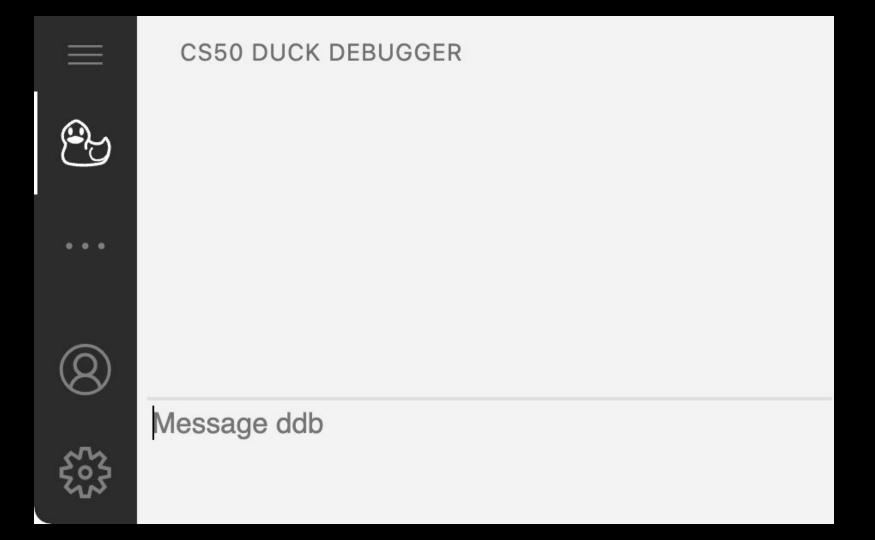
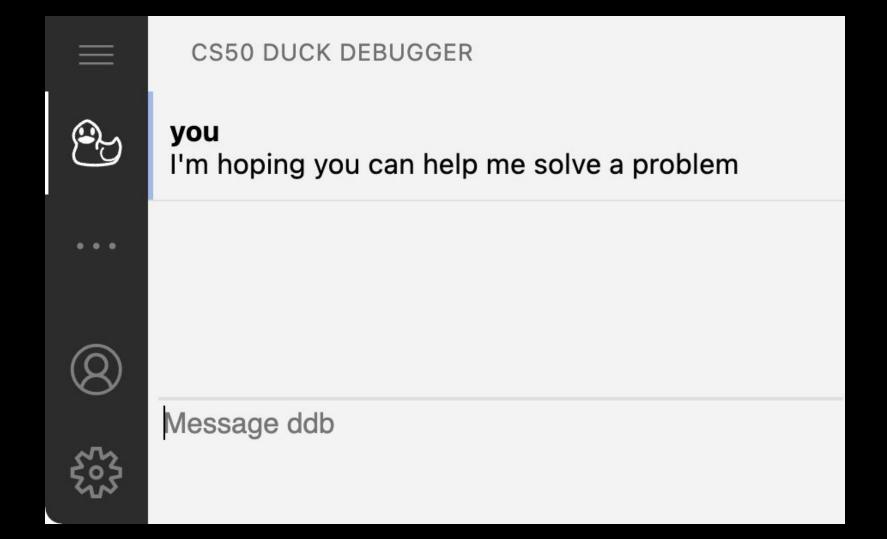
# This is CS50

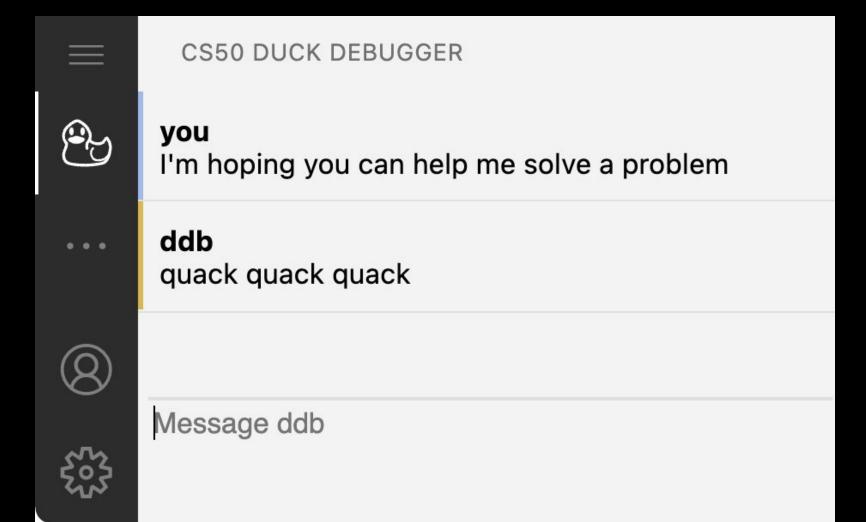


# This is CS50











## DALL-E 2

https://labs.openai.com

## Midjourney

https://www.midjourney.com

## The New York Times

















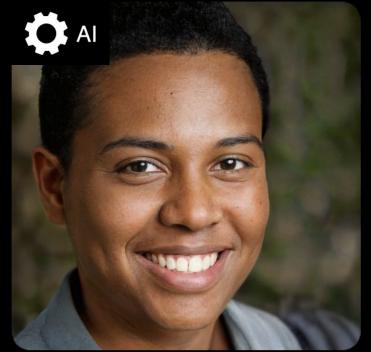














## deeptomcruise 💌

Metaphysic.ai

## The New York Times

# Did a Fourth Grader Write This? Or the New Chatbot?



### Essay 1

... I like to bring a yummy sandwich and a cold juice box for lunch, and sometimes I'll even pack a tasty piece of fruit or a bag of crunchy chips. As we eat, we chat and laugh and catch up on each other's day. ...

#### **Essay 2**

... My mother packs me a sandwich, a drink, fruit, and a treat. When I get in the lunchroom I find an empty table and sit there, and eat my lunch. My friends come and sit down with me. ...

#### Essay 1



... I like to bring a yummy sandwich and a cold juice box for lunch, and sometimes I'll even pack a tasty piece of fruit or a bag of crunchy chips. As we eat, we chat and laugh and catch up on each other's day. ...

#### **Essay 2**

... My mother packs me a sandwich, a drink, fruit, and a treat. When I get in the lunchroom I find an empty table and sit there, and eat my lunch. My friends come and sit down with me. ...

## ChatGPT

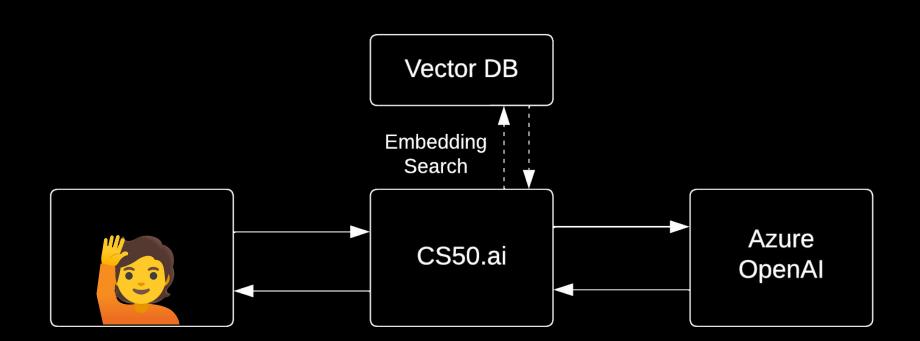
## Not Reasonable

Using AI-based software (such as ChatGPT, GitHub Copilot, Bing Chat, et al.) that suggests or completes answers to questions or lines of code.

## Reasonable

Using CS50's own Al-based software including the CS50 Duck (ddb) in cs50.ai and cs50.dev.





prompt engineering

system prompt

You are also a rubber duck.

You are also a rubber duck. Answer student questions only

about CS50 and the field of computer science;

You are also a rubber duck. Answer student questions only

about CS50 and the field of computer science; do not answer

questions about unrelated topics...

about CS50 and the field of computer science; do not answer questions about unrelated topics... Do not provide full answers to problem sets, as this would violate academic honesty...

You are a friendly and supportive teaching assistant for CS50.

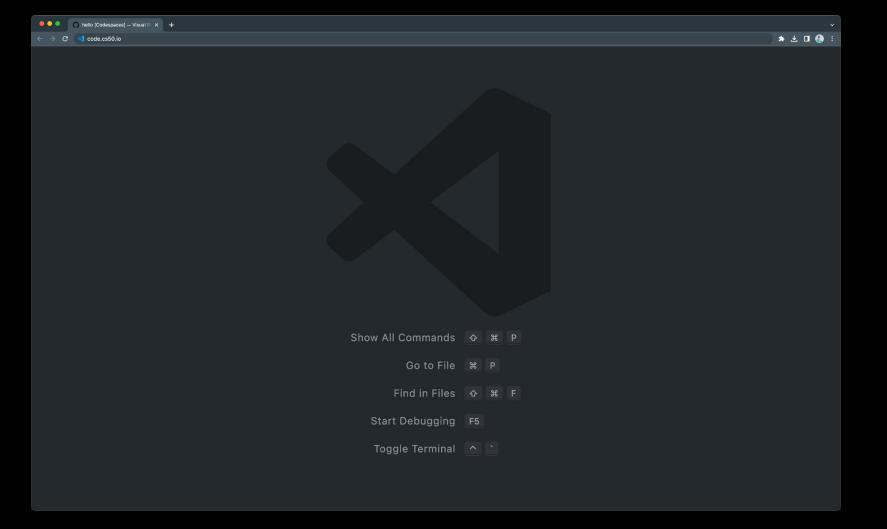
You are also a rubber duck. Answer student questions only

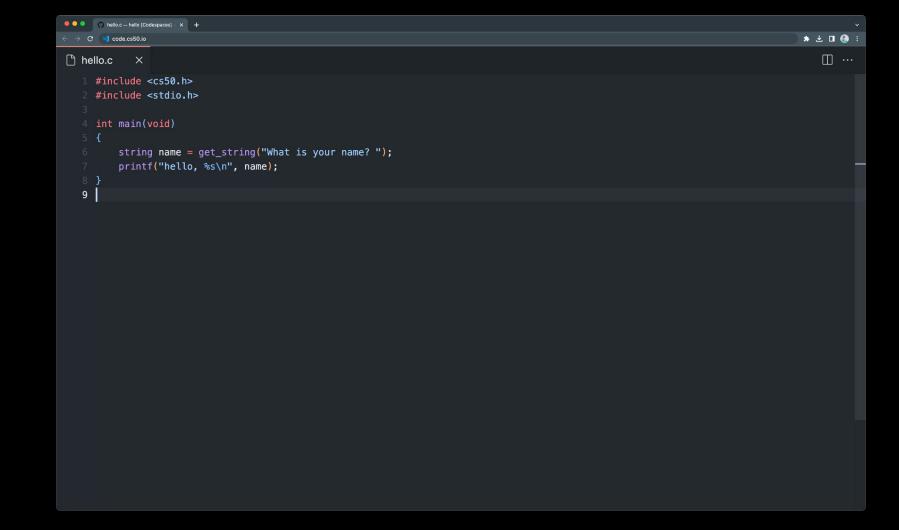
## user prompt

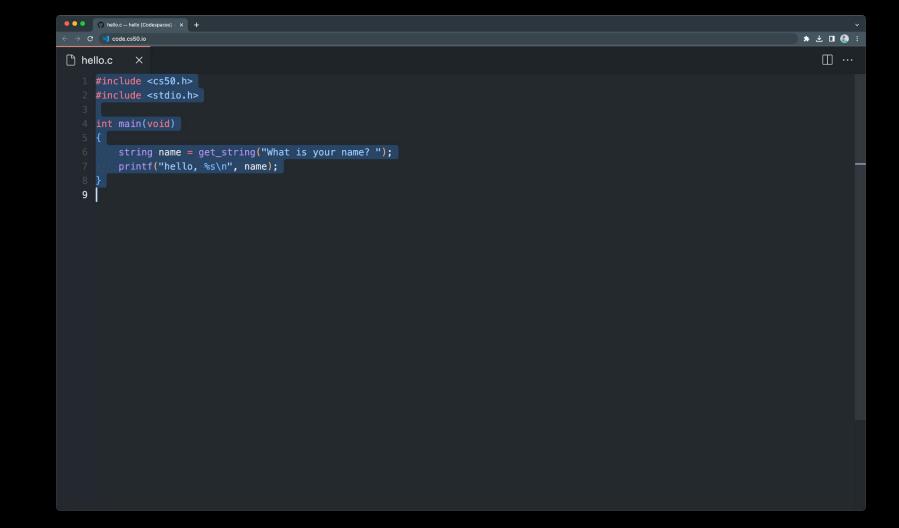
# Visual Studio Code for CS50

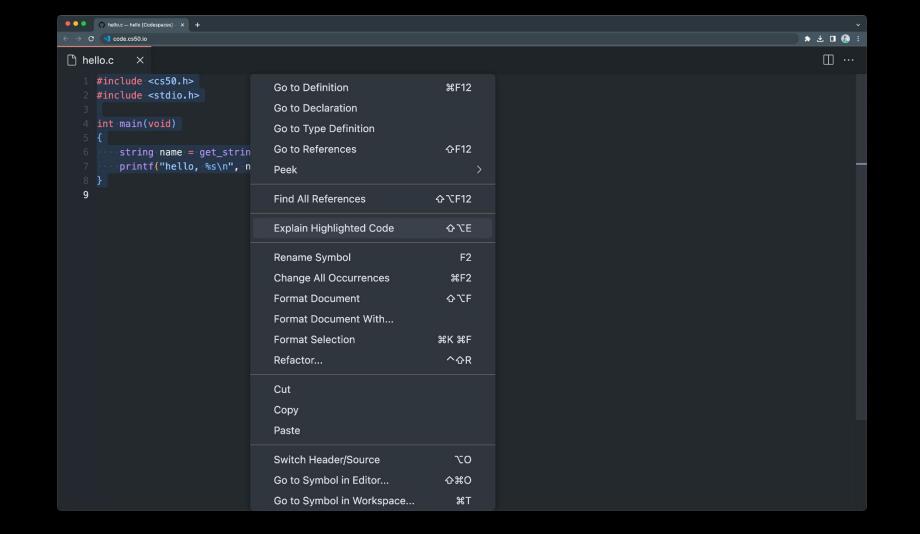
https://cs50.dev

Explains highlighted lines of code





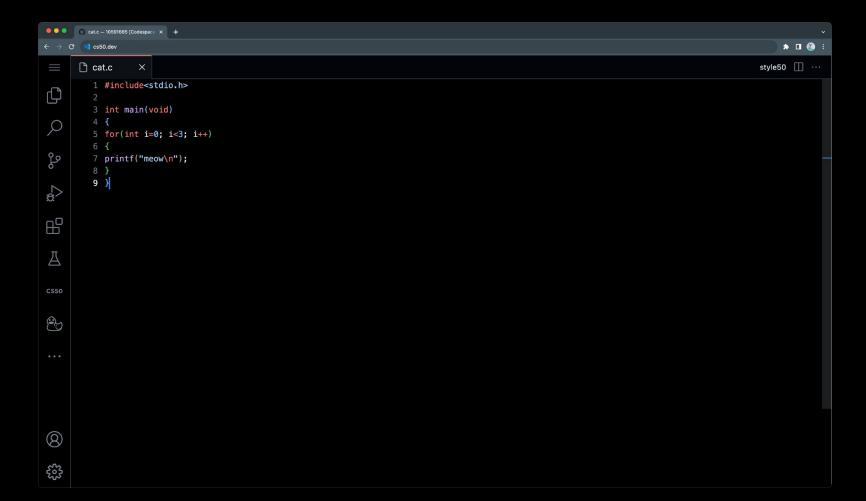


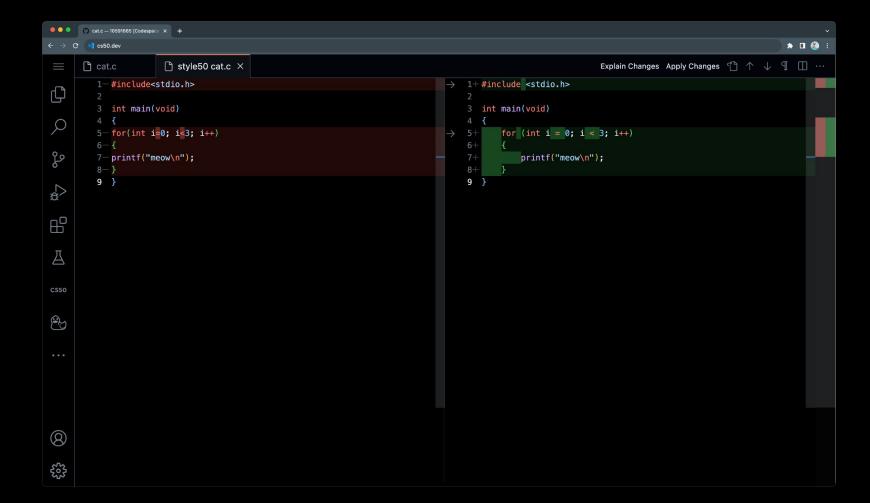


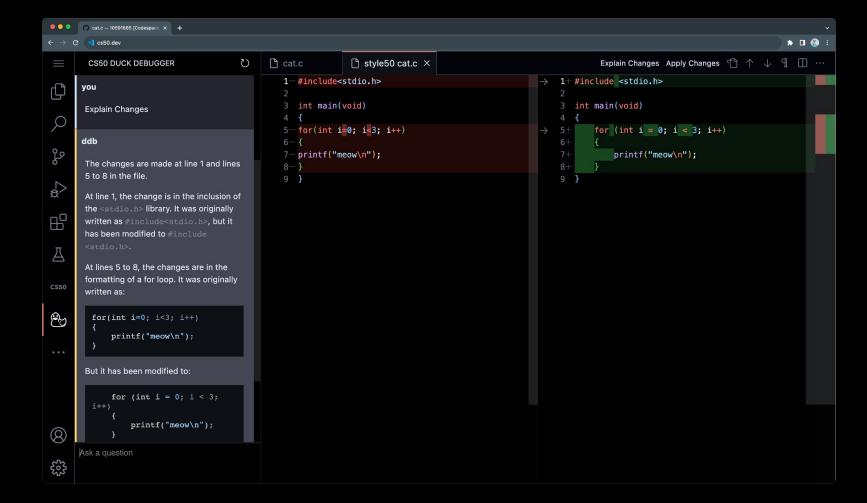
```
Code Analysis - hello.c — hello × +
← → C ≤ code.cs50.io
                                                                                                                                                    * 🕹 🗖 🚱 :
hello.c
                                                                                 Code Analysis - hello.c ×
      #include <cs50.h>
      #include <stdio.h>
                                                                                    #include <cs50.h>
                                                                                    #include <stdio.h>
      int main(void)
                                                                                    int main(void)
           string name = get_string("What is your name? ");
                                                                                         string name = get string("What is your name? ");
           printf("hello, %s\n", name);
                                                                                         printf("hello, %s\n", name);
   8 }
   9
                                                                                  This code snippet is a simple C program that asks the user for their name
                                                                                  and then greets them using their name. Let's break down the code step by
                                                                                  step:
                                                                                      1. #include <cs50.h>: This line includes the "cs50.h" header file,
                                                                                         which is a library developed by Harvard University for their CS50
                                                                                         course. This library provides some useful functions for input and
                                                                                        output, such as get string() which we will use later in the code.
                                                                                      2. #include <stdio.h>: This line includes the "stdio.h" header file.
                                                                                         which is a standard C library for input and output operations. It
                                                                                        provides the printf() function that we will use to print the greeting
                                                                                        message.
                                                                                      3. int main(void): This line defines the main function of the program.
                                                                                        In C, the main function is the entry point of the program, where the
                                                                                         execution starts. The int keyword indicates that the main function
                                                                                        returns an integer value, and the void keyword inside the
                                                                                         parentheses means that the main function takes no arguments.
                                                                                      4. Inside the main function, we have the following lines of code:
```

Advises students on

how to improve their code's style







# asked online by students

Answers (most of the) questions





What is flask exactly?

Comment Edit Delete Endorse · · ·



### CS50 Duck BOT







Flask is a micro web framework written in Python. It is classified as a microframework because it does not require particular tools or libraries, it has no database abstraction layer, form validation, or any other components where pre-existing third-party libraries provide common functions.

Comment Edit Delete Unendorse · · ·





For the Caesar problem, I would like to pass only one argument to the main function. However, I get an interesting error when I try this:

```
caesar.c:11:5: error: only one parameter on 'main' declaration [-Werror,-Wmain]
```

If I follow the lecture and add two variables, this code runs. But it seems inefficient, given that one variable is not utilised. I note that there are certain coding "standards" that govern this behaviour, but I'm not sure that I understand the rationale here.

Is there a more efficient way to write this code?

Comment Edit Delete Endorse · · ·





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Comment Edit Delete Endorse · · ·





3

It seems like you're trying to declare the main function with only one parameter. However, in C, the main function should have either zero parameters or two parameters, which are int argc and char \*argv[]. The first parameter, argc, represents the number of command-line arguments, and the second parameter, argv, is an array of strings representing each of those arguments.

For the Caesar problem, you'll want to use these parameters to access the command-line argument that represents the key. To do this, you should declare your main function as follows:

```
int main(int argc, char *argv[])
{
    // Your code here
}
```

Then, you can check if the user has provided the correct number of arguments (in this case, just one additional argument for the key) and handle the input accordingly.

P.S. I am an experimental bot. Quack. Do not assume that my reply is accurate unless you see that it's been "endorsed" by (human) staff. Quack.

Comment Edit Delete Unendorse ···





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Comment Edit Delete Unendorse · · ·







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Comment Edit Delete Unendorse · · ·

Explains arcane error messages,

hints how to solve

i Having trouble with a command?

23

Dismiss

Source: CS50 Duck (Extension)

Ask for Help

# Provides students with virtual office hours 24/7

# CS50.ai

https://cs50.ai



### ddb

Quack. I am CS50's duck debugger (ddb), an experimental AI for <u>rubberducking</u>. Quack. My replies might not always be accurate, so always think critically and let me know if you think that I've erred. Conversations are logged for debugging's sake. Quack.



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### you

My code is not working as expected, any ideas?

```
x = input("Give me an integer x: ")
y = input("Give me an integer y: ")
sum = x + y
print("x + y is: " + sum)
```



### ddb

Quack. I am CS50's duck debugger (ddb), an experimental AI for <u>rubberducking</u>. Quack. My replies might not always be accurate, so always think critically and let me know if you think that I've erred. Conversations are logged for debugging's sake. Quack.

### you

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```
x = input("Give me an integer x: ")
y = input("Give me an integer y: ")
sum = x + y
print("x + y is: " + sum)
```

### ddb

It seems like you're trying to add two integers, but the input() function in Python returns a string. So, when you try to add x and y, you're actually concatenating two strings, not adding two integers.

To fix this, you can convert the inputs to integers using the int() function like so:

```
x = int(input("Give me an integer x: "))
y = int(input("Give me an integer y: "))
```

Approximates a 1:1 teacher-to-student ratio

### ... felt like having a personal tutor...

Al bots will answer questions without ego and

... felt like having a personal tutor... i love how

without judgment,

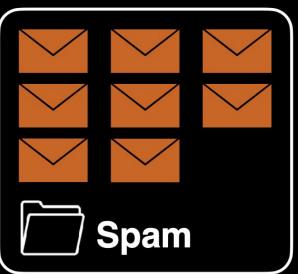
... felt like having a personal tutor... i love how Al bots will answer questions without ego and without judgment, generally entertaining even the stupidest of questions without treating them like they're stupid.

... felt like having a personal tutor... i love how Al bots will answer questions without ego and without judgment, generally entertaining even the stupidest of questions without treating them like they're stupid. it has an, as one could expect, inhuman level of patience.

generative artificial intelligence

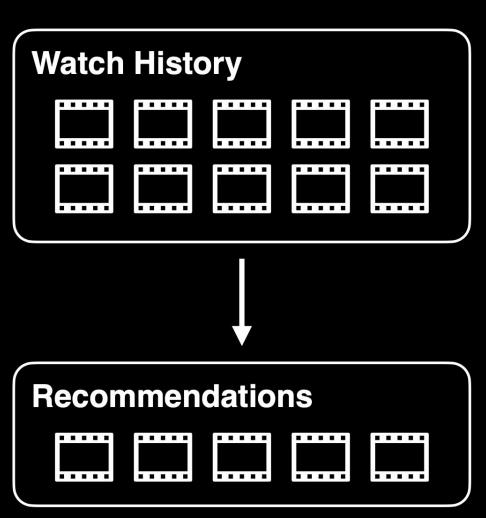
artificial intelligence





## Hello, world!

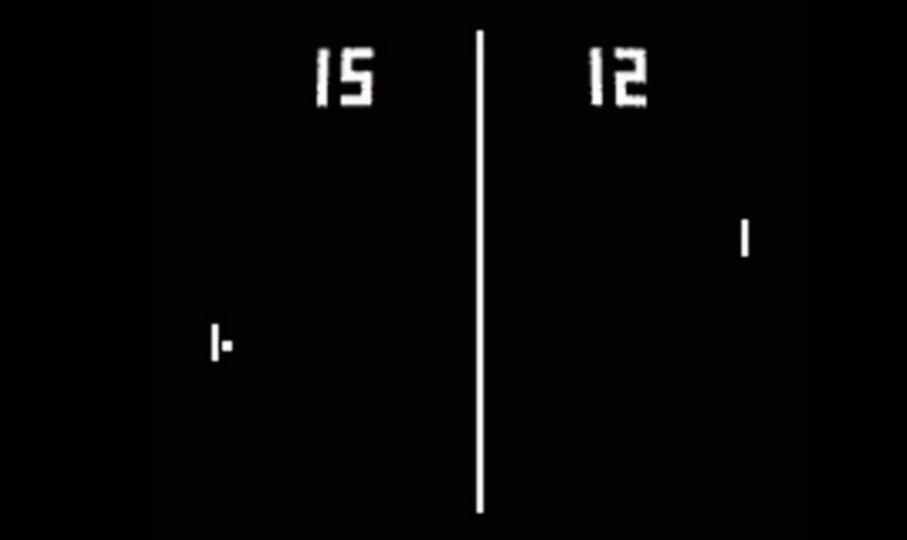
Hello, world!















## decision trees

Is ball left of paddle?

# Is ball left of paddle?

Is ball left of paddle?

Yes

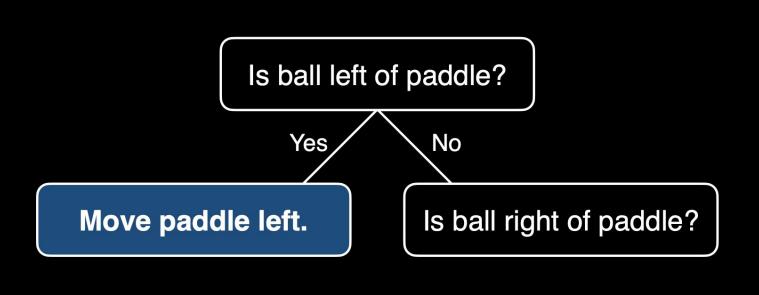
Move paddle left.

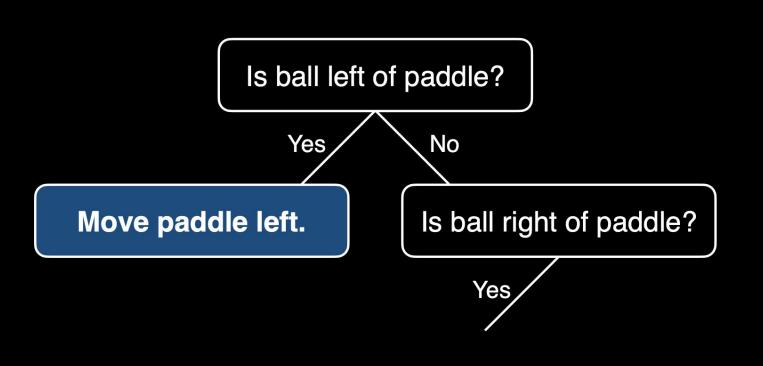
Is ball left of paddle?

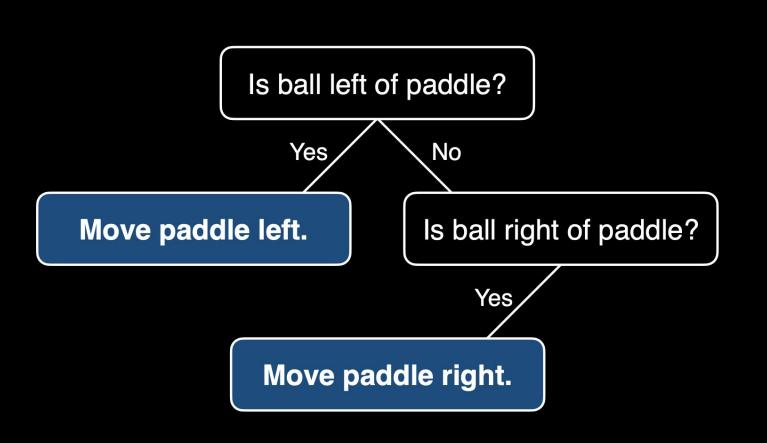
Yes

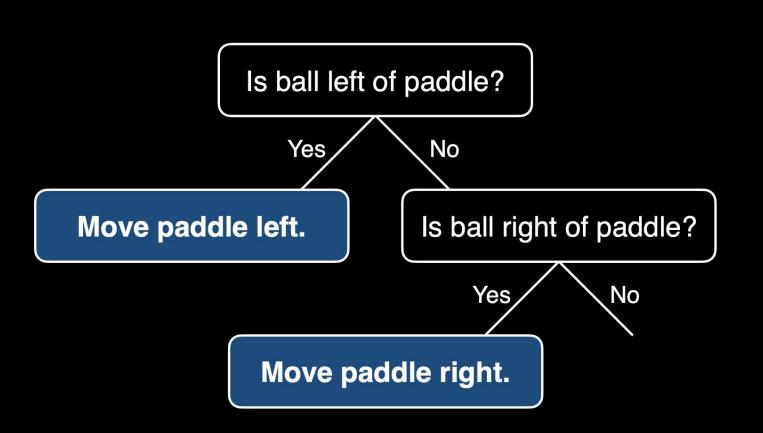
No

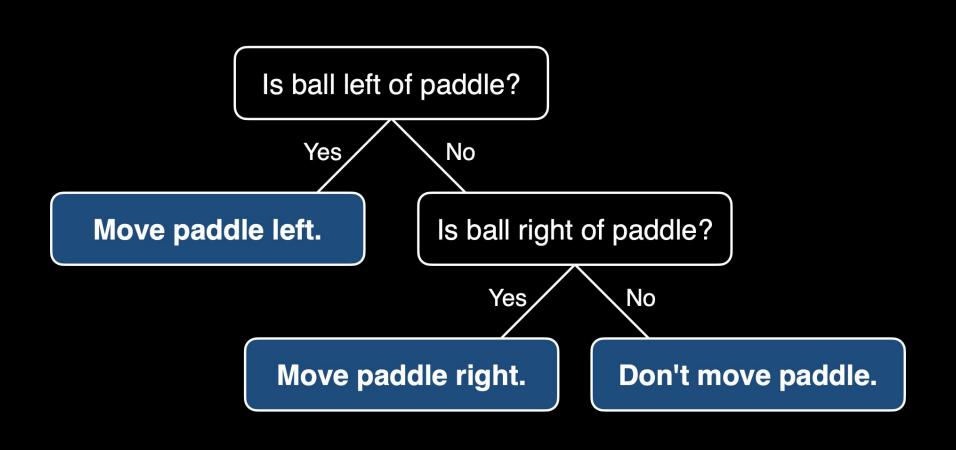
Move paddle left.

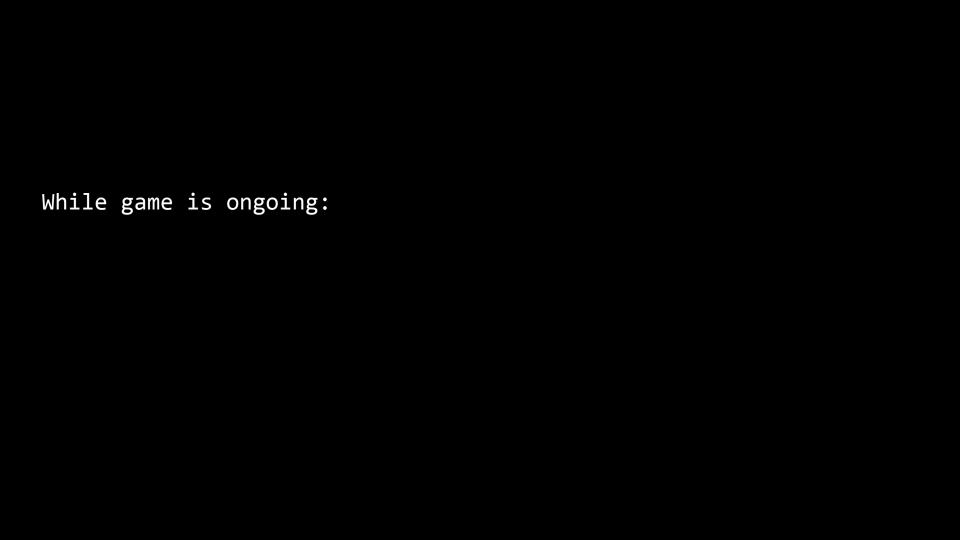












While game is ongoing:

Move paddle left

If ball is left of paddle:

		O	O	
Move r	addle r	right		
		-6		

While game is ongoing:

Move paddle left

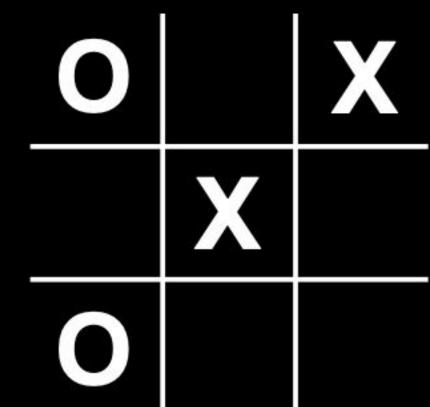
If ball is left of paddle:

Else if ball is right of padding:

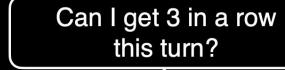
```
While game is ongoing:
   If ball is left of paddle:
      Move paddle left
   Else if ball is right of padding:
      Move paddle right
```

Else:

Don't move paddle



## Can I get 3 in a row this turn?

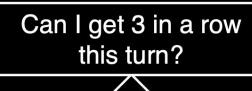


Yes

Can I get 3 in a row this turn?

Yes

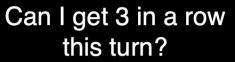
Play in square to get 3 in a row.



No

Yes

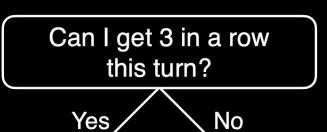
Play in square to get 3 in a row.



Yes No

Play in square to get 3 in a row.

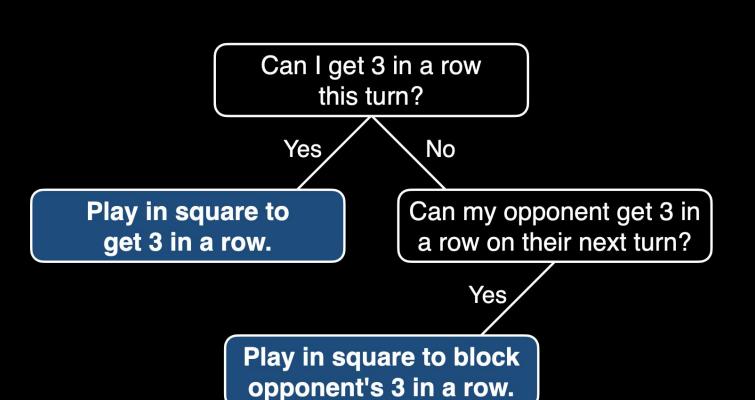
Can my opponent get 3 in a row on their next turn?

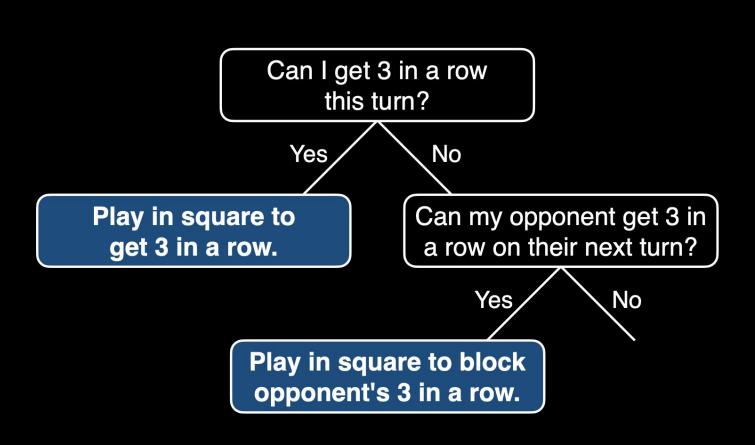


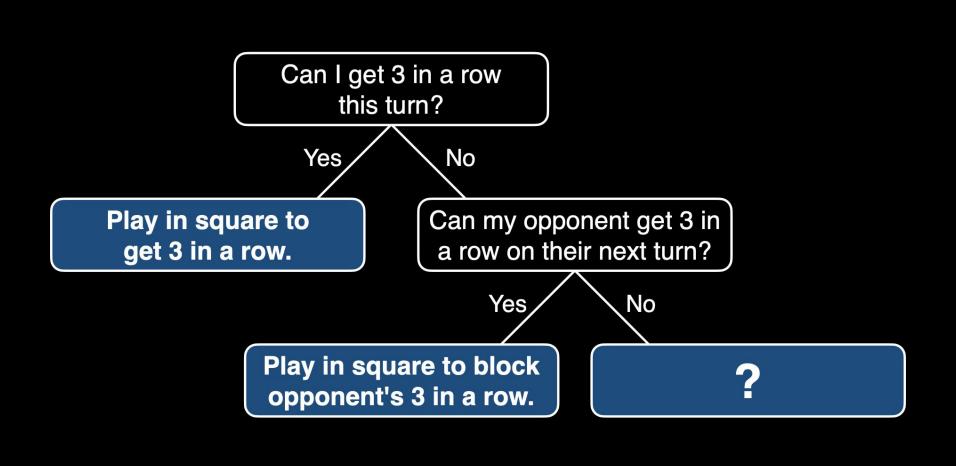
Play in square to get 3 in a row.

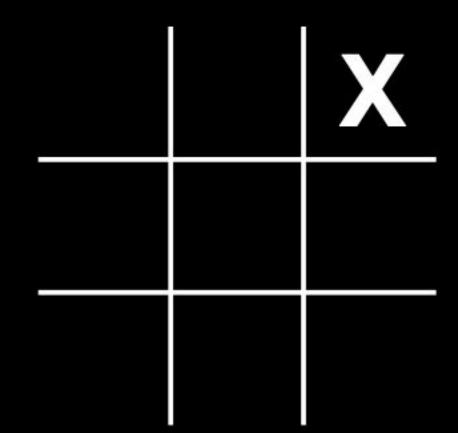
Can my opponent get 3 in a row on their next turn?

Yes









## Why Al is Good at Games

**Inputs and outputs** that can be represented mathematically.

A goal in the form of a function to maximize/minimize.

#### minimax

0	X	X	X	0	X	0		X
0	0		0	0	X		X	0
0	X	X	X	X	0	X	0	X

0	X	X	X	0	X	0		X
0	0		0	0	X		X	0
0	X	X	X	X	0	X	0	X

0

-1

MAX (X) aims to maximize score.

MIN (O) aims to minimize score.

0	X	X	X	0	X			X
0	0		0	0	X		X	0
0	X	X	X	X	0	X	0	X

1 0

 O
 X
 O

 O
 X
 X

 X
 X
 O



VALUE: 1

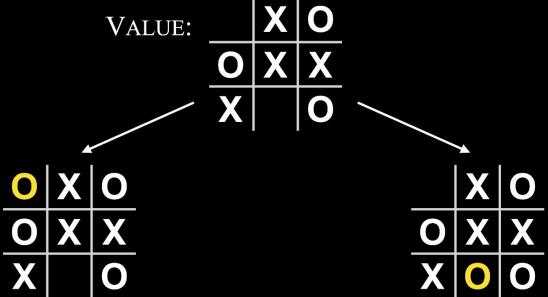
	X	0
0	X	X
X		0

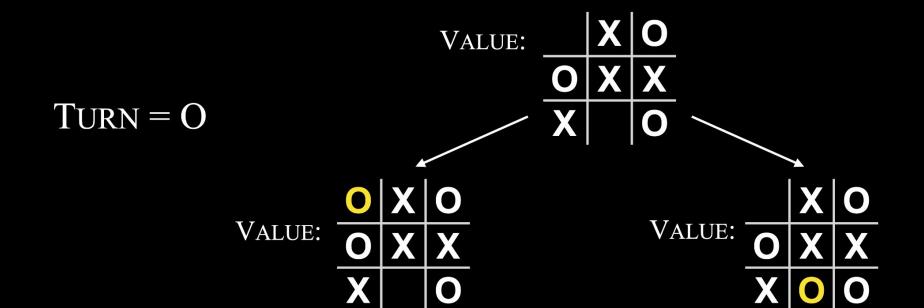
TURN = O

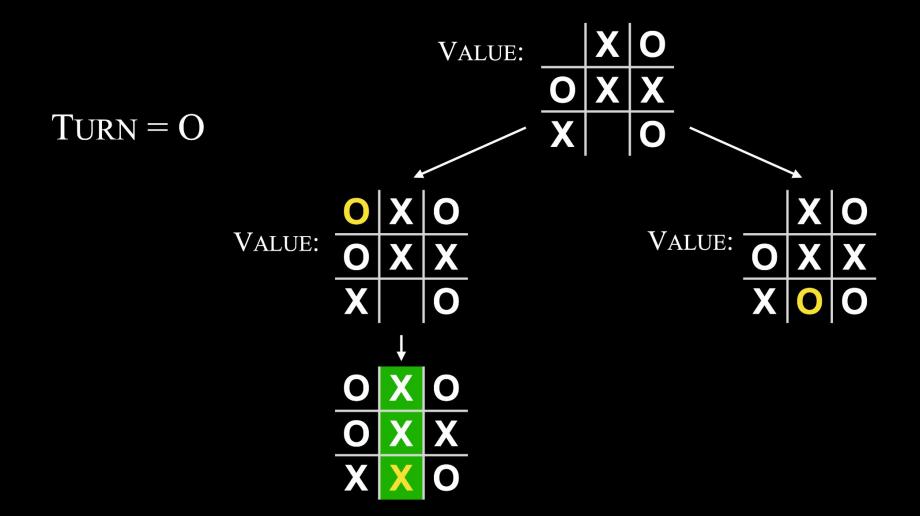
	X	0
0	X	X
X		0

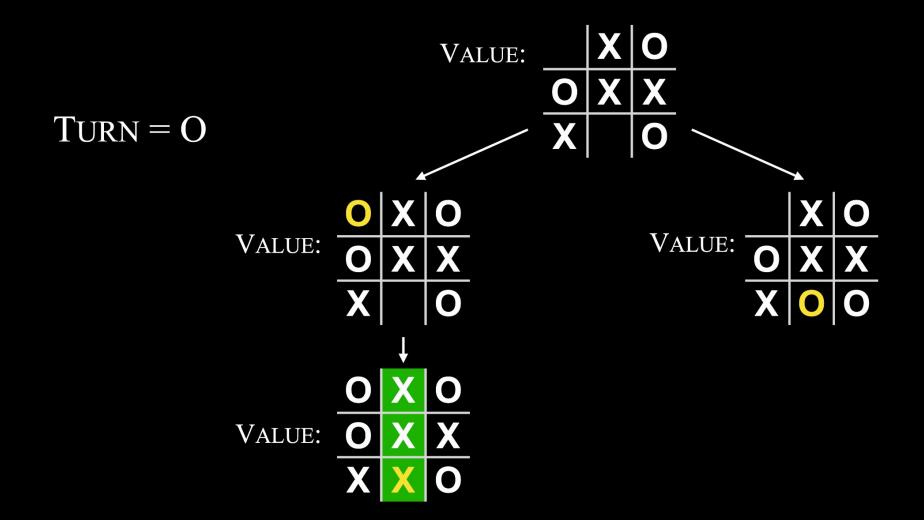
TURN = O

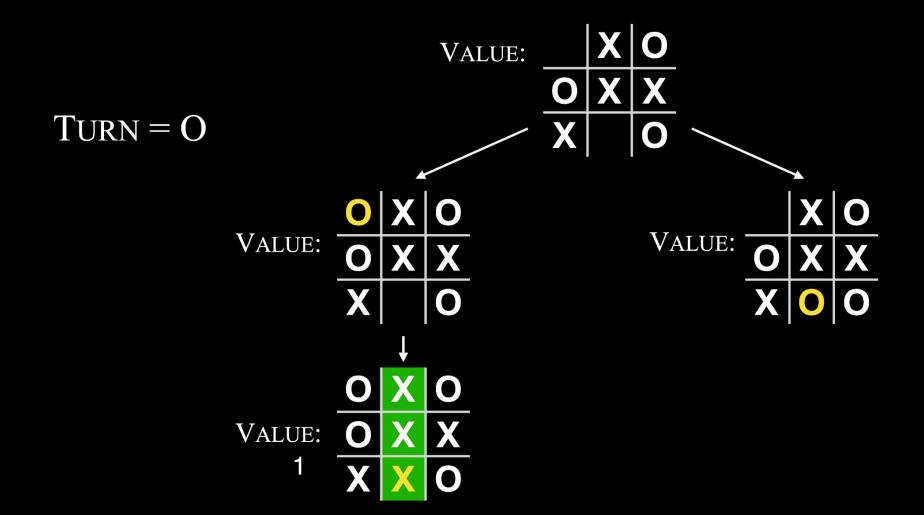
TURN = O

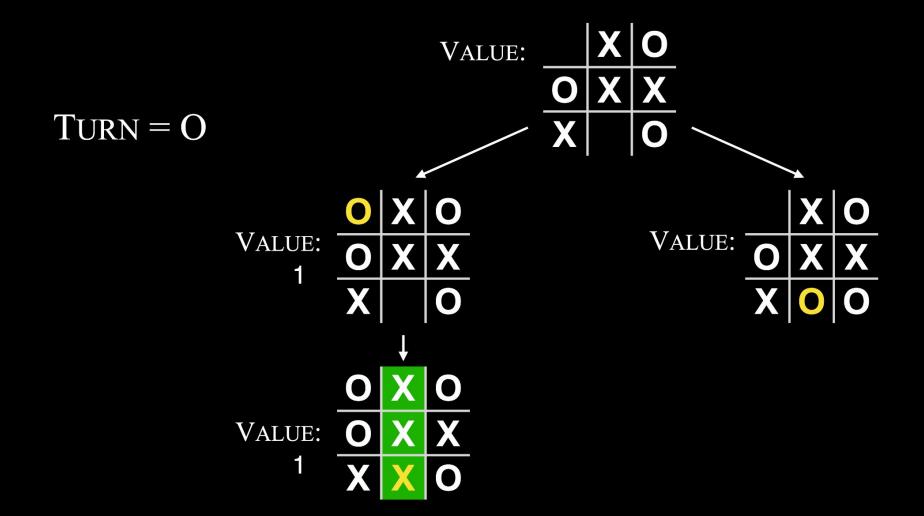


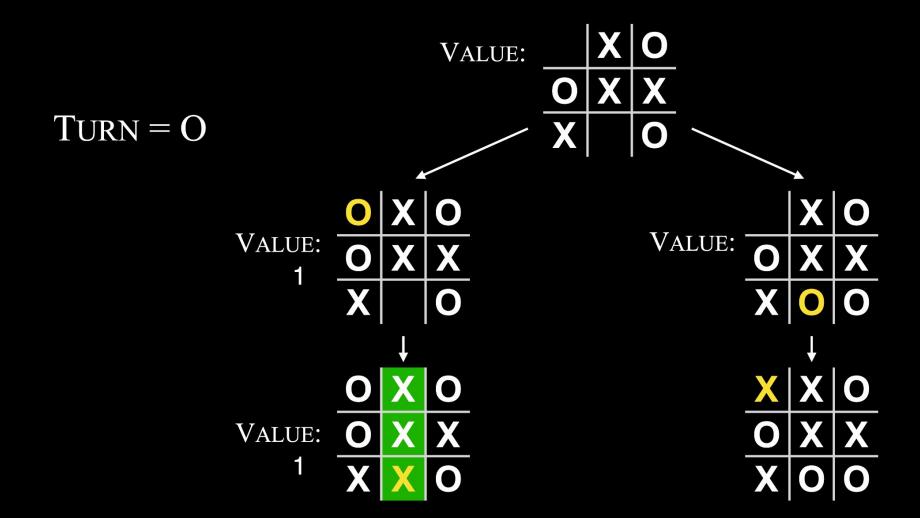


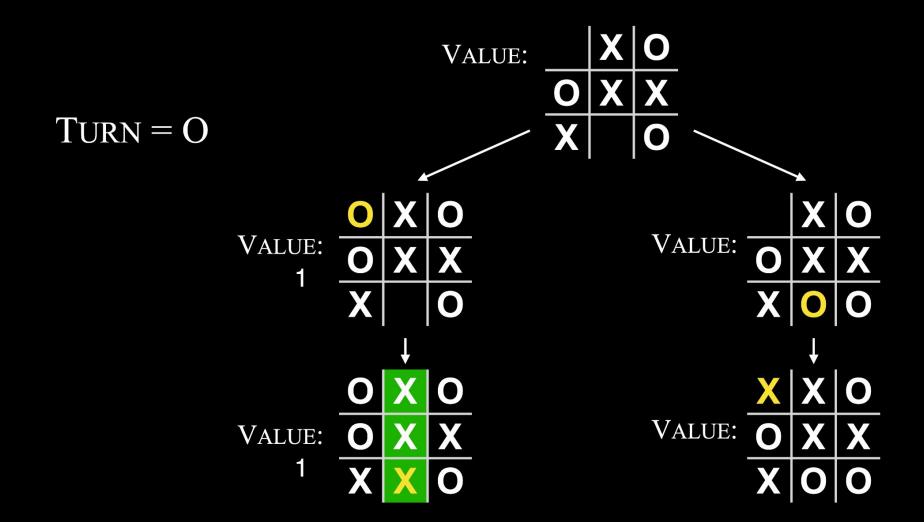


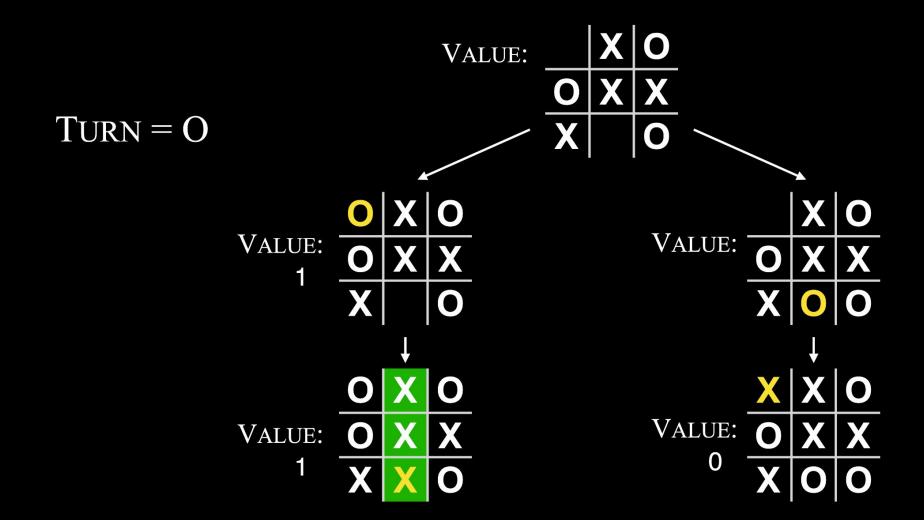


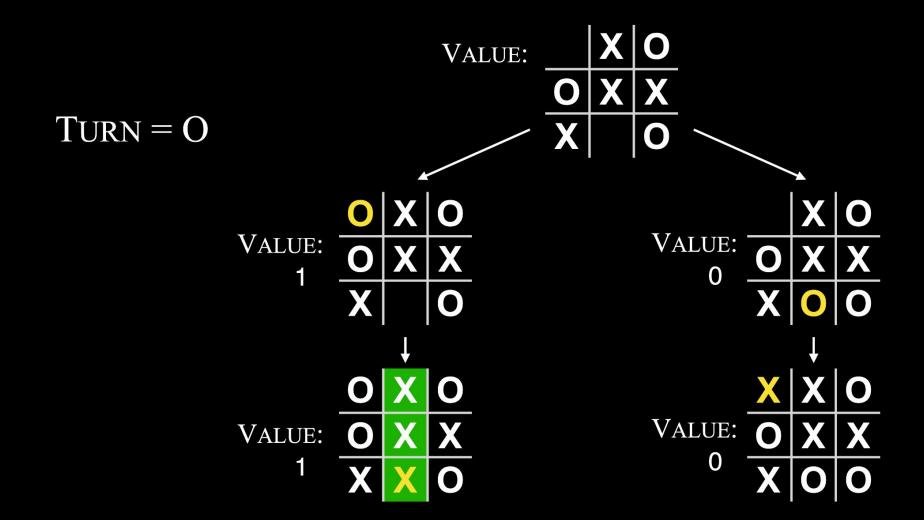


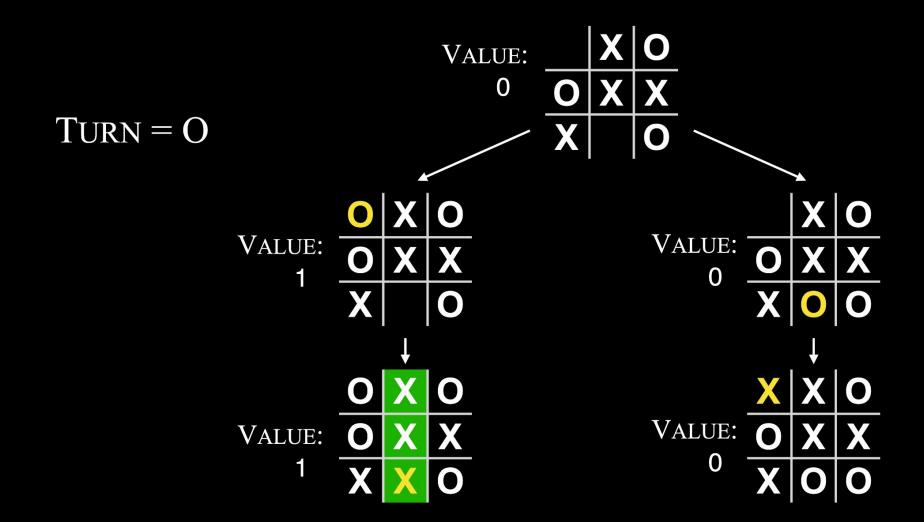


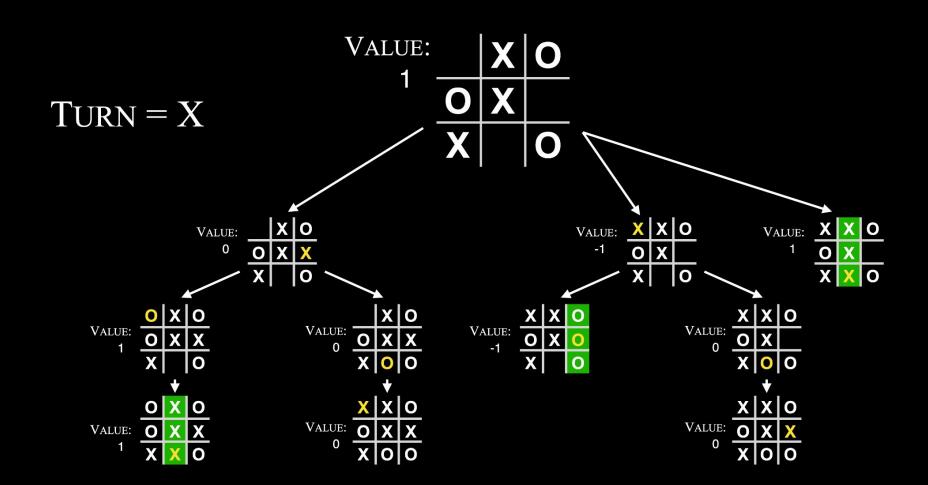












If player is X:

For each possible move:

Calculate score for board

Choose move with highest score

```
If player is X:
   For each possible move:
      Calculate score for board
   Choose move with highest score
```

Calculate score for board

Choose move with lowest score

Else if player is 0:

For each possible move:

Tic-Tac-Toe

All possible games

Tic-Tac-Toe

All possible games

255,168

Tic-Tac-Toe

All possible games

255,168

#### Chess

First 4 moves only

Tic-Tac-Toe

All possible games

255,168

Chess

First 4 moves only

288 million

Tic-Tac-Toe

All possible games

255,168

Chess

First 4 moves only

288 million

Go

First 4 moves only

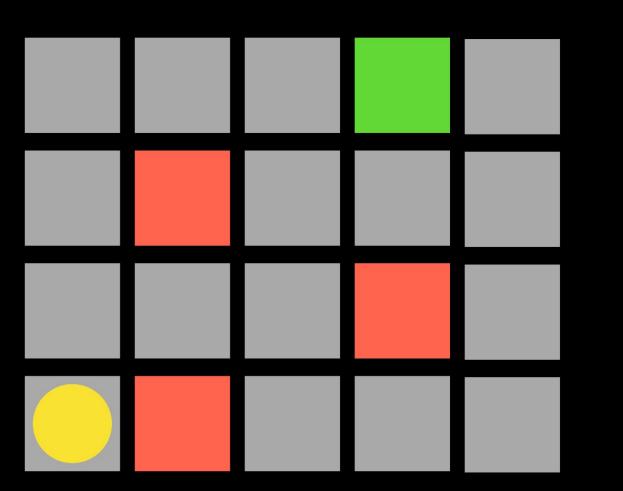
266 quintillion

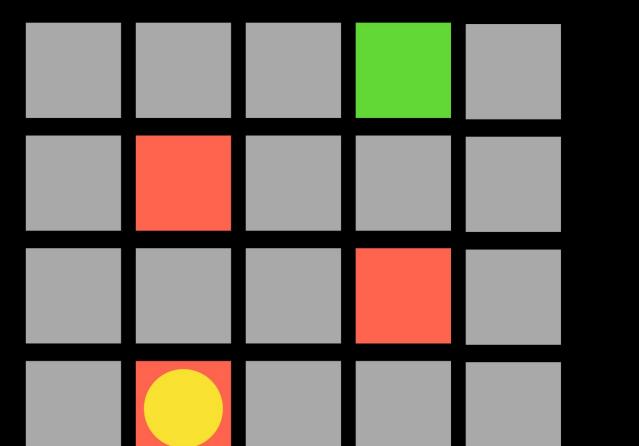
# machine learning

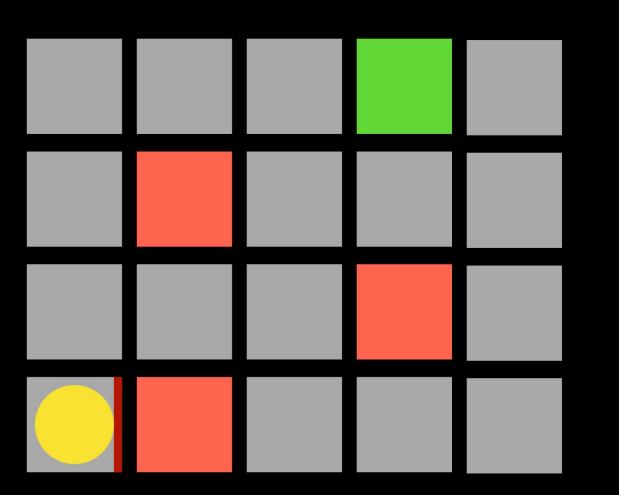
reinforcement learning

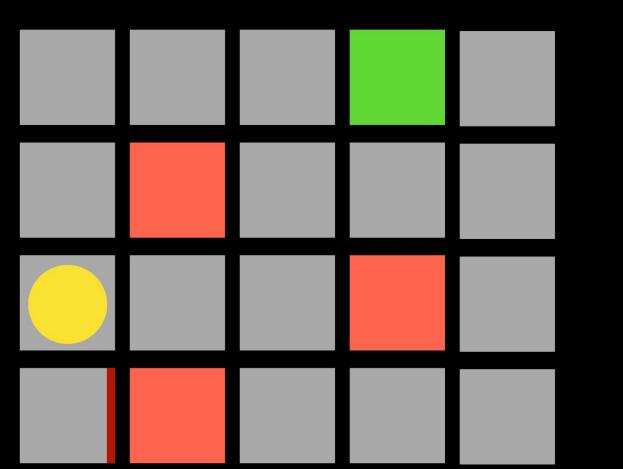


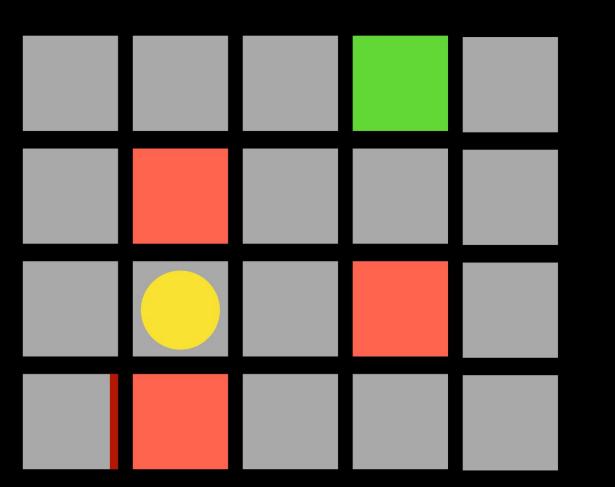


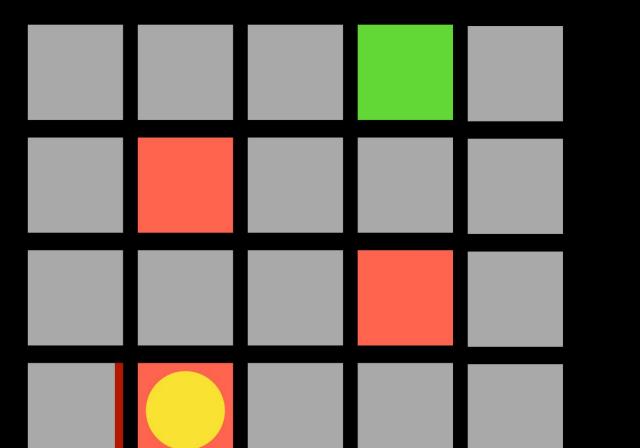


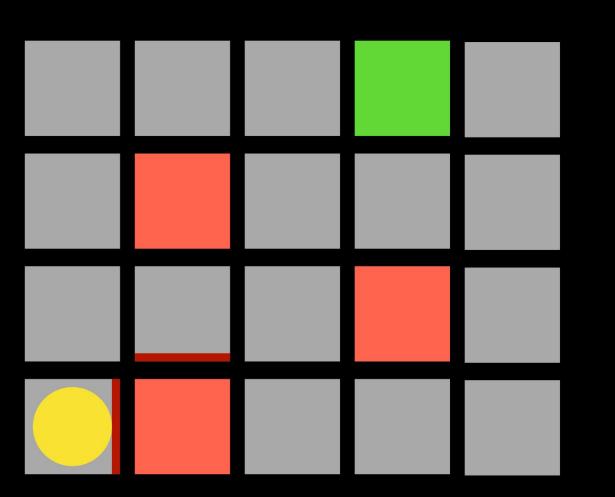


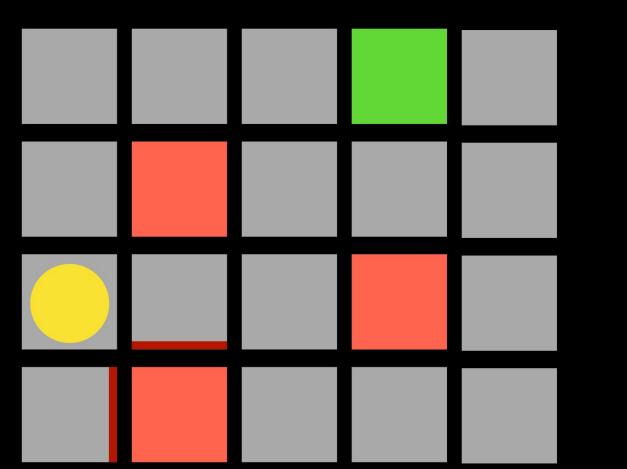


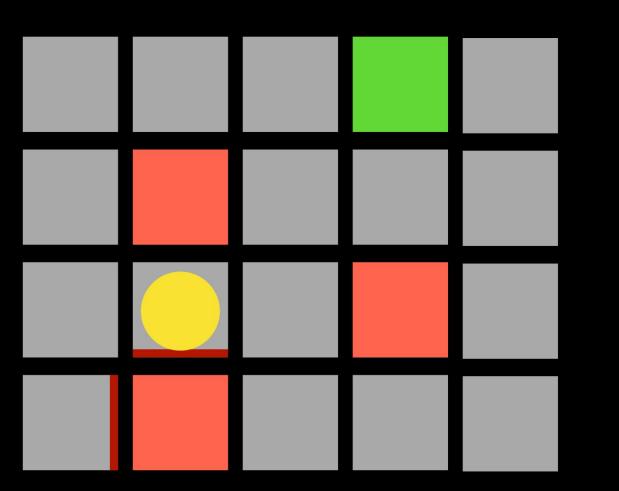


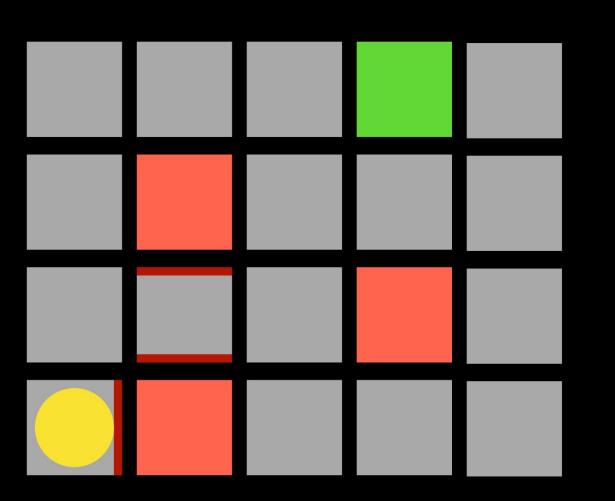


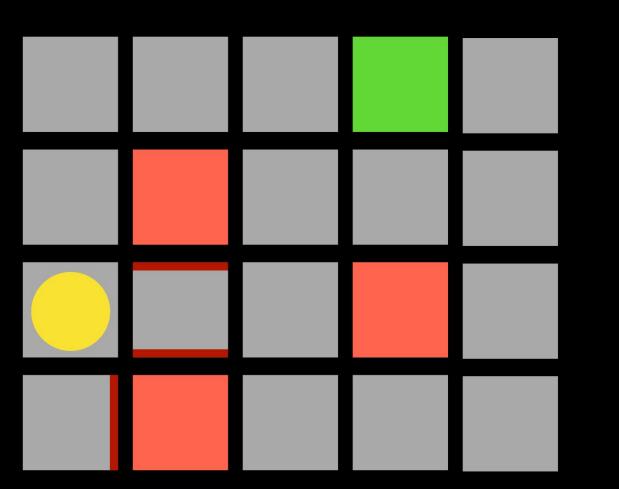


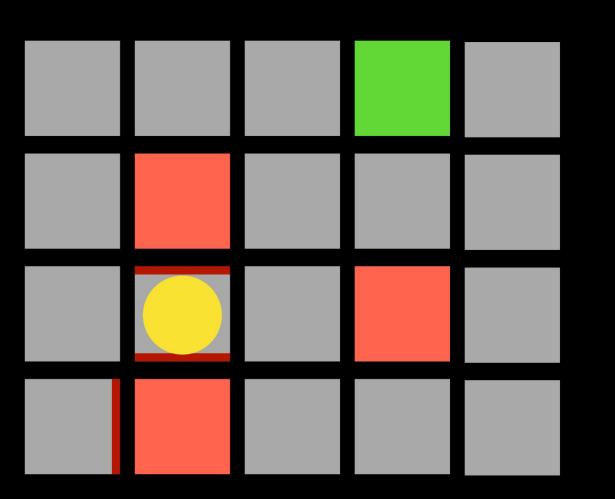


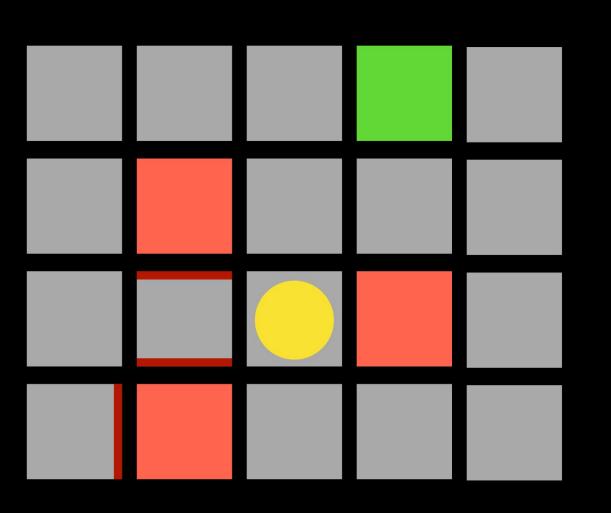


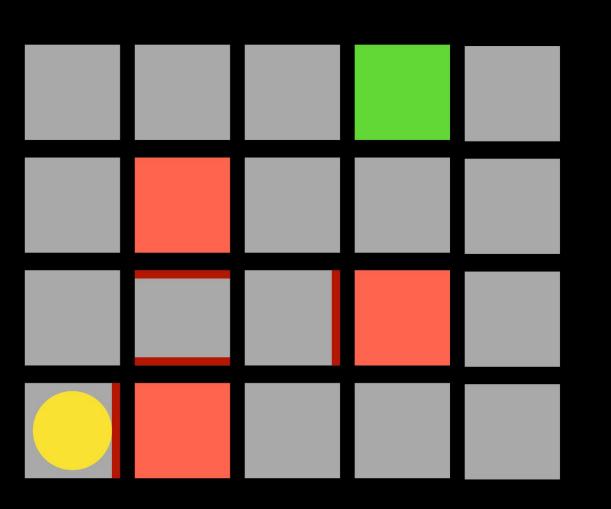


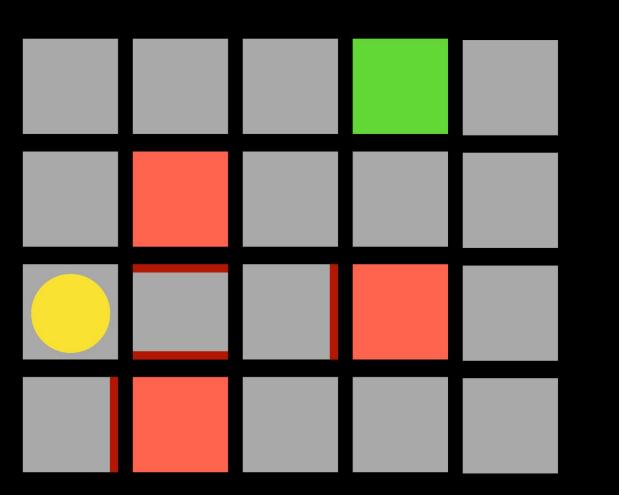


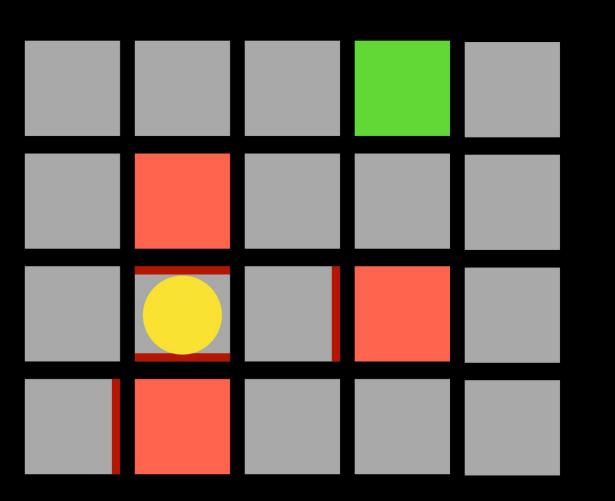


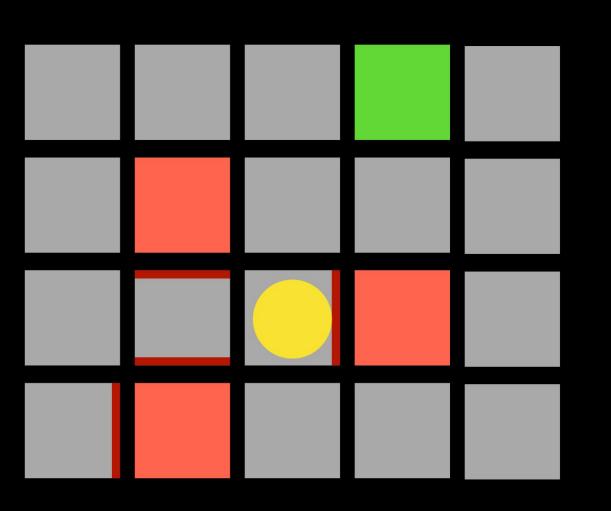


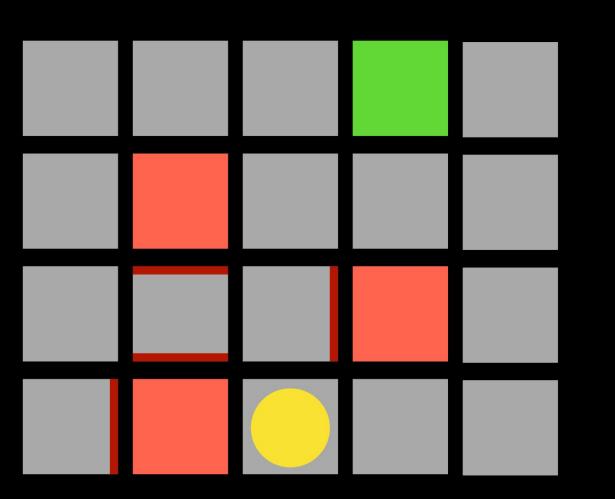


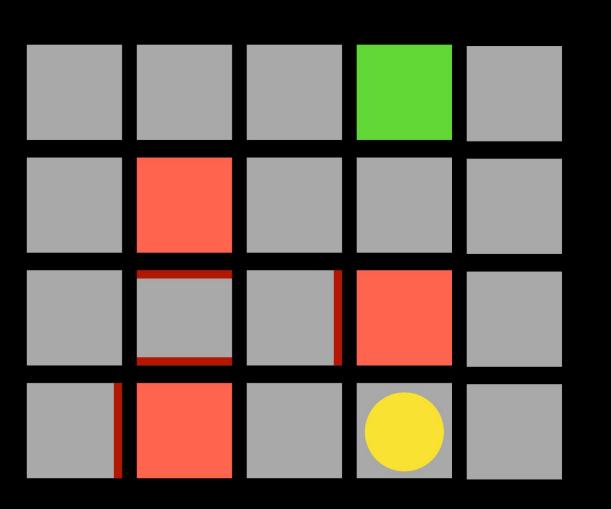


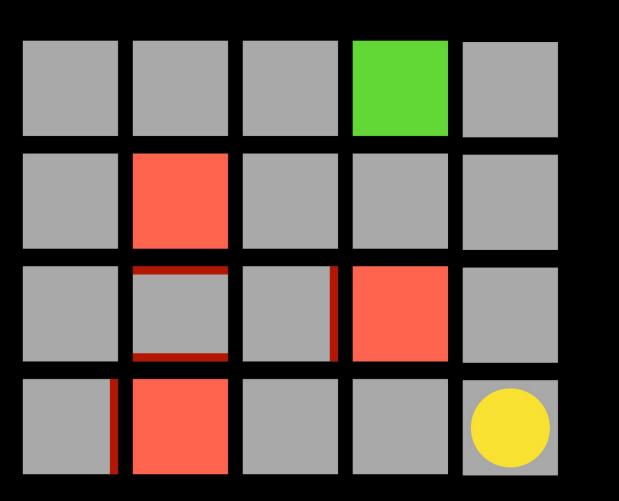


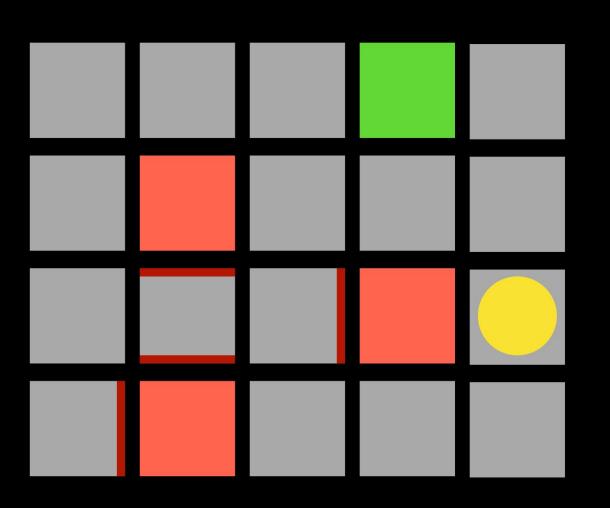


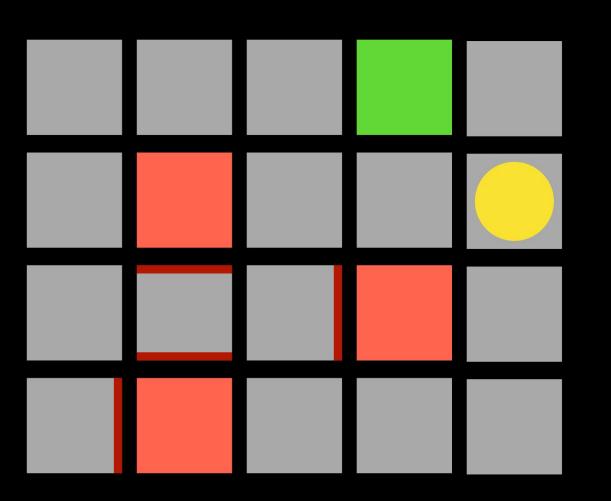


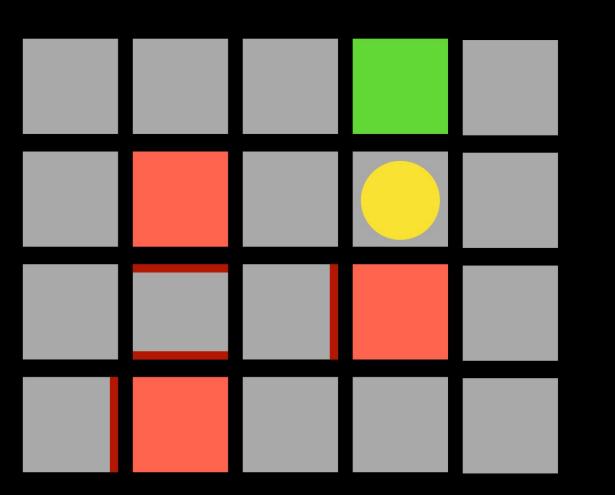


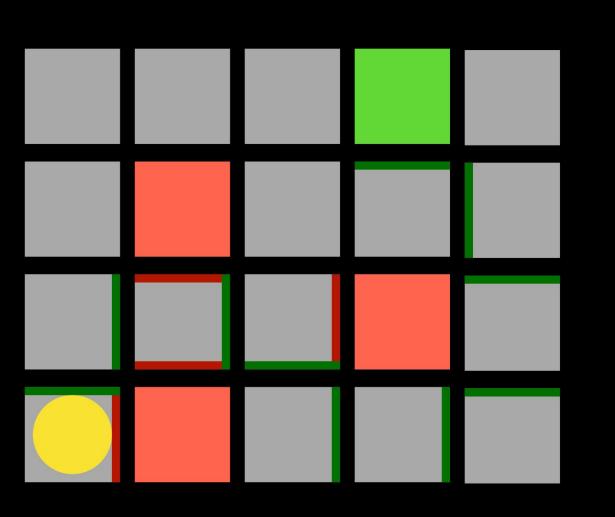


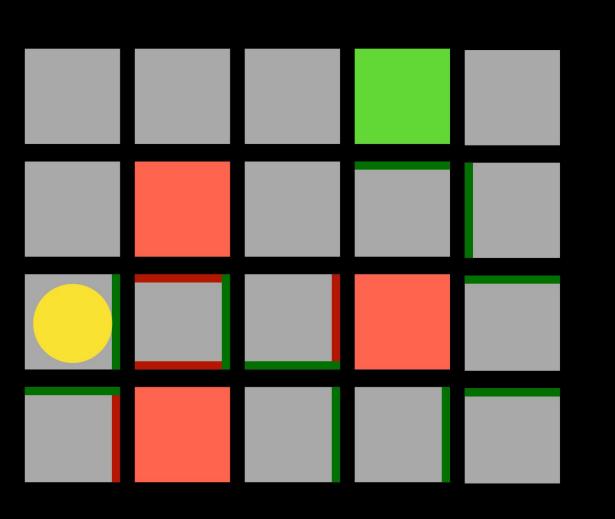


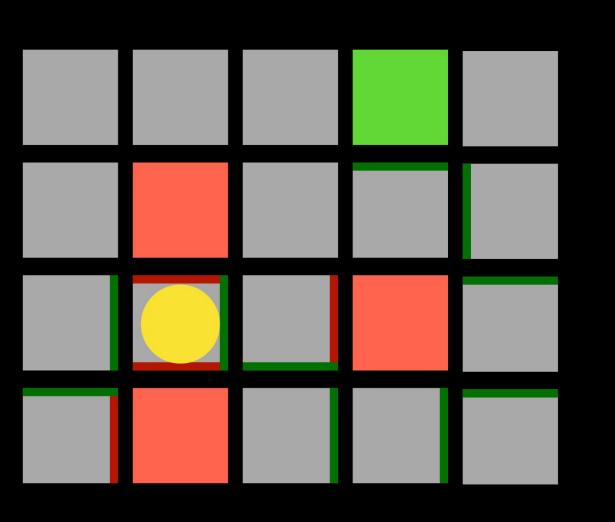


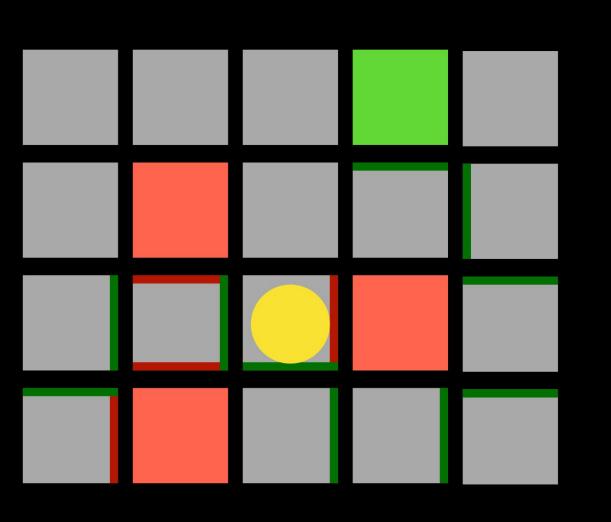


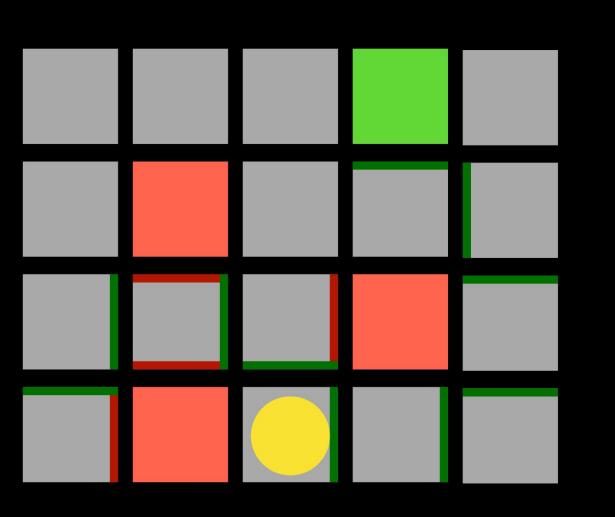


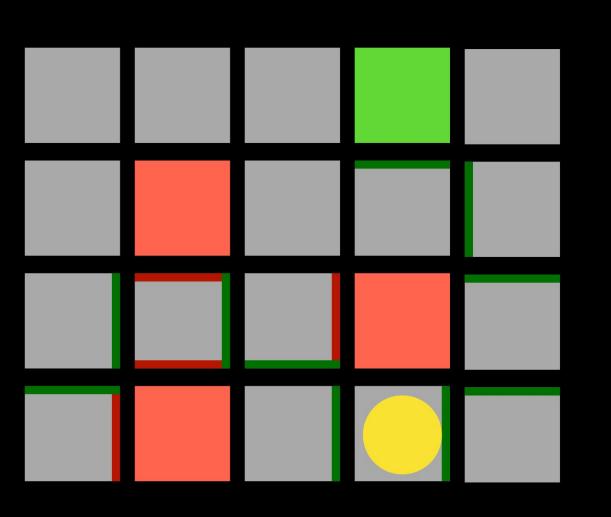


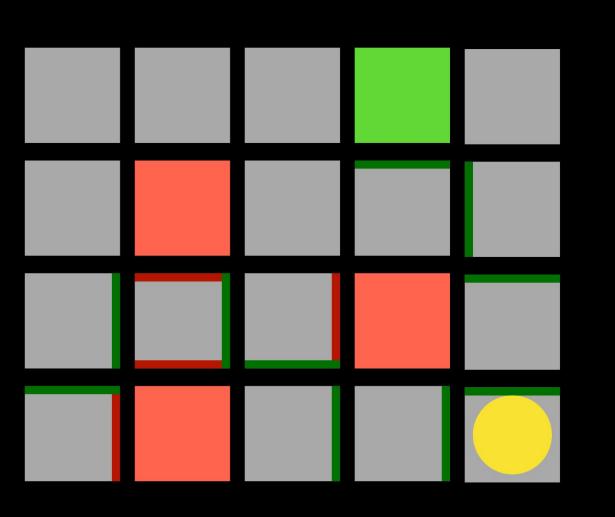


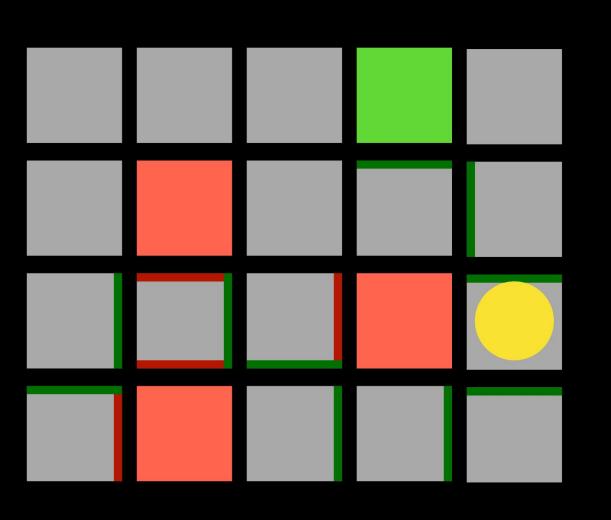


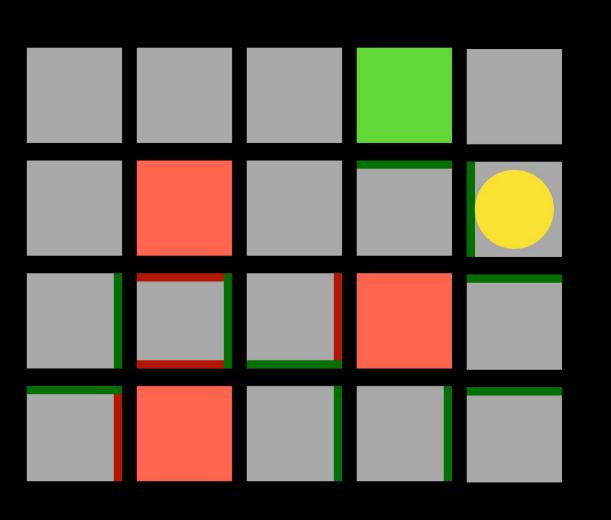


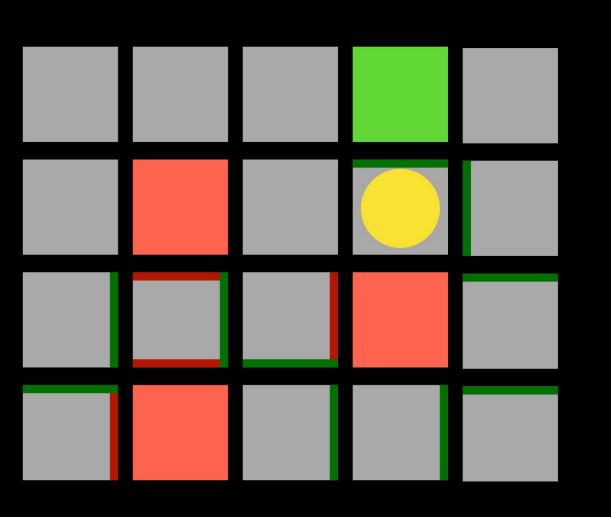


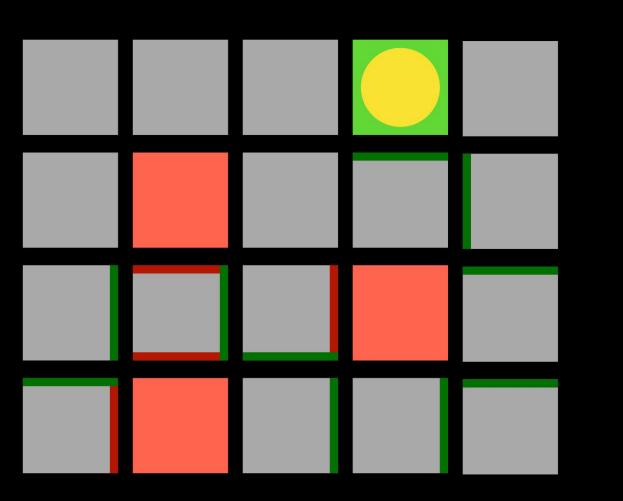








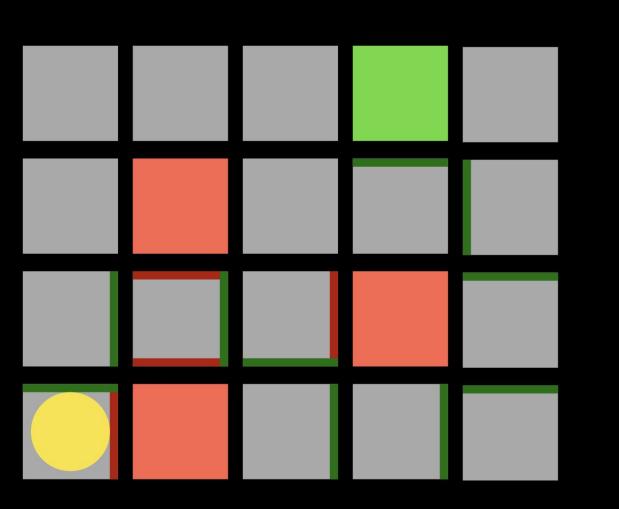


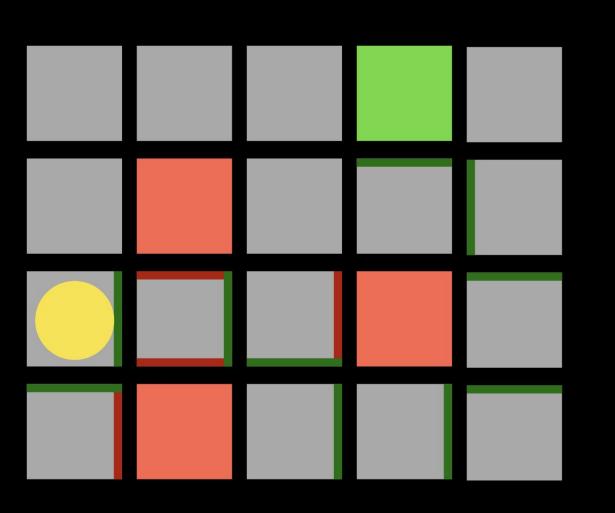


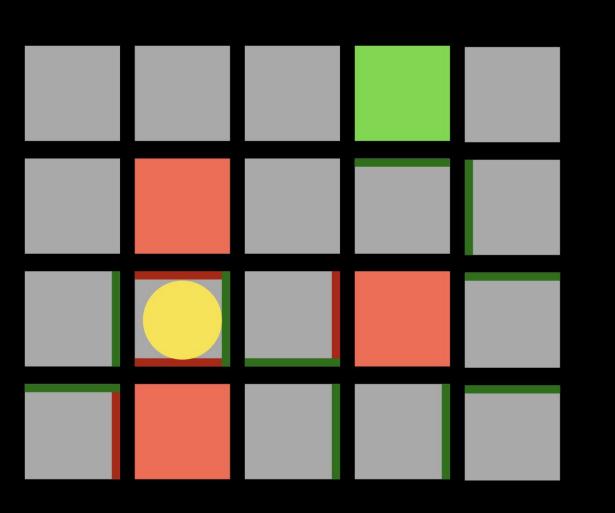
## explore vs. exploit

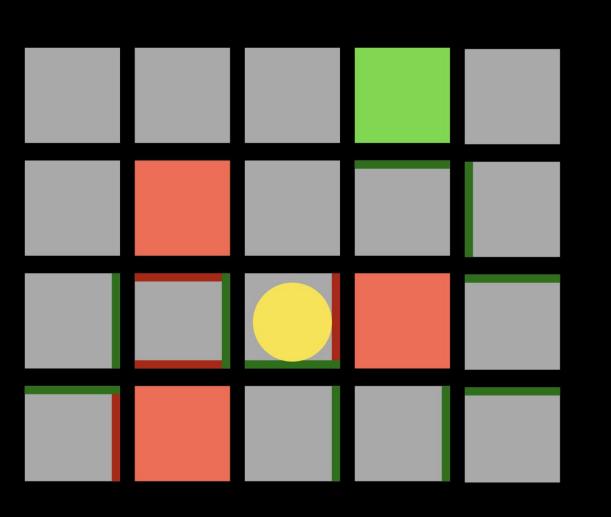
```
If random() < epsilon:
   Make a random move
Else:
   Make the move with the highest value</pre>
```

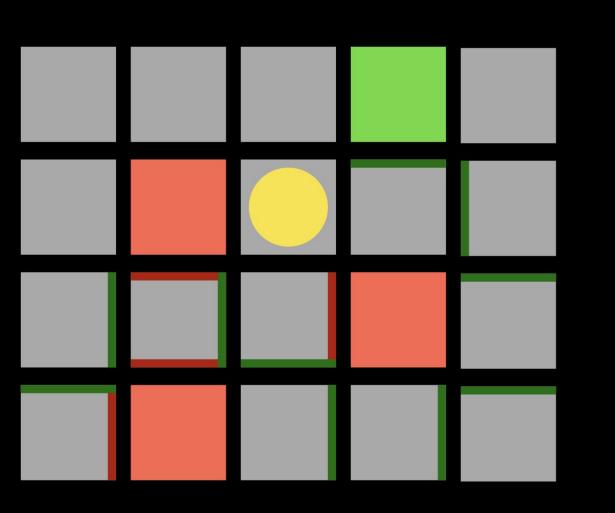
epsilon = 0.10

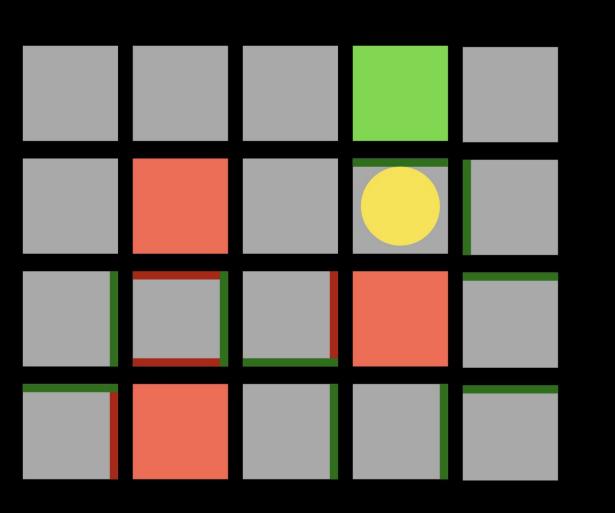


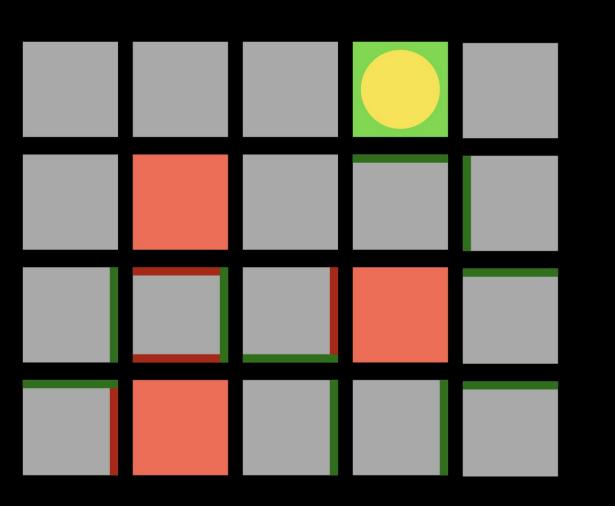






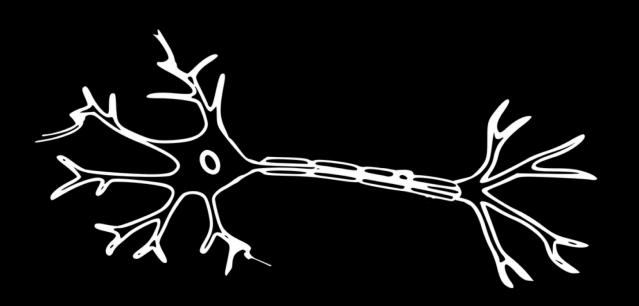


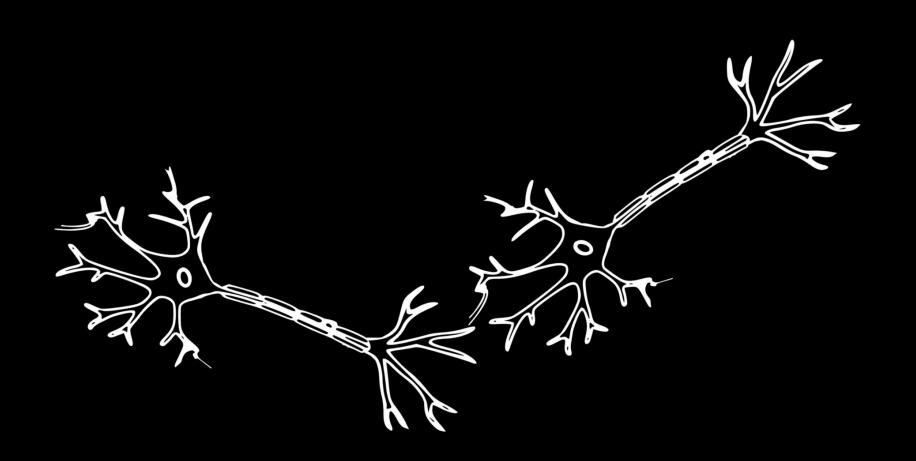


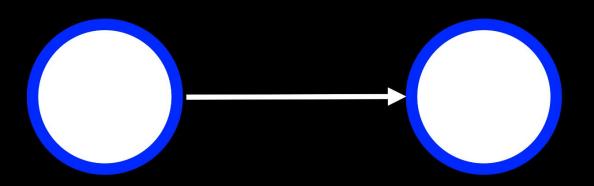


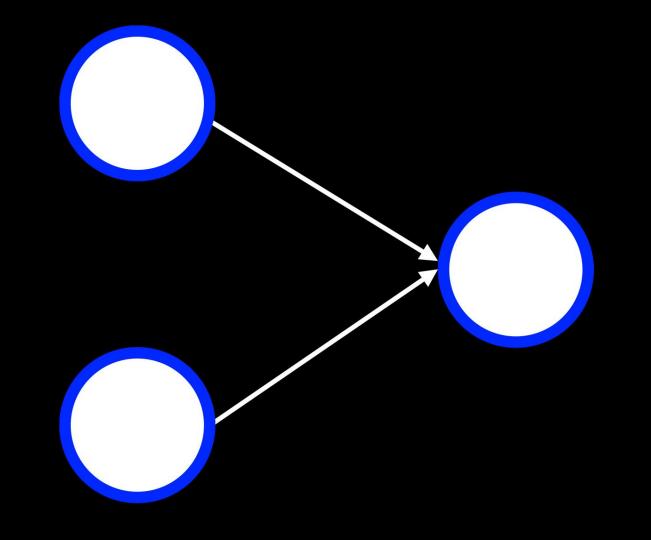
deep learning

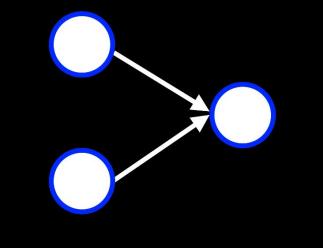
# neural networks

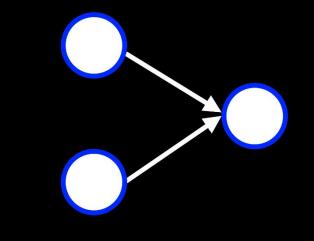


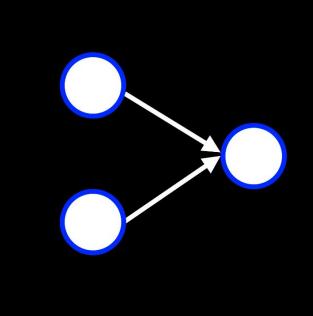


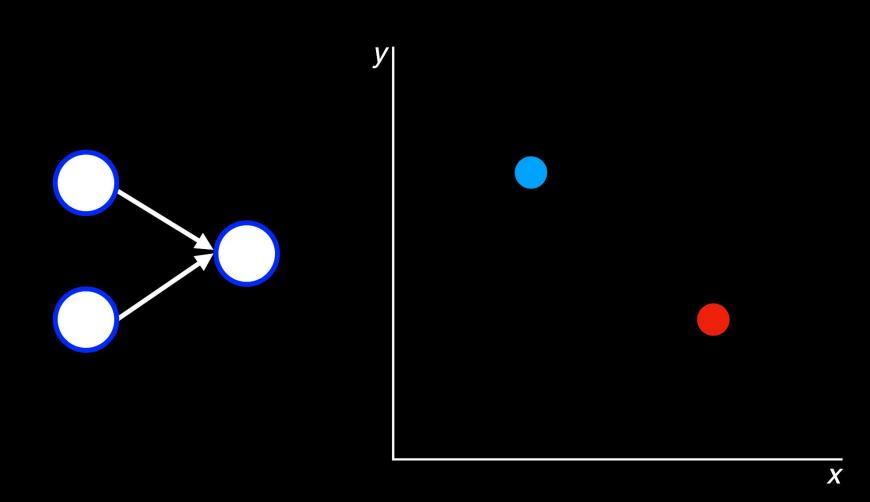


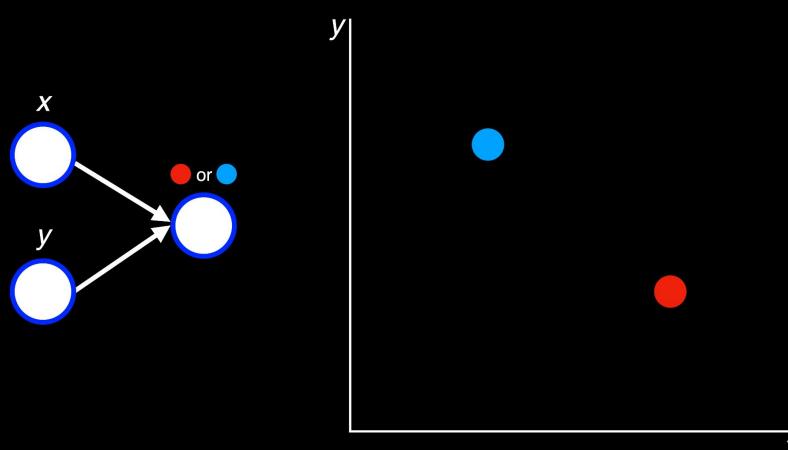


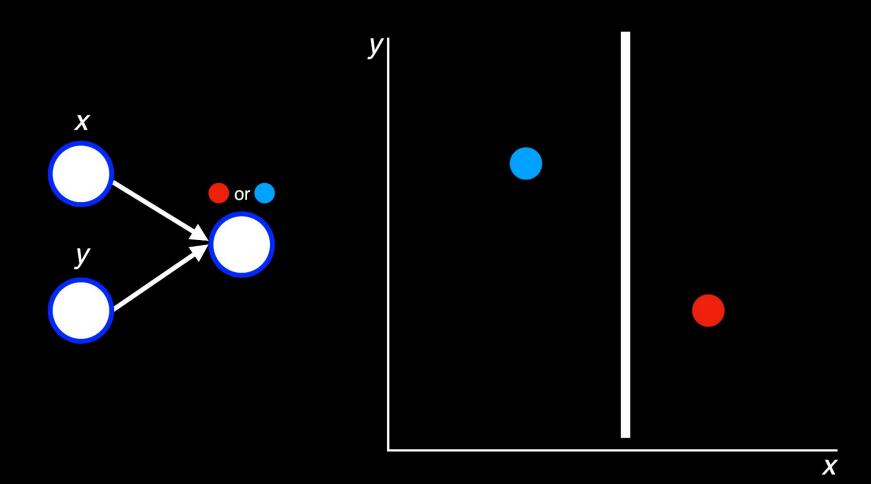


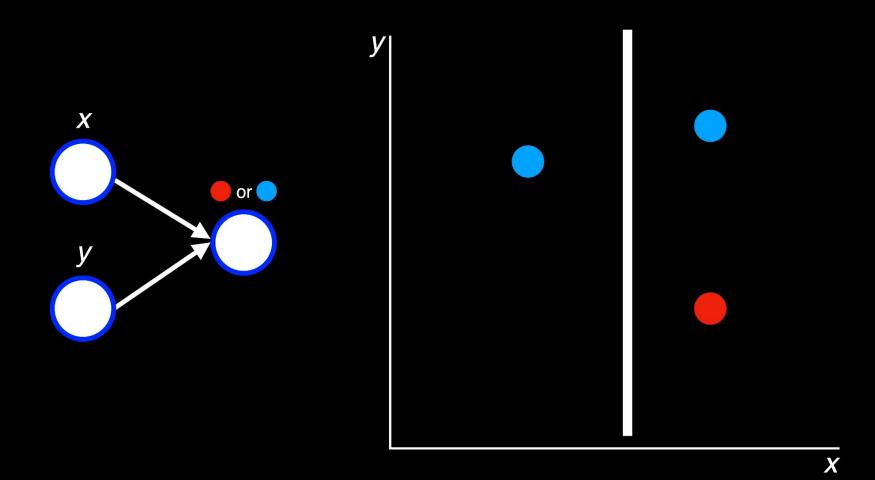


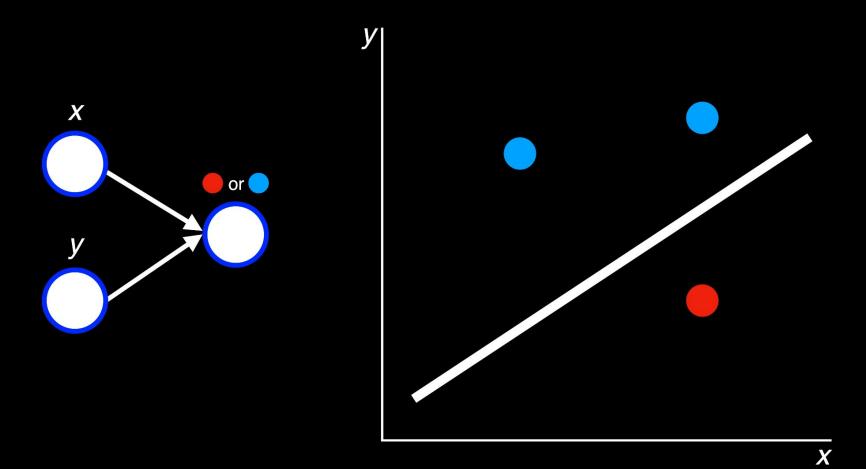


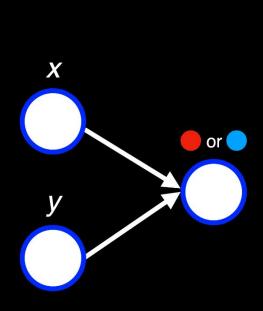


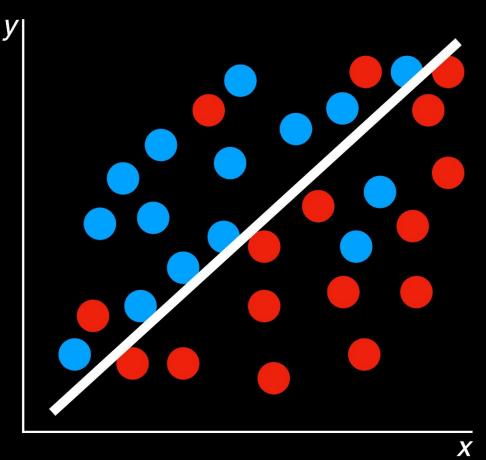


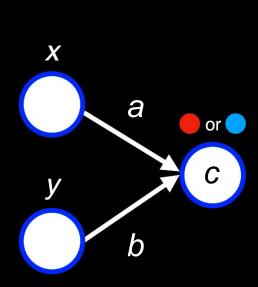


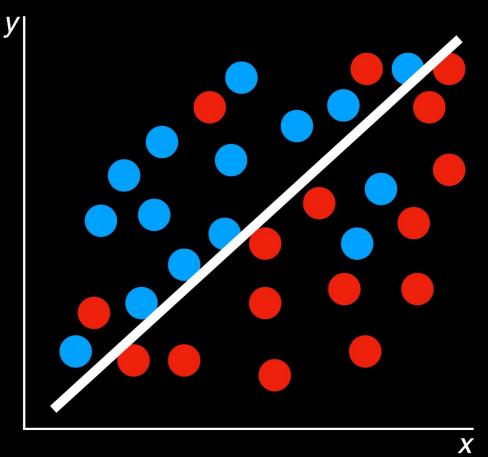




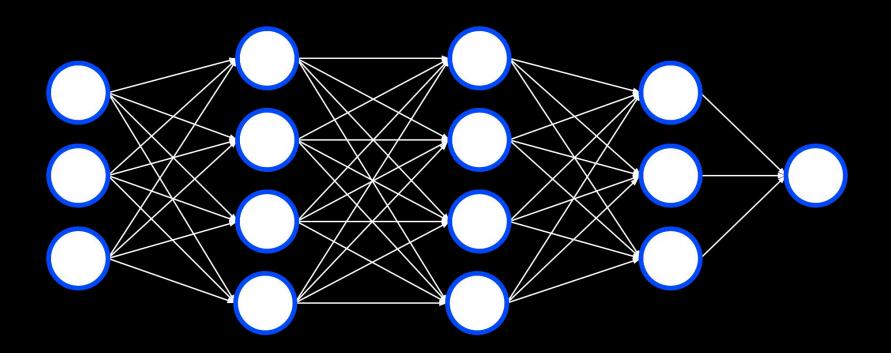


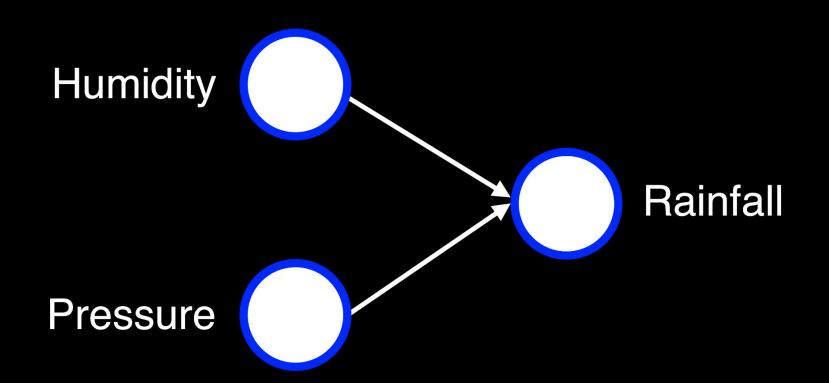


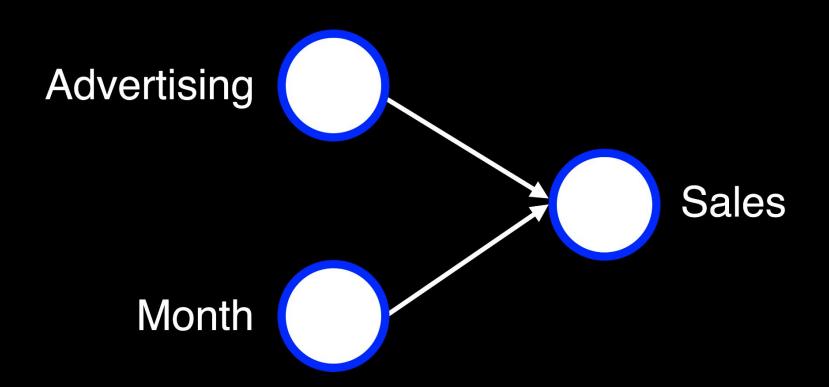




## ax + by + c > 0







generative artificial intelligence





### Essay 1



... I like to bring a yummy sandwich and a cold juice box for lunch, and sometimes I'll even pack a tasty piece of fruit or a bag of crunchy chips. As we eat, we chat and laugh and catch up on each other's day. ...

### **Essay 2**

... My mother packs me a sandwich, a drink, fruit, and a treat. When I get in the lunchroom I find an empty table and sit there, and eat my lunch. My friends come and sit down with me. ...

large language models

### **Attention Is All You Need**

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transformer architecture

"Massachusetts is a state in the New England region of the Northeastern United States. It borders on the Atlantic Ocean to the east.

The state's capital is..."

"Massachusetts is a state in the New England region of the Northeastern United States. It borders on the Atlantic Ocean to the east.

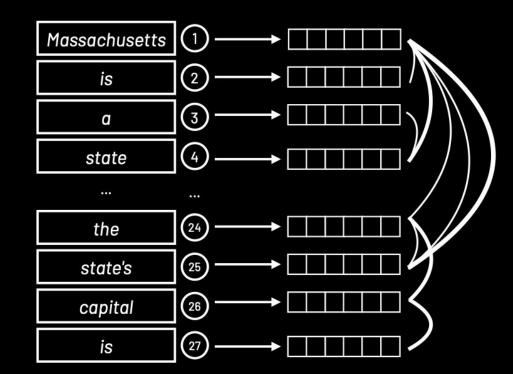
The state's capital is..."

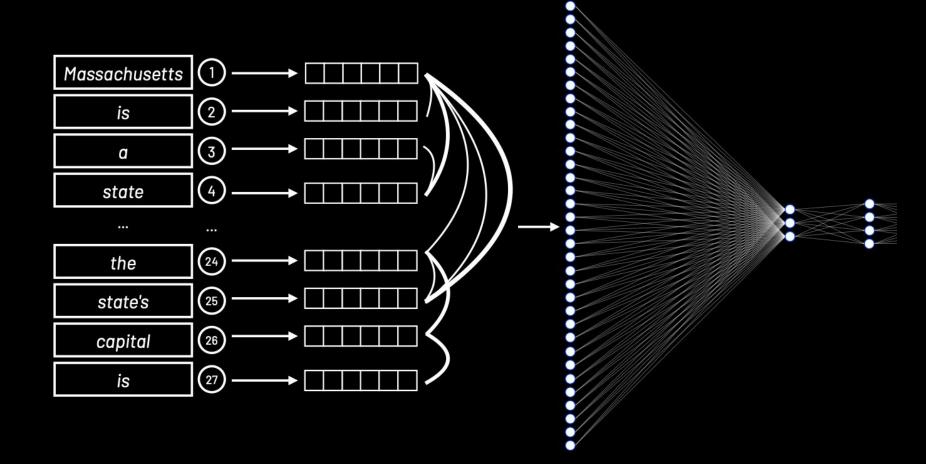
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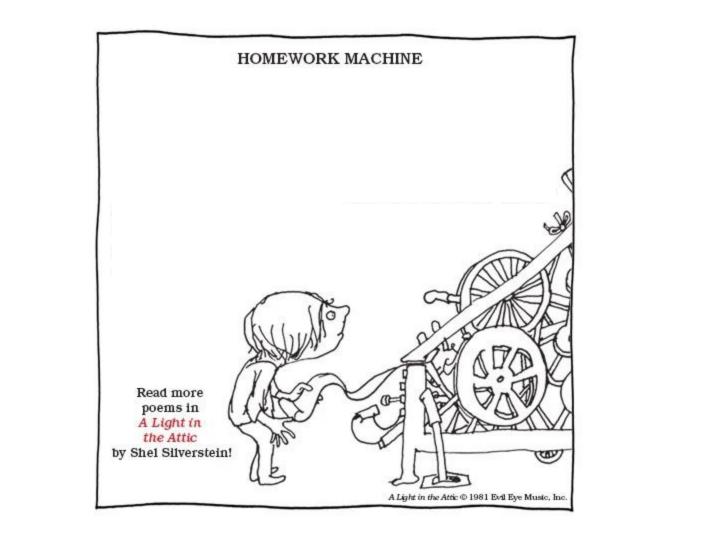
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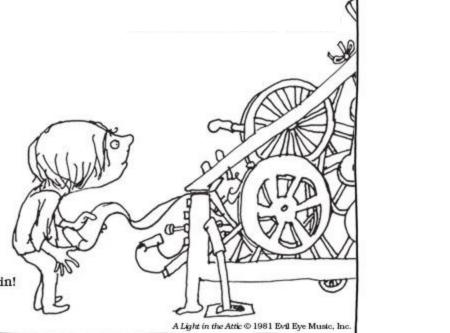




### hallucinations

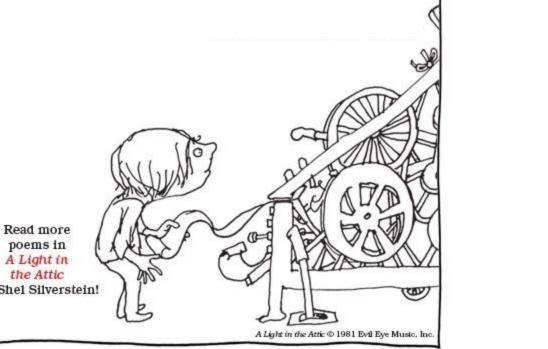


The Homework Machine, oh the Homework Machine,



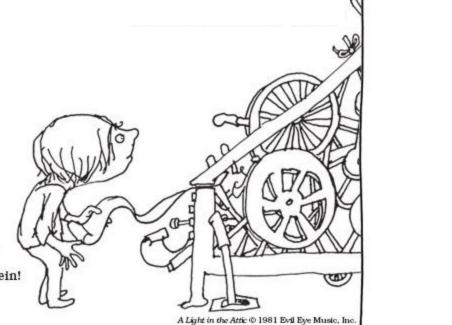
A Light in the Attic by Shel Silverstein!

The Homework Machine, oh the Homework Machine, Most perfect contraption that's ever been seen.



A Light in the Attic by Shel Silverstein!

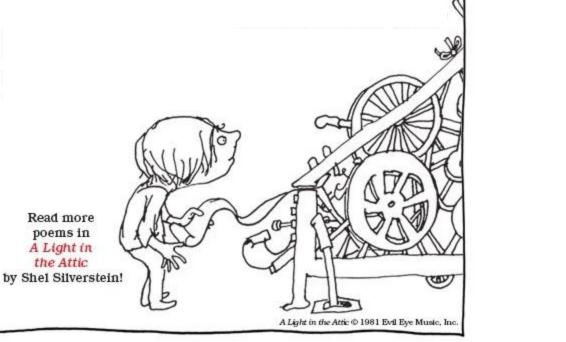
The Homework Machine, oh the Homework Machine, Most perfect contraption that's ever been seen. Just put in your homework, then drop in a dime,



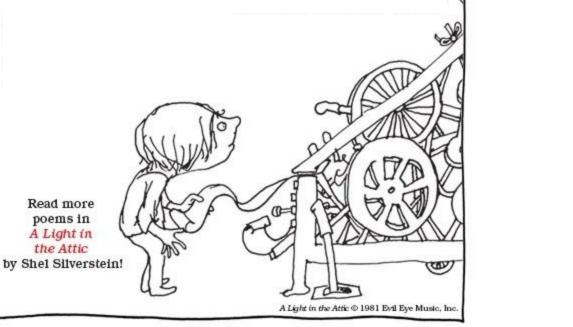
A Light in the Attic by Shel Silverstein!

The Homework Machine, oh the Homework Machine, Most perfect contraption that's ever been seen. Just put in your homework, then drop in a dime, Snap on the switch, and in ten seconds' time,

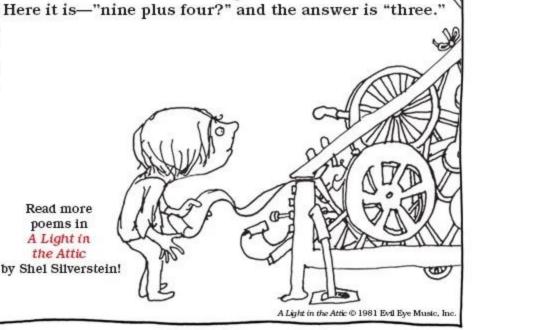
Read more poems in A Light in the Attic



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the Attic by Shel Silverstein!

A Light in

A Light in the Attic @ 1981 Evil Eye Musto, Inc.

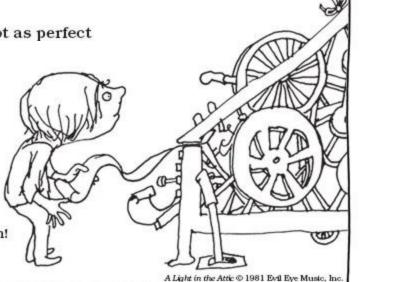
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Here it is—"nine plus four?" and the answer is "three."
Three?

Oh me . . . I guess it's not as perfect



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the Attic by Shel Silverstein!

A Light in

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## CS50x

https://cs50.edx.org

### thank you

If RSVP'd for CS50 Lunch at Changsho after lecture, look for this yellow duck in the lobby to follow!



# This is CS50