

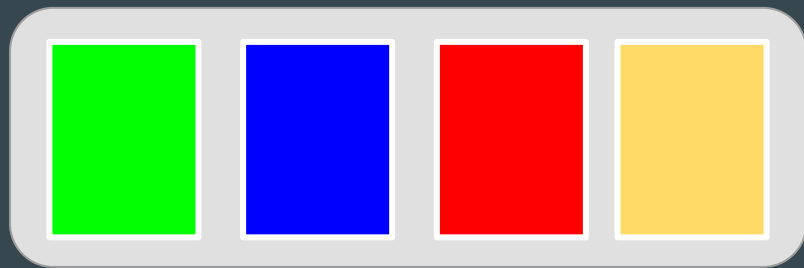
Quantum

...

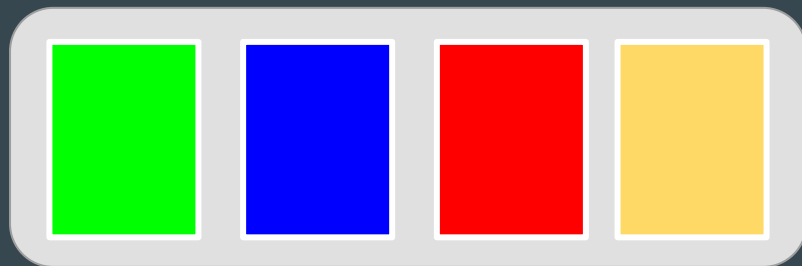
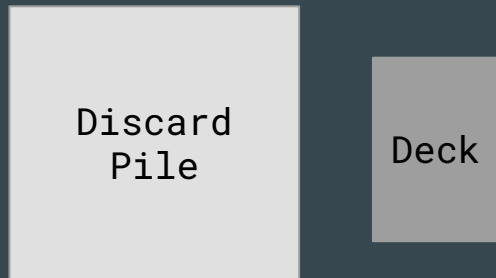
Abdullah Assaf, Richard Noh, Emily Padilla

Structure and Gameplay

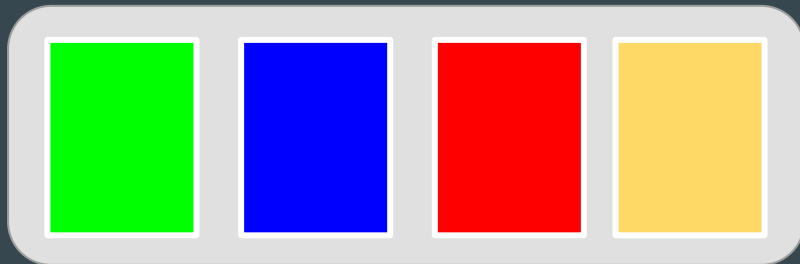
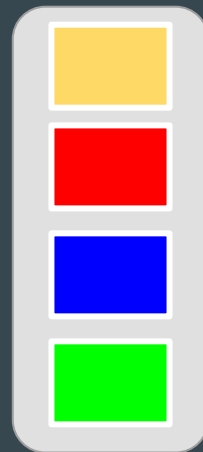
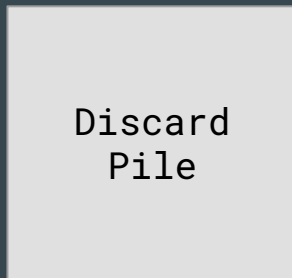
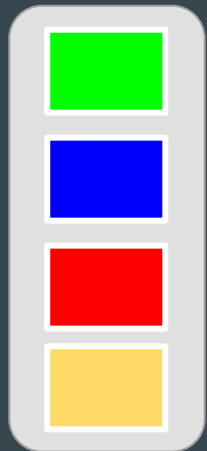
Just like UNO...



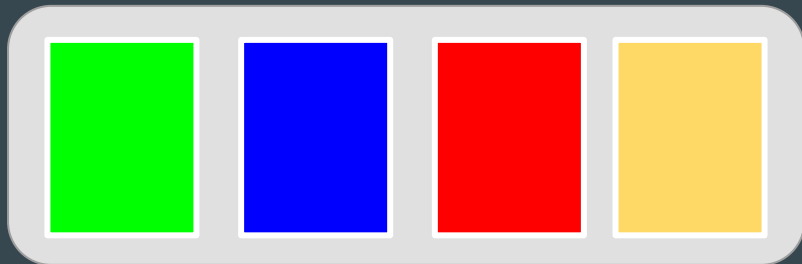
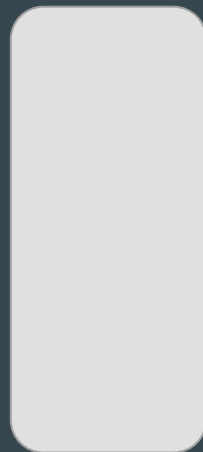
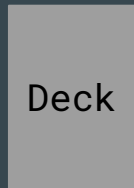
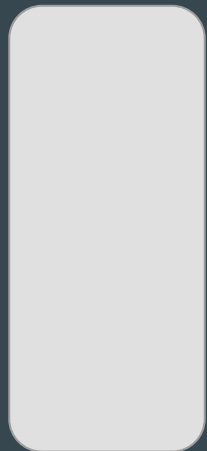
Just like UNO...



Just like UNO...



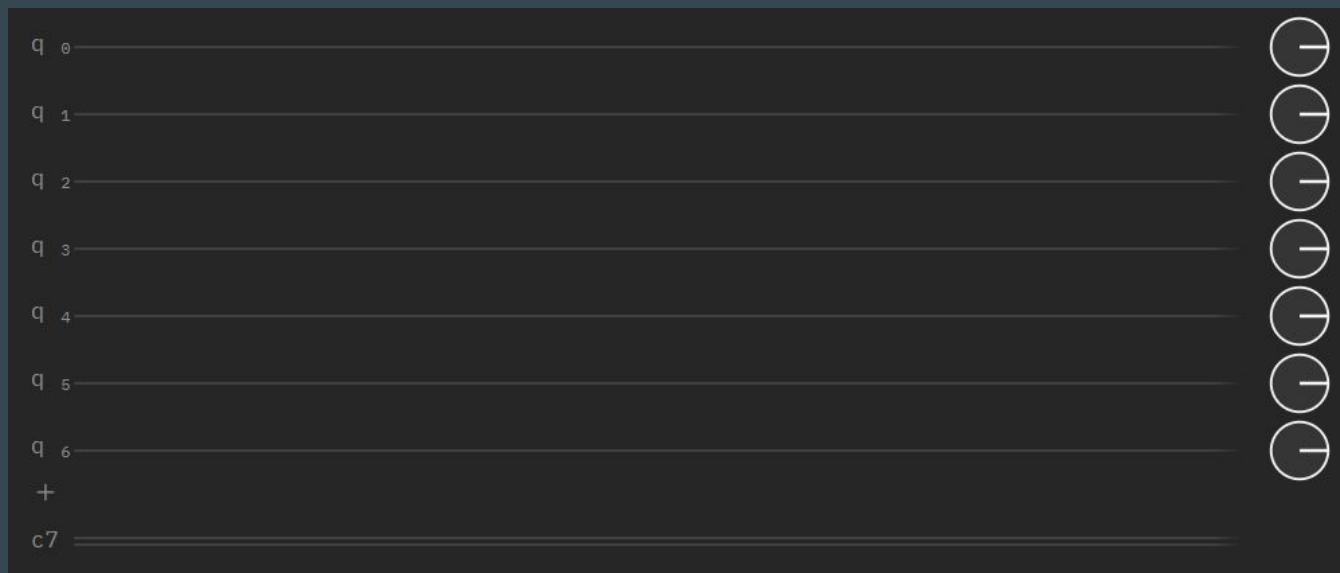
Just like UNO...



With a twist :)



With a twist :)



7 qubit system

With a twist :)



Output

q 0

q 1

q 2

q 3

q 4

q 5

q 6

+

c7



With a twist :)



Output
Color[0]
Color[1]

q₀
q₁
q₂
q₃
q₄
q₅
q₆
+
c7



With a twist :)

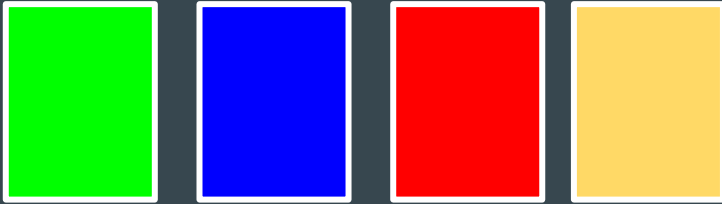


Output
Color[0]
Color[1]
Type[0]
Type[1]
Type[2]
Type[3]

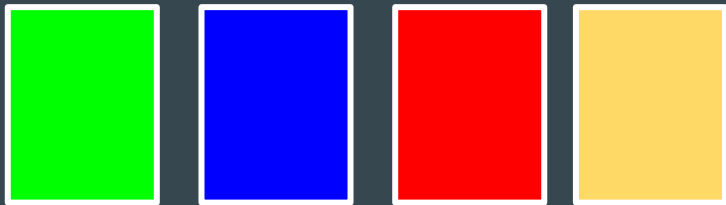
q 0
q 1
q 2
q 3
q 4
q 5
q 6
+
c7



Why 7 qubits?

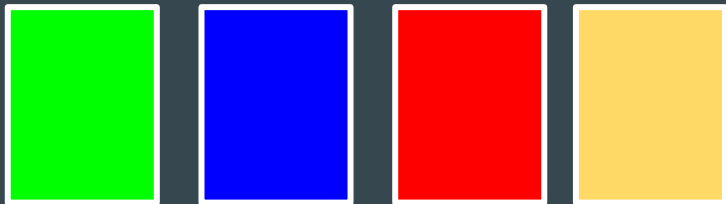


Why 7 qubits?



2 color
qubits

Why 7 qubits?

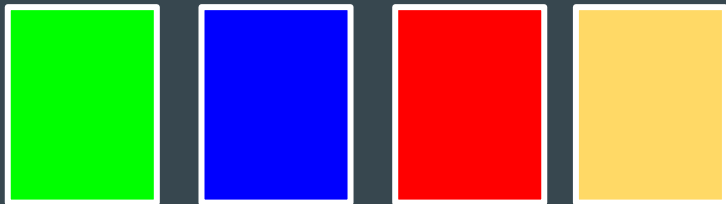


2 color
qubits

Number Cards

- 9 values

Why 7 qubits?

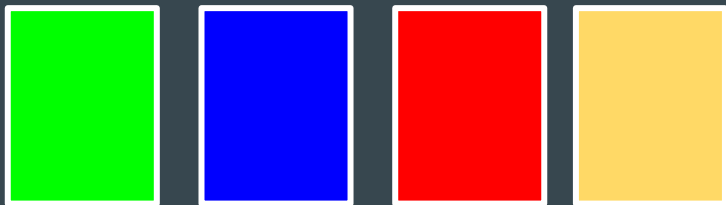


2 color
qubits

Number Cards - 9 values

Special Cards

Why 7 qubits?



2 color
qubits

Number Cards - 9 values

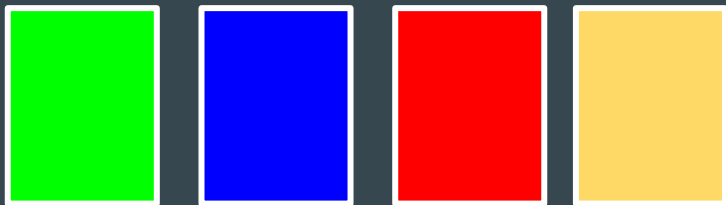
Special Cards

Phase - 1 value

Entanglement - 6 values

4 type
qubits

Why 7 qubits?



2 color
qubits

Number Cards - 9 values

Special Cards

Phase - 1 value

Entanglement - 6 values

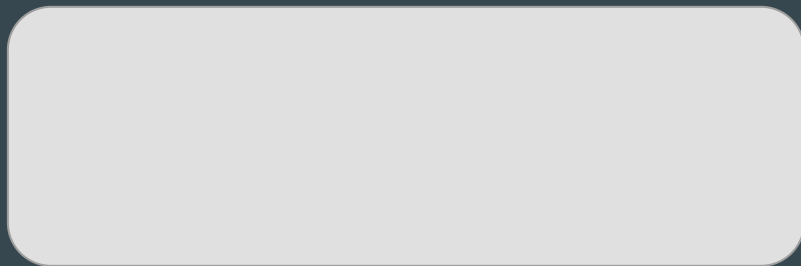
4 type
qubits

+1 output qubit

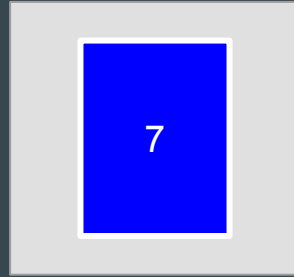
Superposition in QUNO

Superposition Cards

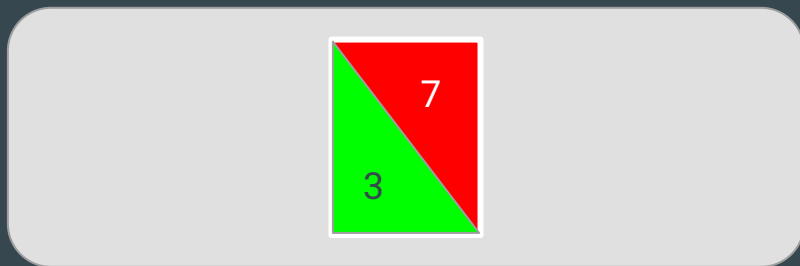
Discard
Pile



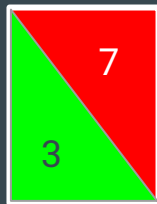
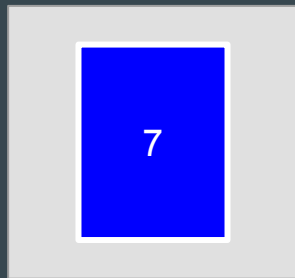
Superposition Cards



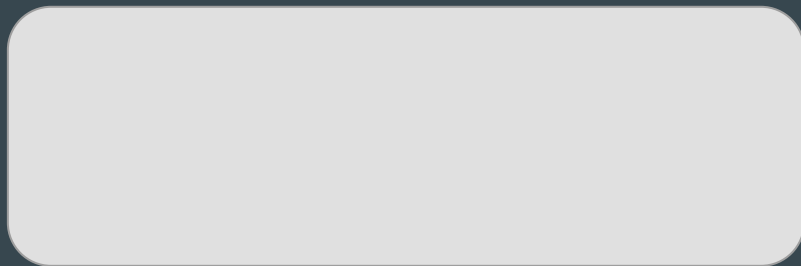
Superposition Cards



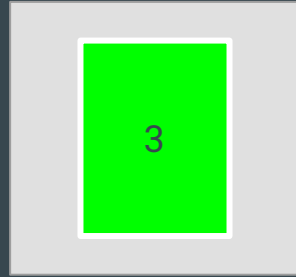
Superposition Cards



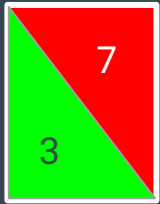
Measure the quantum circuit



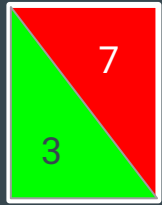
Superposition Cards



How does it work? (First Idea)

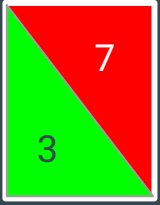


How does it work? (First Idea)



Red 7 = $(00\ 0110)_2$

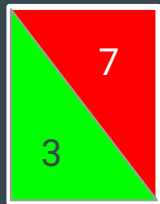
How does it work? (First Idea)



Red 7 = (00 0110)₂

Green 3 = (11 0010)₂

How does it work? (First Idea)

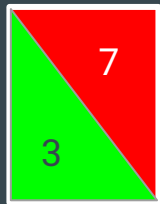


Red 7 = $(00\ 0110)_2$

Green 3 = $(11\ 0010)_2$

$$\frac{|000110\rangle + |110010\rangle}{\text{sqrt}(2)}$$

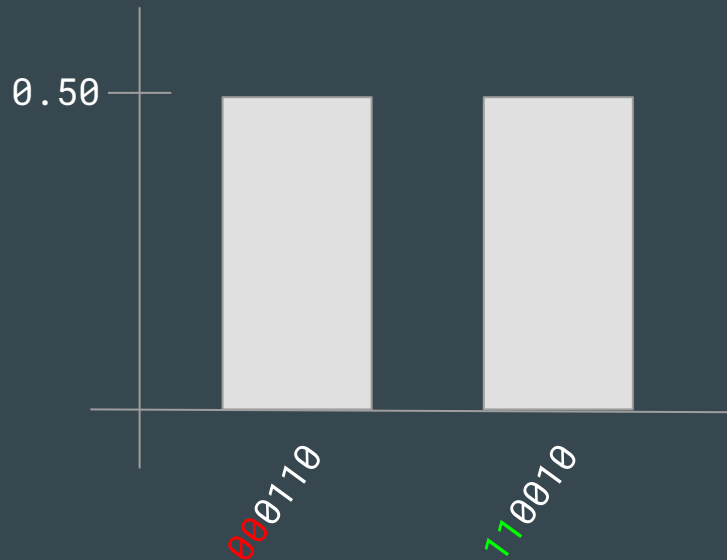
How does it work? (First Idea)



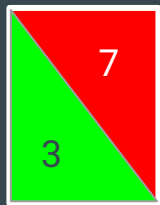
Red 7 = $(00\ 0110)_2$

Green 3 = $(11\ 0010)_2$

$$\frac{|000110\rangle + |110010\rangle}{\text{sqrt}(2)}$$

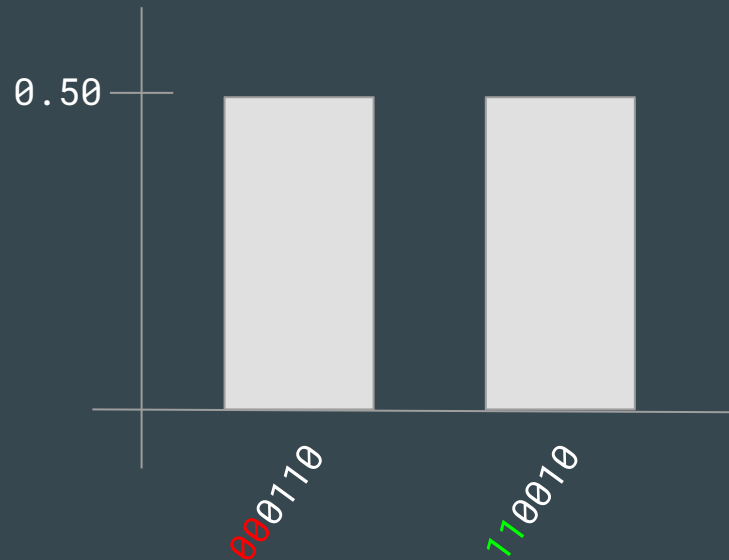
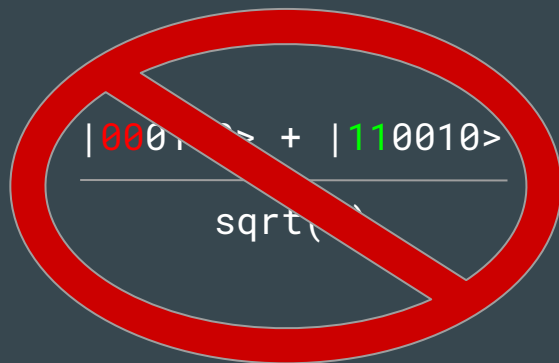


How does it work? (First Idea)



Red 7 = $(00\ 0110)_2$

Green 3 = $(11\ 0010)_2$



How does it work? (Better? Idea)

Grover's Search Algorithm for M Solutions

How does it work? (Better? Idea)

2

Grover's Search Algorithm for ~~M~~ Solutions

How does it work? (Better? Idea)

2

Grover's Search Algorithm for ~~M~~ Solutions

General Boolean Search Problem

Let $f : \{0, \dots, N - 1\} \rightarrow \{0, 1\}$ be a Boolean function. ($N = 2^n$)

$f(x) = 1$ for $x \in \{a_1, \dots, a_M\}$ Notice the multiple solutions!

$f(x) = 0$ for all other x

How does it work? (Better Idea)

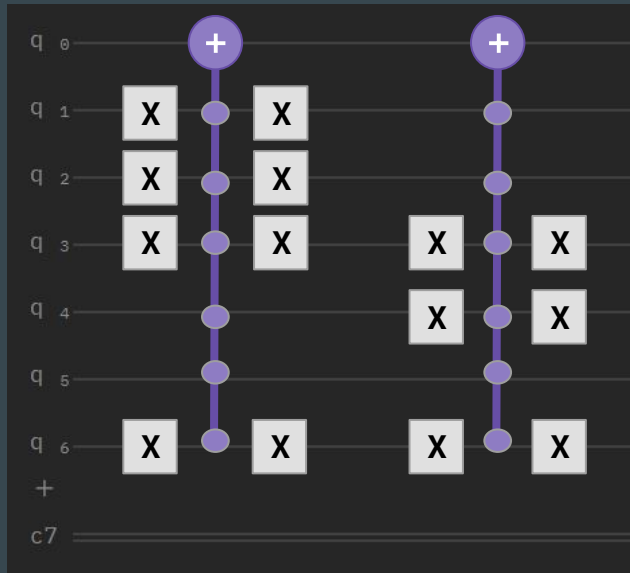
$$f(x) = (\text{Red } 7) \text{ or } (\text{Green } 3)$$

How does it work? (Better Idea)

$$\begin{aligned}f(x) &= (\text{Red } 7) \text{ or } (\text{Green } 3) \\ &= (000110) \text{ or } (110010)\end{aligned}$$

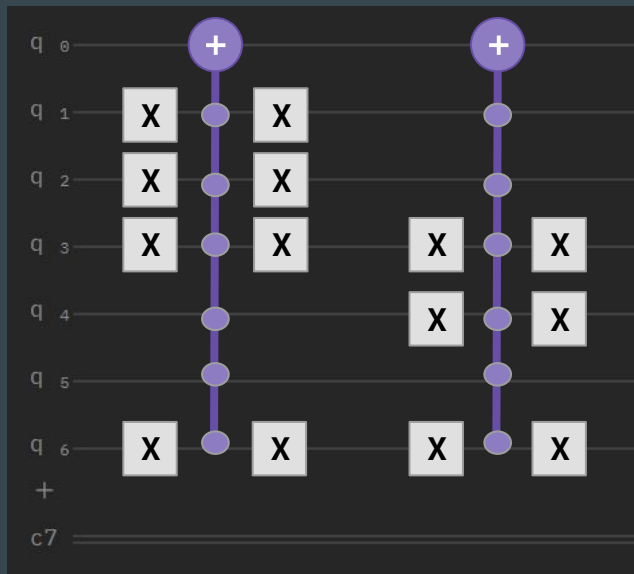
How does it work? (Better Idea)

$$f(x) = (\text{Red } 7) \text{ or } (\text{Green } 3)$$
$$= (000110) \text{ or } (110010)$$



How does it work? (Better Idea)

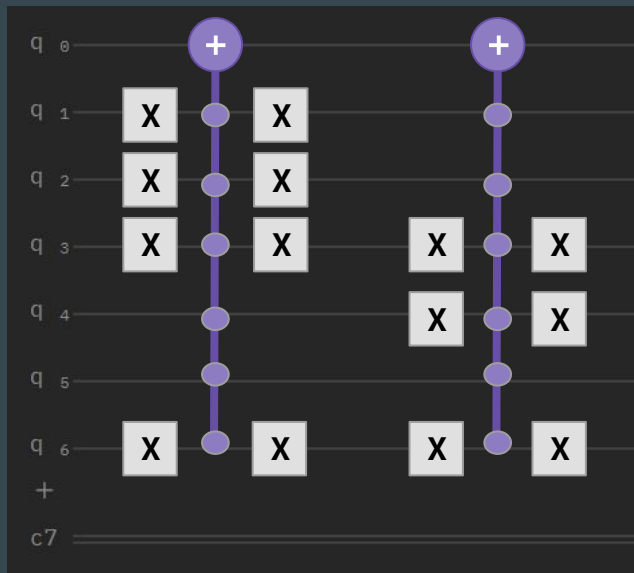
$$\begin{aligned} f(x) &= (\text{Red } 7) \text{ or } (\text{Green } 3) \\ &= (000110) \text{ or } (110010) \end{aligned}$$



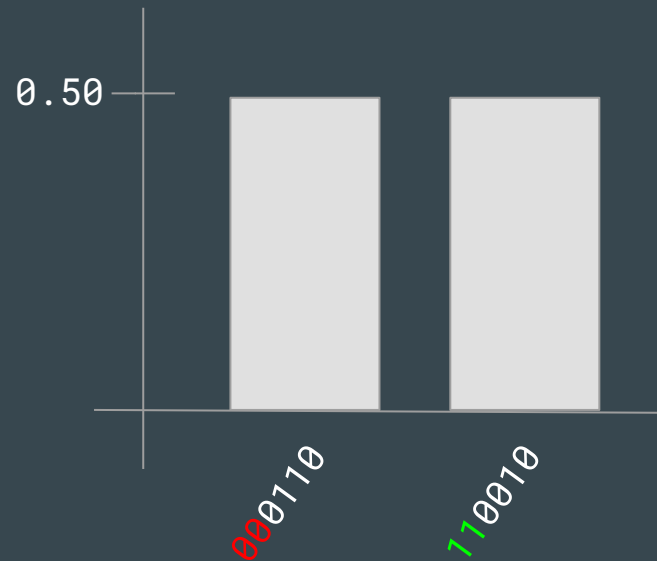
GROVER'S

How does it work? (Better Idea)

$$f(x) = (\text{Red } 7) \text{ or } (\text{Green } 3) \\ = (000110) \text{ or } (110010)$$

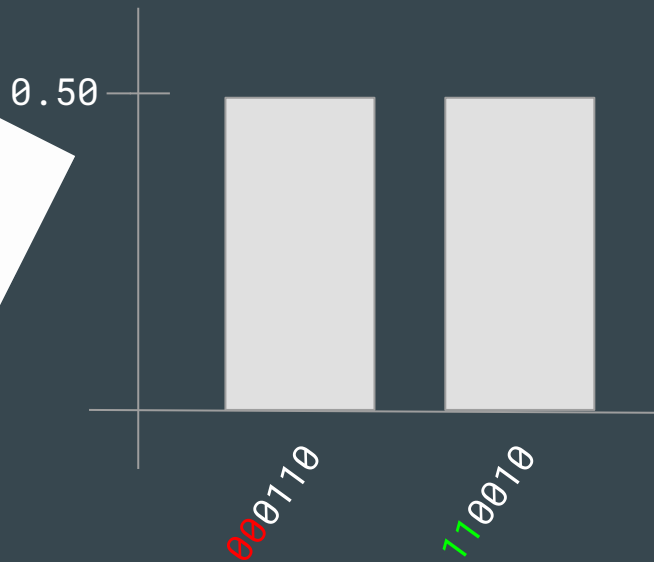
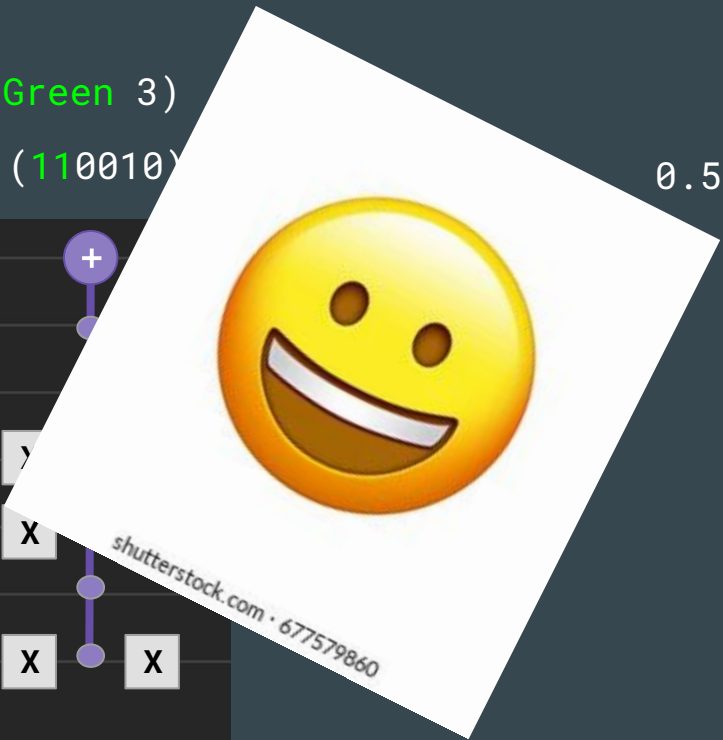
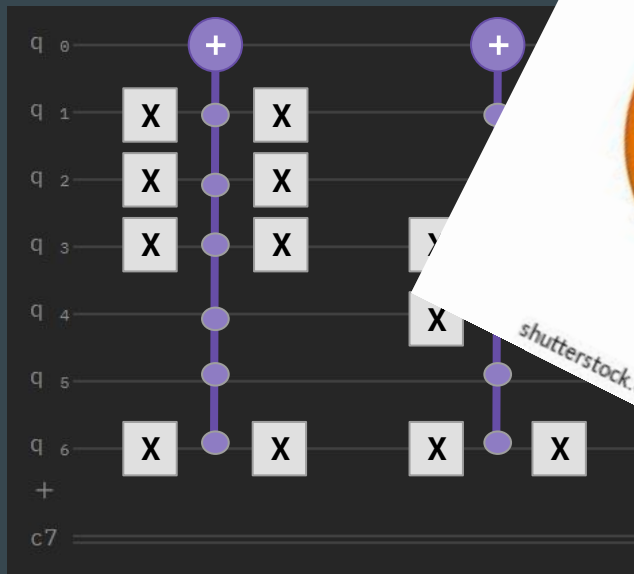


GROVER'S



How does it work? (Better Idea)

$$f(x) = (\text{Red } 7) \text{ or } (\text{Green } 3) \\ = (000110) \text{ or } (110010)$$

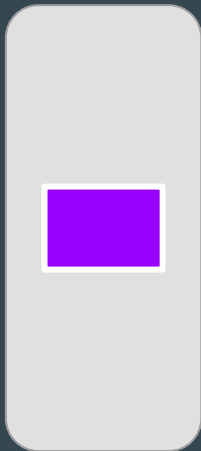


Entanglement

Make Entangle Card

Alice

Make
Entangle
X/Y Card

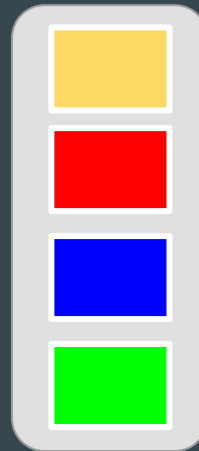


Turn
Alice

Discard
Pile



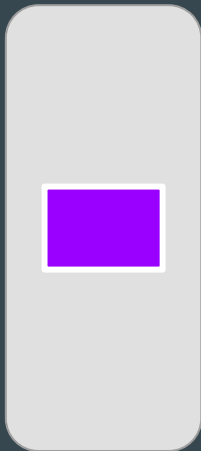
Bob



Make Entangle Card

Make
Entangle
Red/Blue
Card

Alice

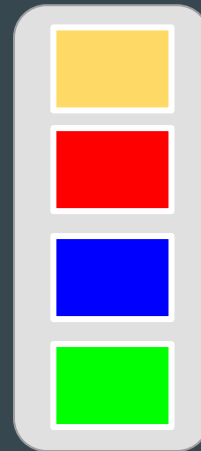


Turn
Alice

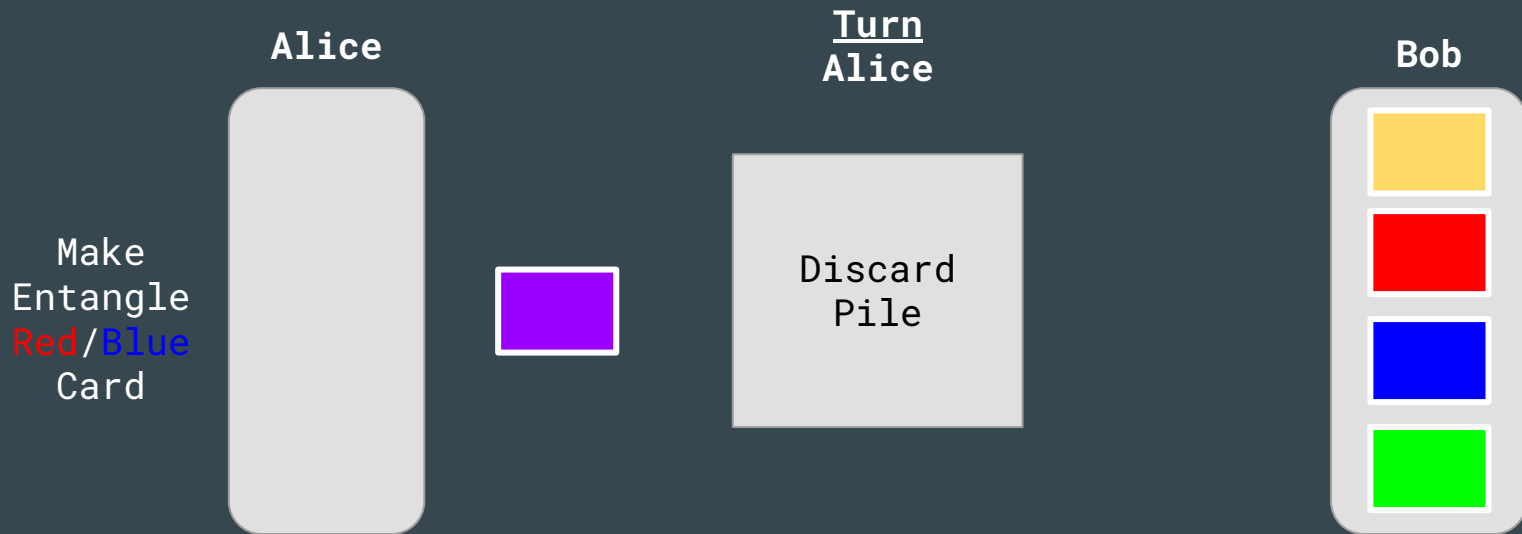
Discard
Pile



Bob

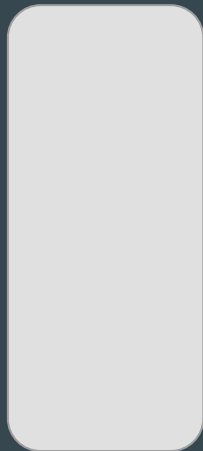


Make Entangle Card



Make Entangle Card

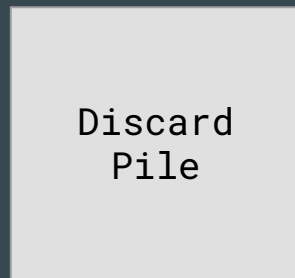
Alice



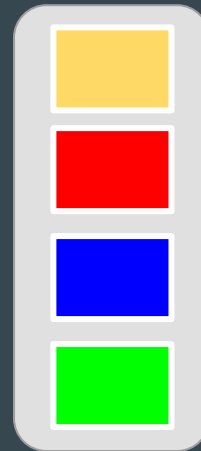
"Entangled"
Pair



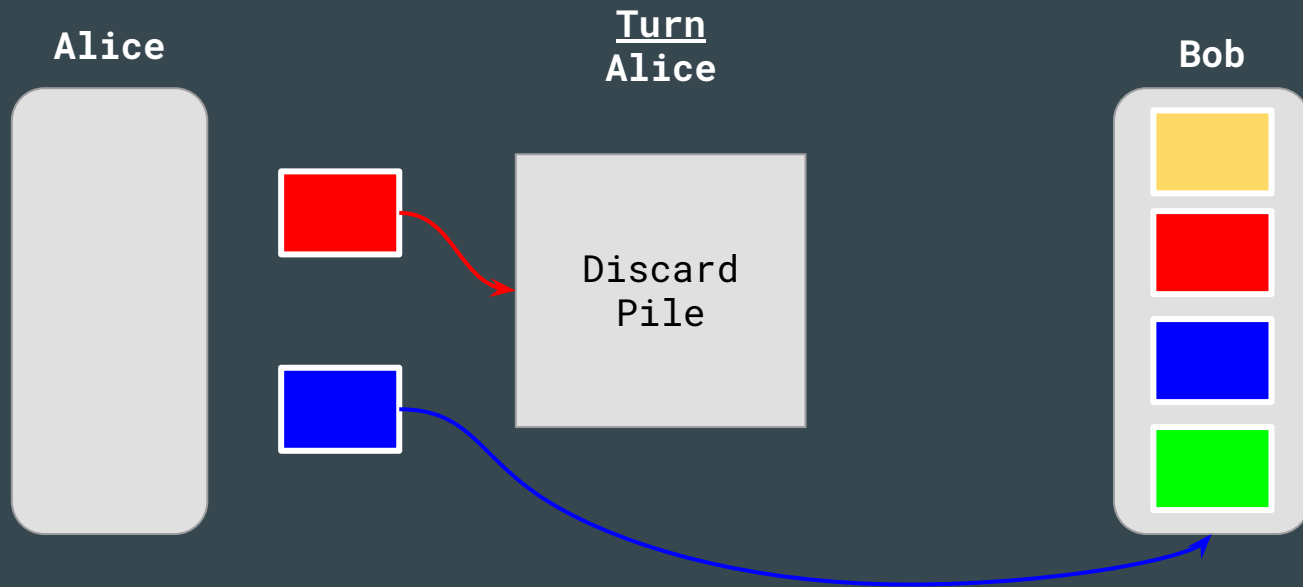
Turn
Alice



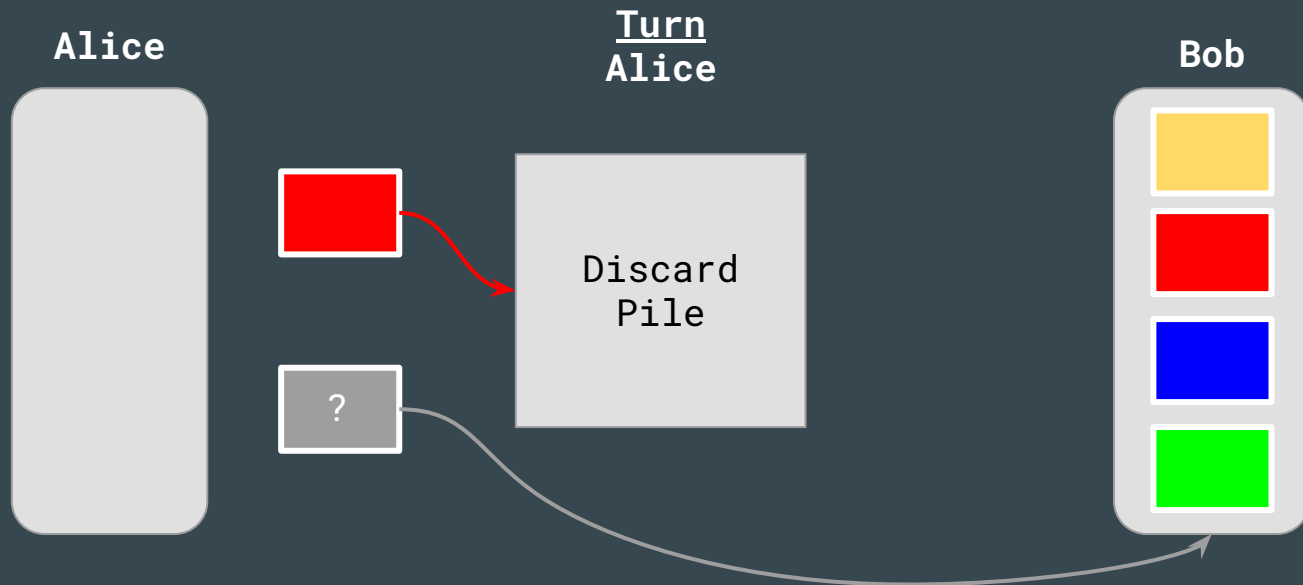
Bob



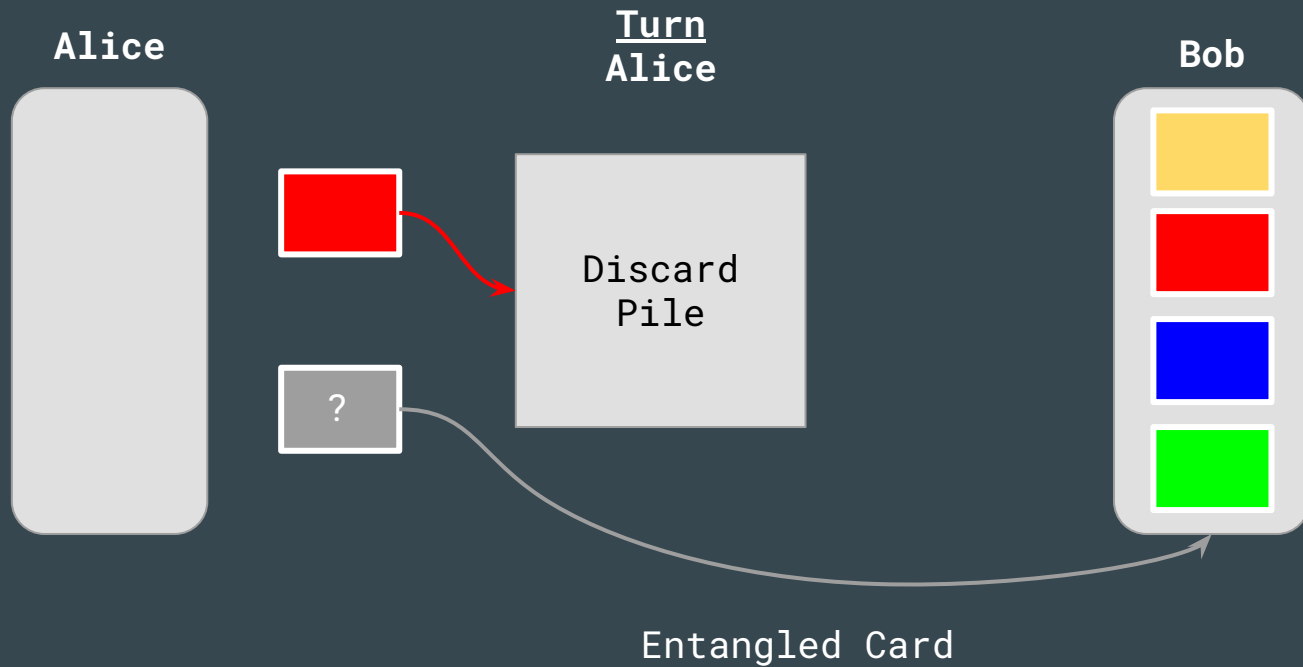
Make Entangle Card



Make Entangle Card

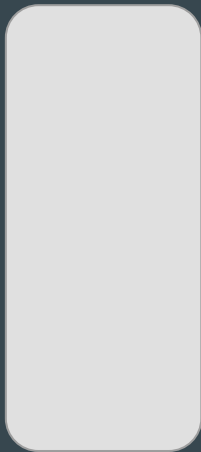


Make Entangle Card

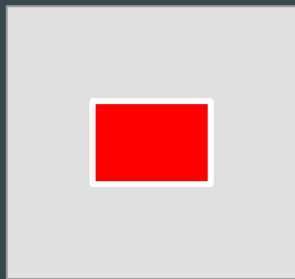


Make Entangle Card

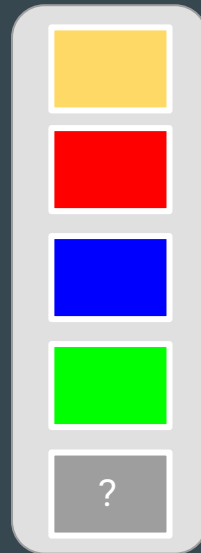
Alice



Turn
Alice

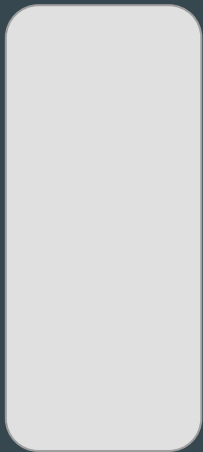


Bob

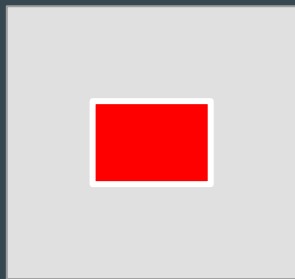


Make Entangle Card

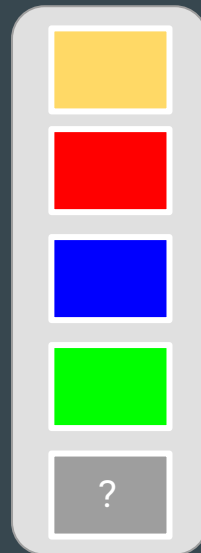
Alice



Turn
Bob

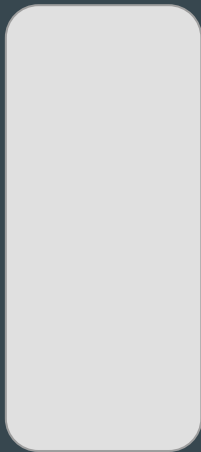


Bob

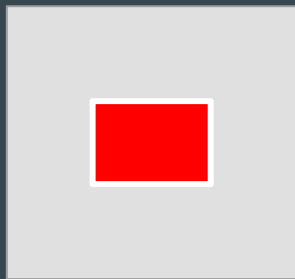


Make Entangle Card

Alice

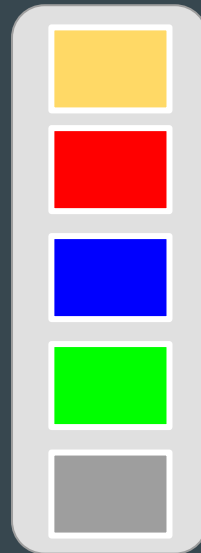


Turn
Bob



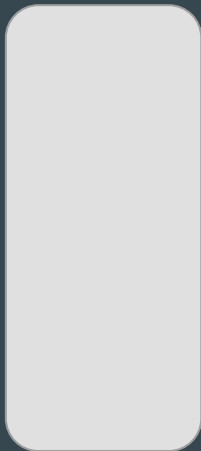
"Measure" Entangled
Card

Bob

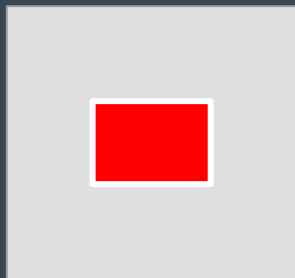


Make Entangle Card

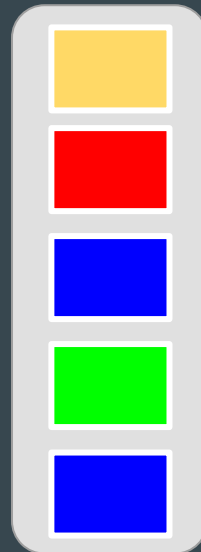
Alice



Turn
Bob

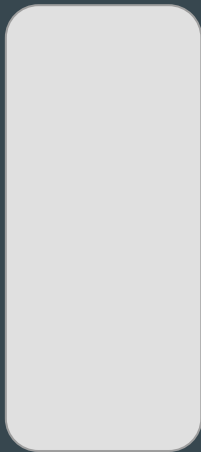


Bob

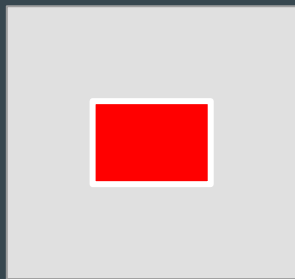


Make Entangle Card

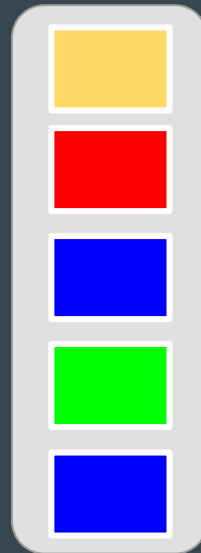
Alice



Turn
Alice

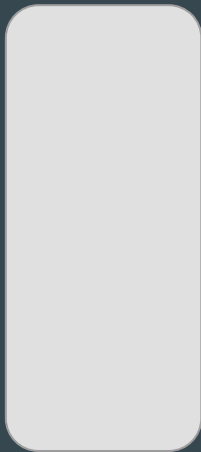


Bob

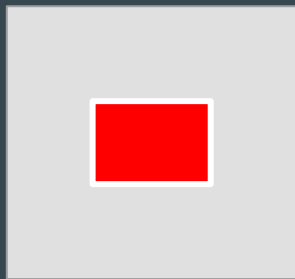


Make Entangle Card

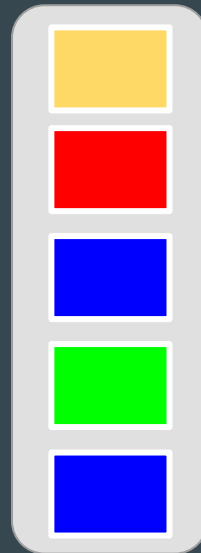
Alice



Turn
Alice

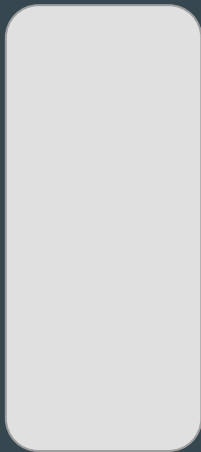


Bob

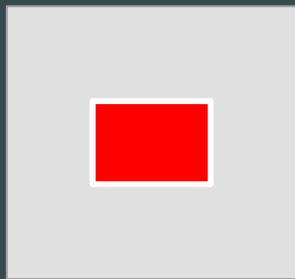


Make Entangle Card

Alice

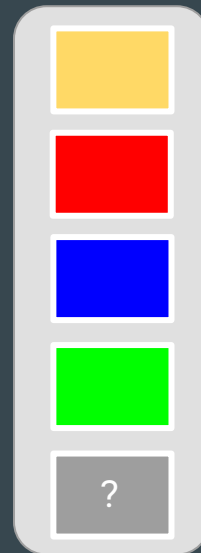


Turn
Bob



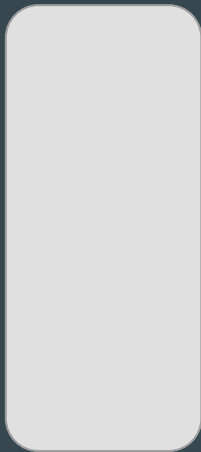
Bob does not have to
measure on his turn

Bob

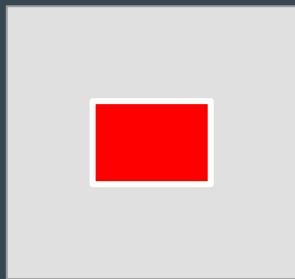


Make Entangle Card

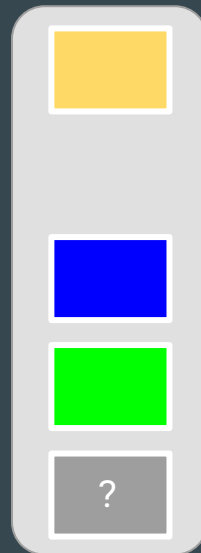
Alice



Turn
Bob



Bob



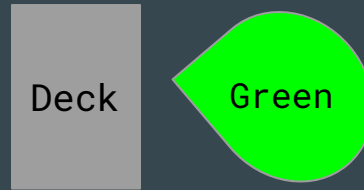
Interference

Deck



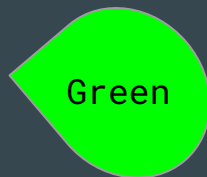
Deck

Top Card Color Is Always Shown



Top Card Color Is Always Shown

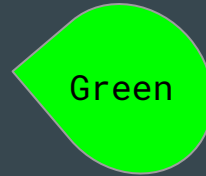
Deck



Red	00
Blue	01
Yellow	10
Green	11

“Add Phase” Card

Deck

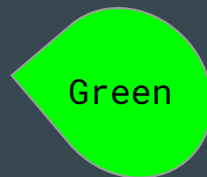


Red	00
Blue	01
Yellow	10
Green	11

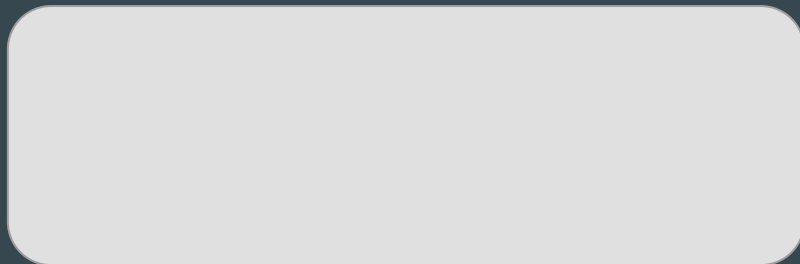


“Add Phase” Card

Deck

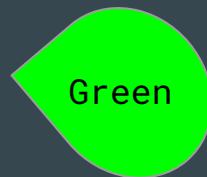


Red	00
Blue	01
Yellow	10
Green	11



“Add Phase” Card

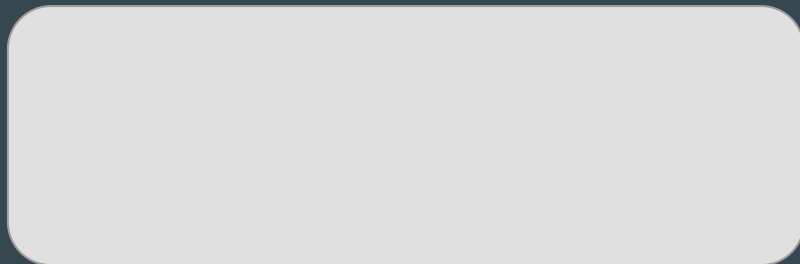
Deck



Red	00
Blue	01
Yellow	10
Green	11

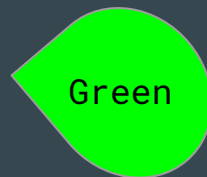


Rotate Y Gate
Phase: $\pi/2$
On Color[0]



“Add Phase” Card

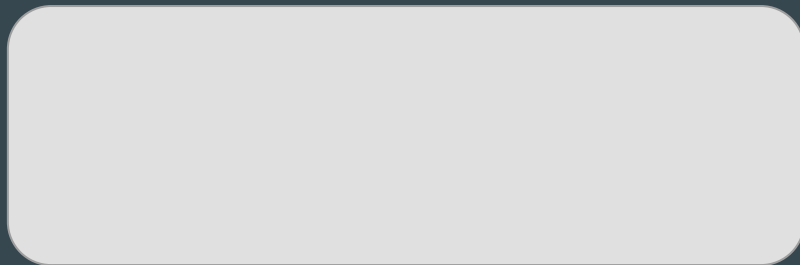
Deck



Red	00
Blue	01
Yellow	10
Green	11

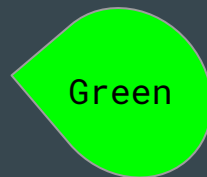


Rotate Y Gate
Phase: $\pi/2$
On Color[0]



“Add Phase” Card

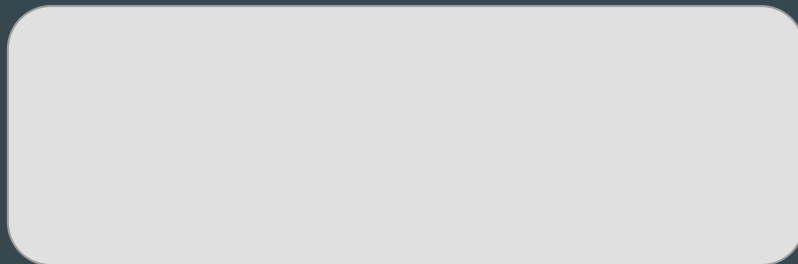
Deck



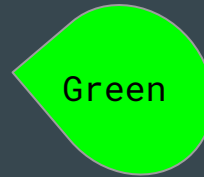
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



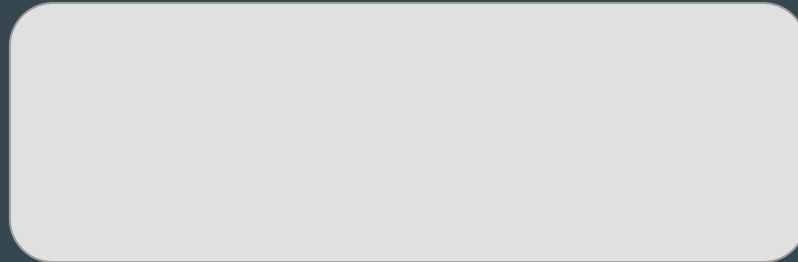
Rotate Y Gate
Phase: $\pi/2$
On Color[0]



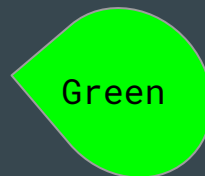
“Add Phase” Card



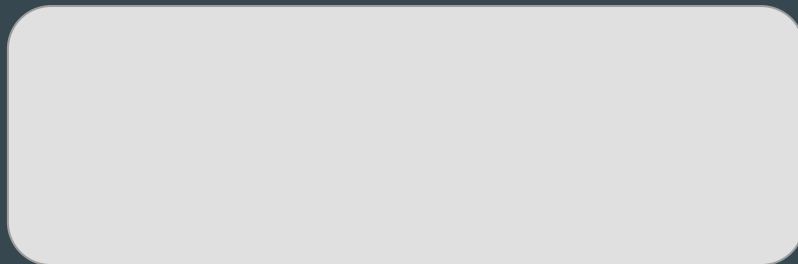
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



“Add Phase” Card



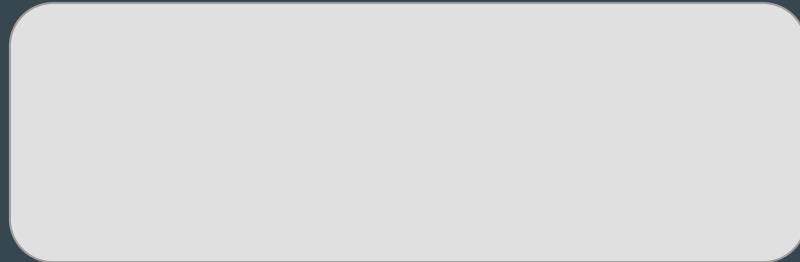
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



“Add Phase” Card



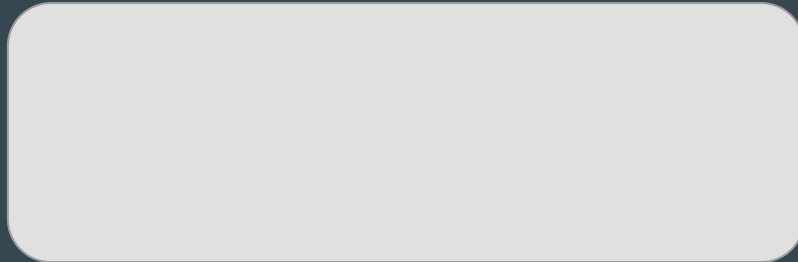
Red	0 <u>0</u>
Blue	0 <u>1</u>
Yellow	1 <u>0</u>
Green	1 <u>1</u>



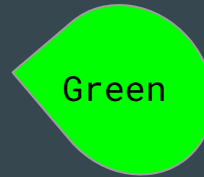
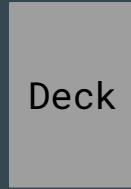
“Add Phase” Card



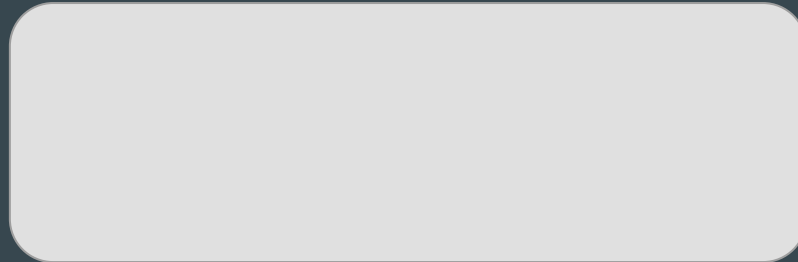
Red	0 <u>0</u>
Blue	0 <u>1</u>
Yellow	1 <u>0</u>
Green	1 <u>1</u>



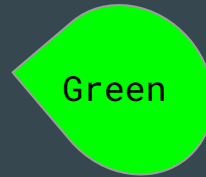
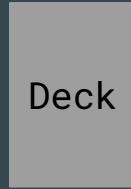
“Add Phase” Card



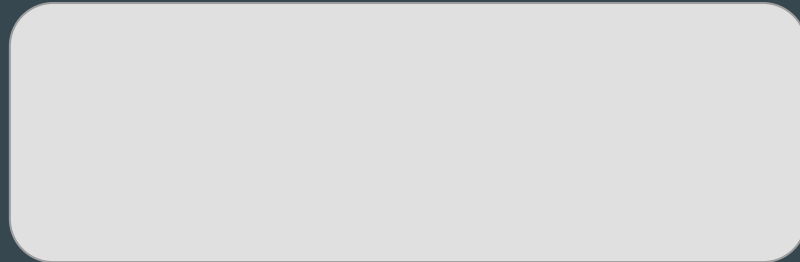
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



“Add Phase” Card

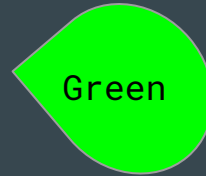


Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>

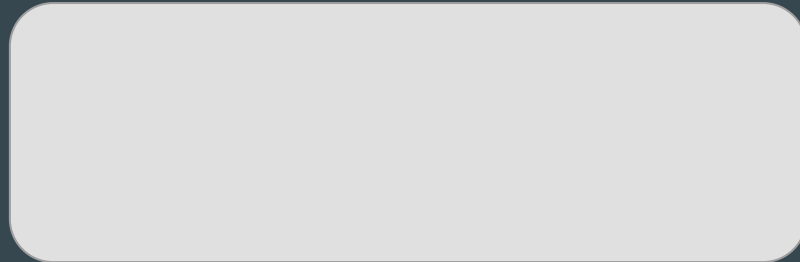


“Add Phase” Card

Deck

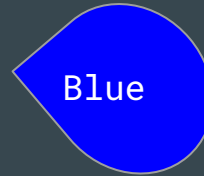


Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>

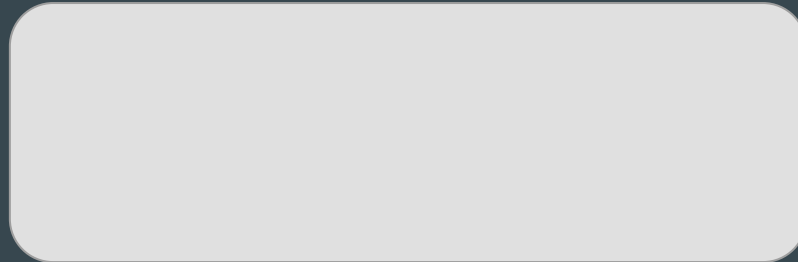


“Add Phase” Card

Deck

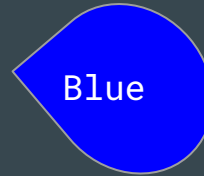


Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>

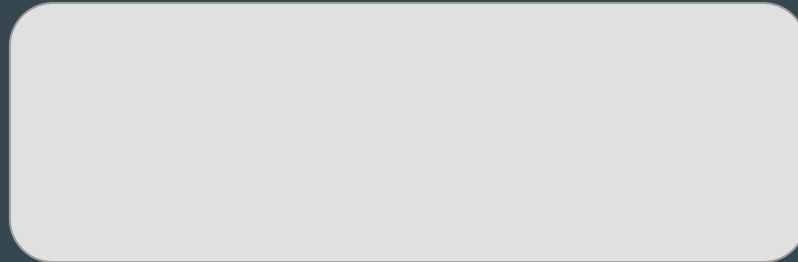


“Add Phase” Card

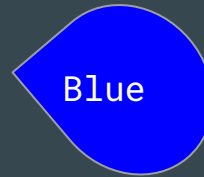
Deck



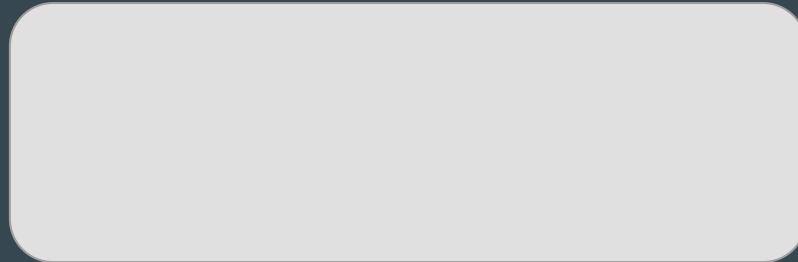
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



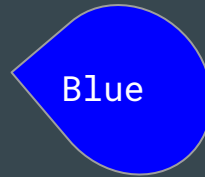
“Add Phase” Card



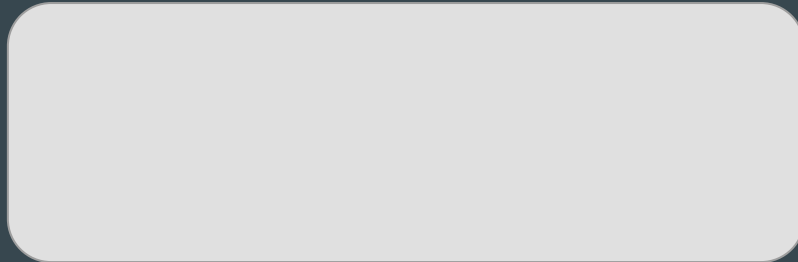
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



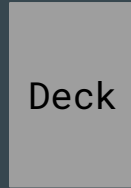
“Add Phase” Card



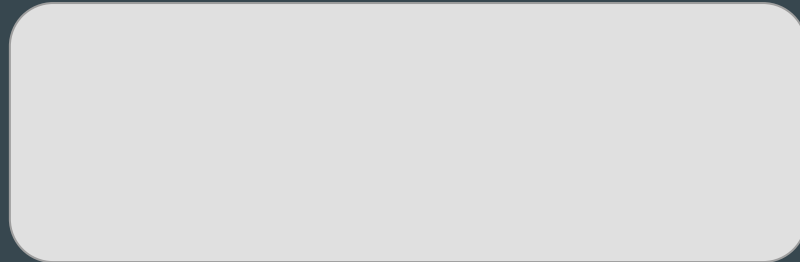
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



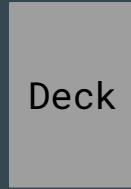
“Add Phase” Card



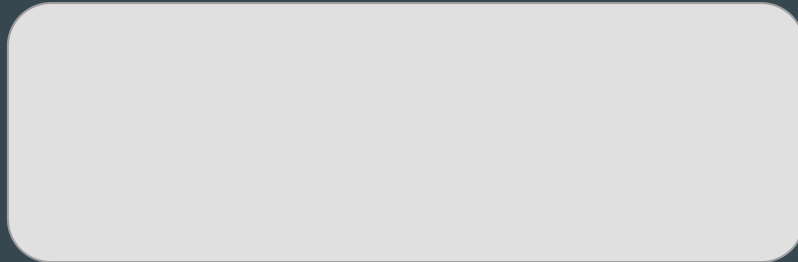
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



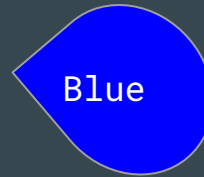
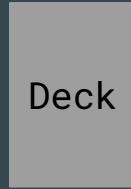
“Add Phase” Card



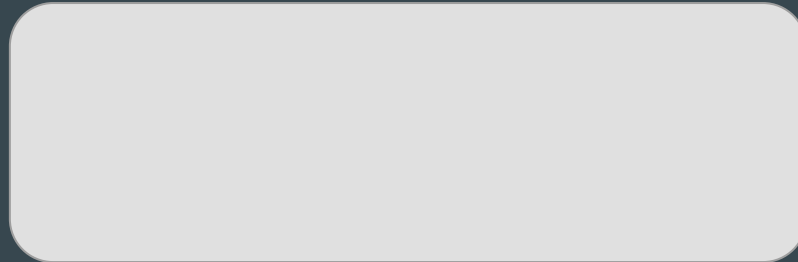
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



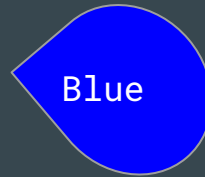
“Add Phase” Card



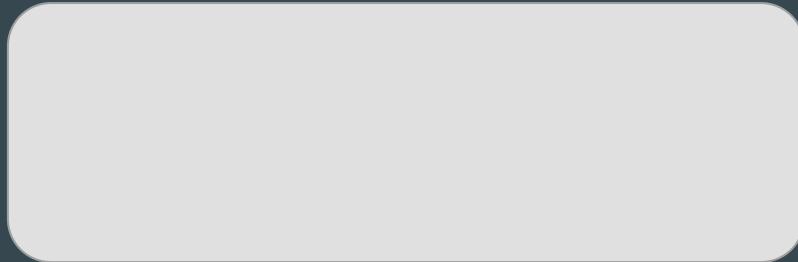
Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>



“Add Phase” Card

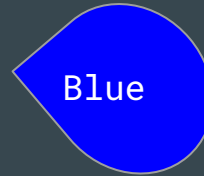


Red	<u>00</u>
Blue	<u>01</u>
Yellow	<u>10</u>
Green	<u>11</u>

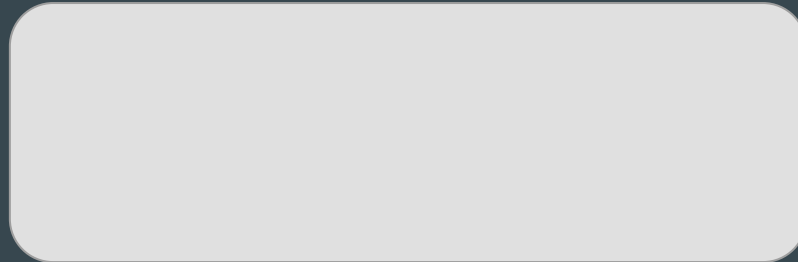


“Add Phase” Card

Deck



Red	0 <u>0</u>
Blue	0 <u>1</u>
Yellow	1 <u>0</u>
Green	1 <u>1</u>



Actual Game