learn how to program

learn how to solve problems

learn how to represent numbers

learn how to represent letters

learn how to represent colors

learn how to represent images

learn how to represent videos

learn how to represent audio

learn how to write algorithms

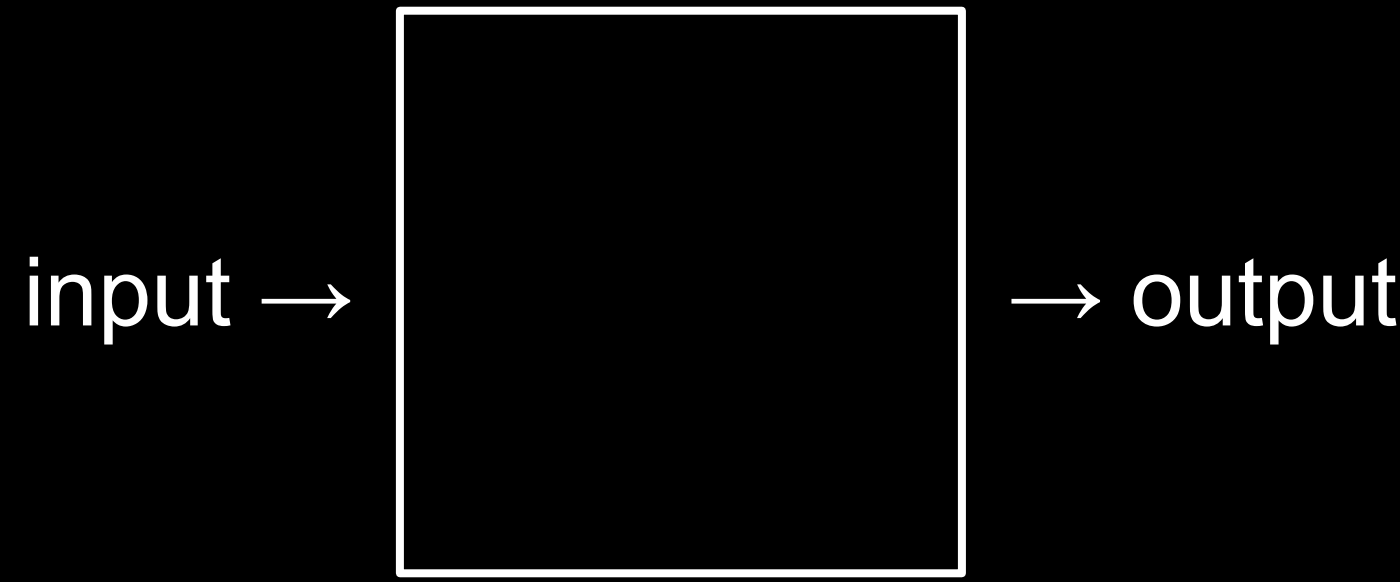
learn how to write code

what ultimately matters in this course is not so much where you end up relative to your classmates but where you end up relative to yourself when you began

computer science

problem solving

computational thinking


input →
→ output

representation

base-1

base-2

binary

binary digit

bit

0

1

base-10

decimal

123

123

10 1

123


100 10 1
123

100 10 1

123

100 × 1

100 10 1

123

100 × 1 + 10 × 2

100 10 1

123

100 × 1 + 10 × 2 + 1 × 3

100 10 1

123

100 + 20 + 3

123

100 10 1

###

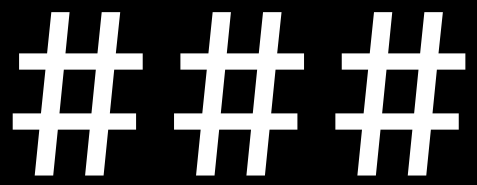
10^2 10^1 10^0

###

2^2 2^1 2^0

###

4 2 1




4 2 1
000

4 2 1

001

4 2 1

0 1 0

4 2 1

011

4 2 1

100

4 2 1

101

4 2 1

110

4 2 1

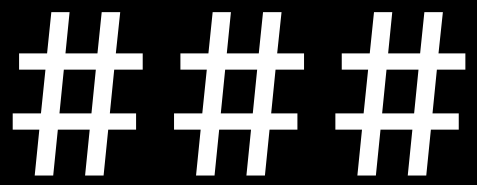
111


4 2 1
000

8 4 2 1

1000

4 2 1



byte

00000000

11111111

A

65

01000001

ASCII

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

01001000 01001001 00100001

72 73 33

H I

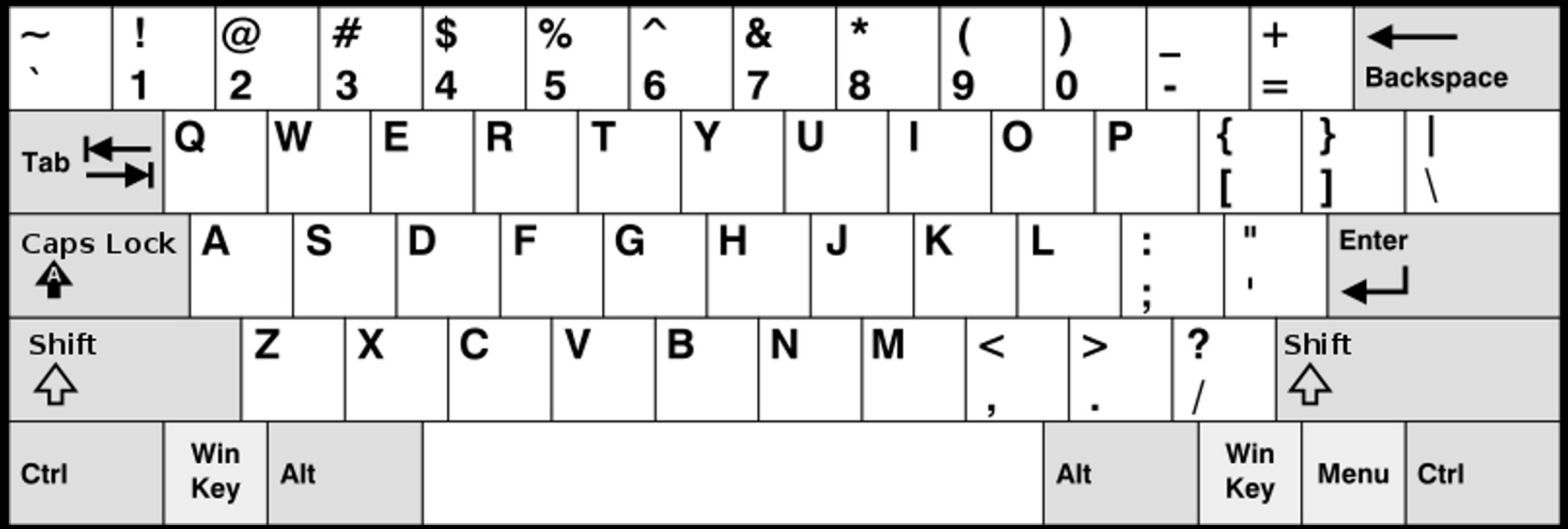
72 73 33

H	I	!
72	73	33

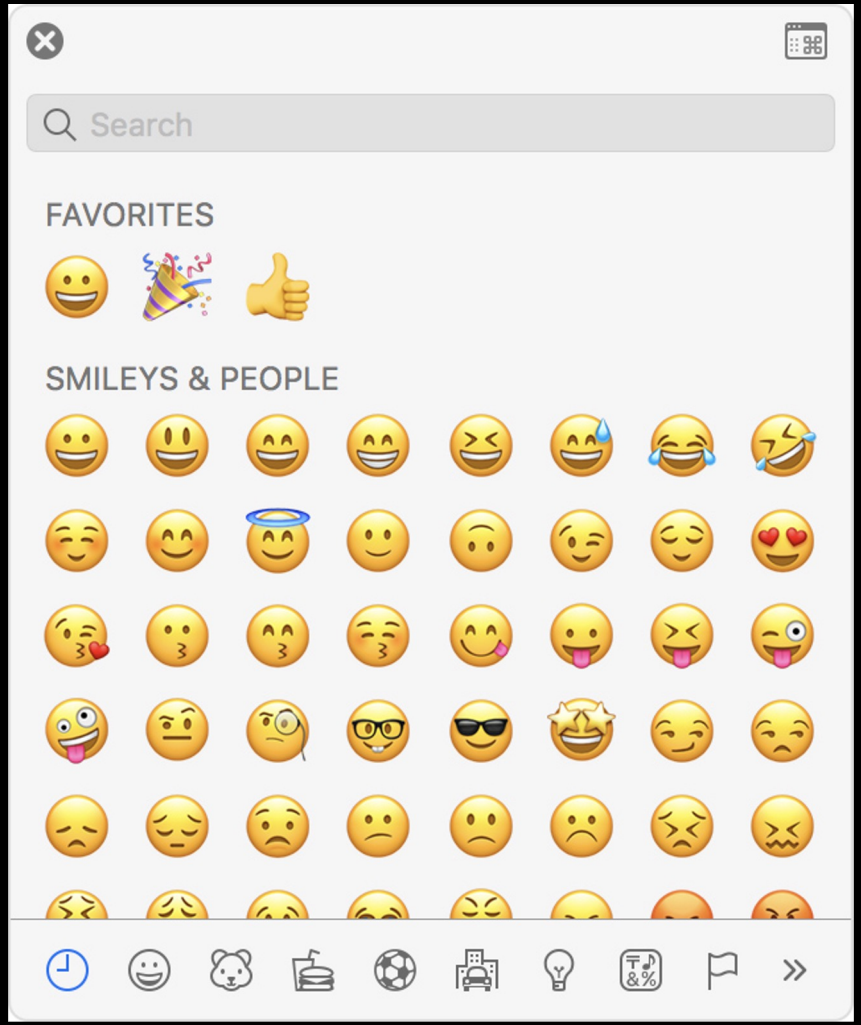
0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL


~ `
! 1
@ 2
# 3
$ 4
% 5
^ 6
& 7
* 8
(9
) 0
_ -
+ =
Backspace
Tab
Q
W
E
R
T
Y
U
I
O
P
{ [
}]
| \
Caps Lock
A
S
D
F
G
H
J
K
L
: ;
" '
Enter
Shift
Z
X
C
V
B
N
M
< ,
> .
? /
Shift
Ctrl
Win Key
Alt
Alt
Win Key
Menu
Ctrl


à á â ä æ ã å ā
1 2 3 4 5 6 7 8
a


Search
FAVORITES
SMILEYS & PEOPLE

Unicode

11110000100111111001100010000010

4036991106

U+1F602

U+1F44D

U+1F44D U+1F3FD

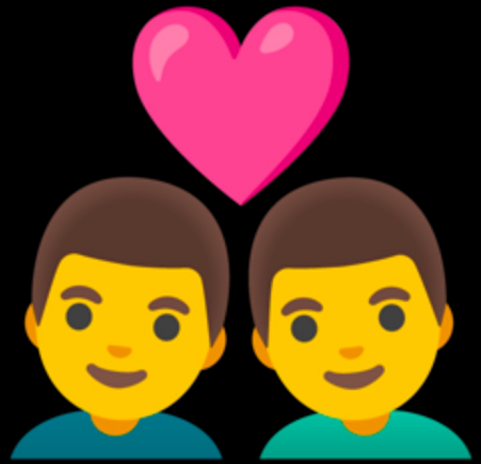
U+1F491

U+1F469 U+200D U+2764 U+FE0F U+200D U+1F468

U+1F469 U+200D U+2764 U+FE0F U+200D U+1F468

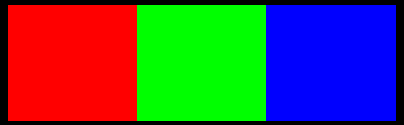
U+1F469 U+200D U+2764 U+FE0F U+200D U+1F468

U+1F469 U+200D U+2764 U+FE0F U+200D U+1F469



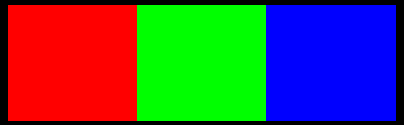
U+1F468 U+200D U+2764 U+FE0F U+200D U+1F468

RGB



72 73 33


72
73
33

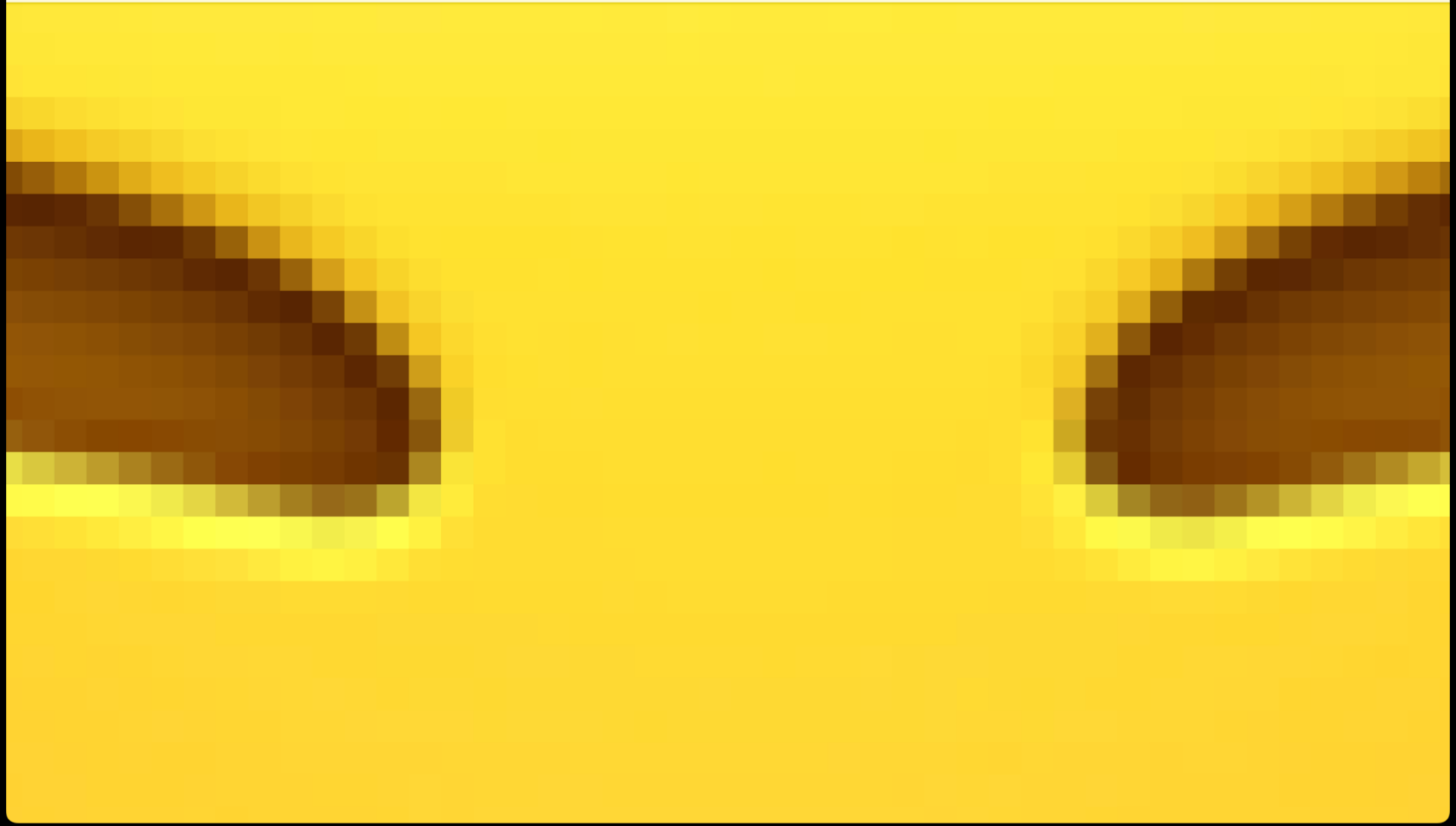


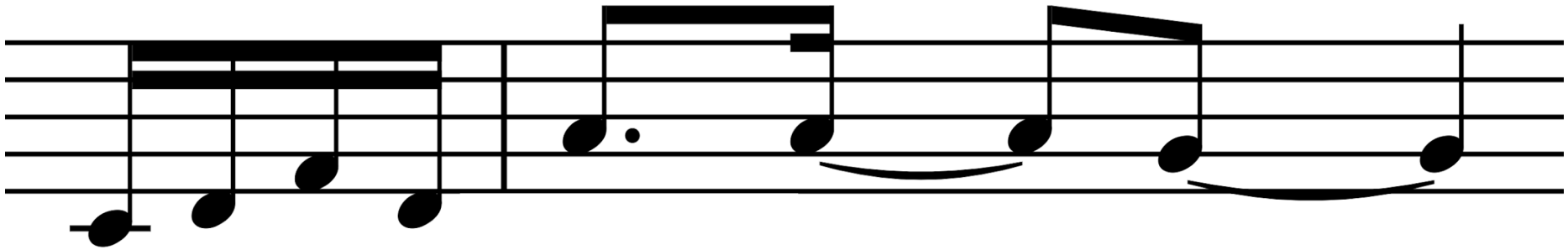
face-with-tears-of-joy_1f602.png

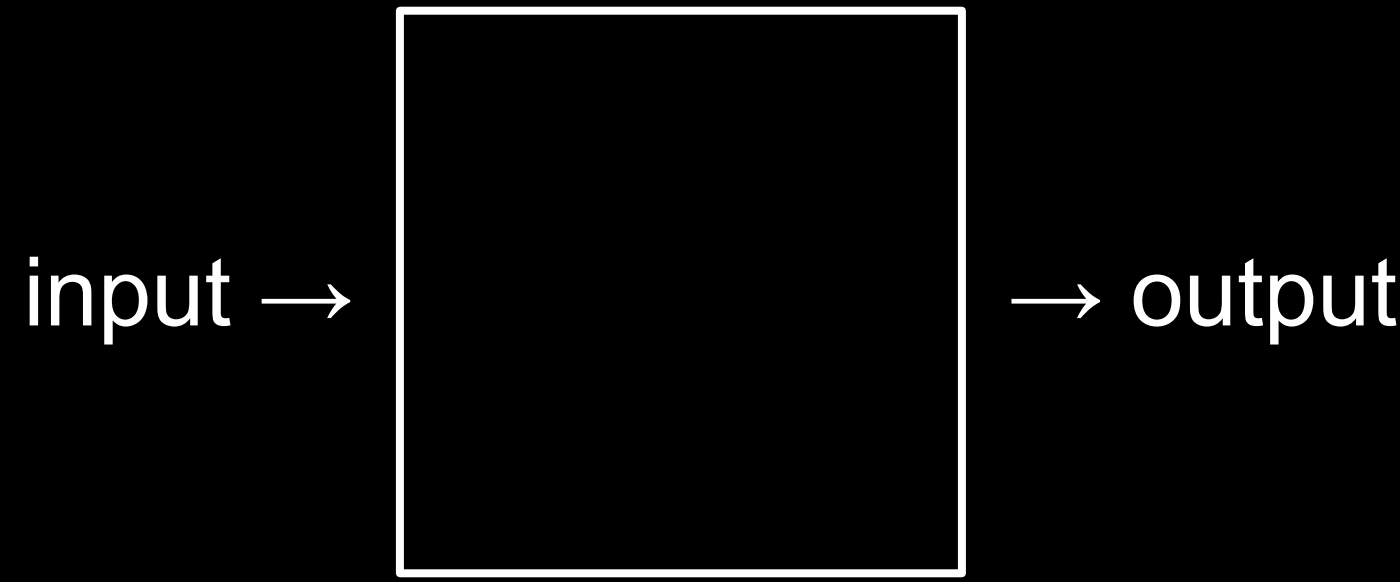
Search

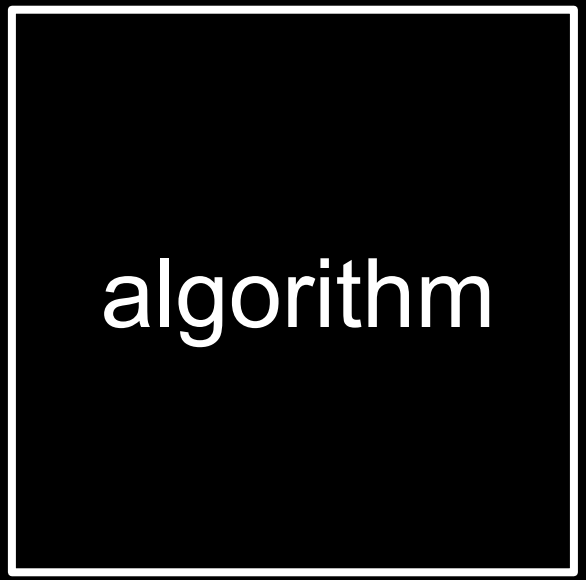
face-with-tears-of-joy_1f602.png

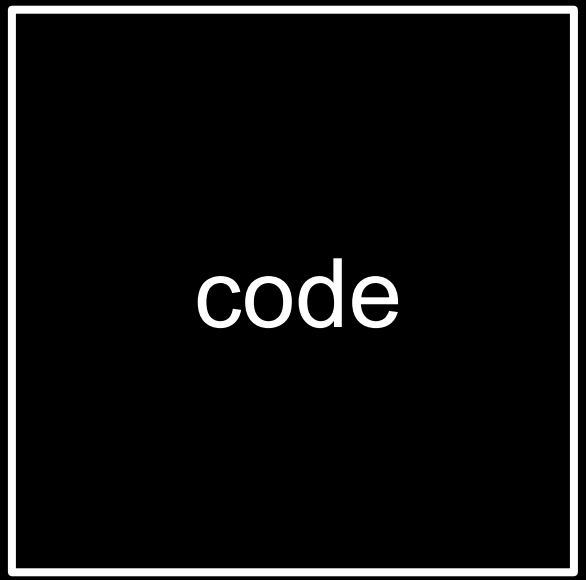
Search

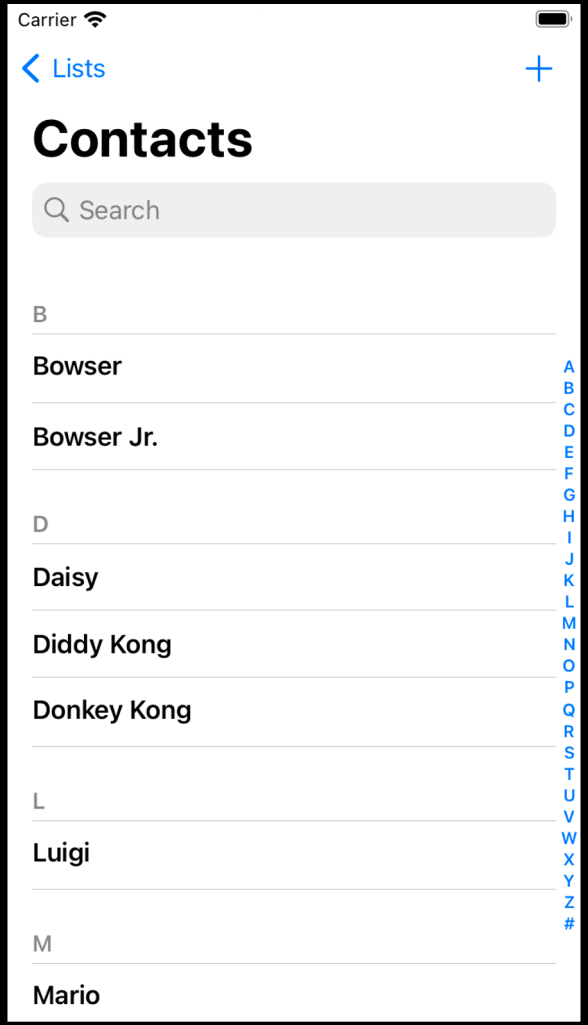

face-with-tears-of-joy_1f602.png
Search

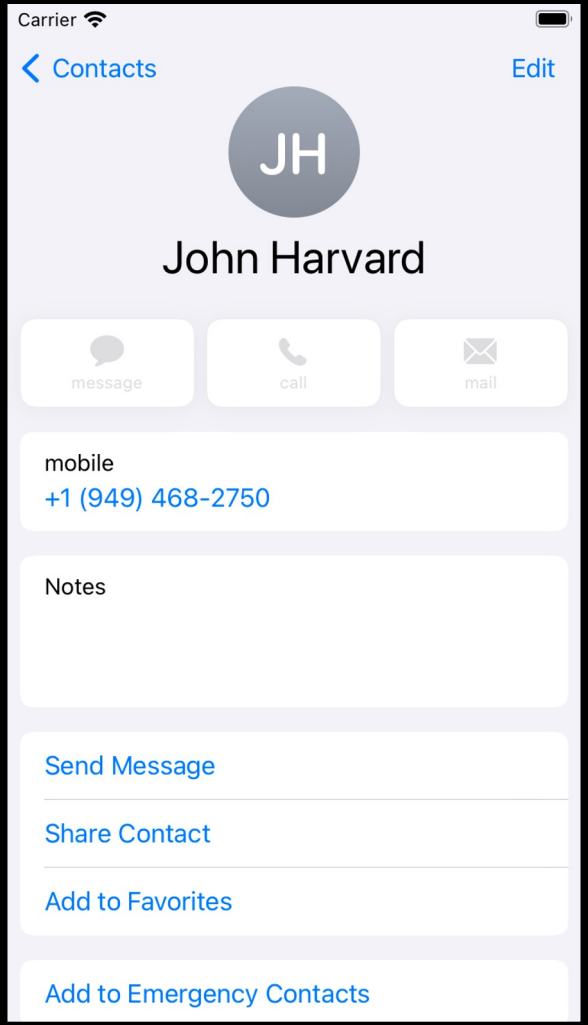


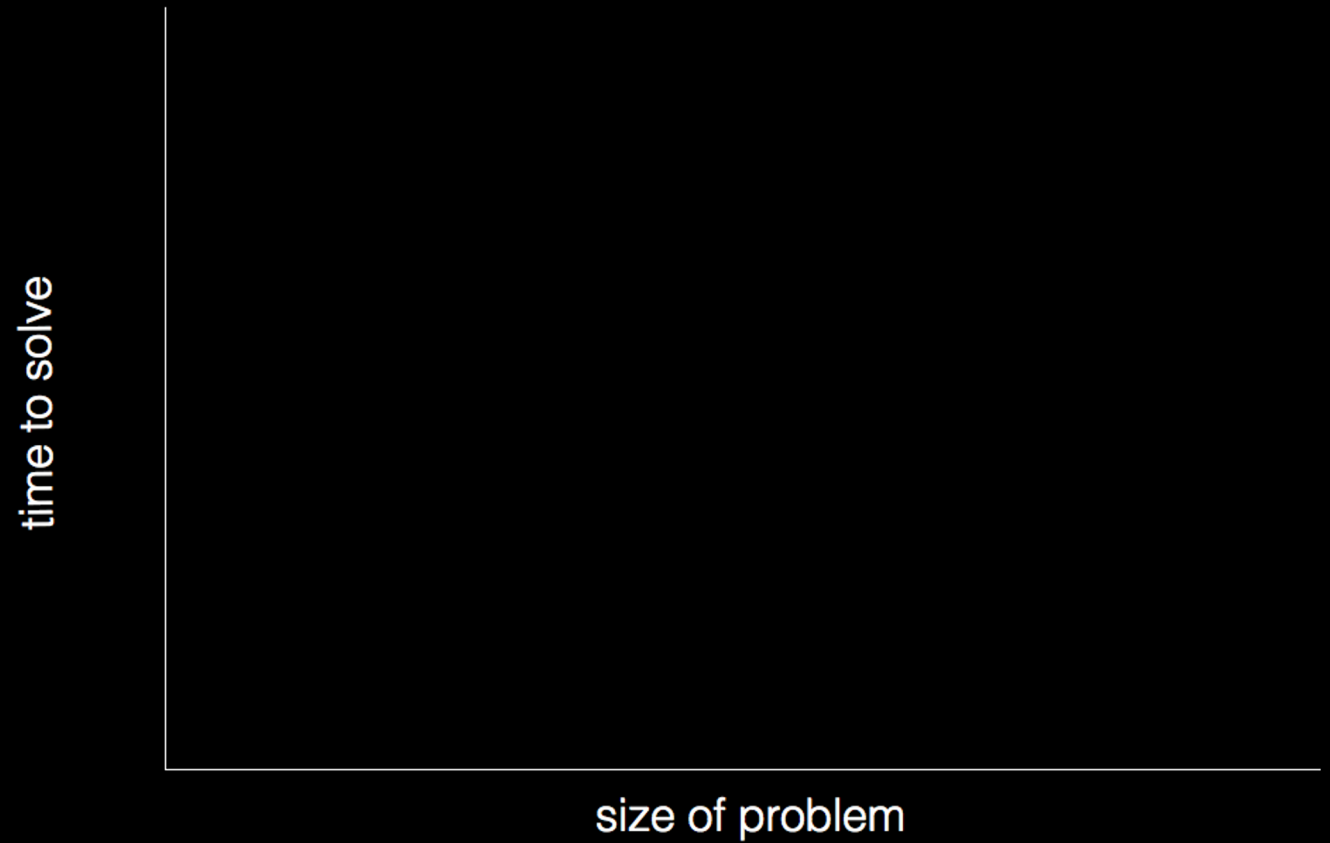

input →
→ output

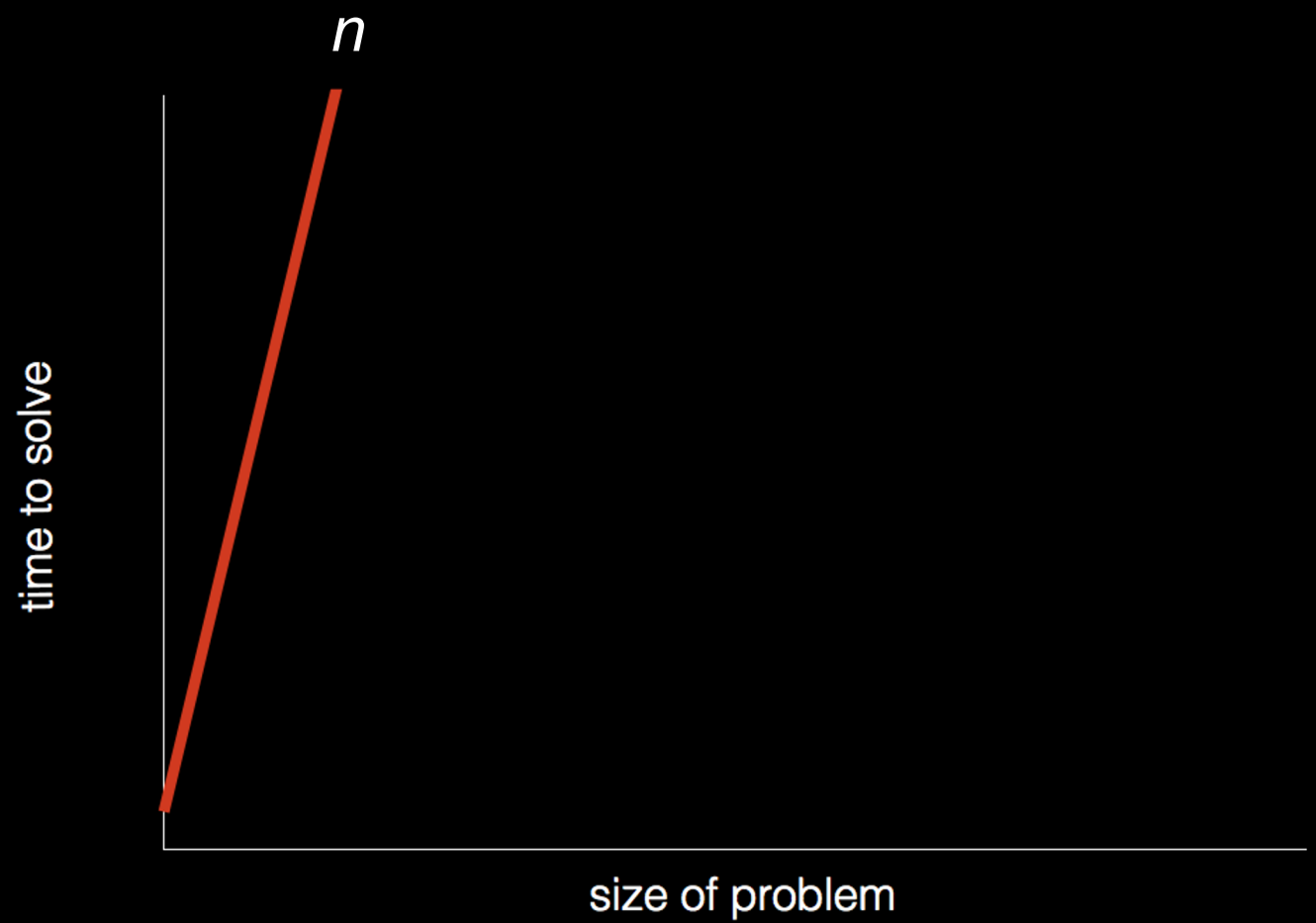

algorithm

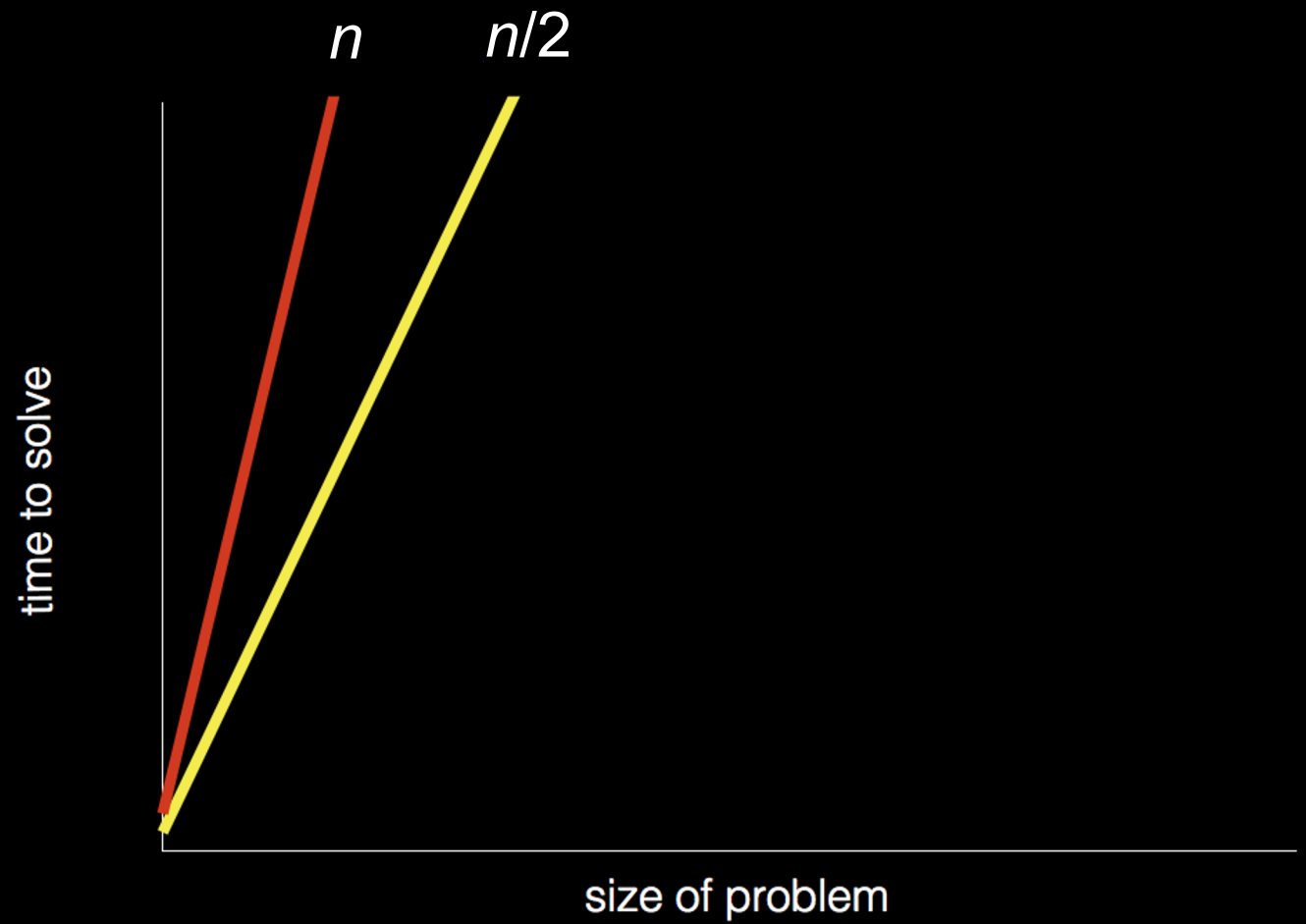

code

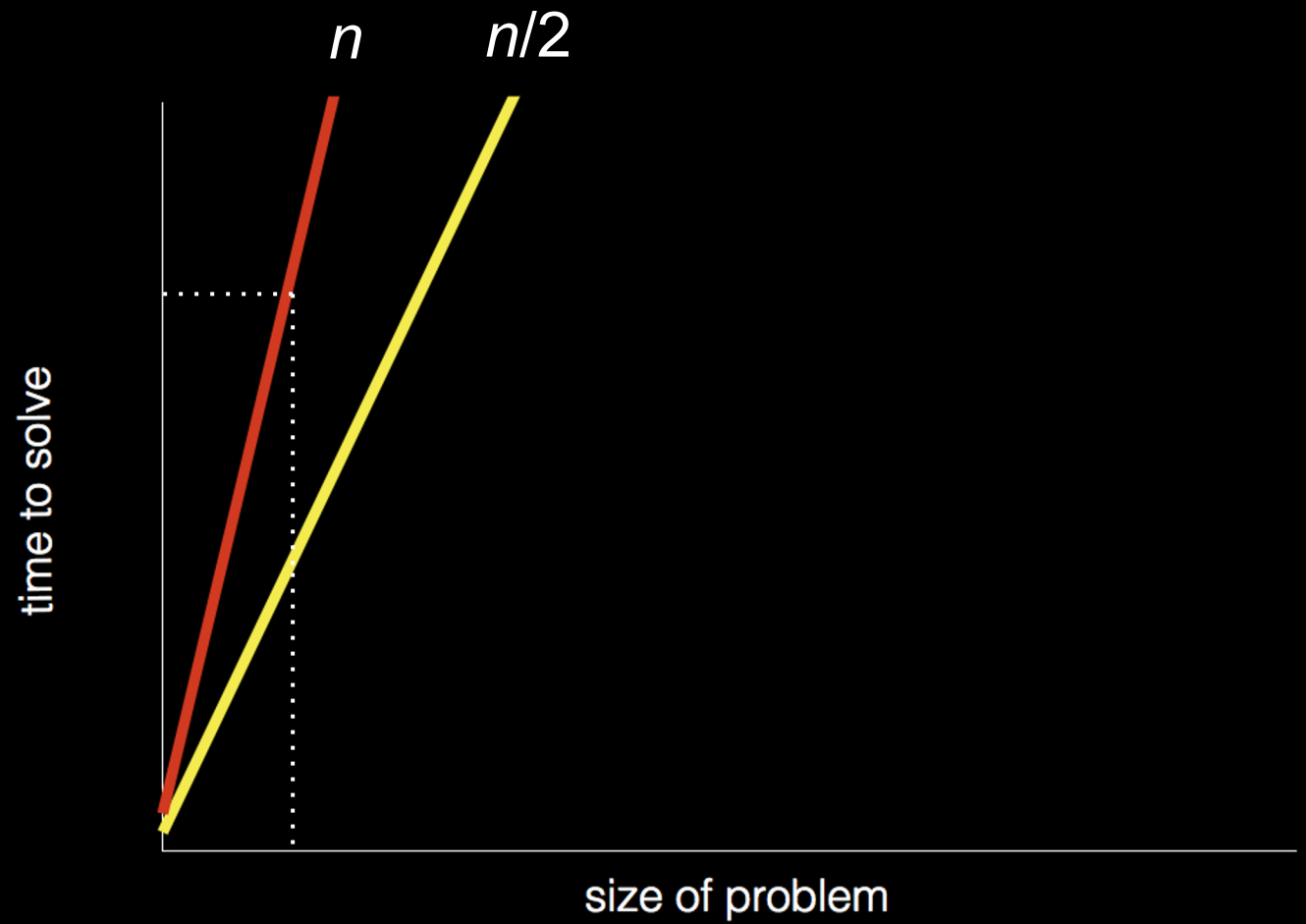

Carrier
Lists
Contacts
Search
B
Bowser
Bowser Jr.
D
Daisy
Diddy Kong
Donkey Kong
L
Luigi
M
Mario
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
#

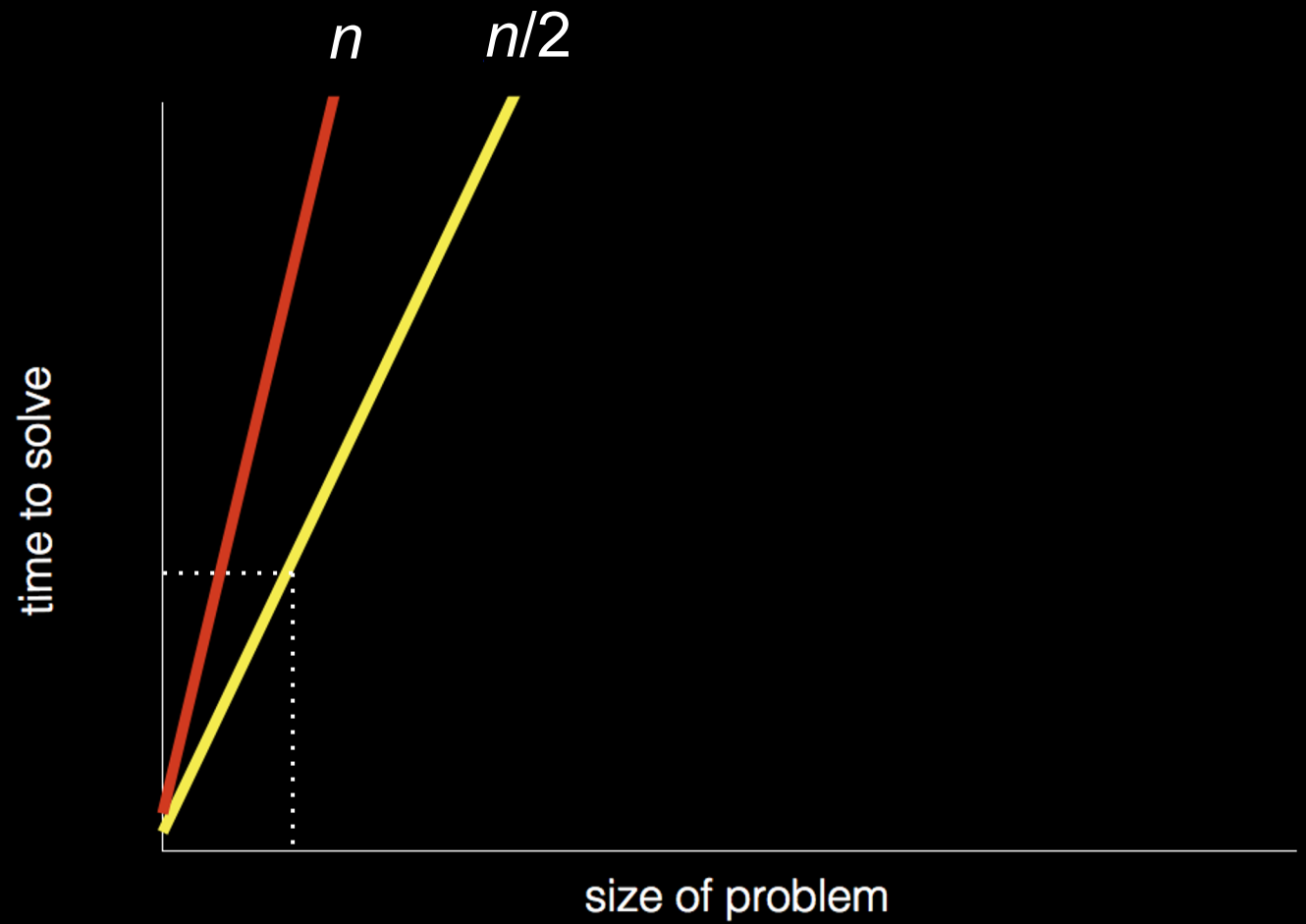

Carrier
Contacts
Edit
JH
John Harvard
message
call
mail
mobile
+1 (949) 468-2750
Notes
Send Message
Share Contact
Add to Favorites
Add to Emergency Contacts

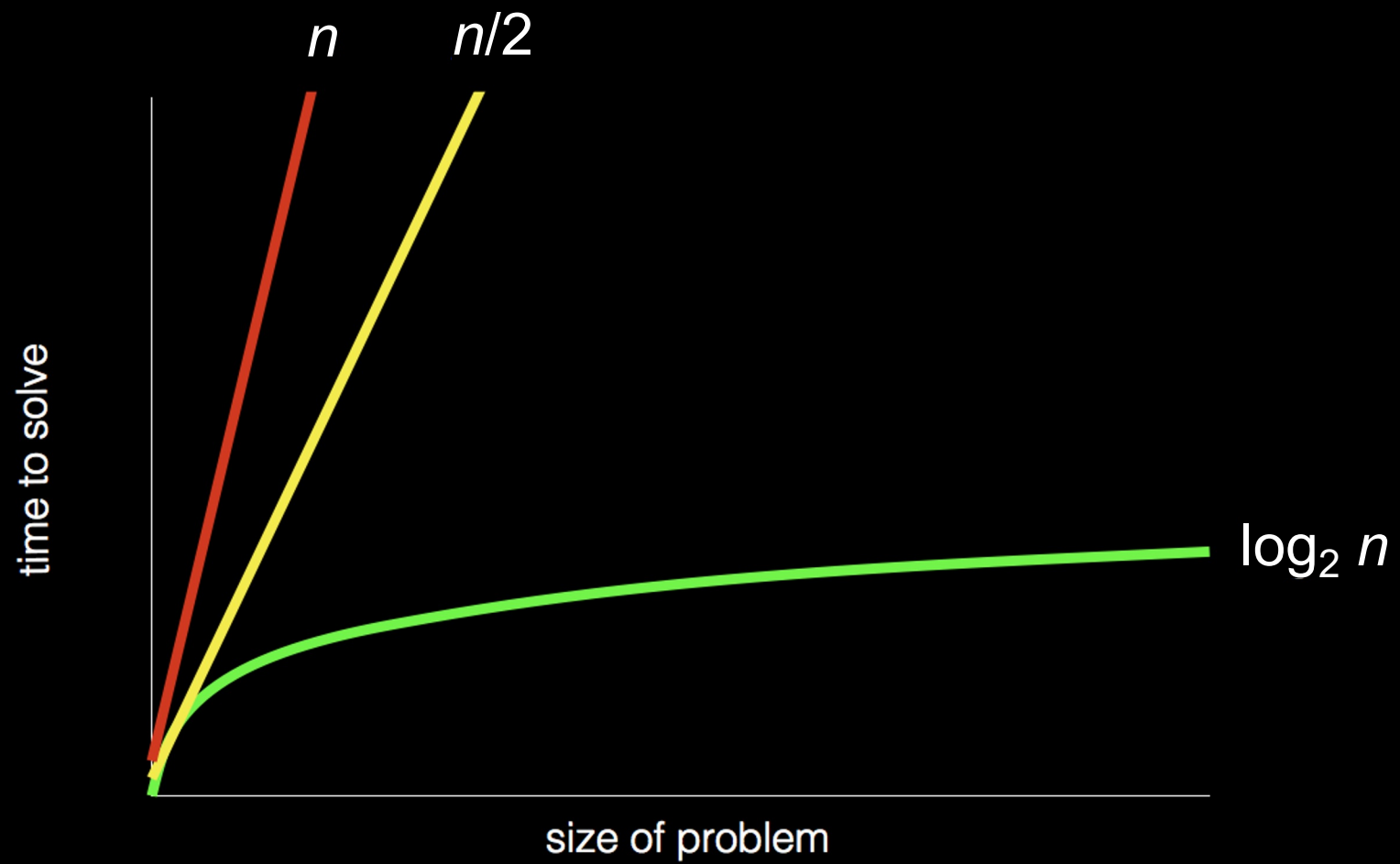

time to solve
size of problem


n
time to solve
size of problem


n
n/2
time to solve
size of problem


n
n/2
time to solve
size of problem


n
n/2
time to solve
size of problem


n
n/2
log2 n
time to solve
size of problem

pseudocode

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

```
1   Pick up phone book
2   Open to middle of phone book
3   Look at page
4   If person is on page
5       Call person
6   Else if person is earlier in book
7       Open to middle of left half of book
8       Go back to line 3
9   Else if person is later in book
10      Open to middle of right half of book
11      Go back to line 3
12  Else
13      Quit
```

functions
conditionals
Boolean expressions
loops
…

artificial intelligence

```
If student says hello
    Say hello back
```

```
If student says hello
    Say hello back
Else if student says goodbye
    Say goodbye back
```

```
If student says hello
    Say hello back
Else if student says goodbye
    Say goodbye back
Else if student asks how you are
    Say you're well
```

```
If student says hello
    Say hello back
Else if student says goodbye
    Say goodbye back
Else if student asks how you are
    Say you're well
Else if student asks why 111 in binary is 7 is decimal
    …
```

01111111010001010100110001000110000000100000000100000001000000000000000000000000000000000000000000
00000000000000000000000000000000001000000000011111000000000000000000100000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000010100000000000001000000000000000000000000000000000000000000000000000000000000000
000000000000001000000000000000000000000000000000000000000000100000000000000000000101000000000000000000010
0000000010101010100100010001001111001010100100010000011111011000001000000110001110000001000100111000 1
1101001000101111110000000000000000000000000000000000000000000000000000000000000000001011000000000000000111
0100000000000000000000000000000000000001001000101111110000000000000000000000000000000000000000000000000000000
00000000000000000001001000...0111111101000101010011000100011000000010000000010000000100000000000000000000
0000000000000000000000000000000000000000000000000000000011000000000011111000000000000000000010000000
00000000000000000011000000000001111000000000000000000000000000000000000000000000100000000000000000000
0000000000000000000000000000000000000000000000101000000110010000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000001000000000000000000011100000000000000000011100000000001000000000000
000001110000000000000000110010000000000000000010000000000000000000000000000000001010000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000101110000100
1010000000000000000000000000000000000000000000000...001011110110110001101001011000100110001100101111
00111001101101111001011100011011000100000001011110111010101110011011100100010111101101100011010010110
00100010111101111000001110000011011001011111001101100011010000101101011011000110100101101110011101010
11110000010110101100111011011100111010100101111011011000110100101100010011000110101111110110111001101 1
11011011100111001101101000011000010111001001100101011001000010111001100001001000000010000000100000 1010
10011010111111010011100100010101000101010001000100010101000100001000000001010000010000000010111101101100
01101001011000100010111101111000001110000011011001011111001101100011010000101101011011000110100101101
1100111010101111000001011010110011101101110011101010010111101101100011001000010110101101100011010 0101
10111001110101011110000010110101111000001110000011011000101101001101100011010 0...

```c
#include <stdio.h>

int main(void)
{
    printf("hello, world\n");
}
```

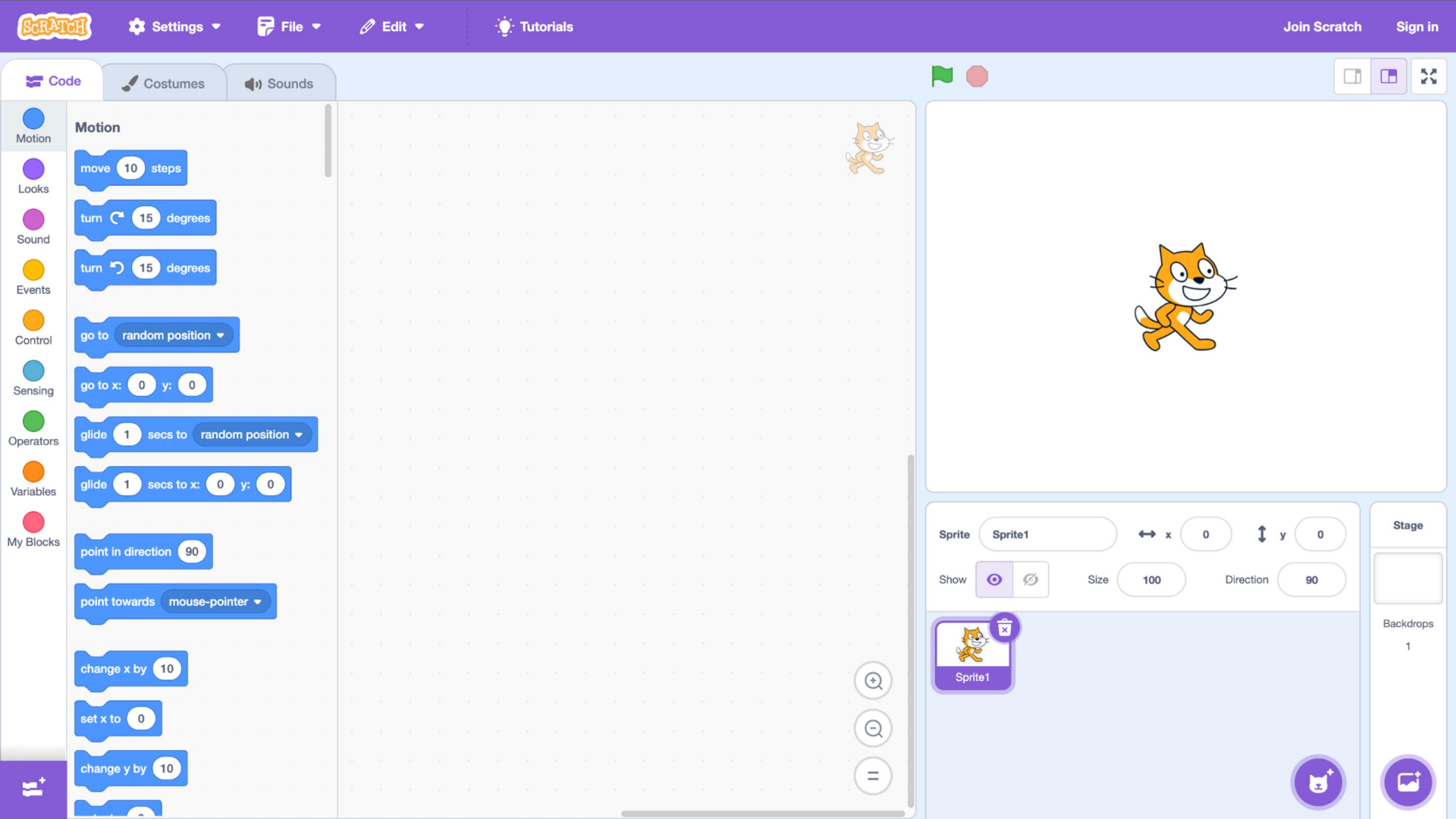
Visual Studio Code for CS50

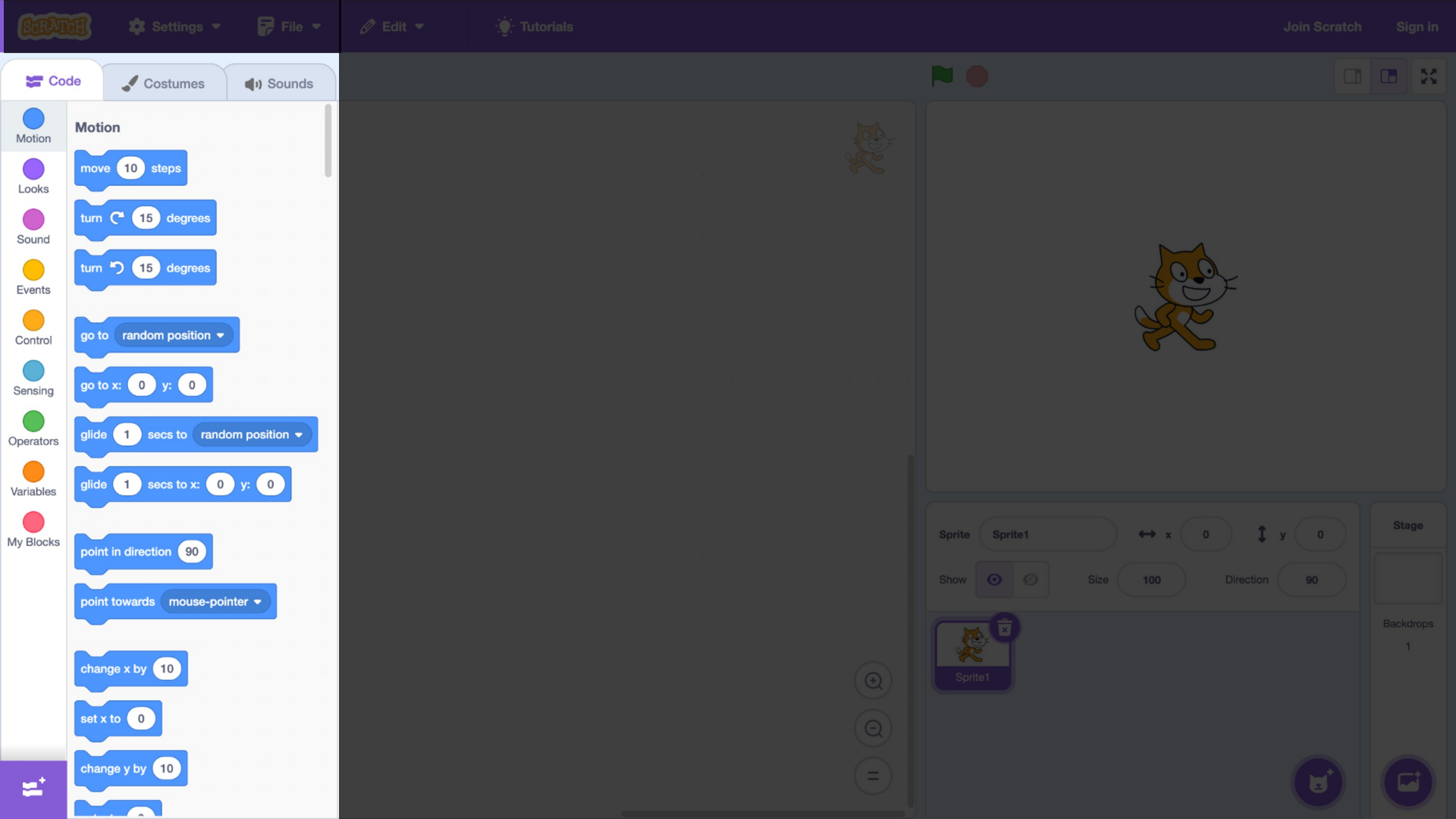
cs50.dev

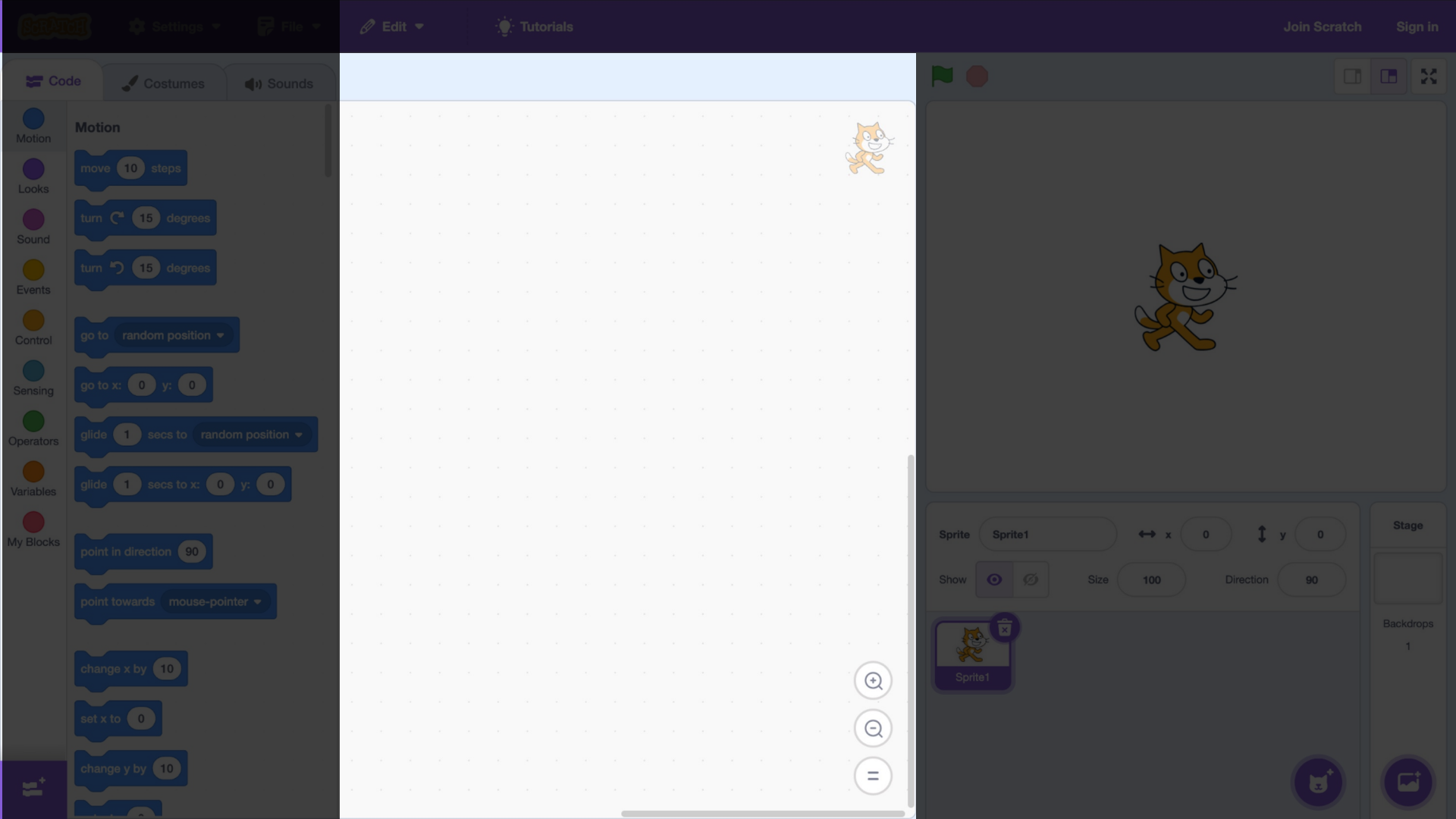
Scratch

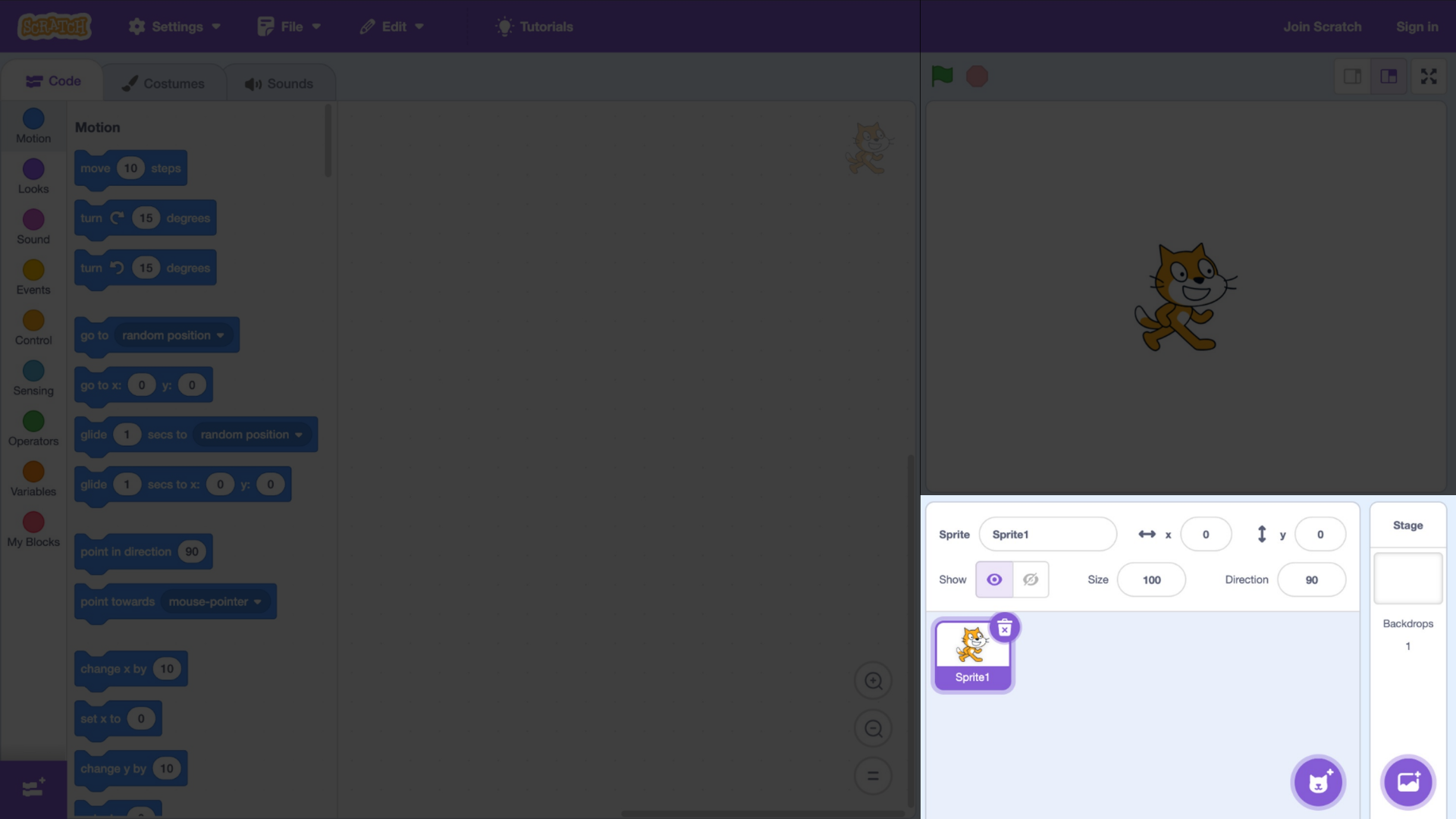
scratch.mit.edu

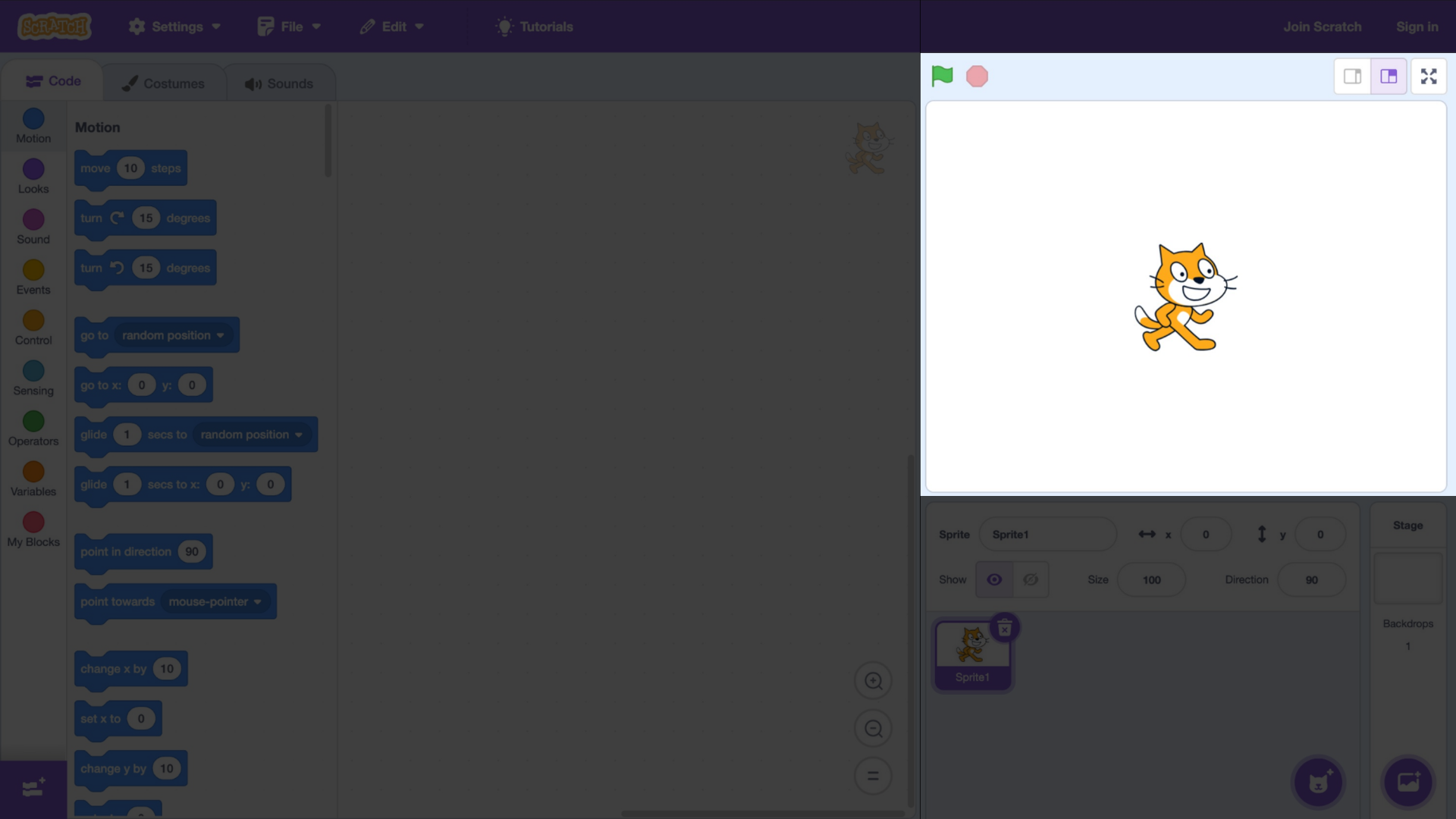

when clicked
say
hello, world

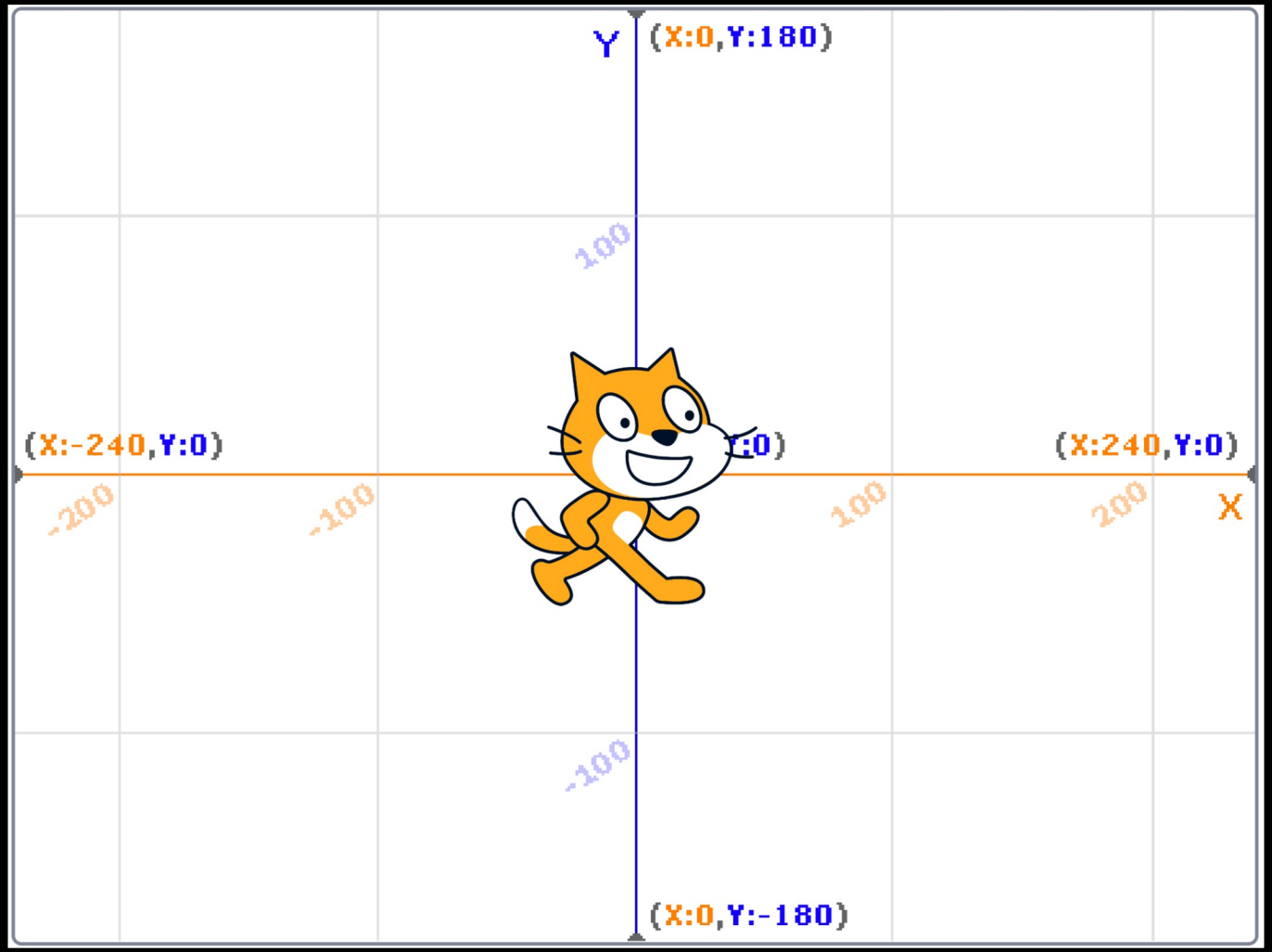

Settings
File
Edit
Tutorials
Join Scratch
Sign in
Code
Costumes
Sounds
Motion
Looks
Sound
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: 0 y: 0
glide 1 secs to random position
glide 1 secs to x: 0 y: 0
point in direction 90
point towards mouse-pointer
change x by 10
set x to 0
change y by 10
Sprite
Sprite1
x
0
y
0
Show
Size
100
Direction
90
Stage
Backdrops
1
Sprite1

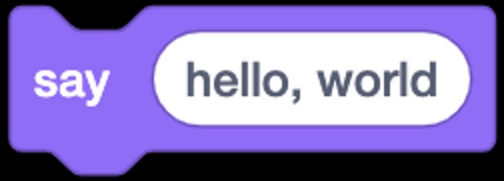

Settings
File
Edit
Tutorials
Join Scratch
Sign in
Code
Costumes
Sounds
Motion
Looks
Sound
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: 0 y: 0
glide 1 secs to random position
glide 1 secs to x: 0 y: 0
point in direction 90
point towards mouse-pointer
change x by 10
set x to 0
change y by 10
Sprite
Sprite1
x 0
y 0
Show
Size 100
Direction 90
Stage
Backdrops 1
Sprite1

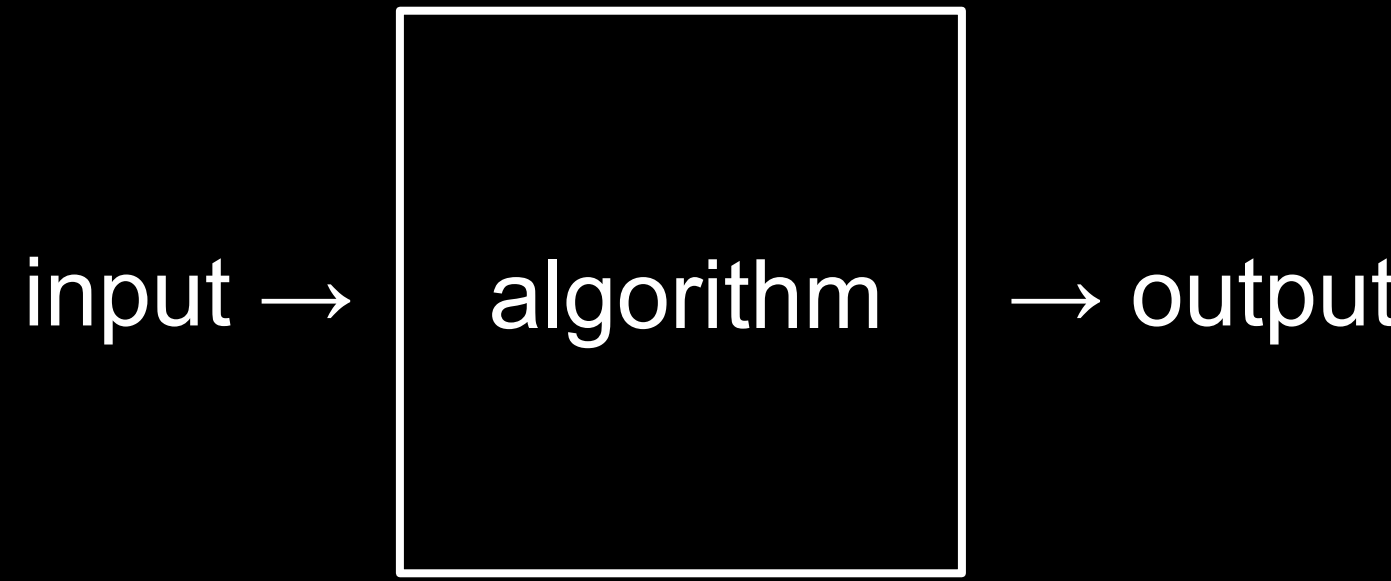

Settings
File
Edit
Tutorials
Join Scratch
Sign in
Code
Costumes
Sounds
Motion
Looks
Sound
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: 0 y: 0
glide 1 secs to random position
glide 1 secs to x: 0 y: 0
point in direction 90
point towards mouse-pointer
change x by 10
set x to 0
change y by 10
Sprite
Sprite1
x 0
y 0
Show
Size 100
Direction 90
Sprite1
Stage
Backdrops 1

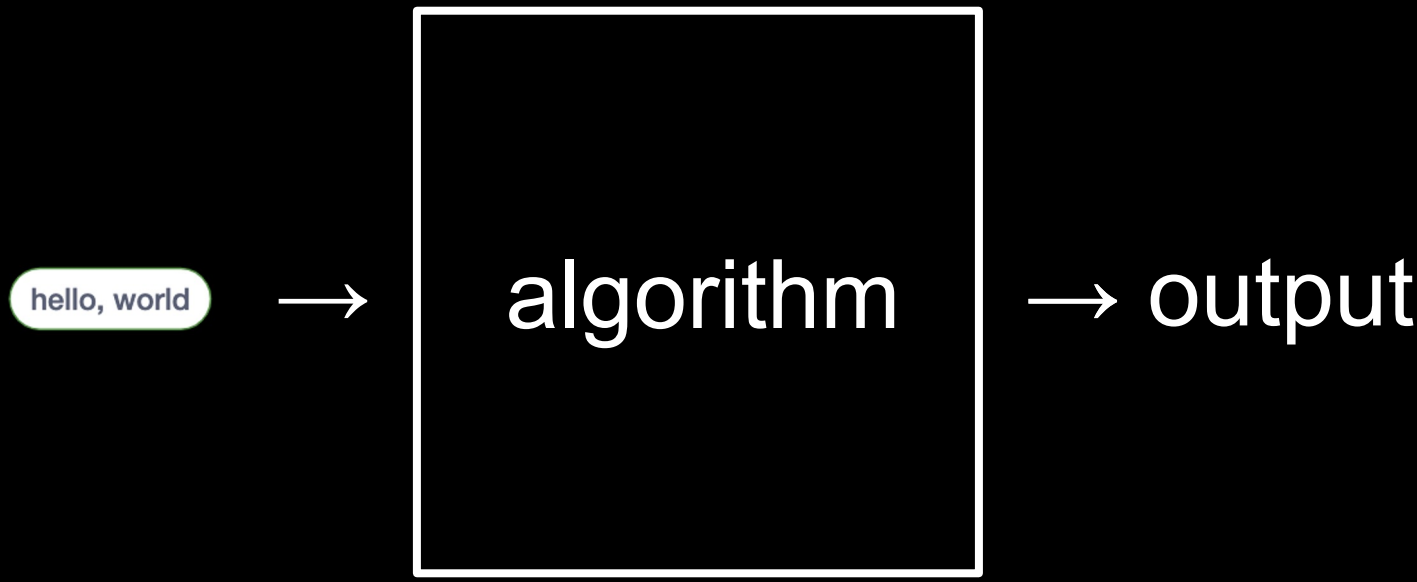

Settings
File
Edit
Tutorials
Join Scratch
Sign in
Code
Costumes
Sounds
Motion
Looks
Sound
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: 0 y: 0
glide 1 secs to random position
glide 1 secs to x: 0 y: 0
point in direction 90
point towards mouse-pointer
change x by 10
set x to 0
change y by 10
Sprite
Sprite1
x
0
y
0
Show
Size
100
Direction
90
Sprite1
Stage
Backdrops
1

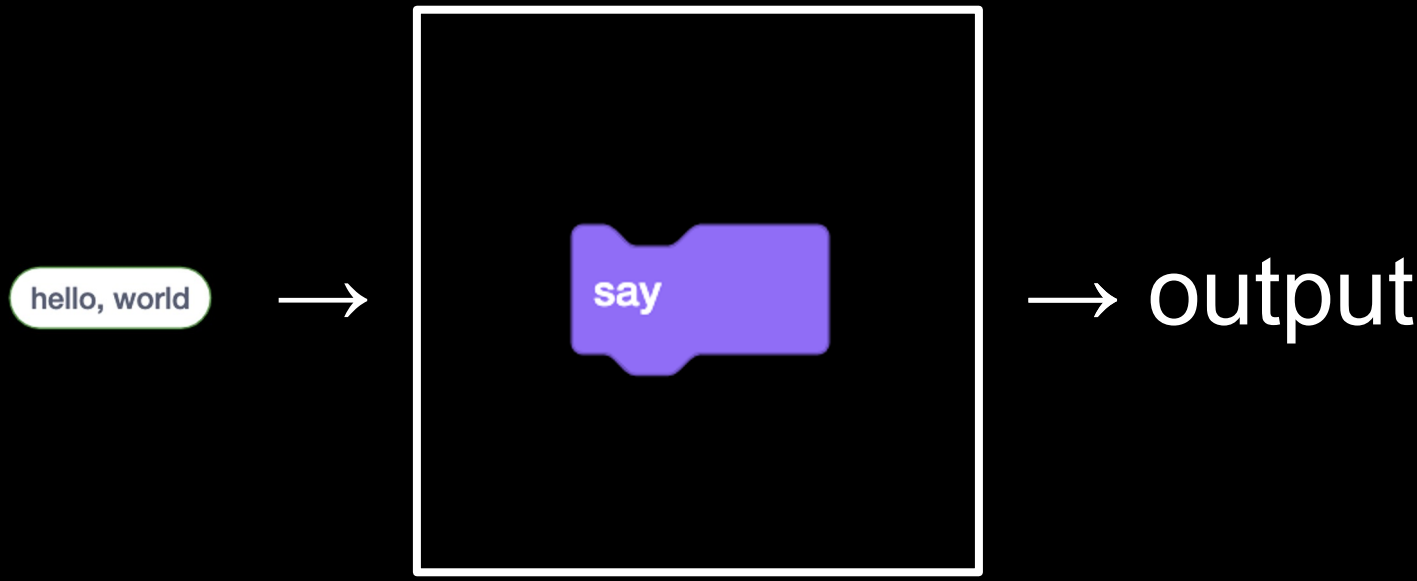

Settings
File
Edit
Tutorials
Join Scratch
Sign in
Code
Costumes
Sounds
Motion
Looks
Sound
Events
Control
Sensing
Operators
Variables
My Blocks
Motion
move 10 steps
turn 15 degrees
turn 15 degrees
go to random position
go to x: 0 y: 0
glide 1 secs to random position
glide 1 secs to x: 0 y: 0
point in direction 90
point towards mouse-pointer
change x by 10
set x to 0
change y by 10
Sprite
Sprite1
x 0
y 0
Show
Size 100
Direction 90
Sprite1
Stage
Backdrops 1

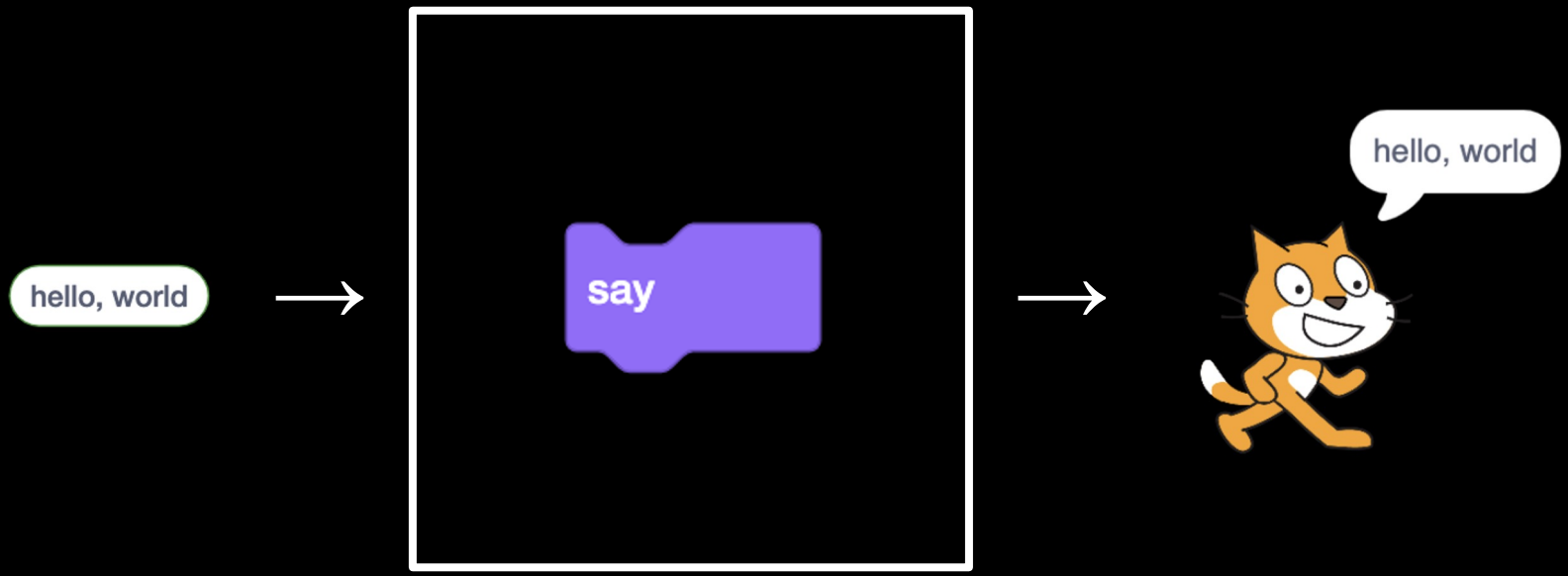

Y
(X:0,Y:180)
100
(X:-240,Y:0)
(X:240,Y:0)
-200
-100
100
200
X
-100
(X:0,Y:-180)


say
hello, world

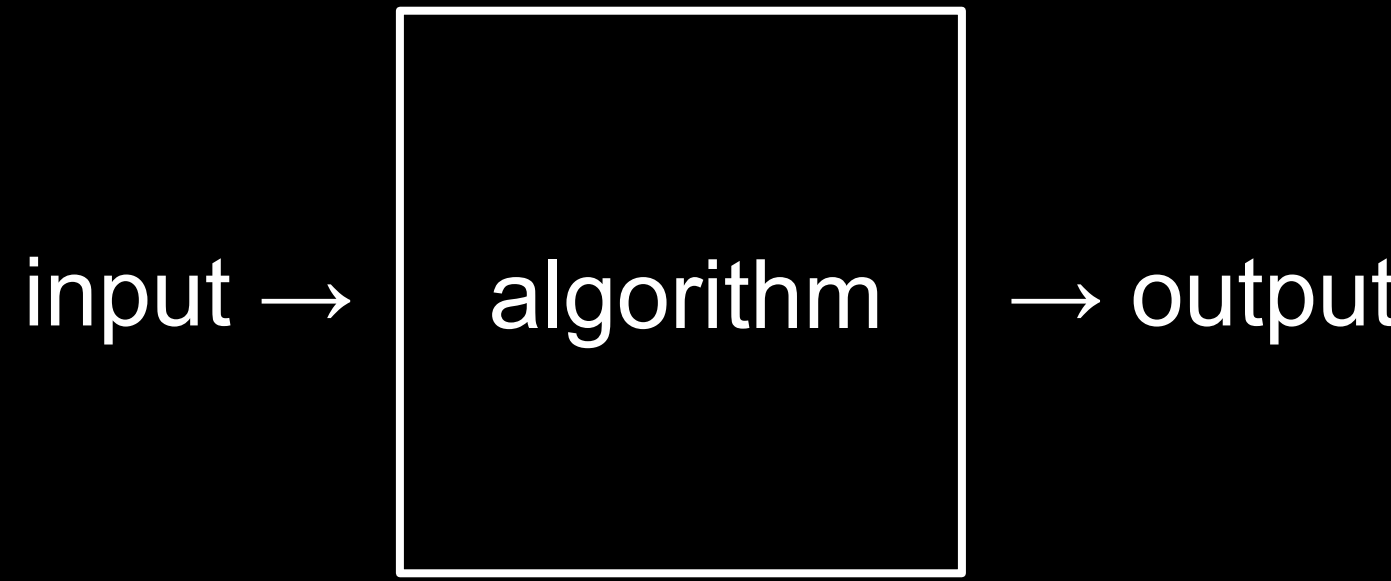

input →
algorithm
→ output

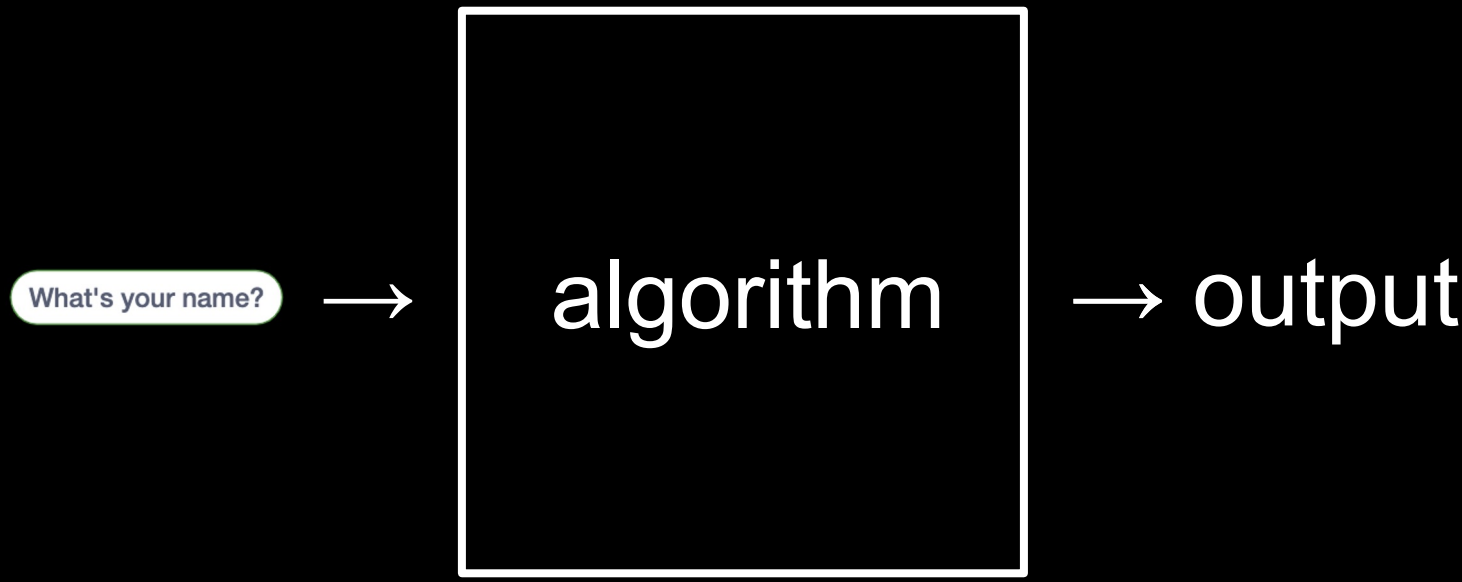

hello, world
algorithm
output

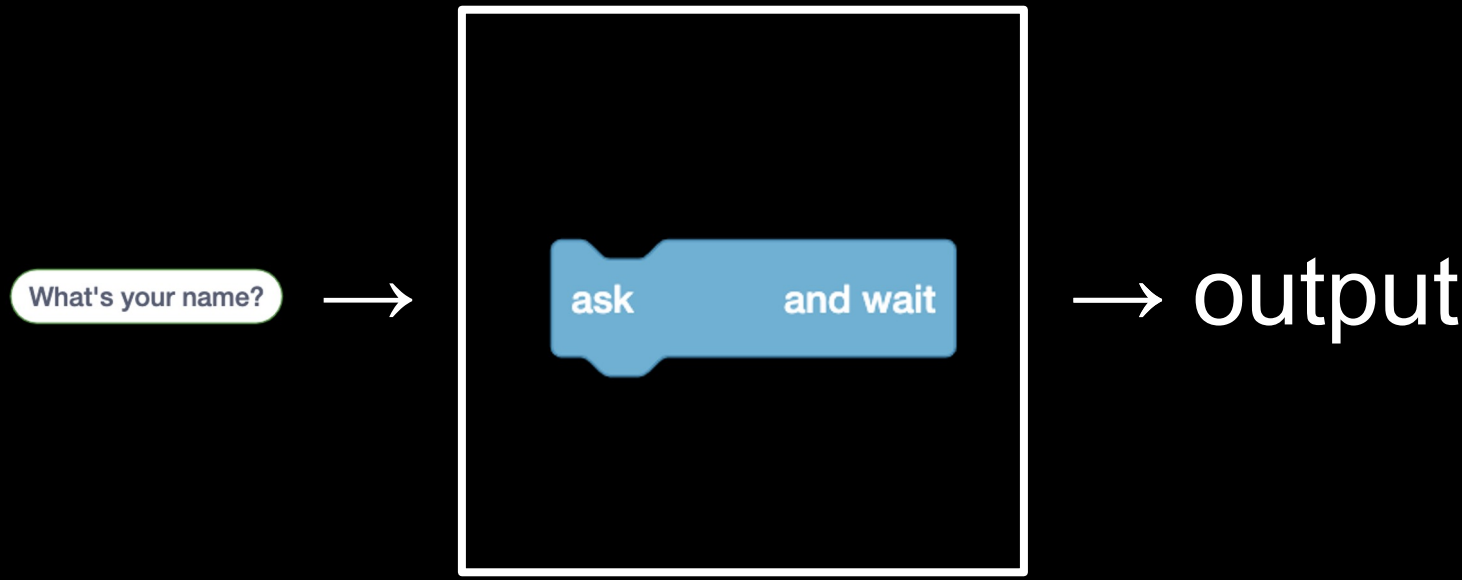

hello, world
say
output

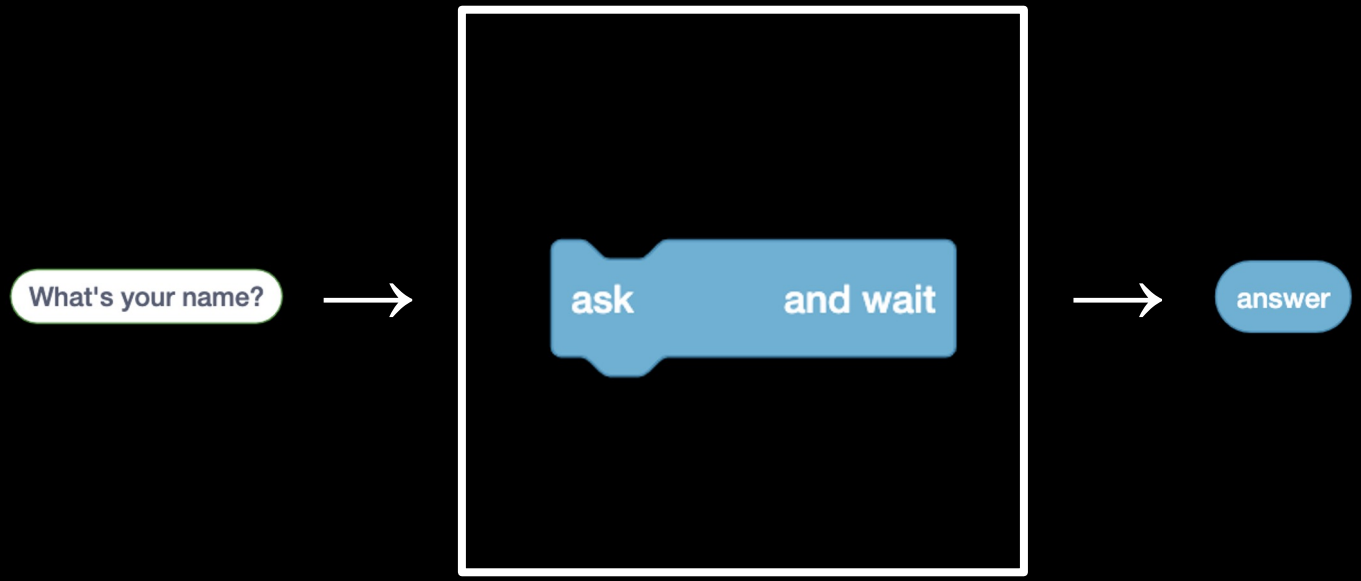

hello, world
say
hello, world


ask
What's your name?
and wait

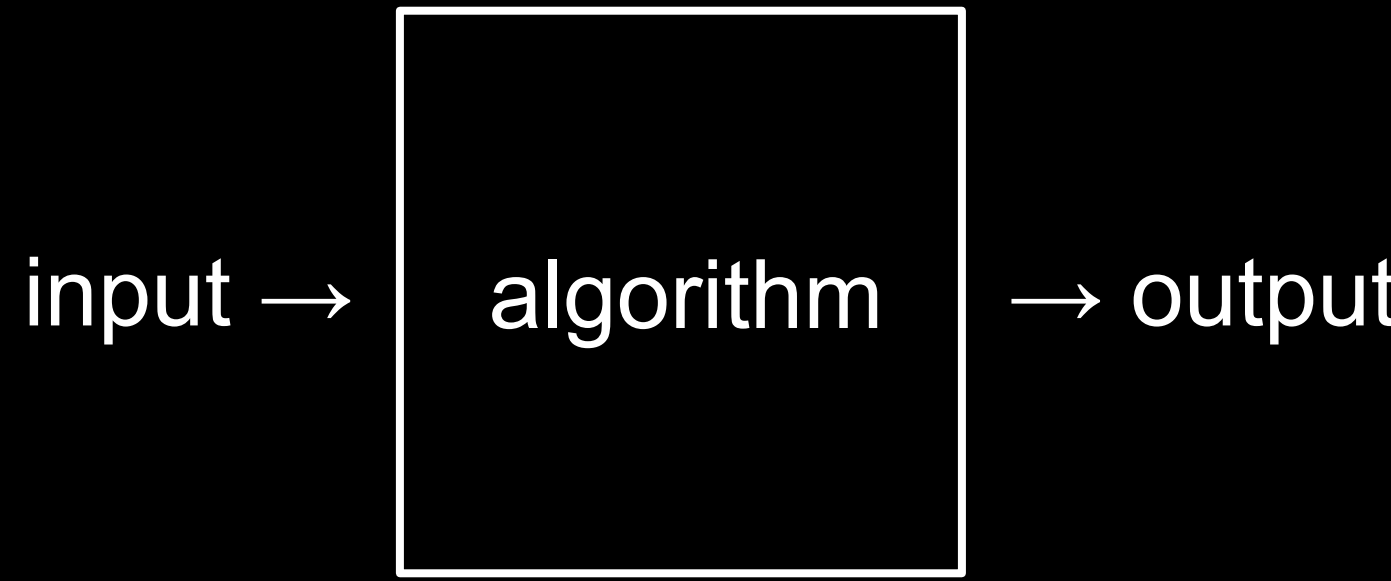

input →
algorithm
→ output

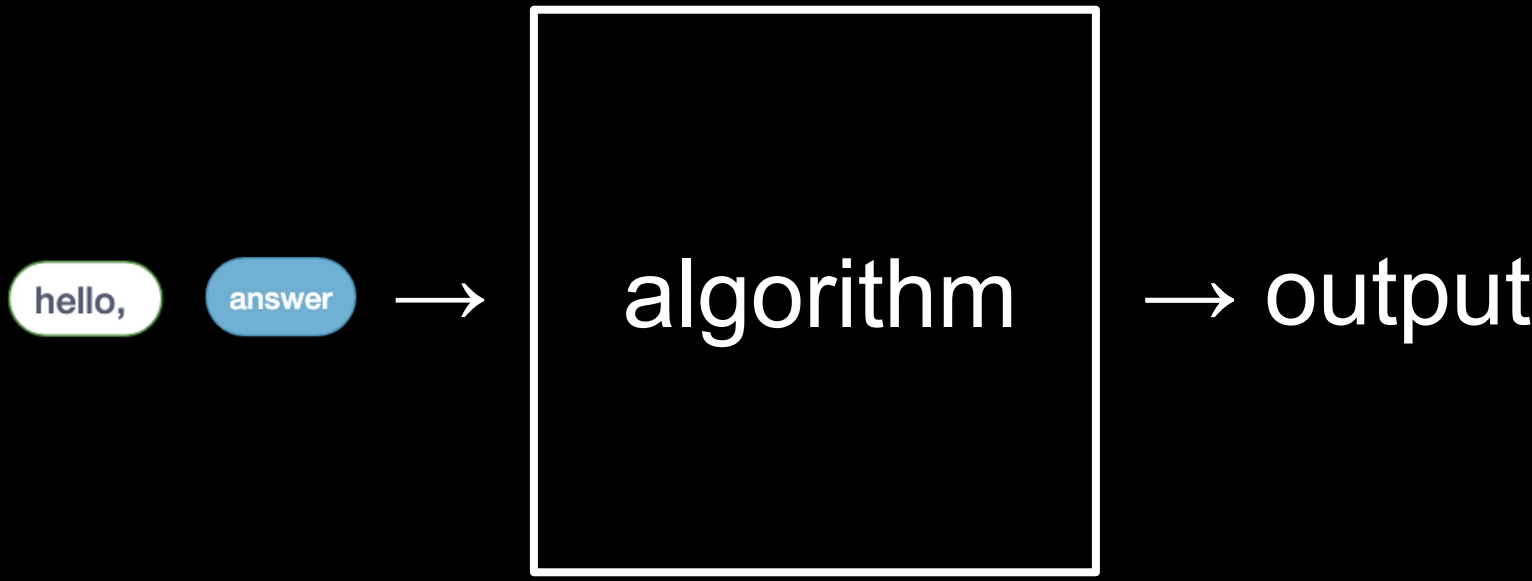

What's your name?
algorithm
output


What's your name?
ask
and wait
output


What's your name?
ask
and wait
answer


say
join
hello,
answer


input →
algorithm
→ output

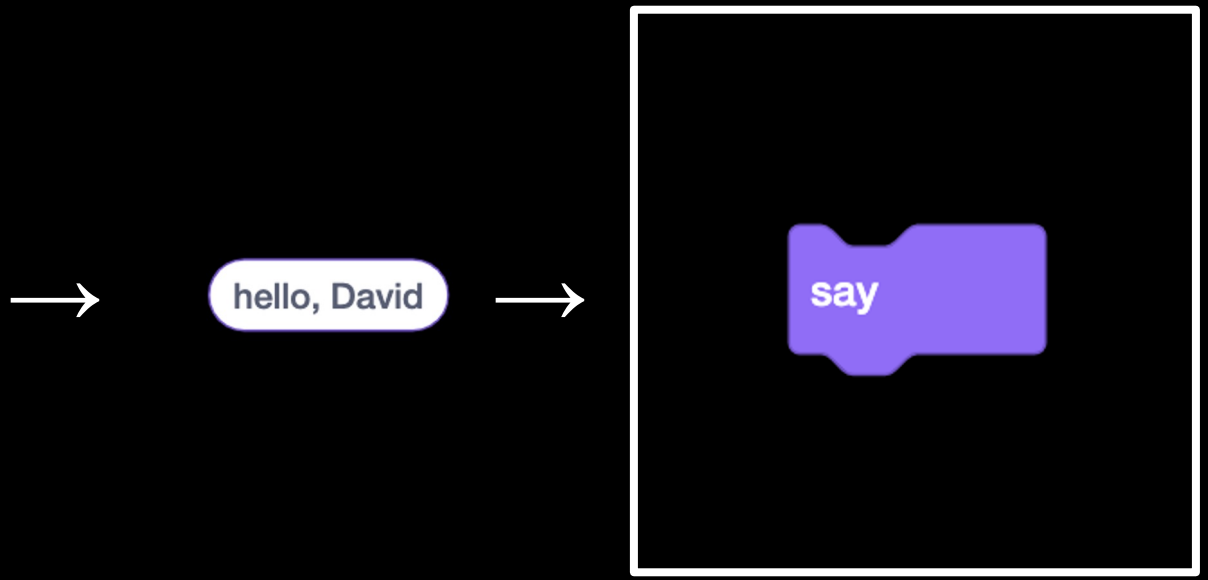

hello,
answer
algorithm
output

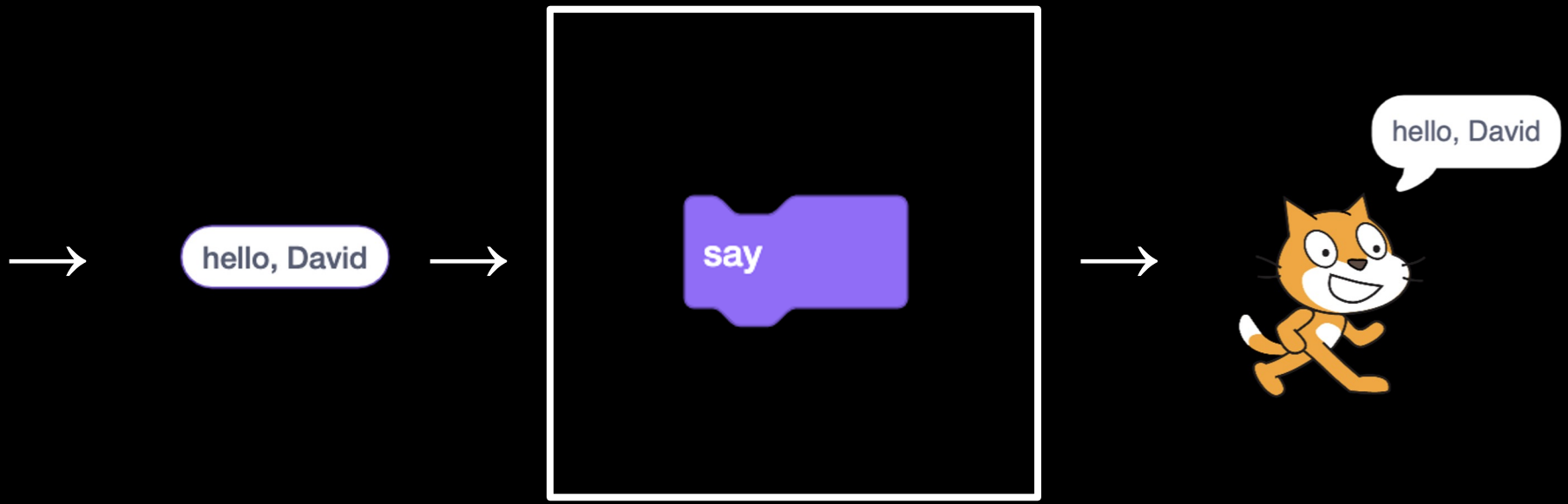

hello,
answer
join
output


hello,
answer
join
hello, David


hello, David


hello, David


hello, David
say


hello, David
say
hello, David