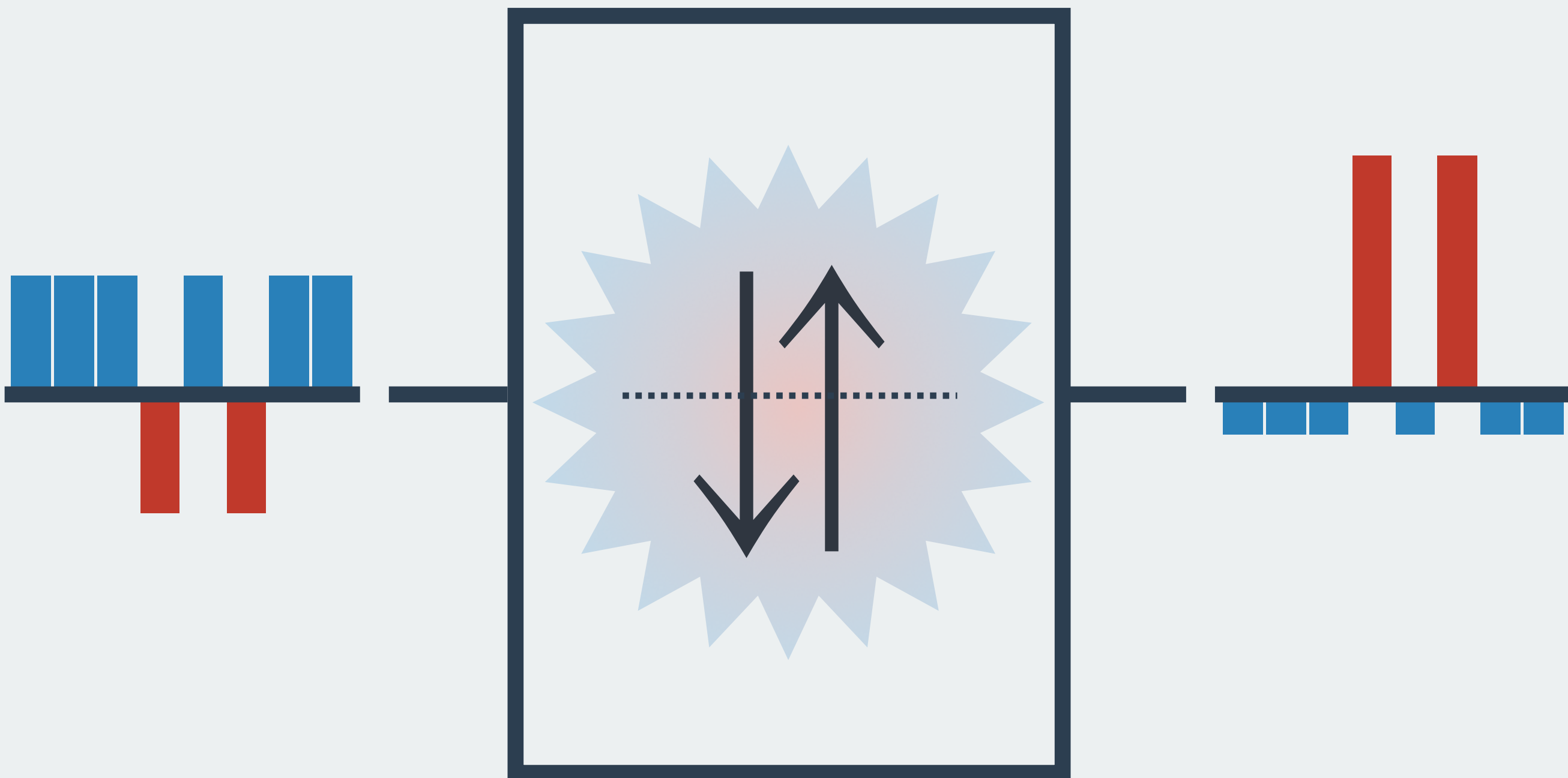


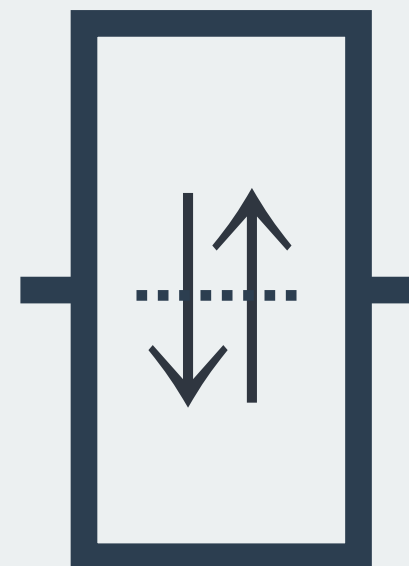
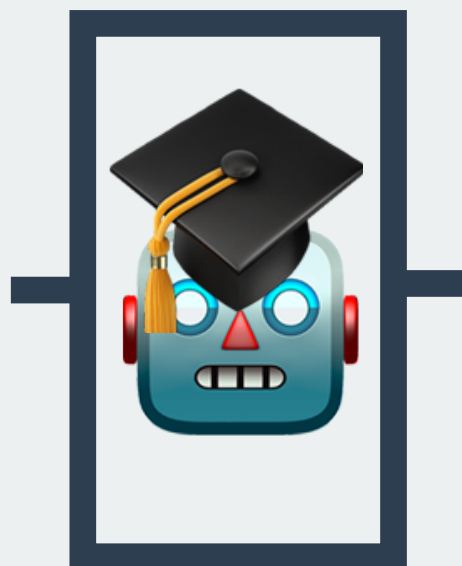


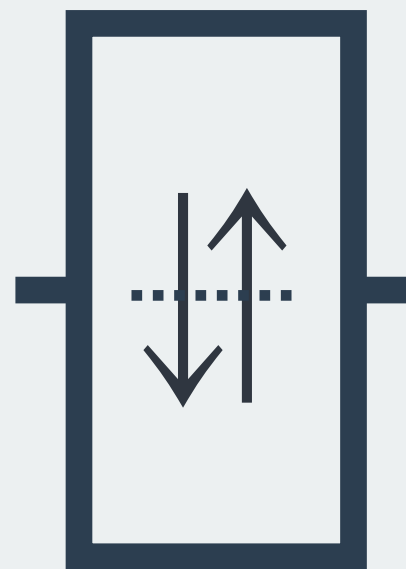
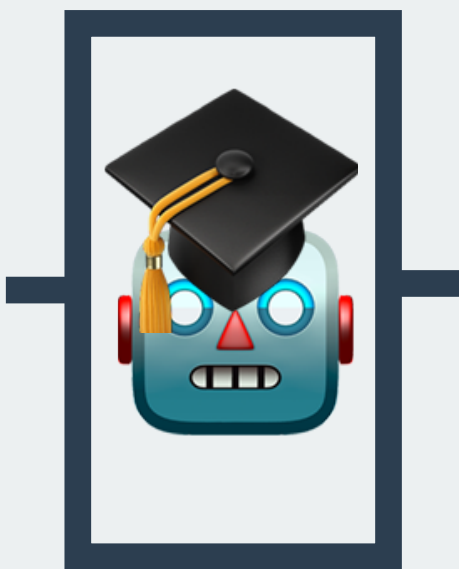
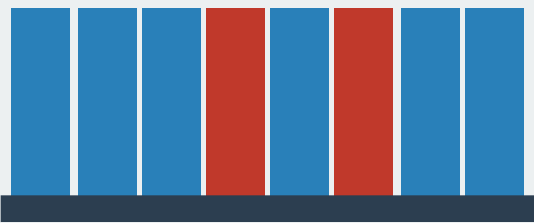


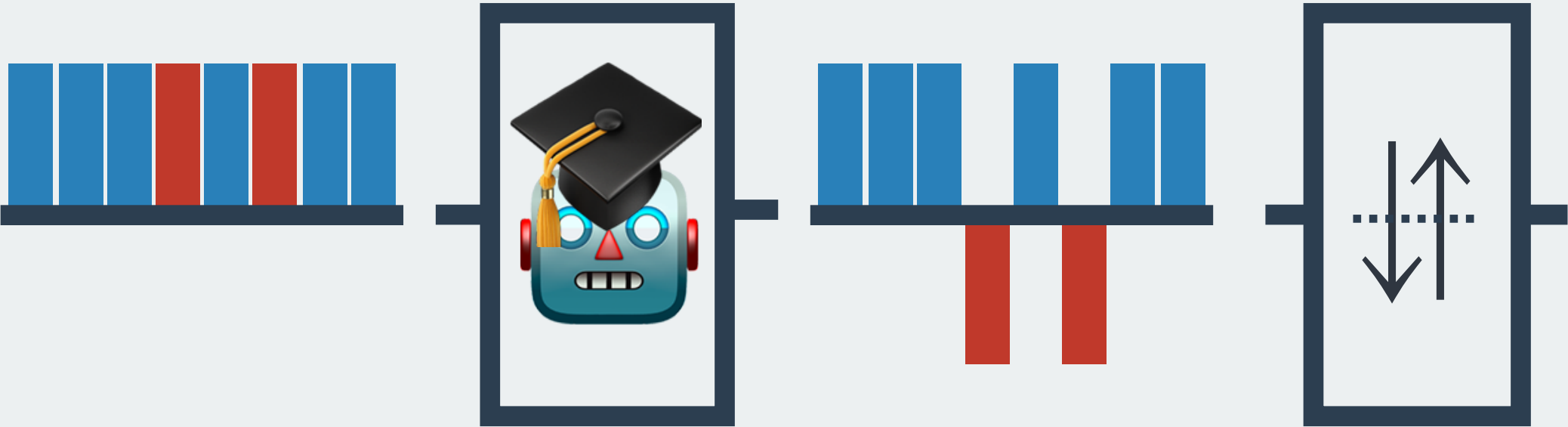


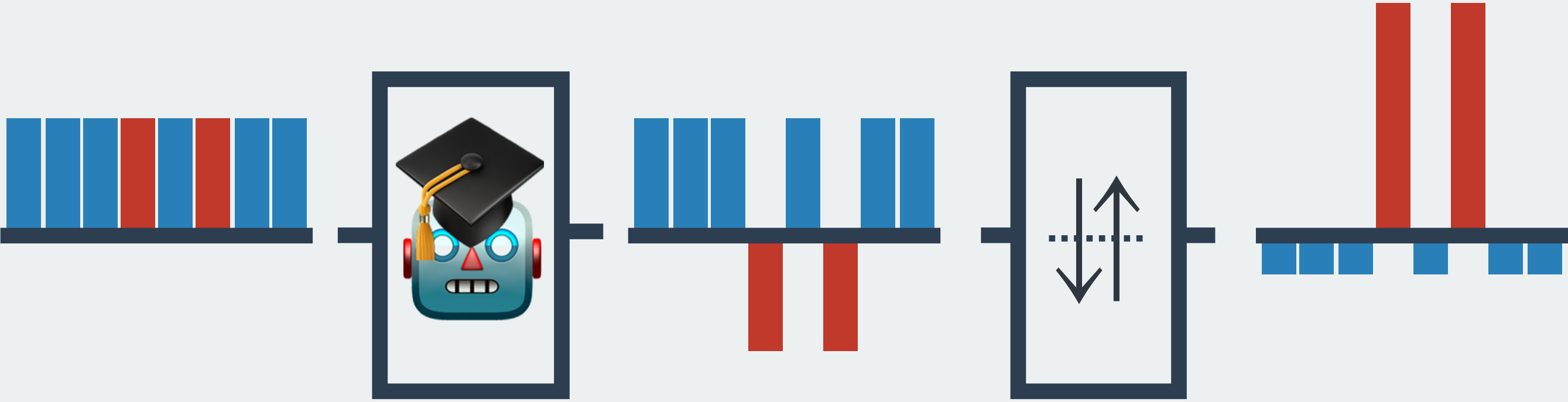


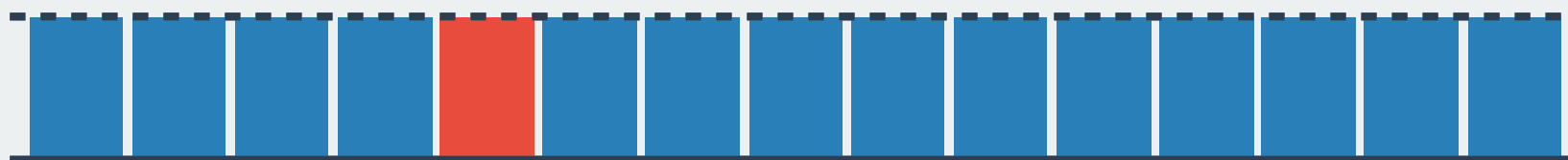


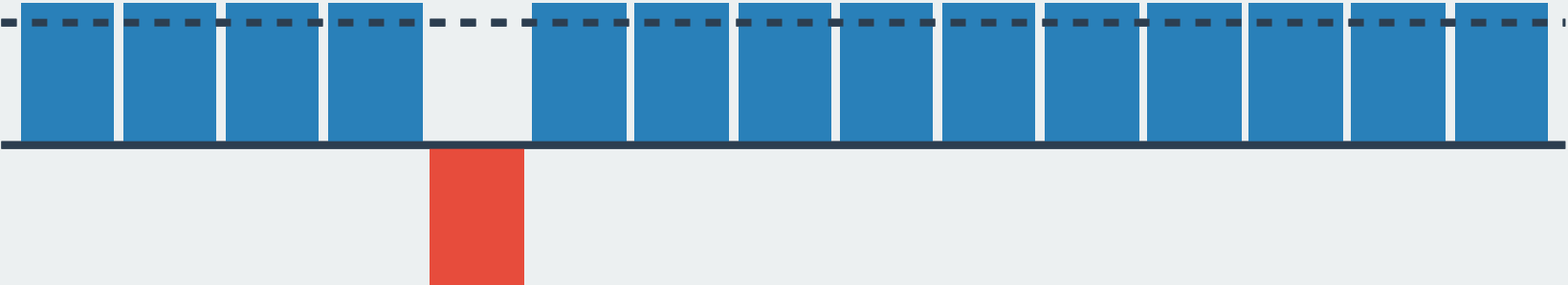


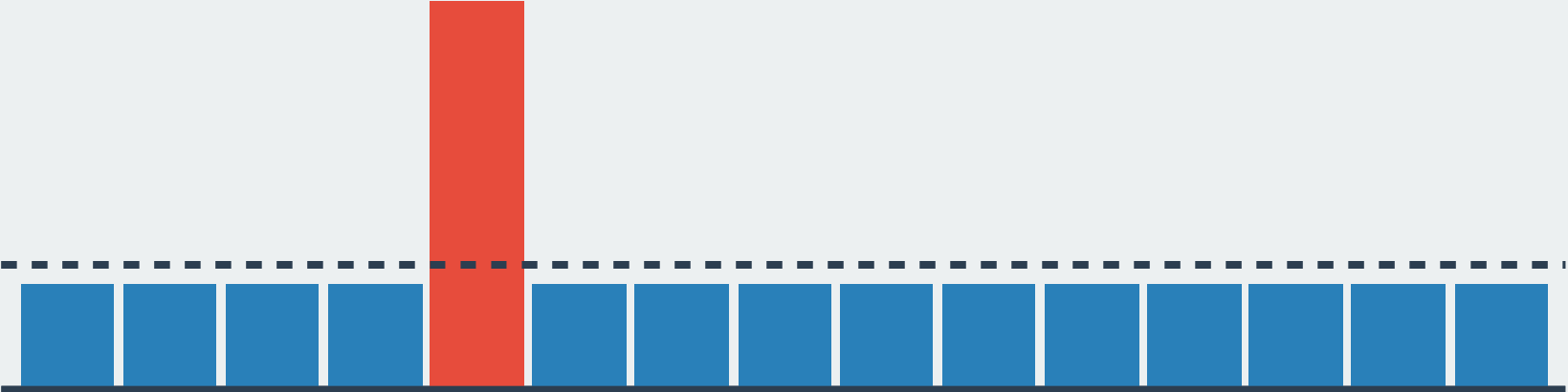


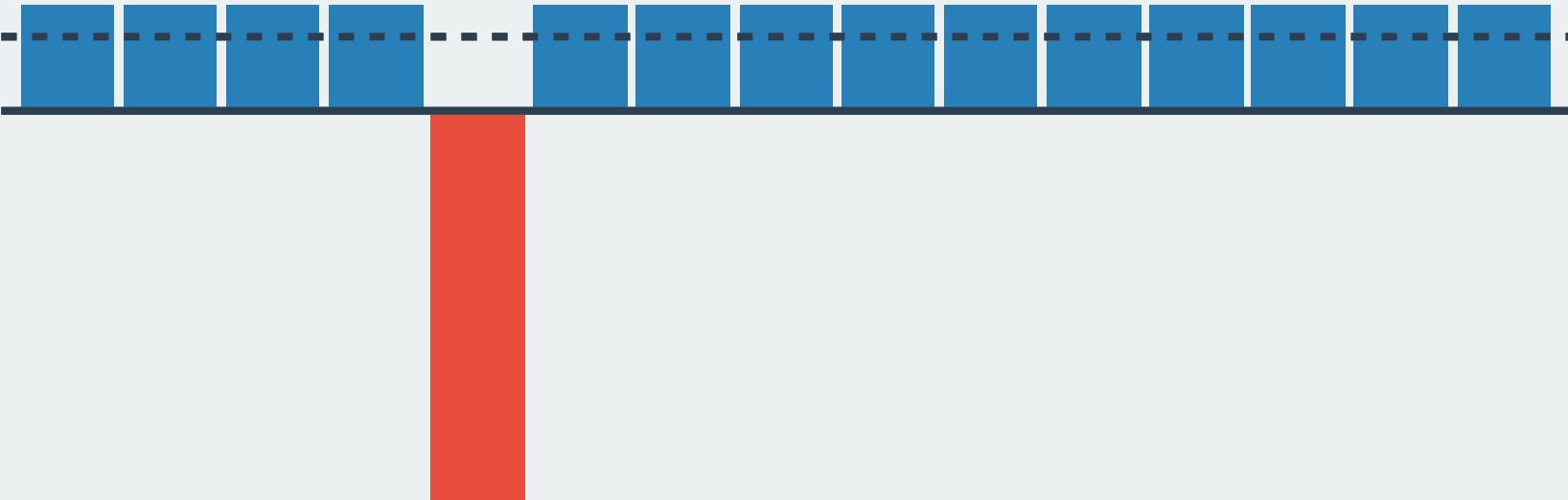


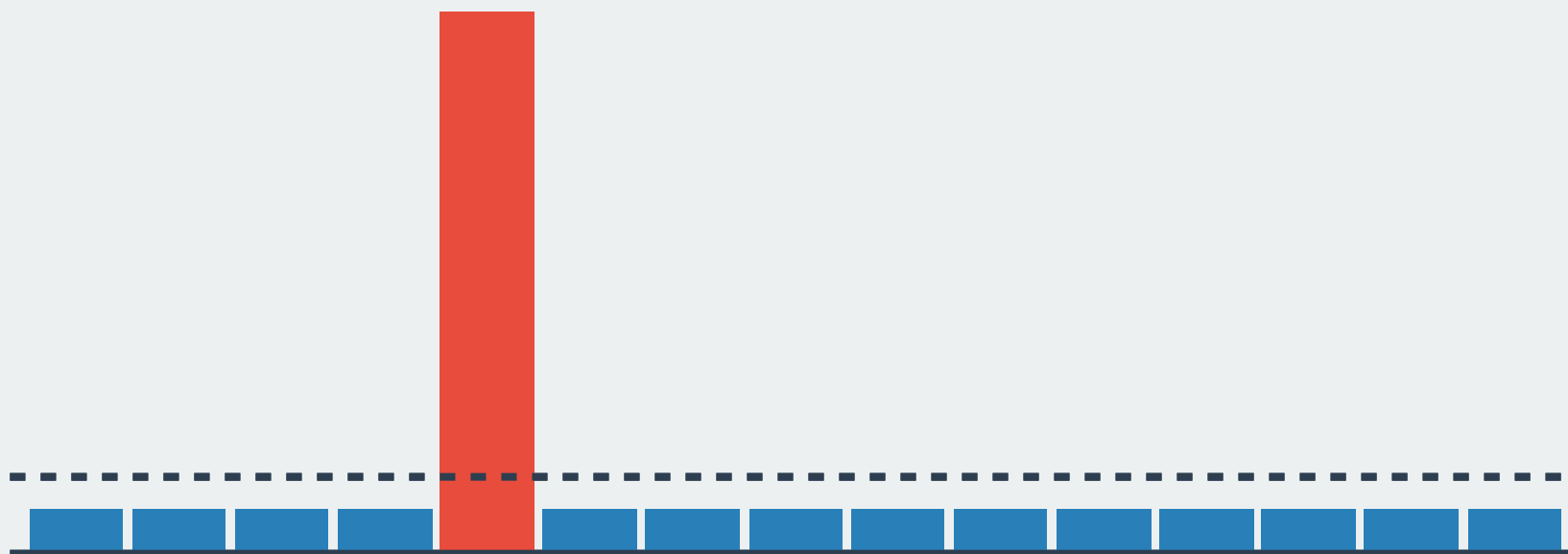


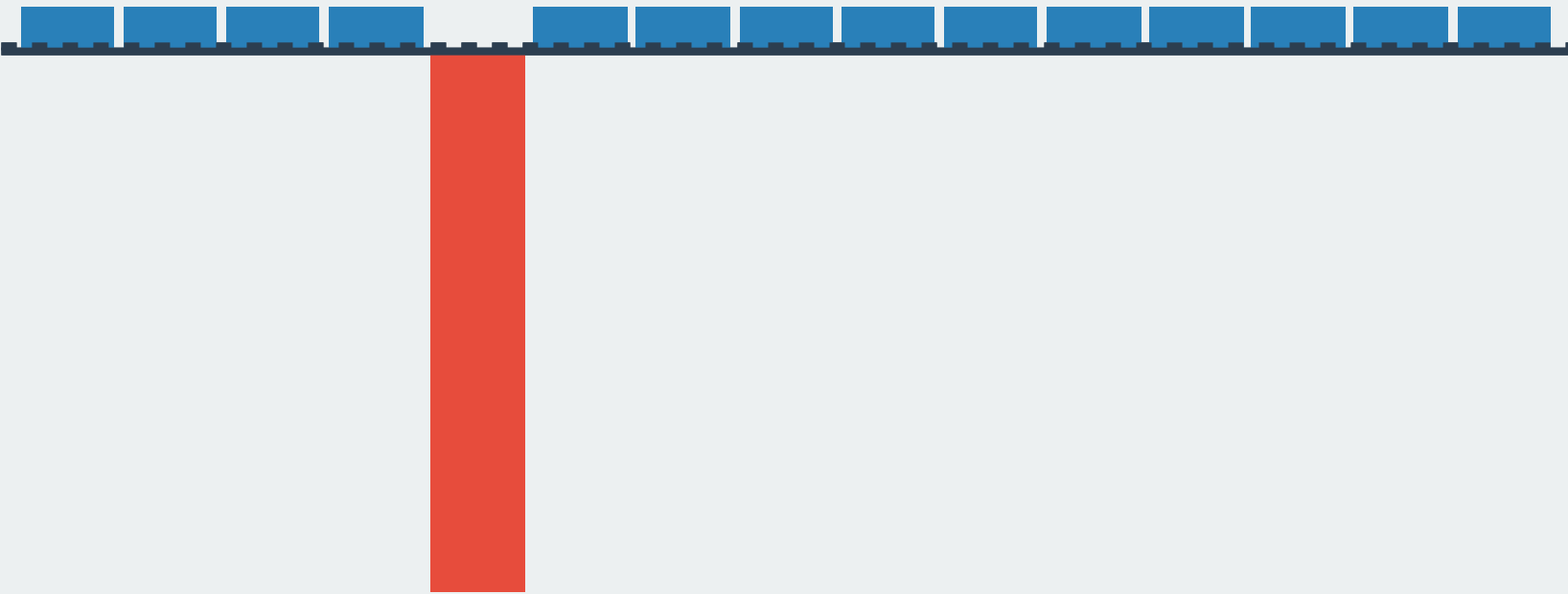


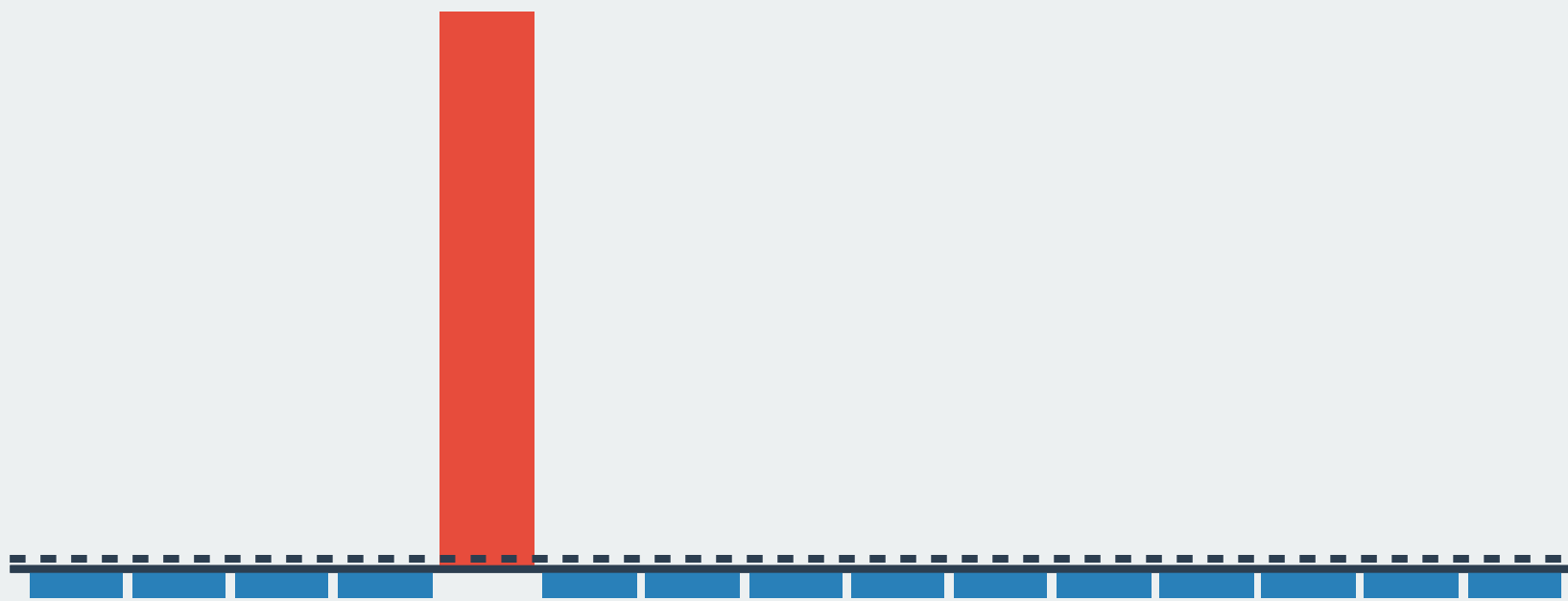


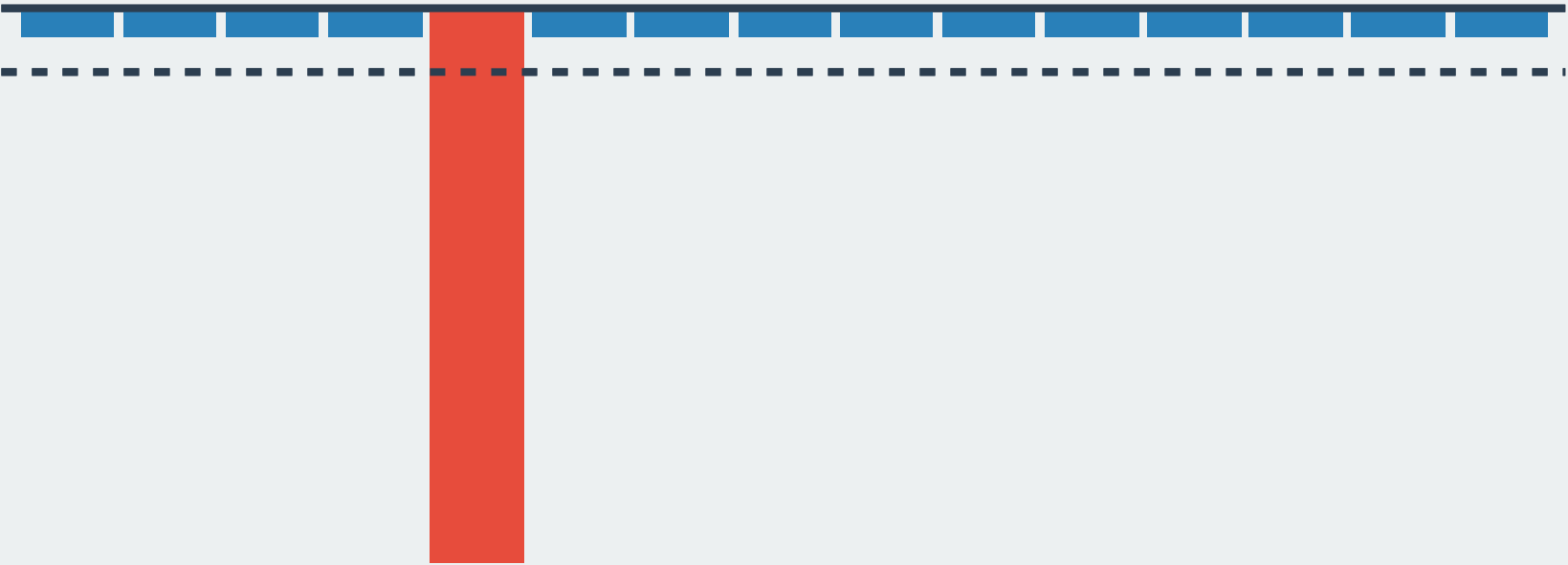


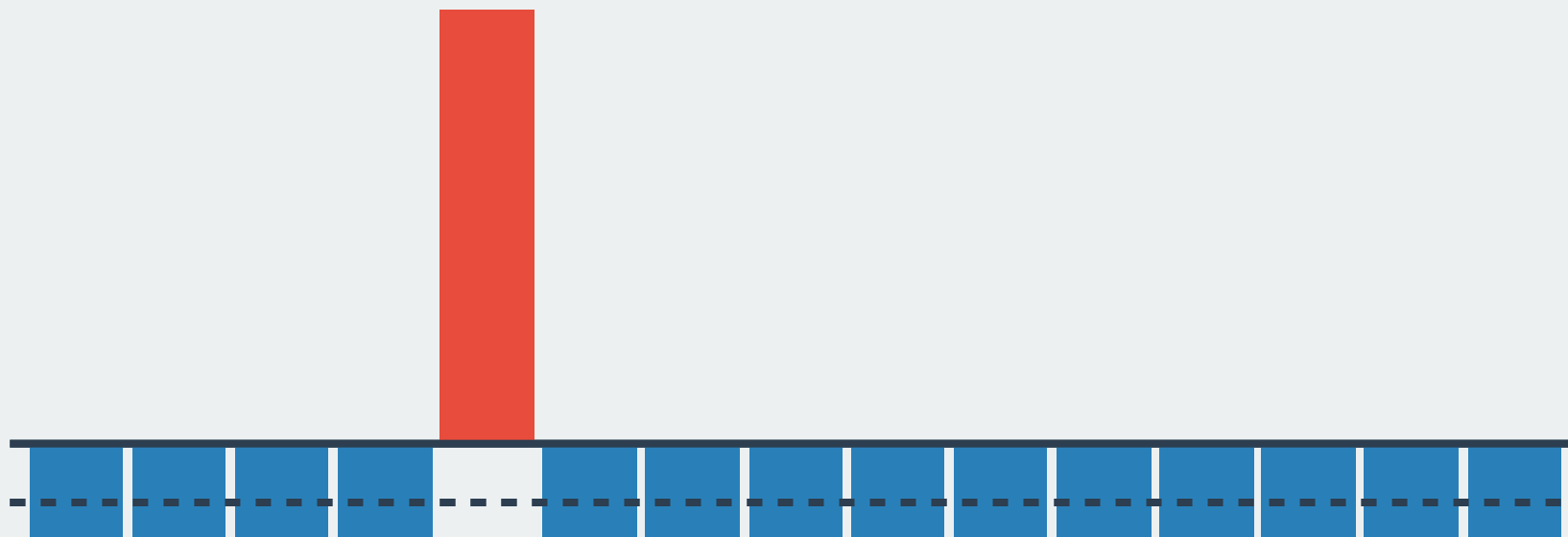


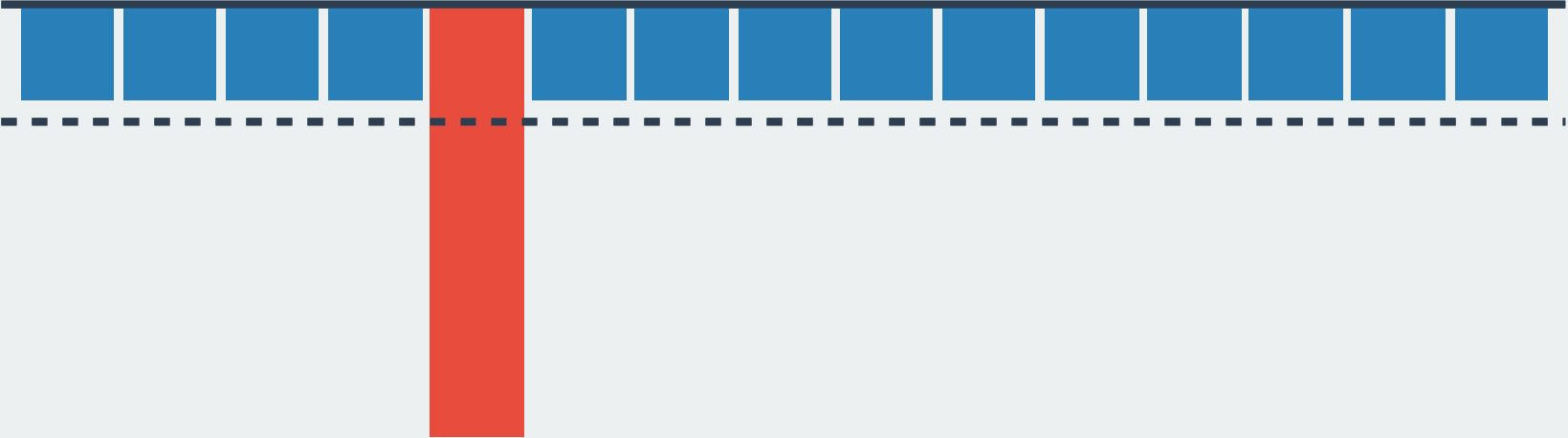


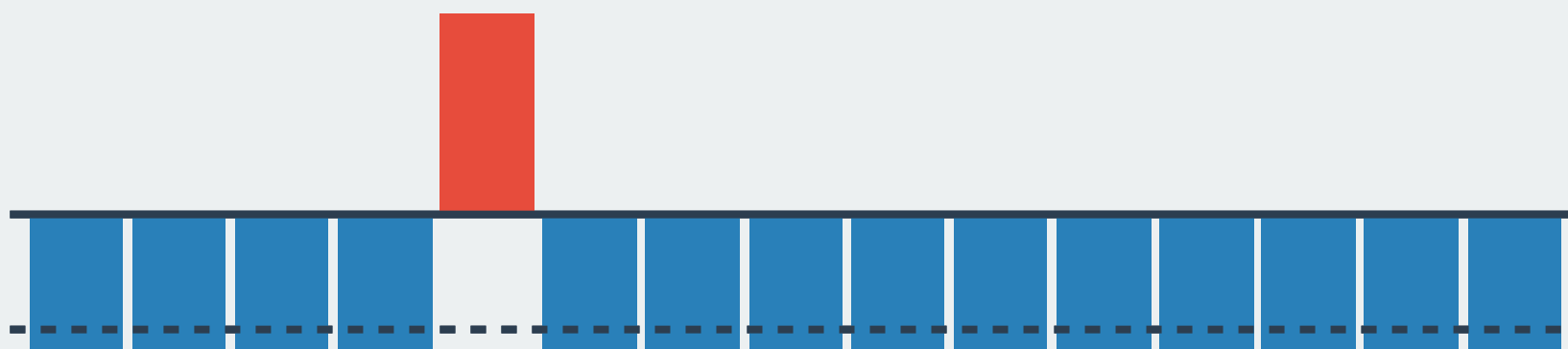




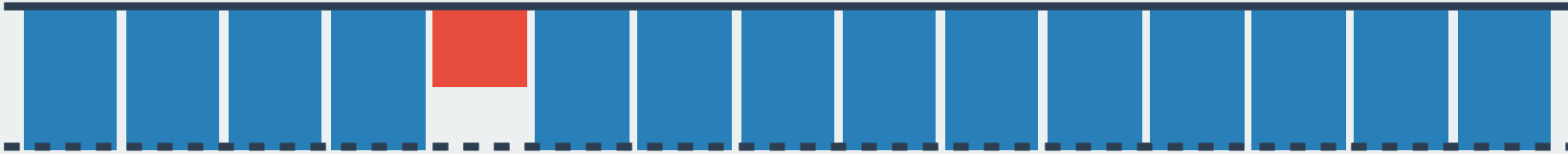












$$\approx \frac{\pi}{4} \sqrt{N}$$



naive search

Grover's algorithm

naive search

Grover's algorithm

N

naive search

Grover's algorithm

$$N$$

$$\approx \frac{\pi}{4} \sqrt{N}$$

naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	

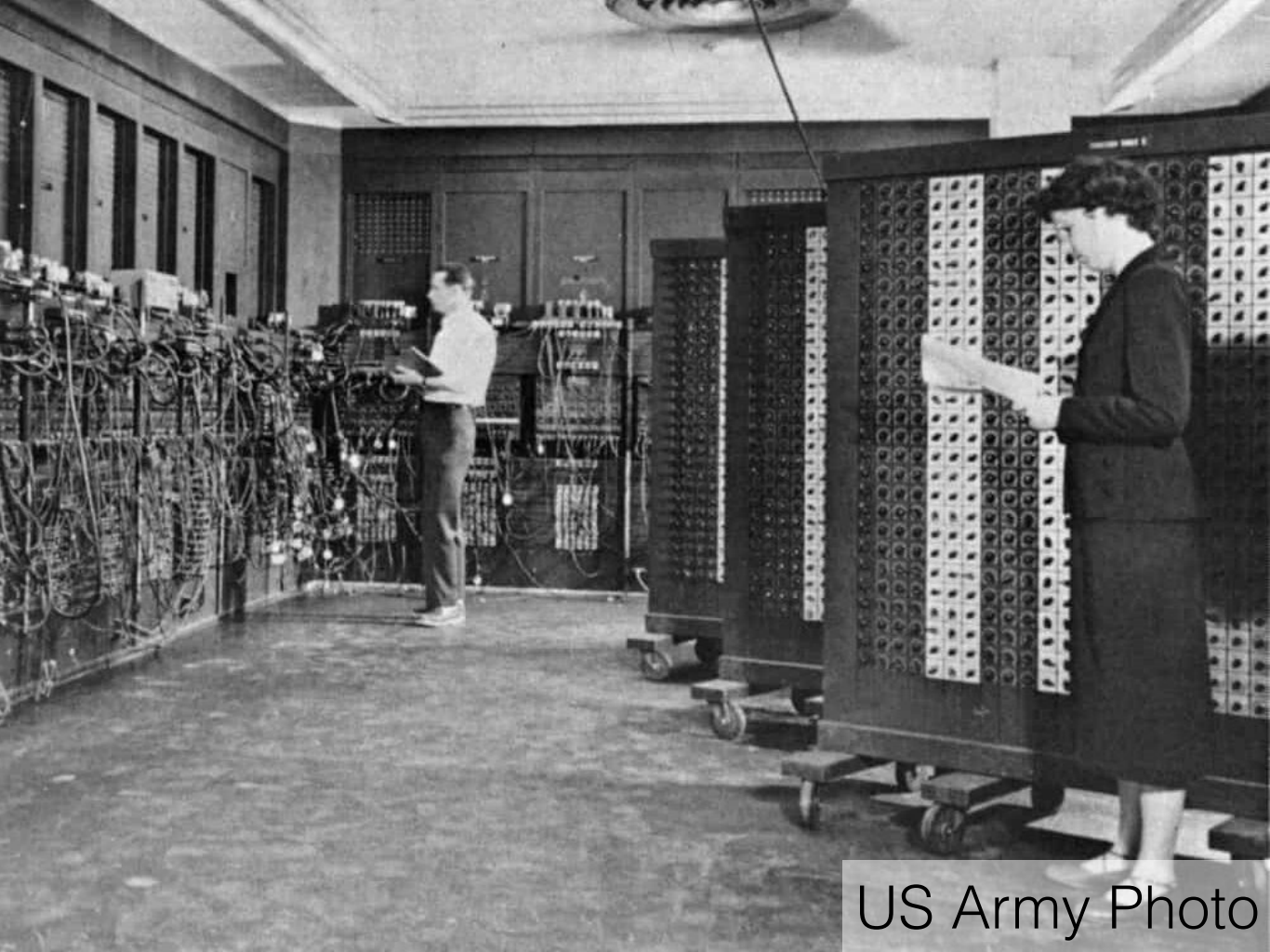
naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	785

naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	785
1 000 000 000 000	

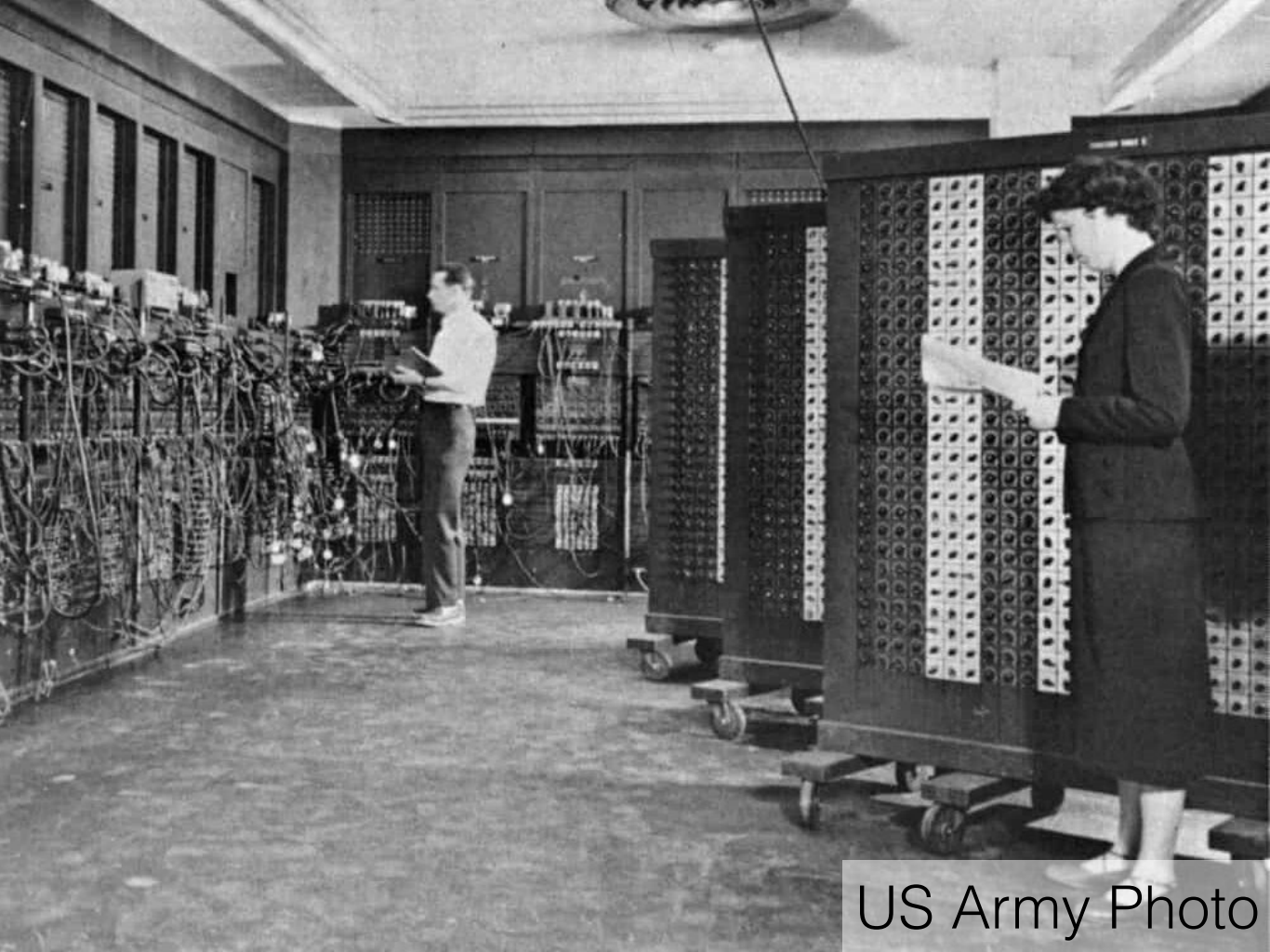
naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	785
1 000 000 000 000	785 000

naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	785
1 000 000 000 000	785 000
12 days	

naive search	Grover's algorithm
N	$\approx \frac{\pi}{4} \sqrt{N}$
1 000 000	785
1 000 000 000 000	785 000
12 days	1 second



US Army Photo



US Army Photo

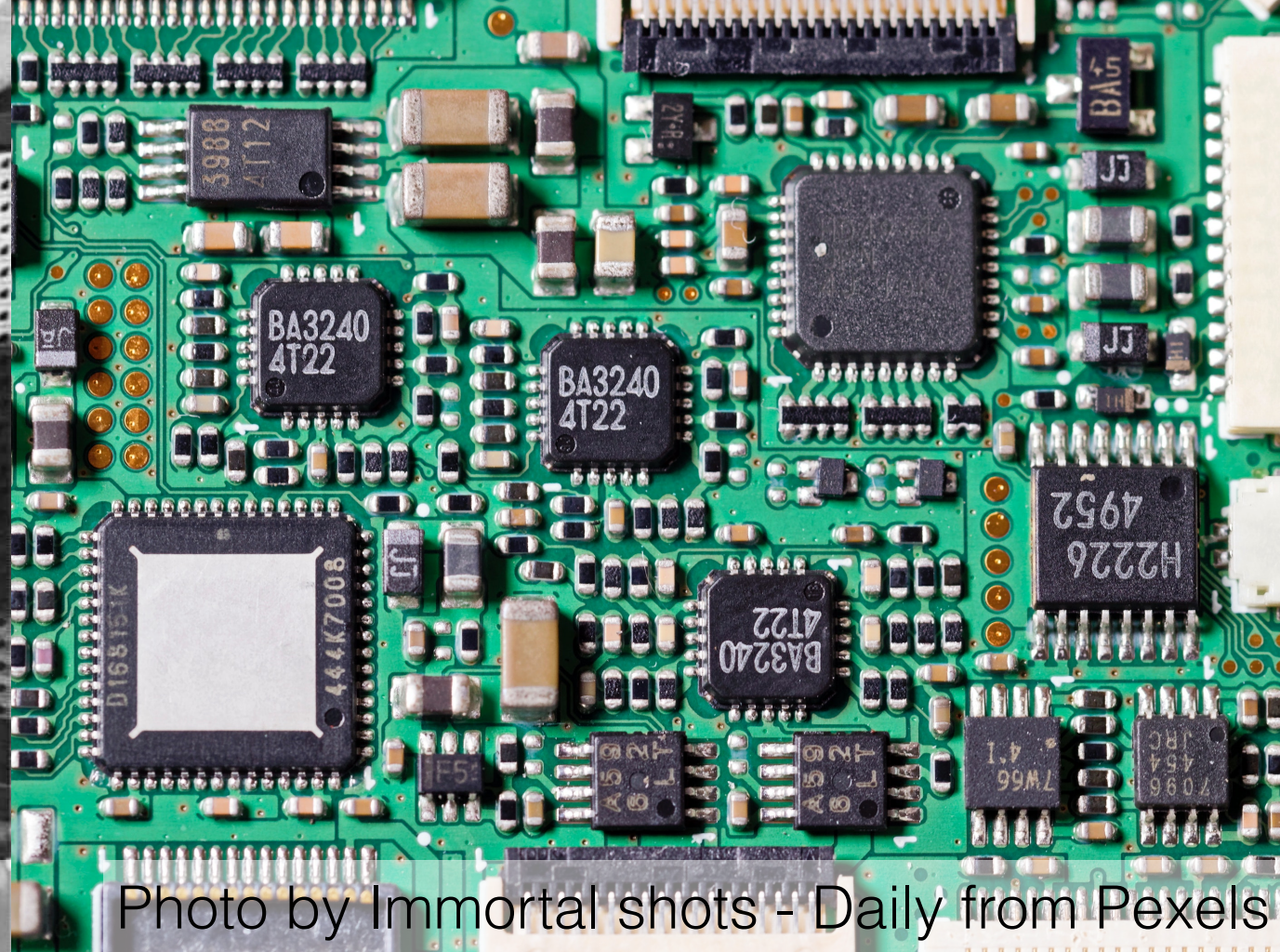
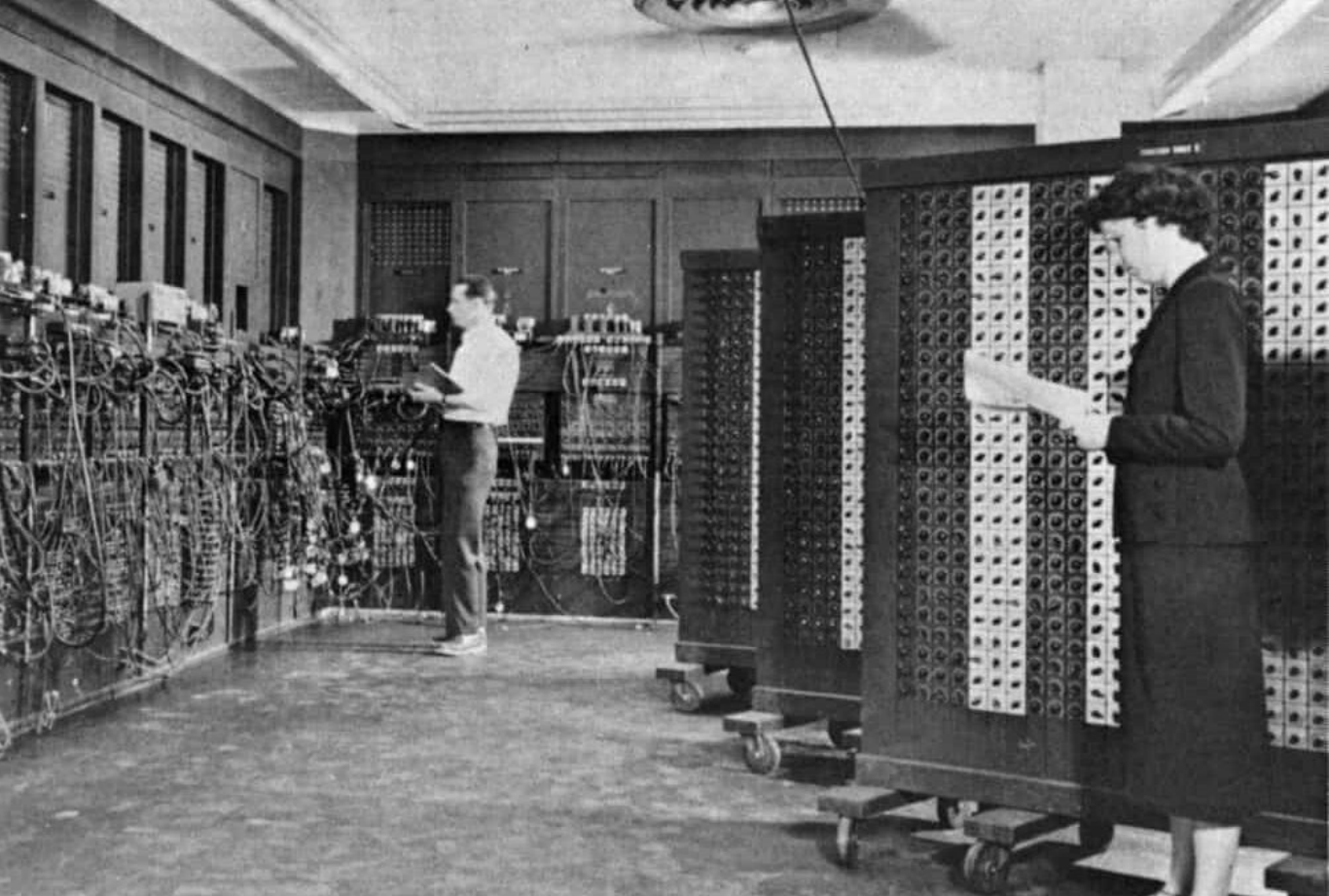


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US Army Photo

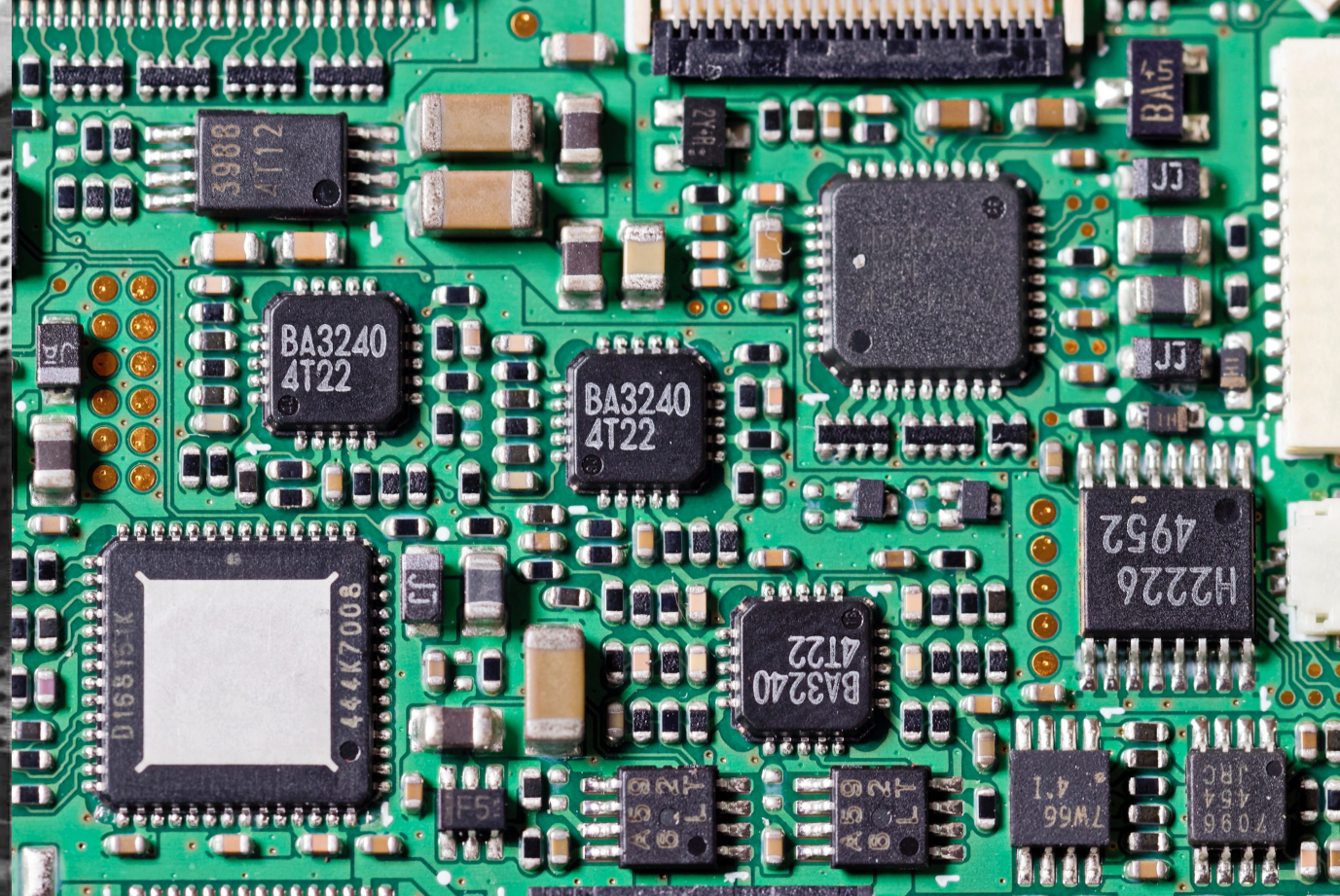
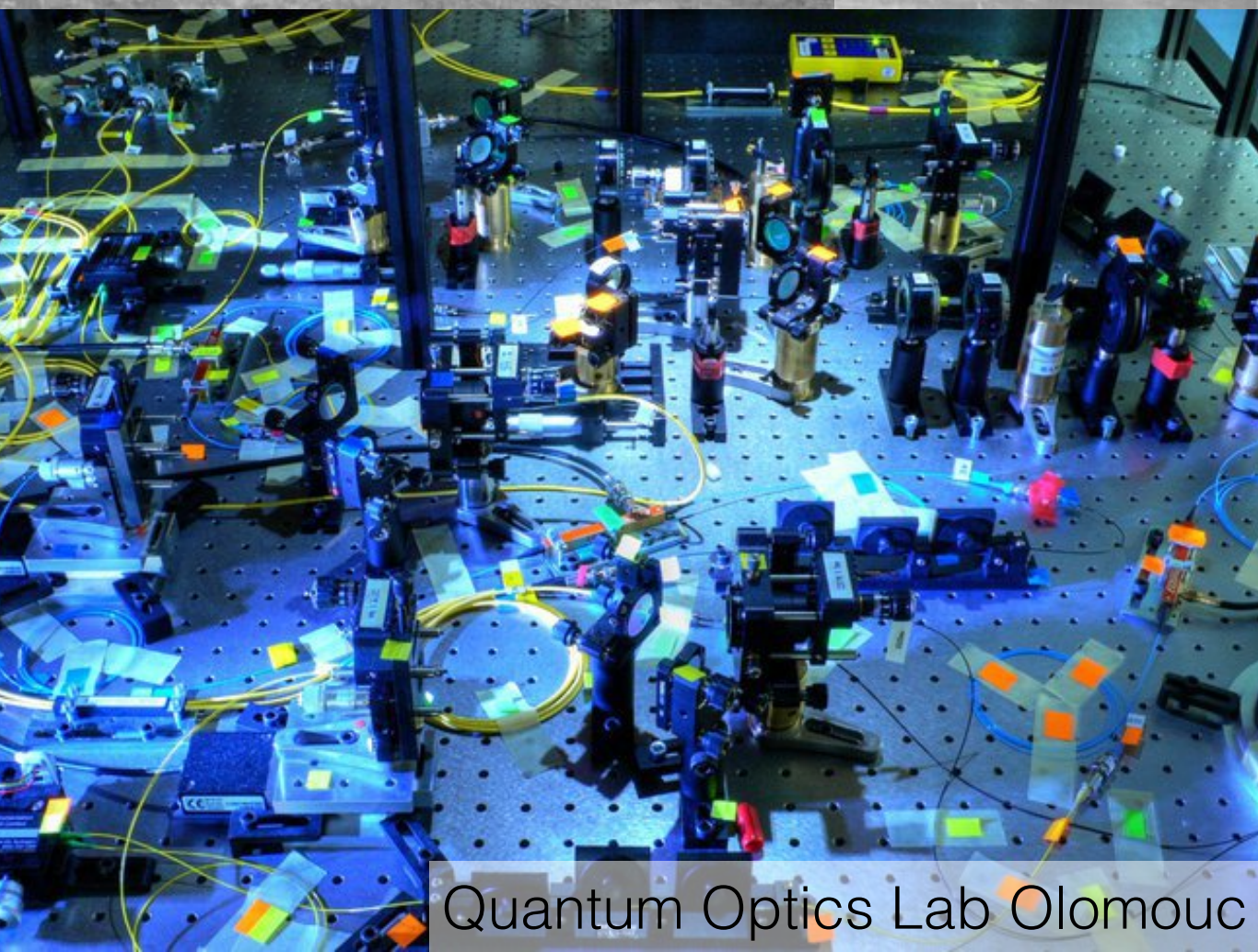
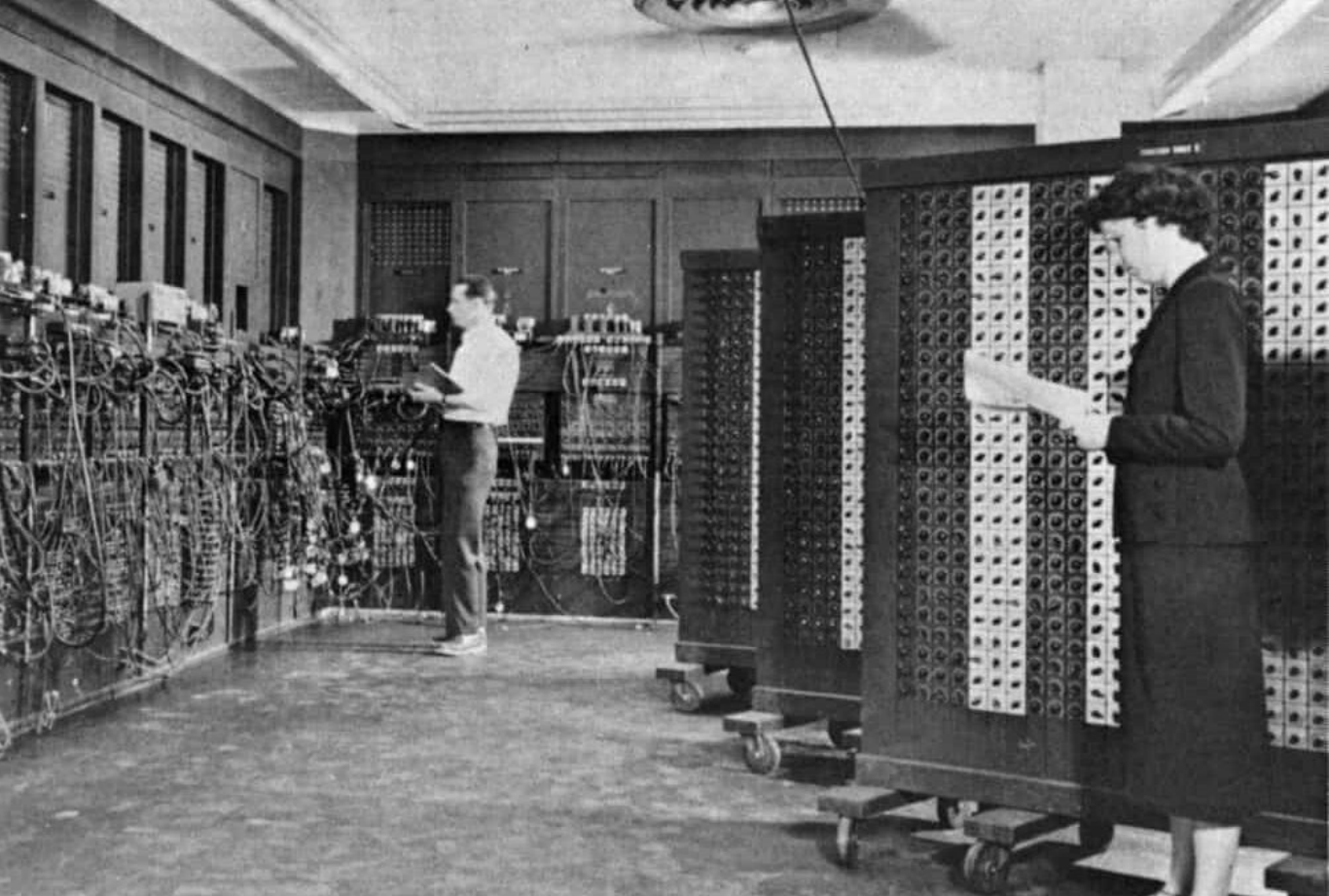


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US Army Photo

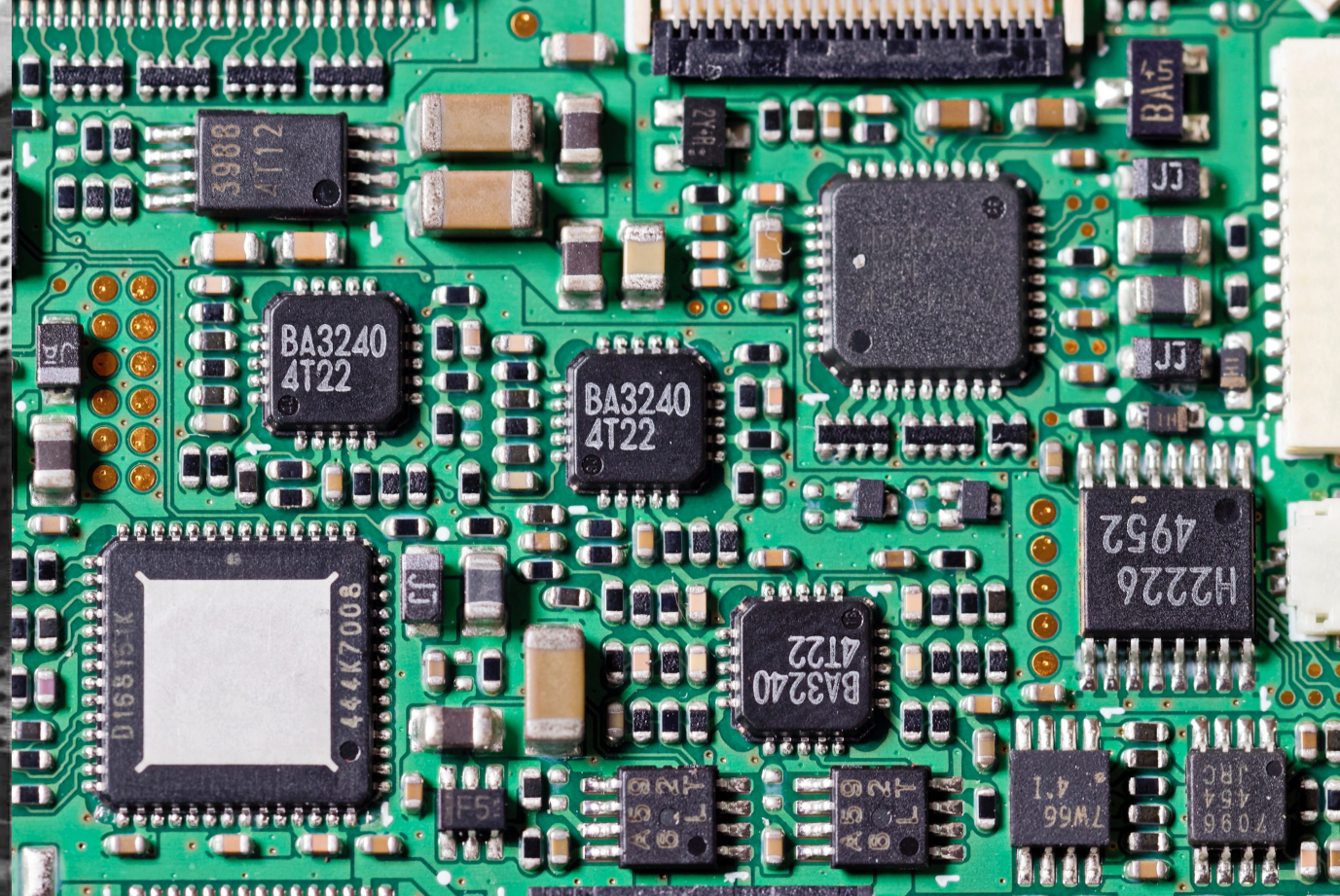
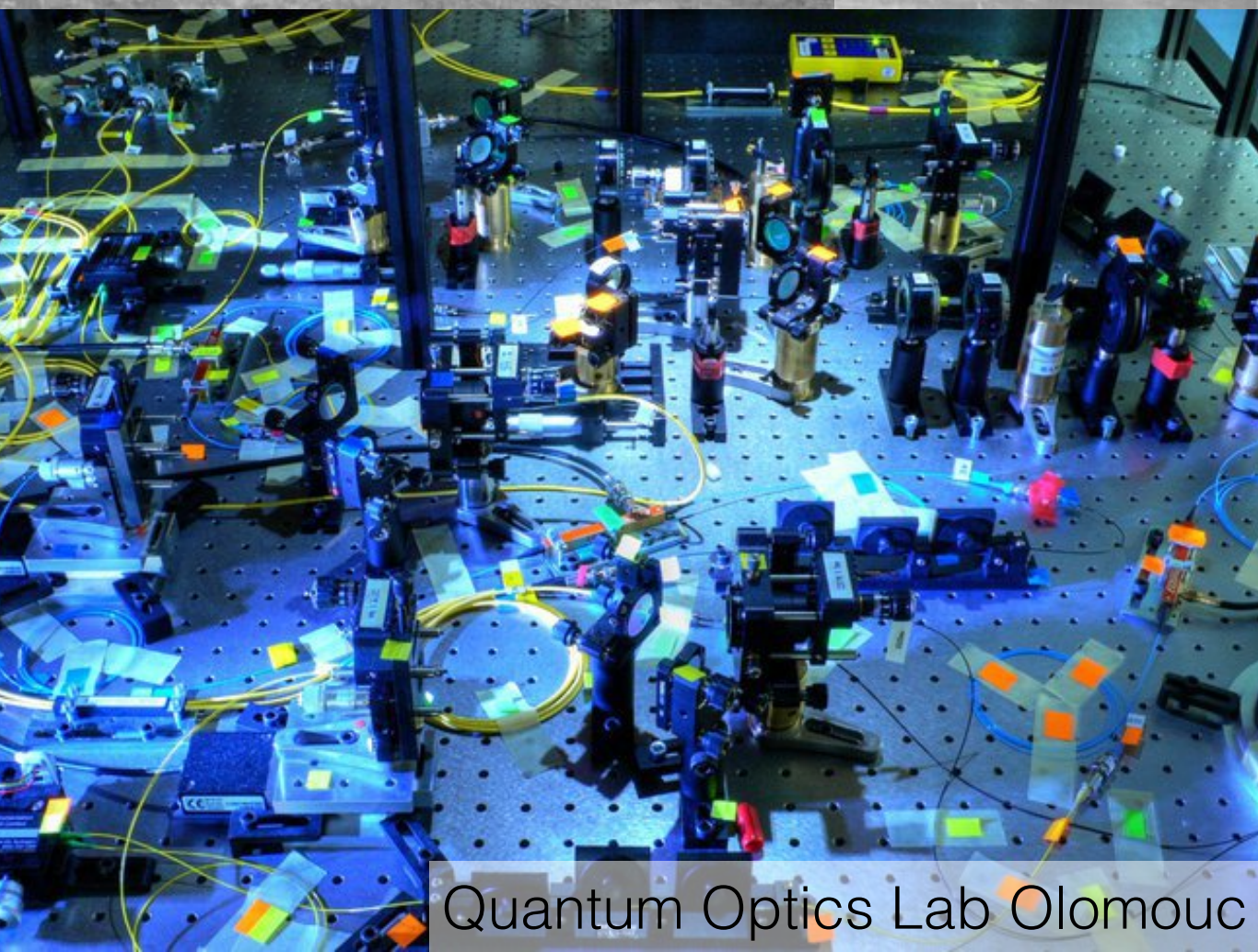


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QUESTIONS?

THANKS!