

This is CS50

# This is CS50

- Visit [cs50.ly/screen](https://cs50.ly/screen) to view projector on your laptop and ask questions via chat.
- Today's snacks will be whoopie pies! 
- If you didn't get a **rubber duck**  yet, ask Carter during break or after class!
- If you'd like to attend **CS50 Lunch** this Fri 10/6 at 1:15pm, RSVP at [cs50.ly/lunch](https://cs50.ly/lunch)!
- Do **say hi or ask questions** during break or after class!

This is CS50



CS50  
STRESS BALL

CS50  
STRESS BALL

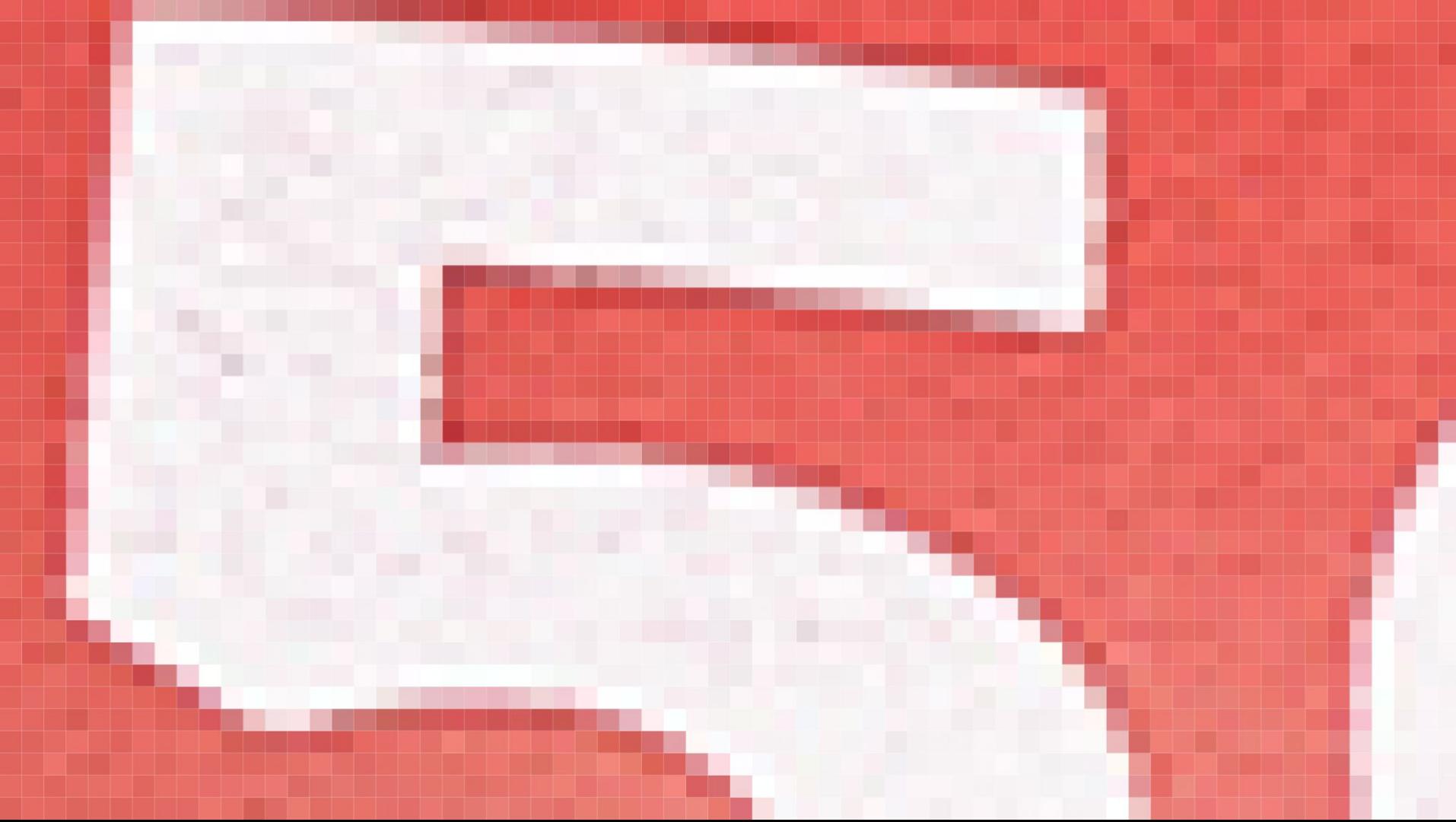
CS50  
STRESS BALL

**CS50**  
**STRESS BALL**

**C**  
**STRE**

**CS50**  
**STRESS BALL**

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1	1	0	0	0	0	1	1
1	0	1	1	1	1	0	1
0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0
0	1	0	1	1	0	1	0
0	1	1	0	0	1	1	0
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1	1	0	0	0	0	1	1

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

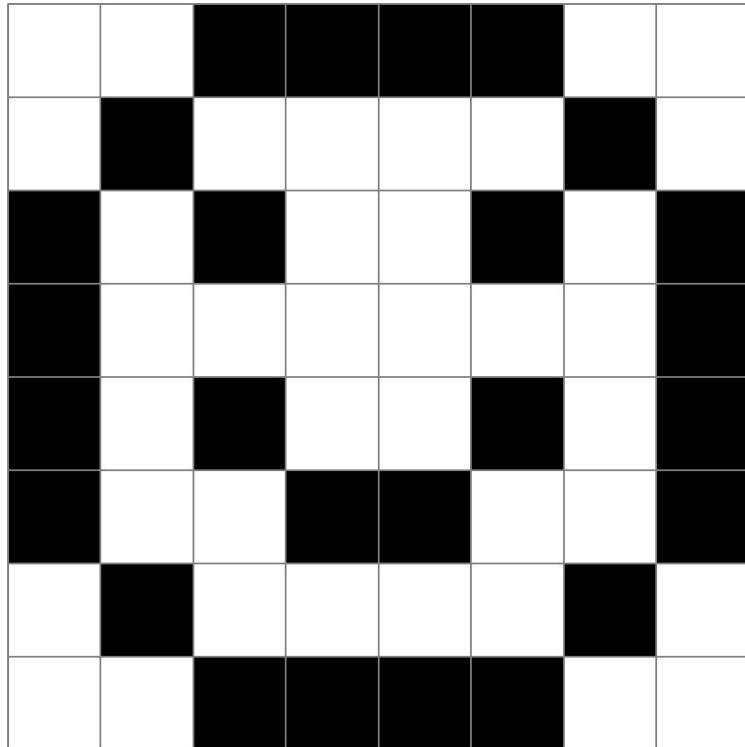
0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

1	1	0	0	0	0	1	1
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0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0
0	1	0	1	1	0	1	0
0	1	1	0	0	1	1	0
1	0	1	1	1	1	0	1
1	1	0	0	0	0	1	1



pixel art

CS50 Pixel Art - Google Sheet

docs.google.com/spreadsheets/d/1u5lFB7e9koG8pxtNdl0v4rN0HWLBoxrNTkfu4zSc2g/edit#gid=0

CS50 Pixel Art

File Edit View Insert Format Data Tools Extensions Help

Share J

AZ2

1 Type @ to insert

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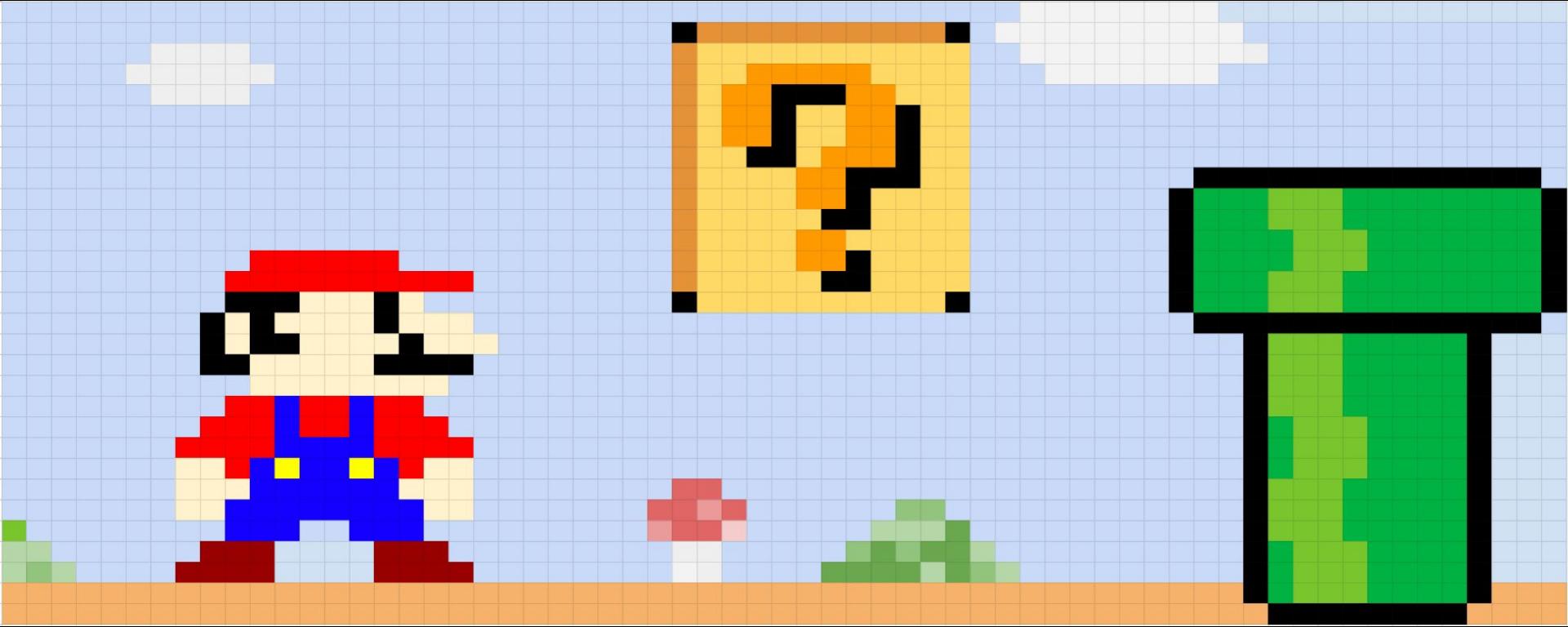
24

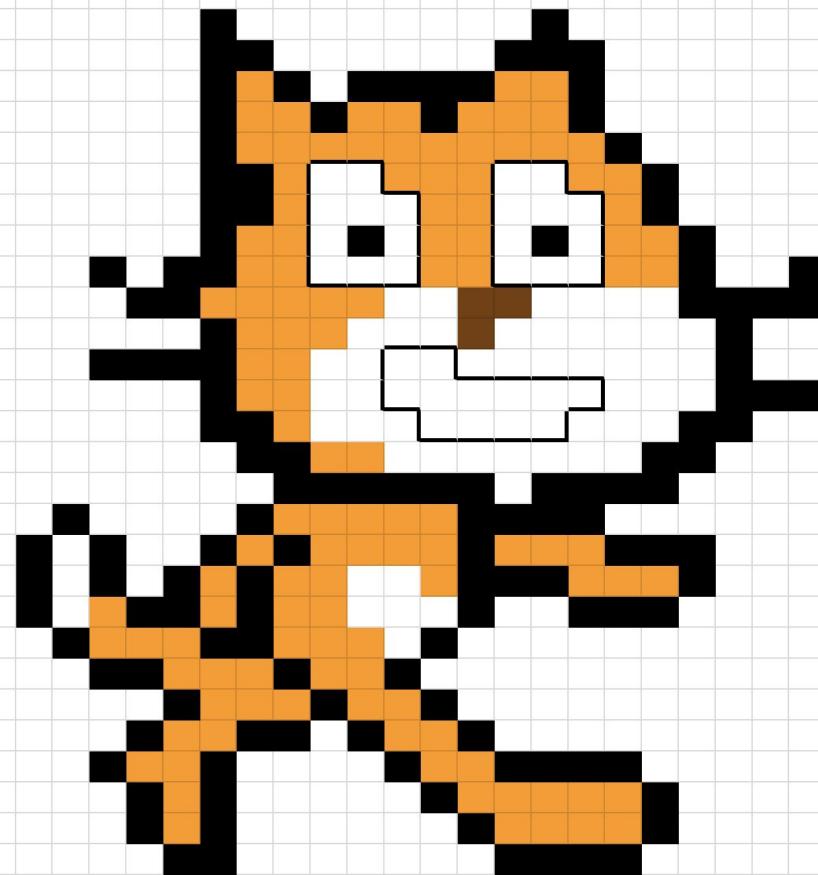
25

26

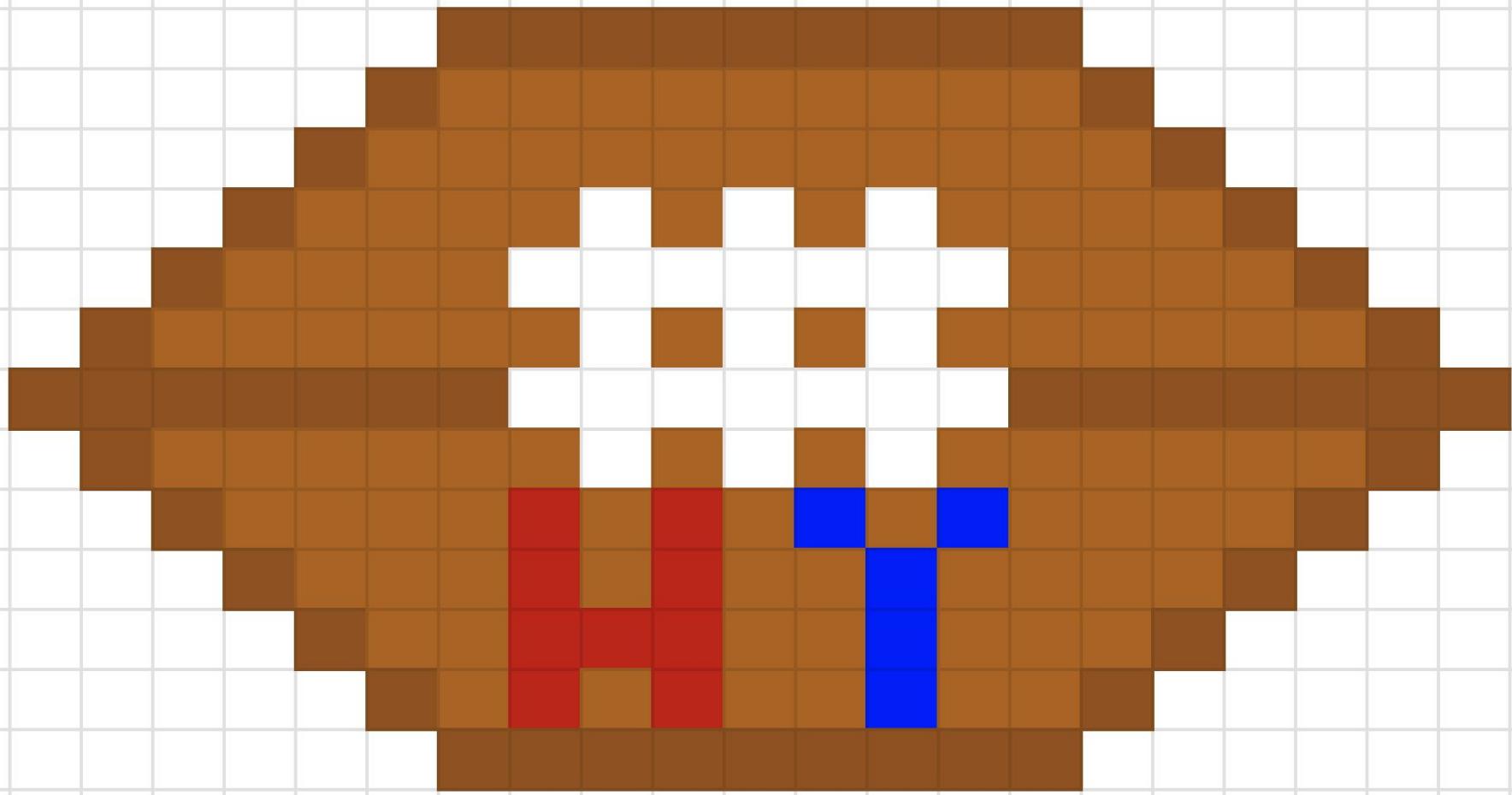
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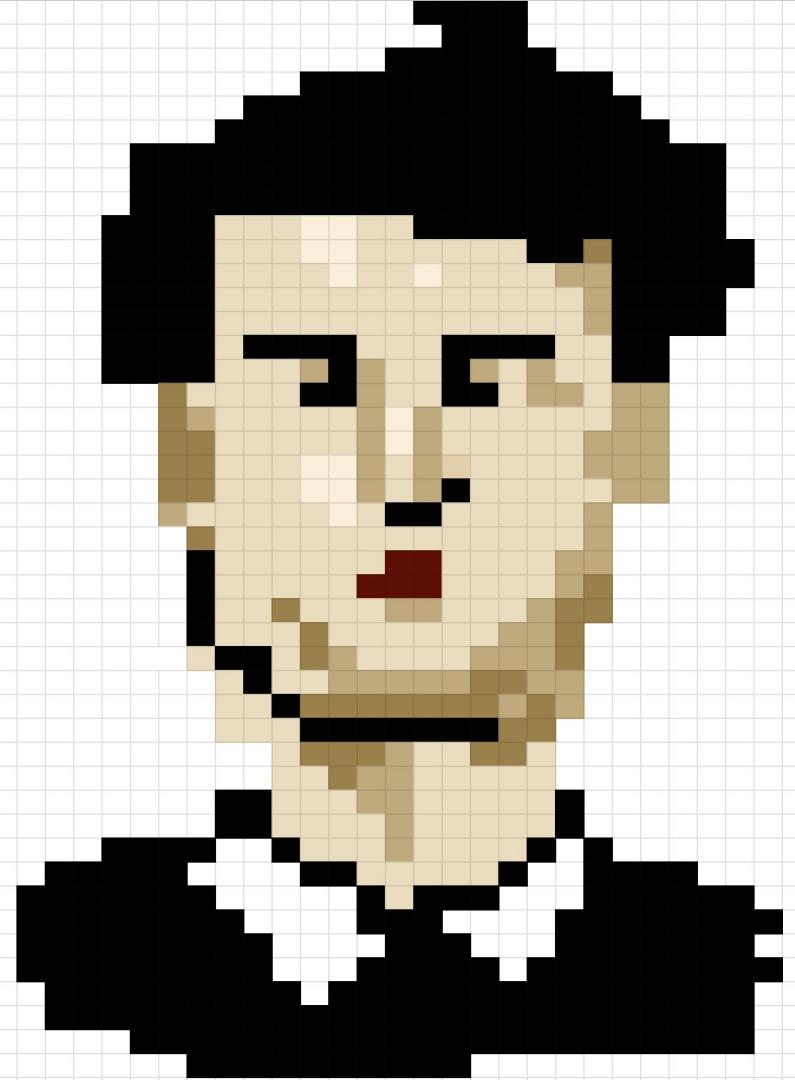
CS50 Pixel Art





SCRATCH CAT

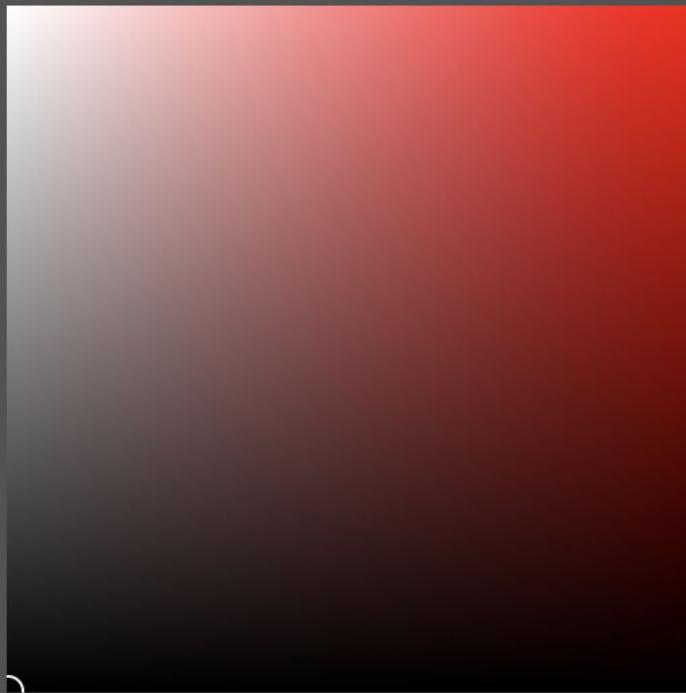




[cs50.ly/art](https://cs50.ly/art)

RGB

## Color Picker (Foreground Color)



new



current

OK

Cancel

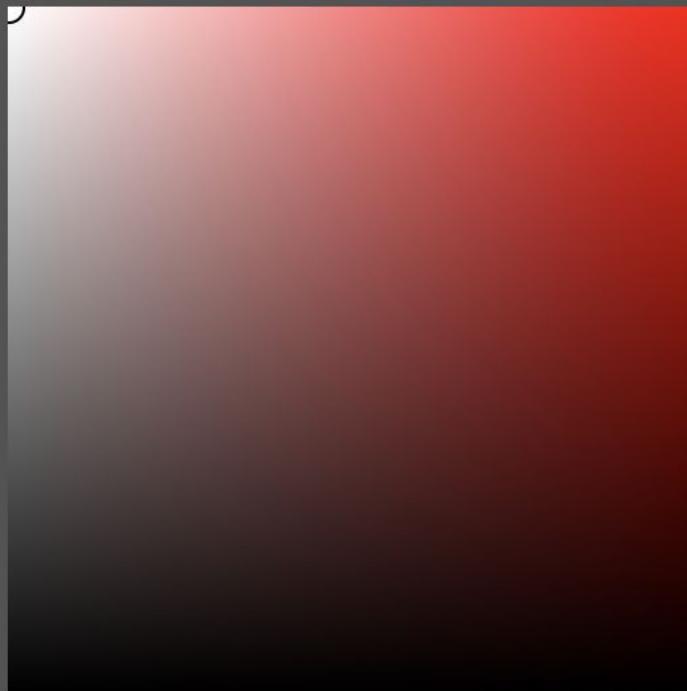
Add to Swatches

Color Libraries

<input checked="" type="radio"/> H:	0	°	<input type="radio"/> L:	0
<input type="radio"/> S:	0	%	<input type="radio"/> a:	0
<input type="radio"/> B:	0	%	<input type="radio"/> b:	0
<input type="radio"/> R:	0		C:	75 %
<input type="radio"/> G:	0		M:	68 %
<input type="radio"/> B:	0		Y:	67 %
#	000000		K:	90 %

Only Web Colors

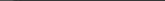
## Color Picker (Foreground Color)



new



current



OK

Cancel

Add to Swatches

Color Libraries

H: 0 °

L: 100

S: 0 %

a: 0

B: 100 %

b: 0

R: 255

C: 0 %

G: 255

M: 0 %

B: 255

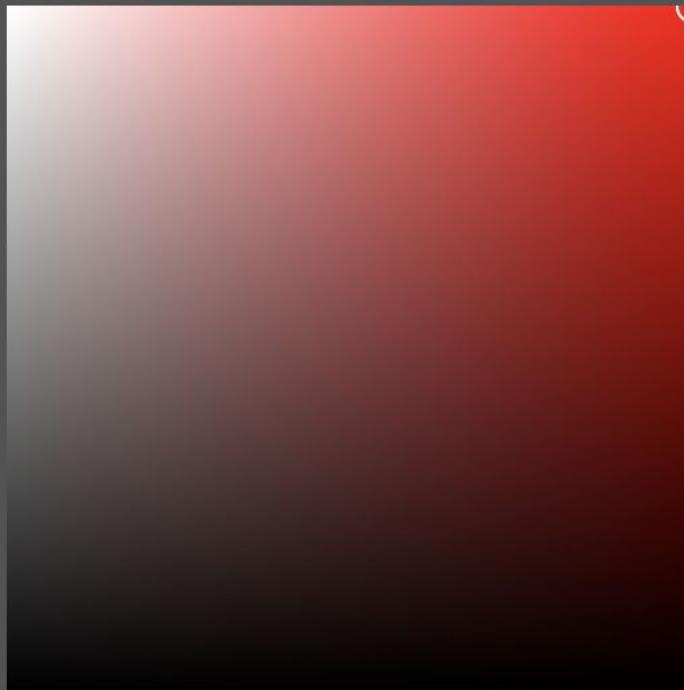
Y: 0 %

# FFFFFF

K: 0 %

Only Web Colors

## Color Picker (Foreground Color)



new



current

OK

Cancel

Add to Swatches

Color Libraries

H: 0 °

S: 100 %

B: 100 %

R: 255

G: 0

B: 0

L: 54

a: 81

b: 70

C: 0 %

M: 99 %

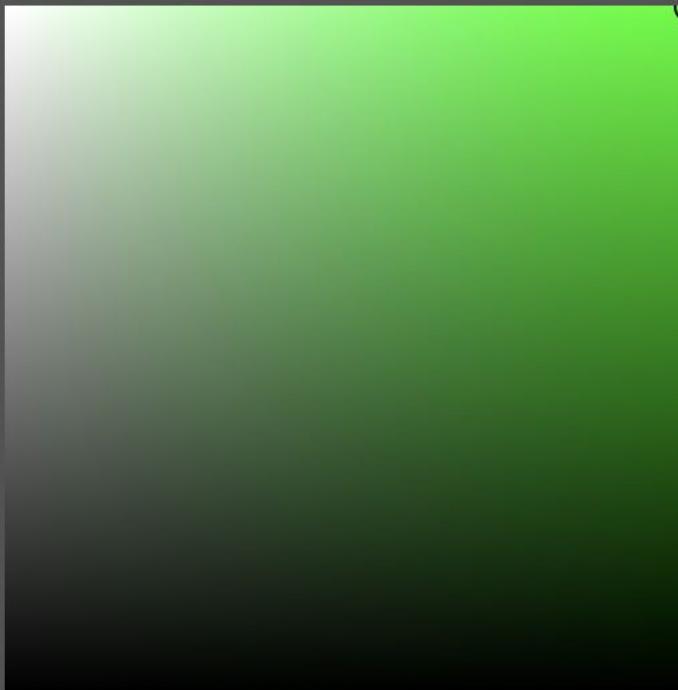
Y: 100 %

K: 0 %

Only Web Colors

# FF0000

## Color Picker (Foreground Color)



new



current

OK

Cancel

Add to Swatches

Color Libraries

H: 120 °

L: 88

S: 100 %

a: -79

B: 100 %

b: 81

R: 0

C: 63 %

G: 255

M: 0 %

B: 0

Y: 100 %

#

K: 0 %

Only Web Colors

## Color Picker (Foreground Color)



new

current



OK

Cancel

Add to Swatches

Color Libraries

H: 240 °

S: 100 %

B: 100 %

R: 0

G: 0

B: 255

L: 30

a: 68

b: -112

C: 88 %

M: 77 %

Y: 0 %

K: 0 %

Only Web Colors

# 0000FF

0 1

0 1 2 3 4 5 6 7 8 9

0 1 2 3 4 5 6 7 8 9 A B C D E F

0 1 2 3 4 5 6 7 8 9 a b c d e f

hexadecimal

base-16

$16^1$      $16^0$

# #

16 1

# #

16 1

00

16 1

θ1

16 1

θ2

16 1

03

16 1

04

16 1

05

16 1

06

16 1

07

16 1

08

16 1

09

16 1

θA

16 1

θB

16 1

θC

16 1

θD

16 1

θE

16 1

θF

16 1

10

16 1

11

16 1

12

16 1

13

16 1

14

16 1



16 1

FF

16 1

FF

$16 \times F + 1 \times F$

16 1

FF

$16 \times 15 + 1 \times 15$

16 1

FF

240 + 15

16 1

FF

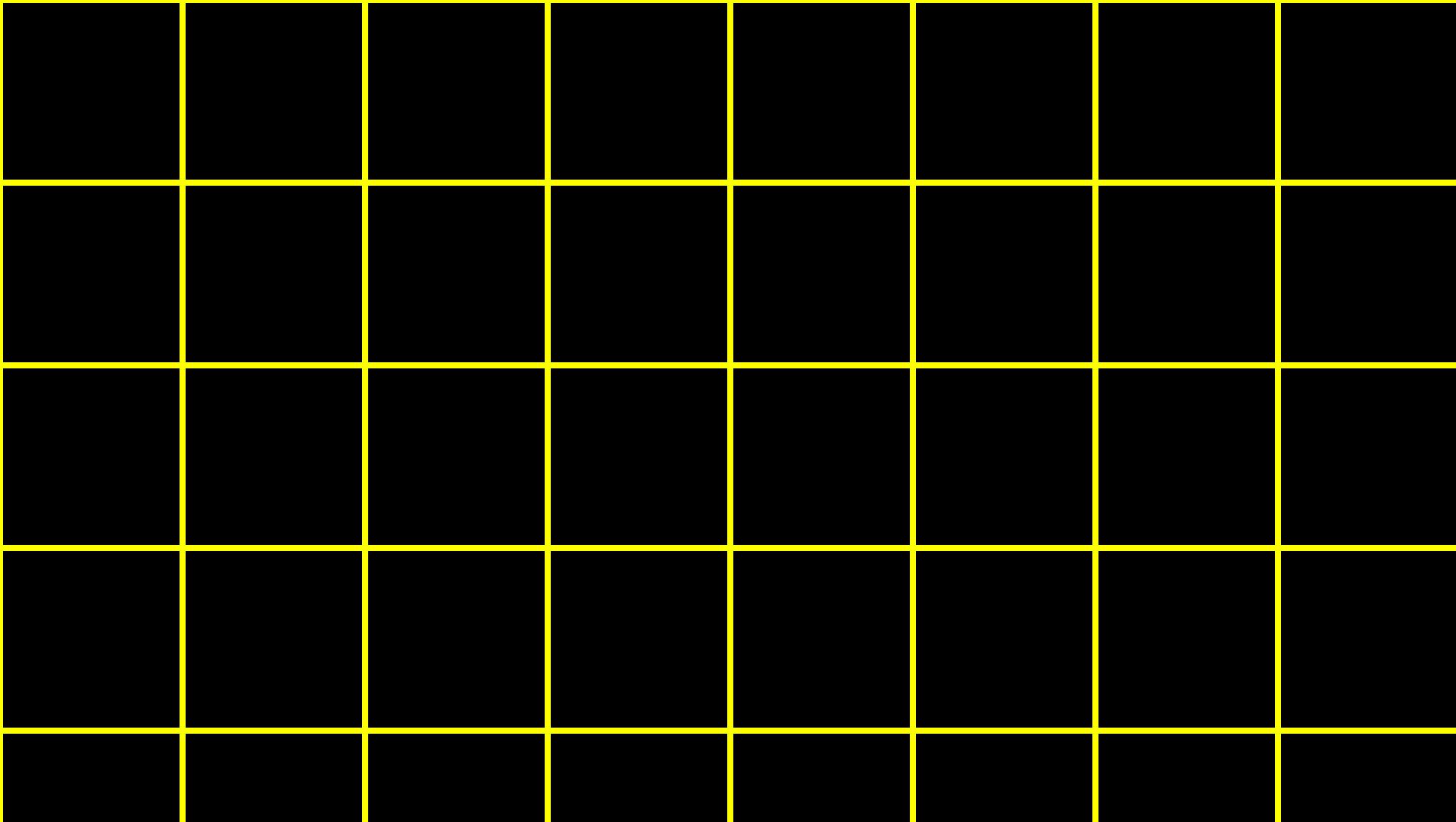
255

F

1111

11111111

FF



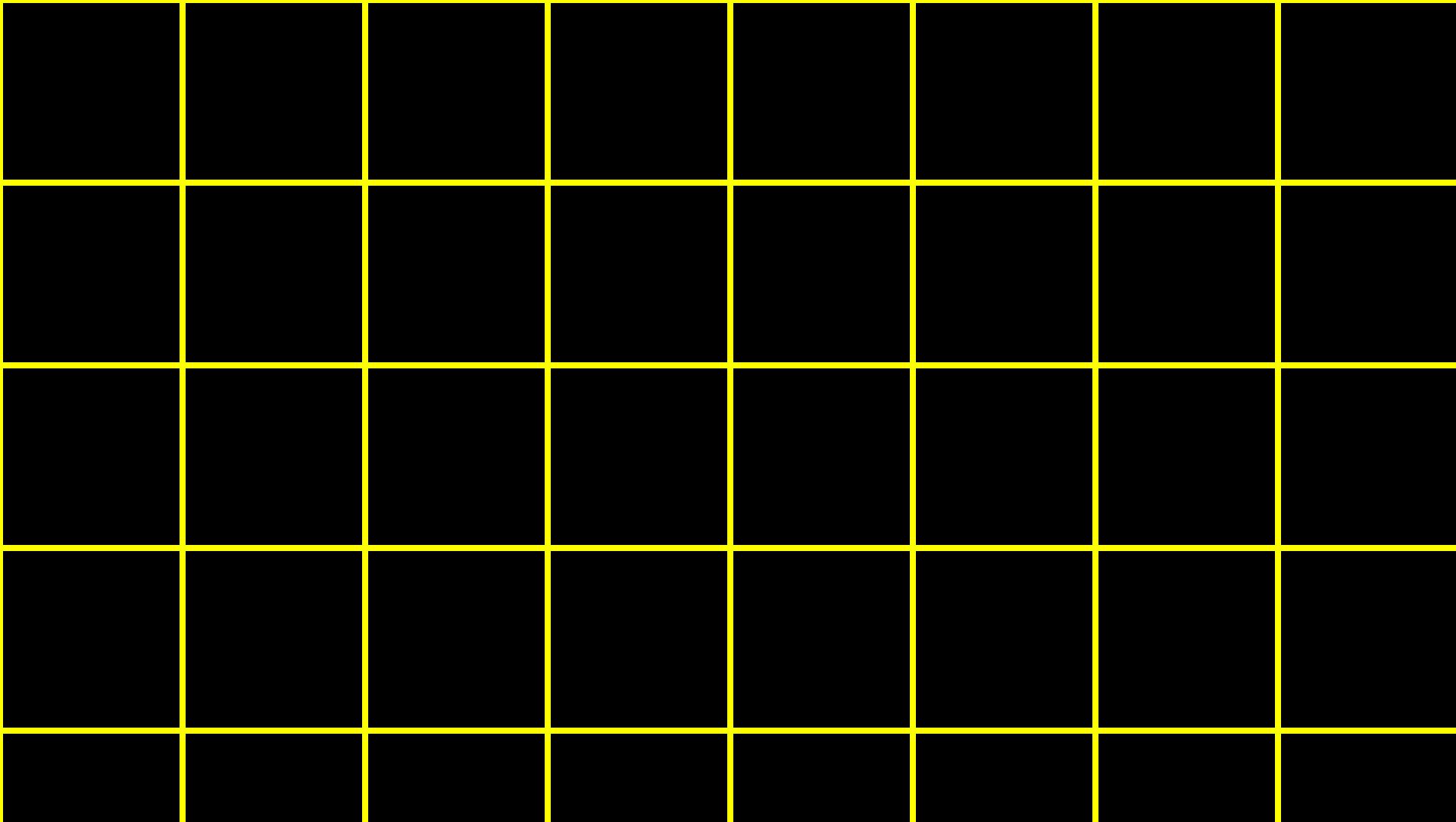
0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15

0	1	2	3	4	5	6	7
8	9	A	B	C	D	E	F

0	1	2	3	4	5	6	7
8	9	A	B	C	D	E	F
10	11	12	13	14	15	16	17
18	19	1A	1B	1C	1D	1E	1F

0x0	0x1	0x2	0x3	0x4	0x5	0x6	0x7
0x8	0x9	0xA	0xB	0xC	0xD	0xE	0xF
0x10	0x11	0x12	0x13	0x14	0x15	0x16	0x17
0x18	0x19	0x1A	0x1B	0x1C	0x1D	0x1E	0x1F

```
int n = 50;
```



50

n

50

0x123

&

\*

pointers

```
int n = 50;
```

```
int *p = &n;
```

```
int n = 50;
```

```
int *p = &n;
```

```
int n = 50;
```

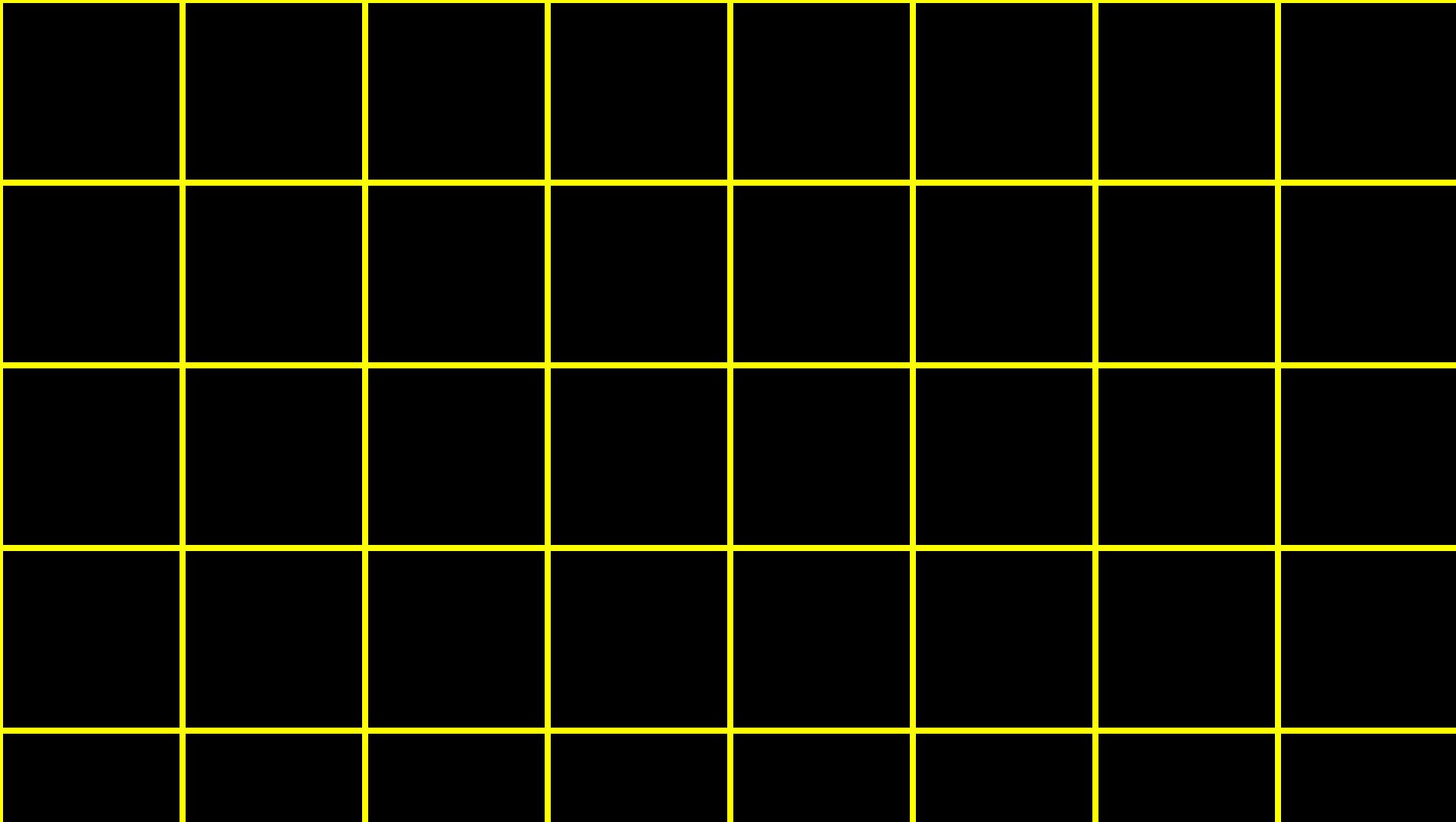
```
int* p = &n;
```

```
int n = 50;
```

```
int * p = &n;
```

```
int n = 50;
```

```
int *p = &n;
```



50

n

50

0x123

0x123

p

50

0x123

0x123

p

50

0x123

p

50

0x123

string

```
string s = "HI!";
```

H	I	!	\0
---	---	---	----

H  
 $s[0]$

I  
 $s[1]$

!  
 $s[2]$

\0  
 $s[3]$

H

0x123

I

0x124

!

0x125

\0

0x126

s

H

0x123

I

0x124

!

0x125

\0

0x126

0x123

s

H

0x123

I

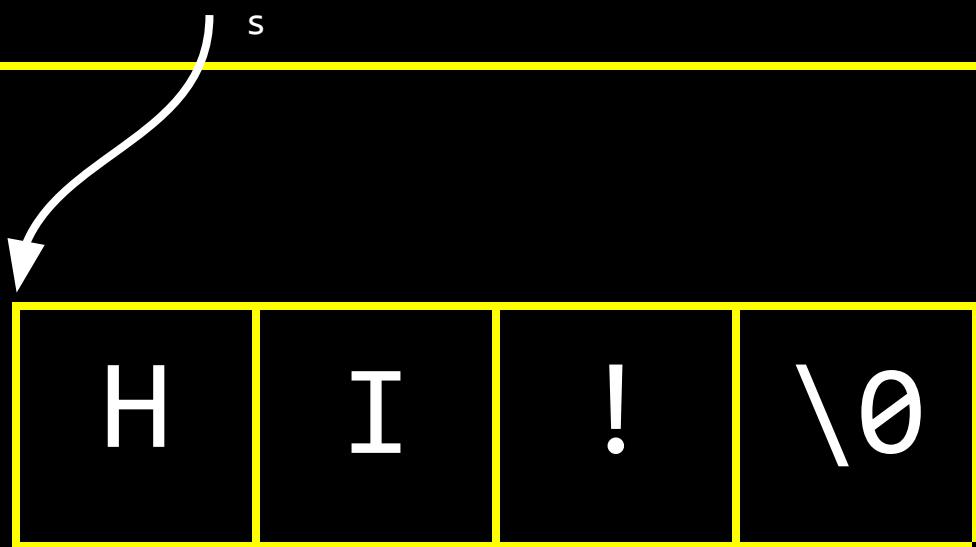
0x124

!

0x125

\0

0x126



```
string s = "HI!";
```

```
string s = "HI!";
```

```
char *s = "HI!";
```

```
typedef struct
{
    string name;
    string number;
} person;
```

```
typedef struct
{
    string name;
    string number;
} person;
```

```
typedef struct
{
    string name;
    string number;
} person;
```

```
typedef struct
{
    string name;
    string number;
} person;
```

```
typedef int integer;
```

```
typedef int integer;
```

```
typedef int integer;
```

```
typedef uint8_t BYTE;
```

```
typedef uint8_t BYTE;
```

```
typedef uint8_t BYTE;
```

```
typedef char *string;
```

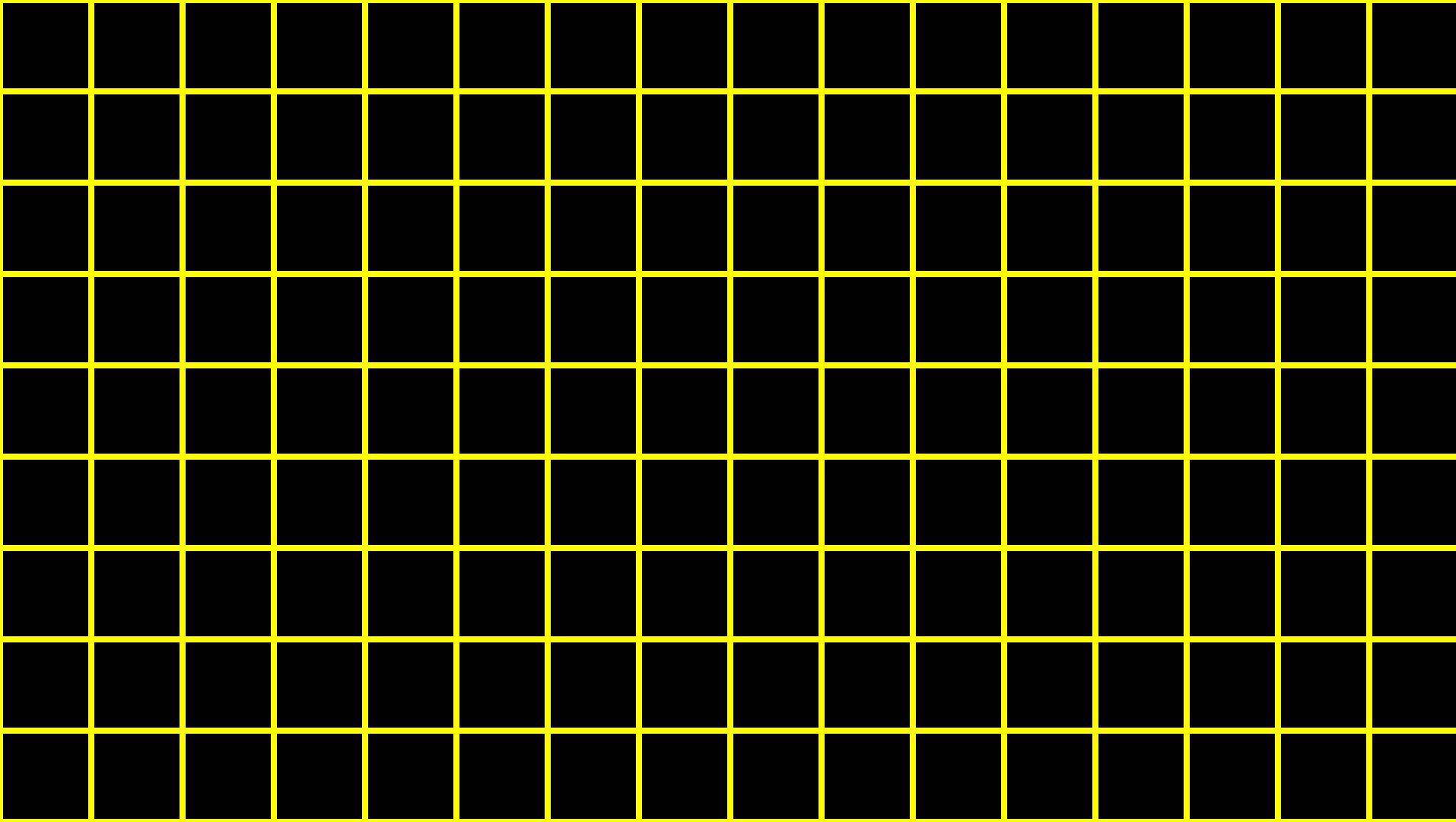
```
typedef char *string;
```

```
typedef char *string;
```

cs50.h

# pointer arithmetic



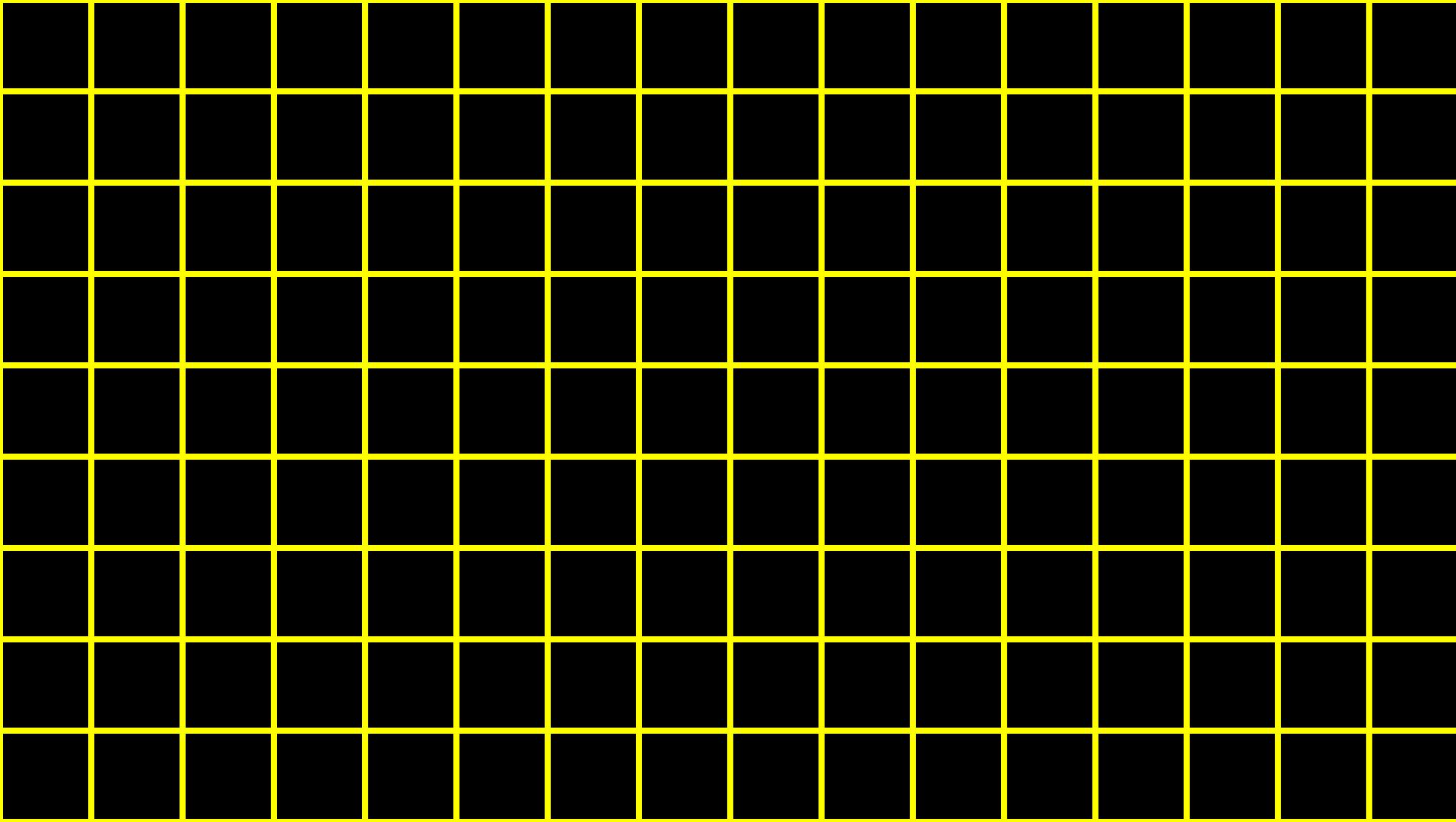


50

i

50

j



$s$

s

H I ! \theta

s

H  
0x123

I  
0x124

!  
0x125

\0  
0x126

0x123

s

H

0x123

I

0x124

!

0x125

\0

0x126

0x123

s

t

H

0x123

I

0x124

!

0x125

\0

0x126

0x123

s

t

H

0x123

I

0x124

!

0x125

\0

0x126

H

0x123

I

0x124

!

0x125

\0

0x126

0x123

s

t

H

0x123

I

0x124

!

0x125

\0

0x126

H

0x456

I

0x457

!

0x458

\0

0x459

0x123

s

0x456

t

H

0x123

I

0x124

!

0x125

\0

0x126

H

0x456

I

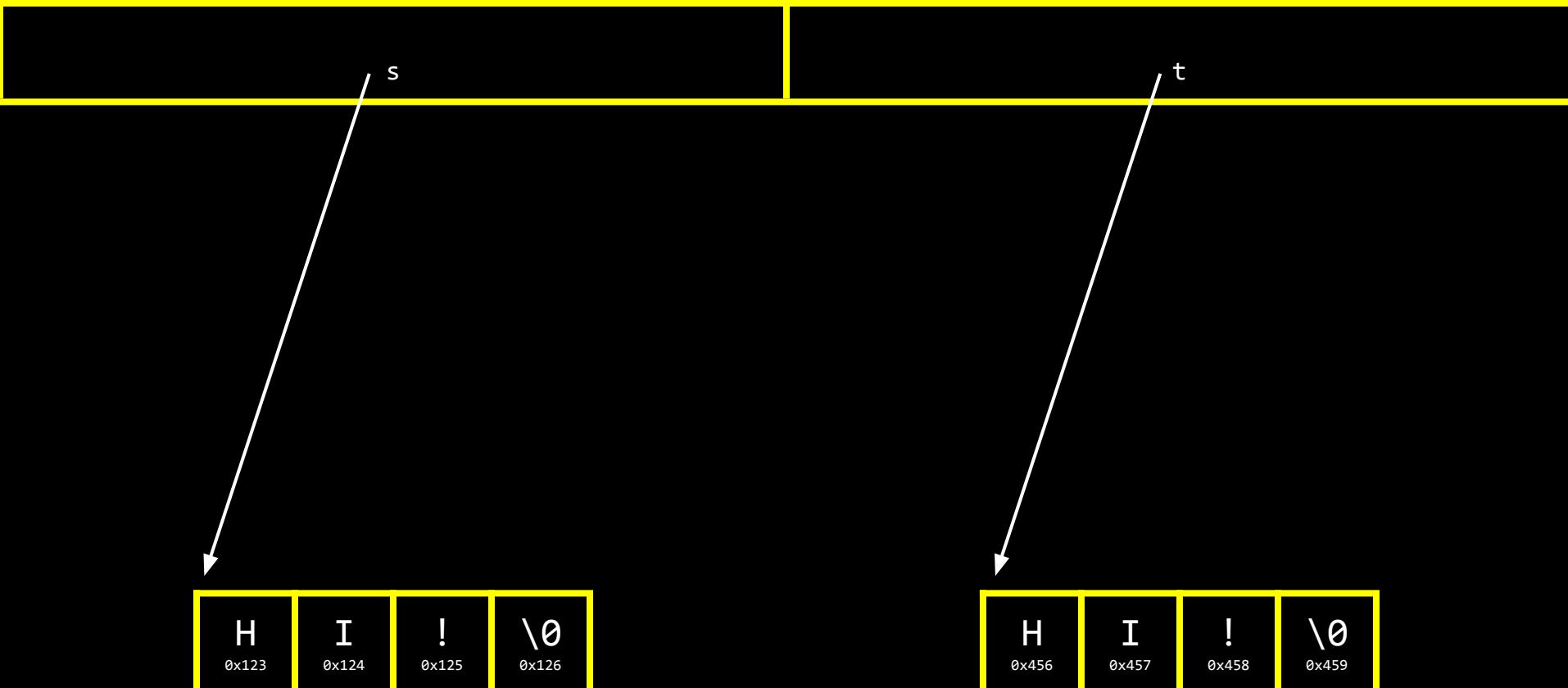
0x457

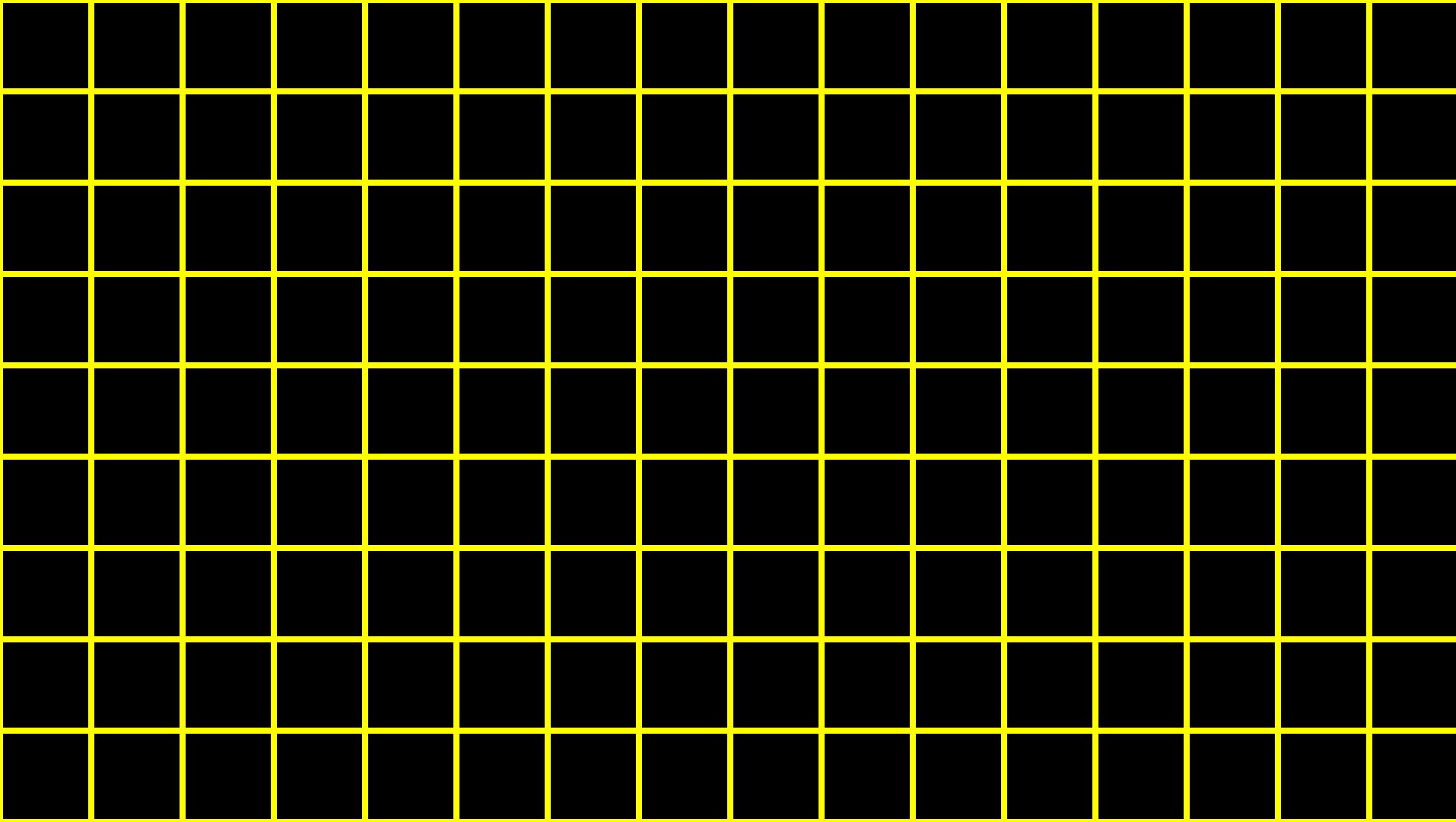
!

0x458

\0

0x459





$s$

s

h i ! \theta

s

h      i      !      \0  
0x123    0x124    0x125    0x126

0x123

s

h  
0x123

i  
0x124

!  
0x125

\0  
0x126

0x123

s

t

h

0x123

i

0x124

!

0x125

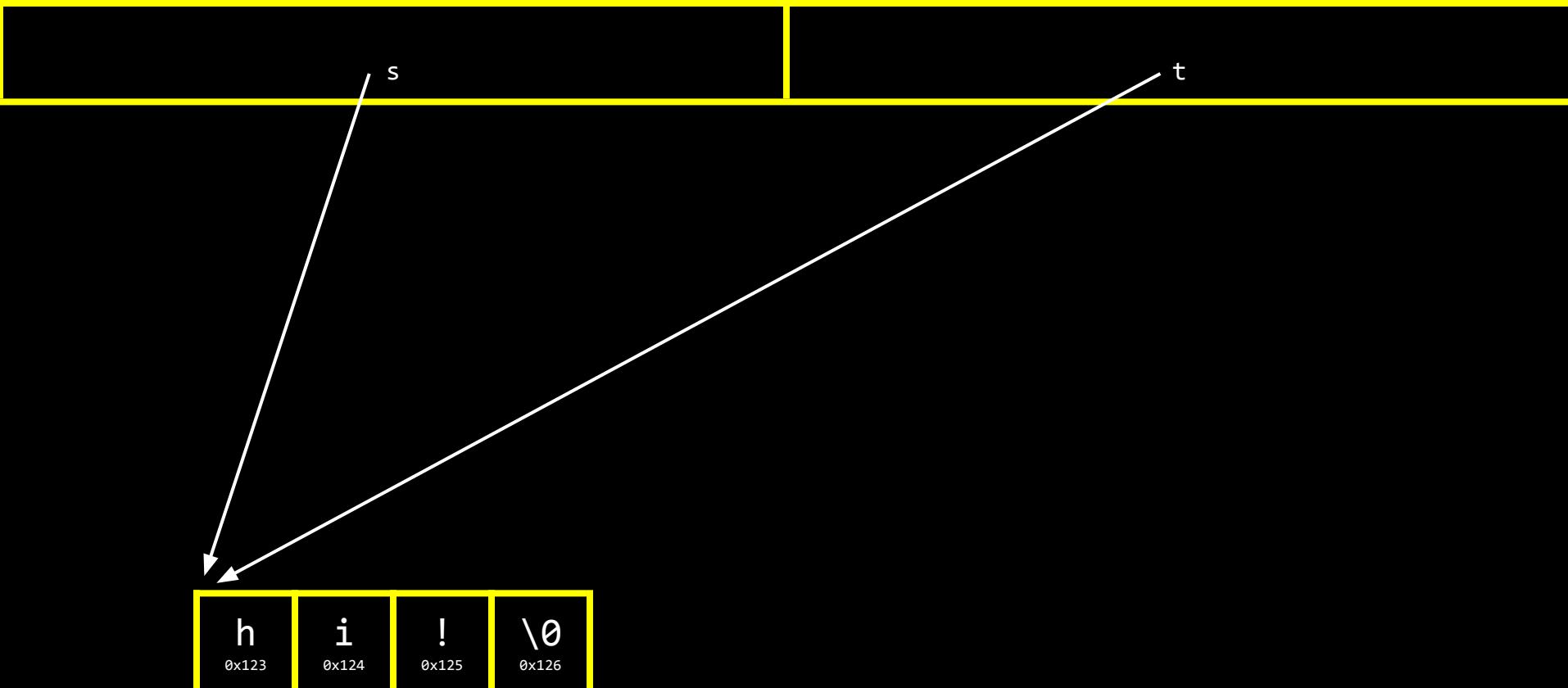
\0

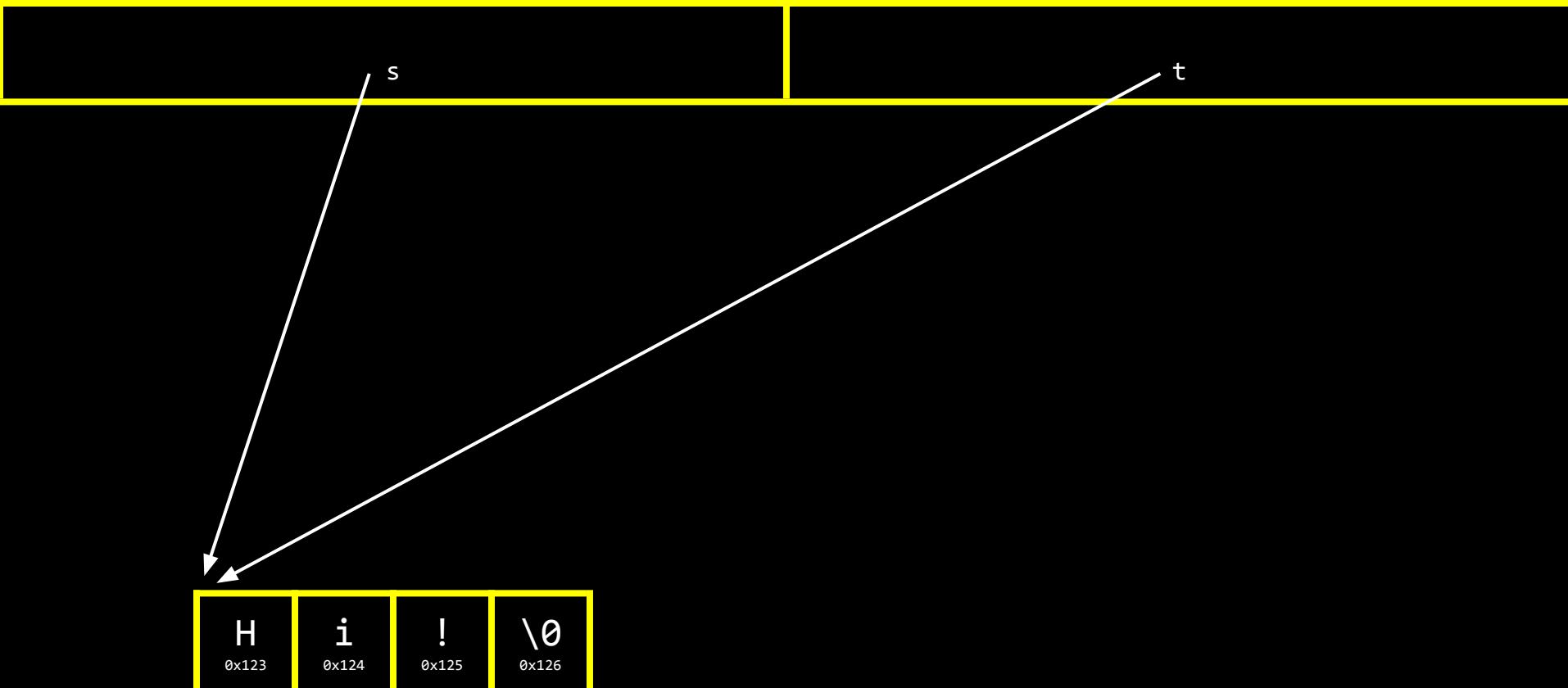
0x126

0x123  
s

0x123  
t

h      i      !      \0  
0x123    0x124    0x125    0x126





malloc

free

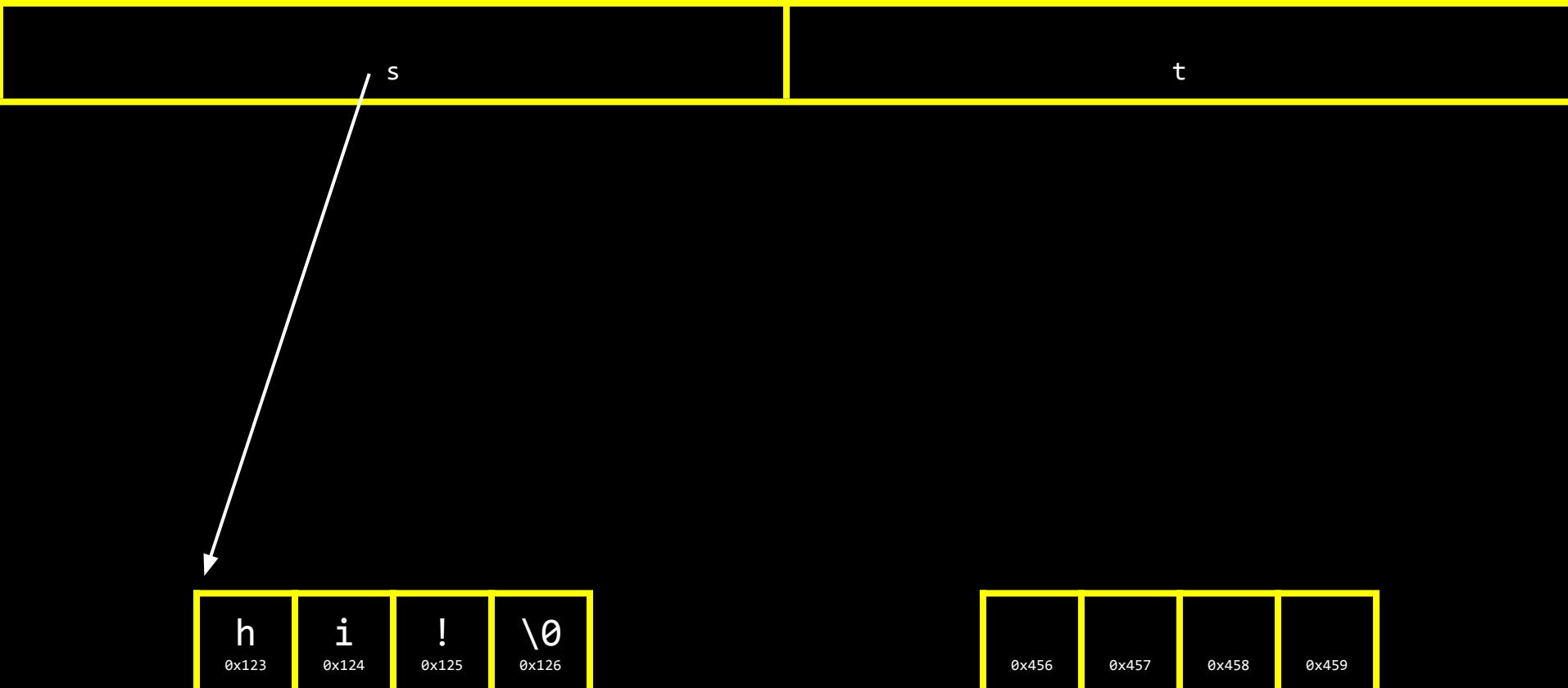
...

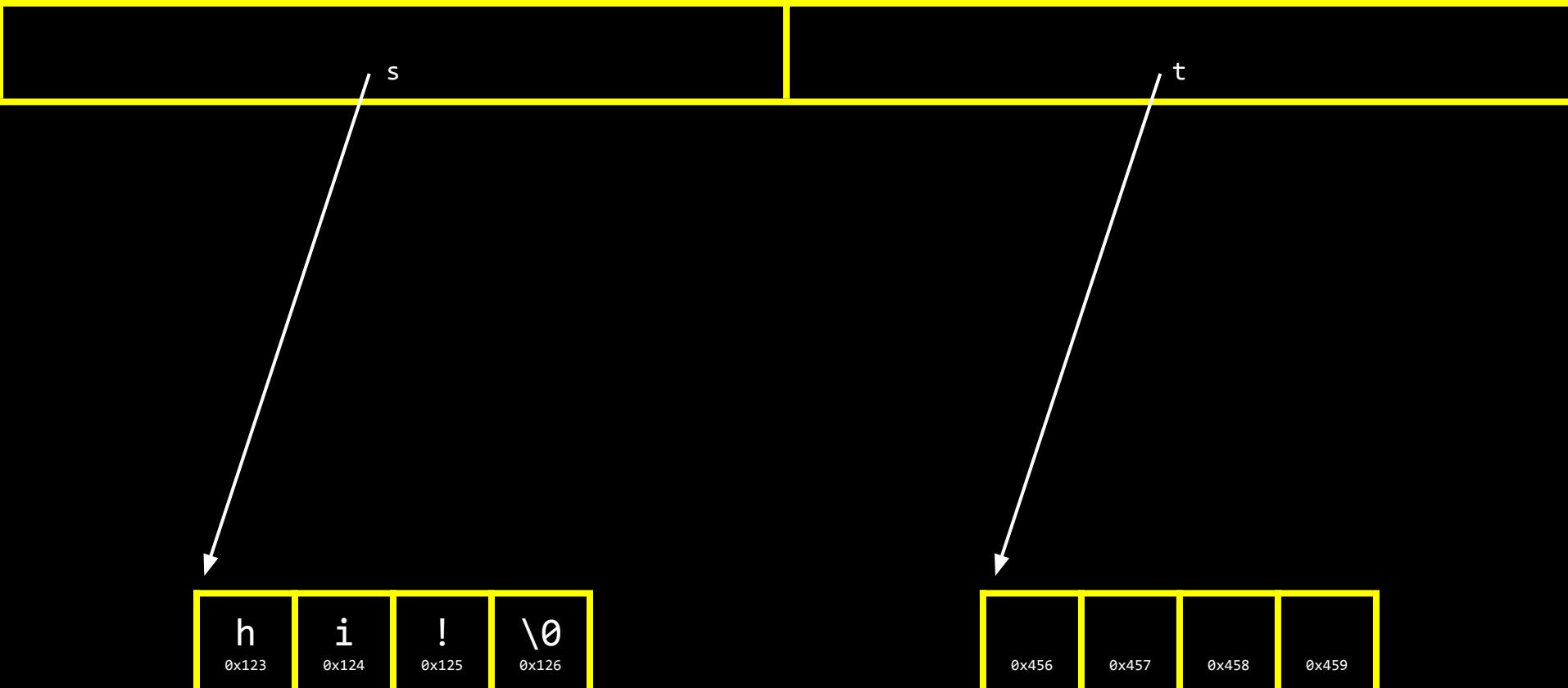


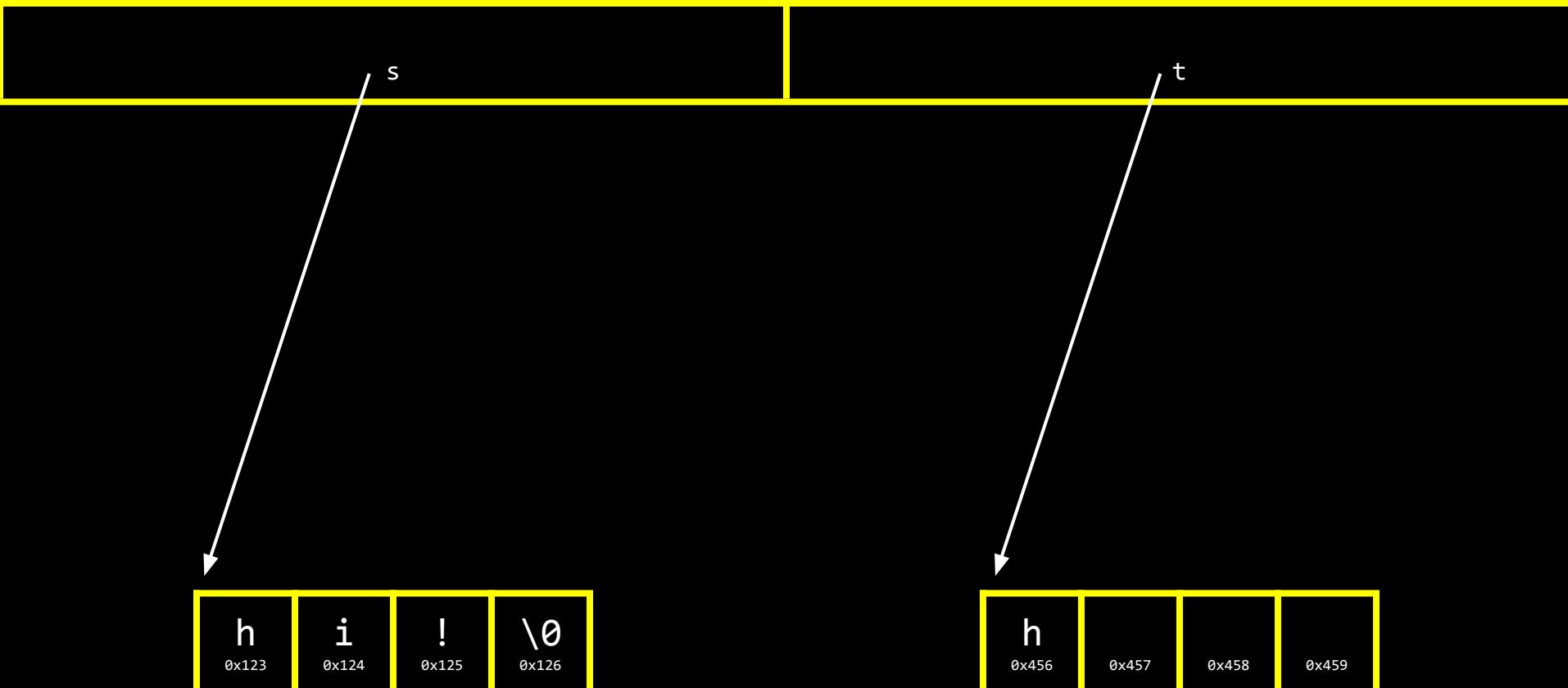
s

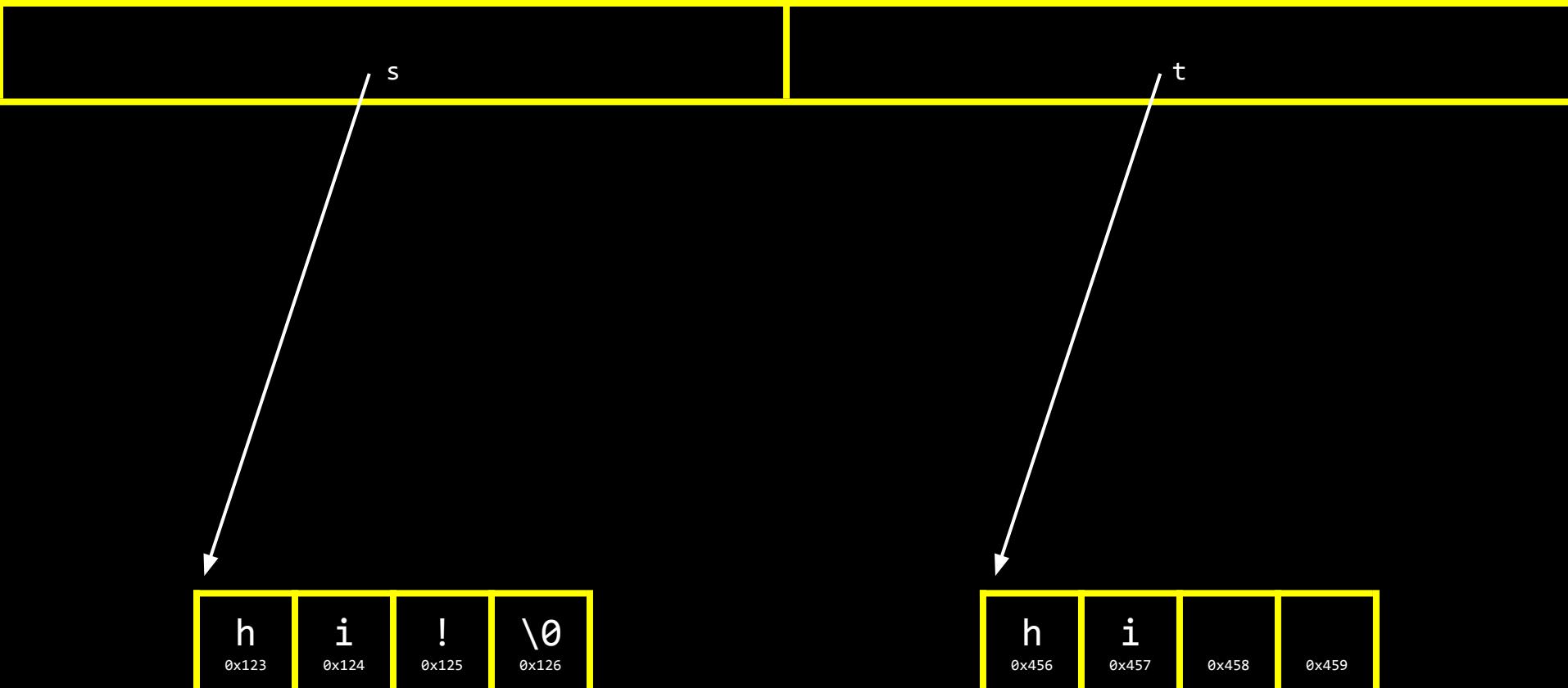


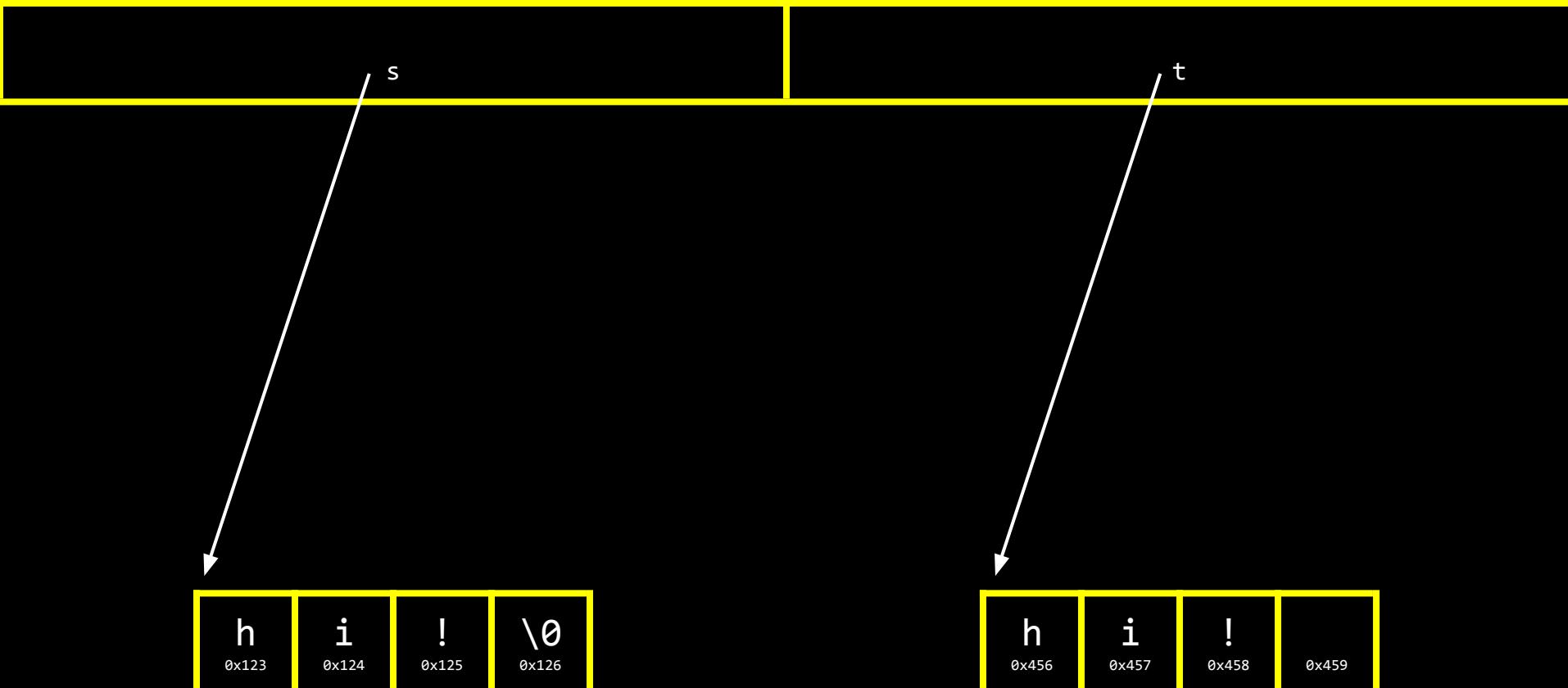


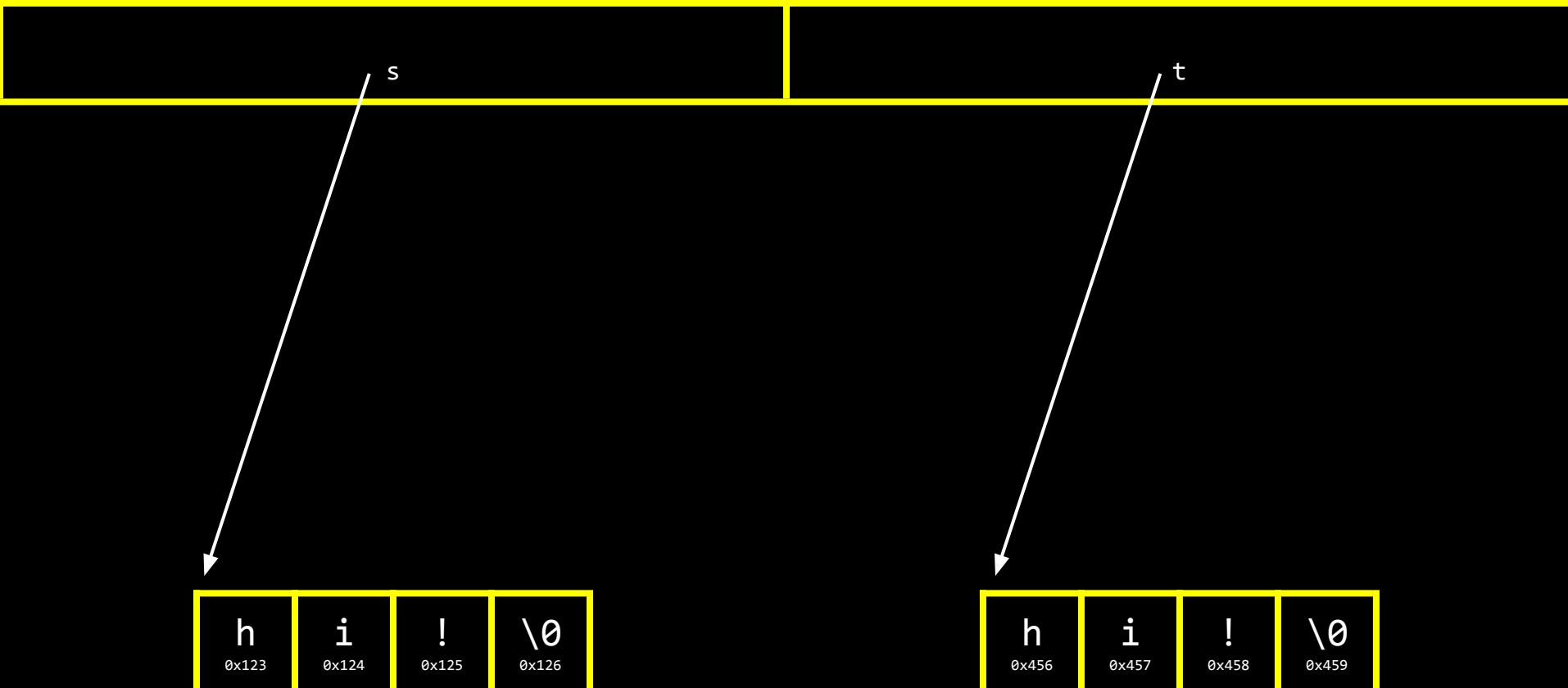


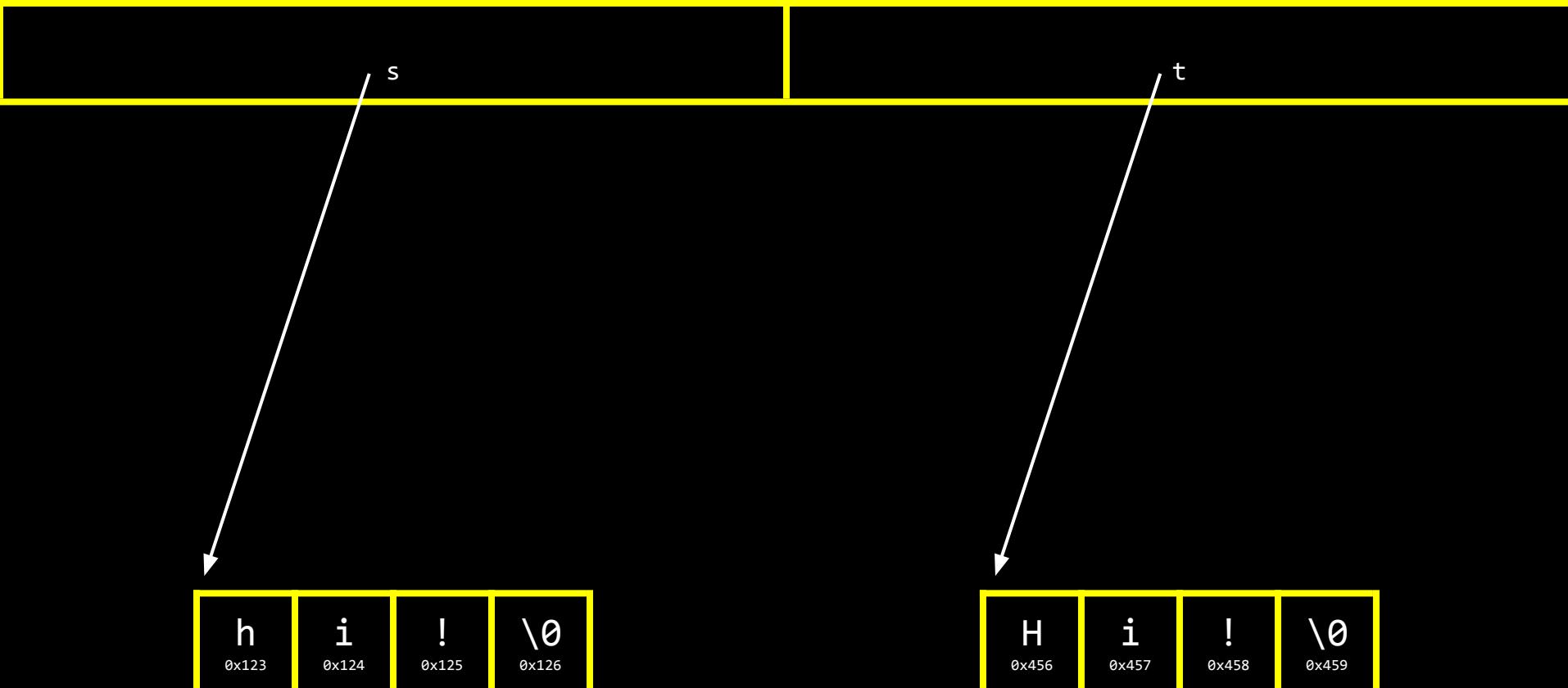












NULL

valgrind

garbage values

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;
    *y = 13;

    y = x;

    *y = 13;
}
```

```
int main(void)
```

```
{
```

```
    int *x;
```

```
    int *y;
```

```
    x = malloc(sizeof(int));
```

```
    *x = 42;
```

```
    *y = 13;
```

```
    y = x;
```

```
    *y = 13;
```

```
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;
    *y = 13;

    y = x;

    *y = 13;
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;
    *y = 13;

    y = x;

    *y = 13;
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;
    *y = 13;

    y = x;

    *y = 13;
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;

    y = x;

    *y = 13;
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;

    y = x;

    *y = 13;
}
```

```
int main(void)
{
    int *x;
    int *y;

    x = malloc(sizeof(int));

    *x = 42;

    y = x;

    *y = 13;
}
```



\*y = 13;

```
void swap(int a, int b)
{
}
```

```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```



scope

passing by value



8BB12  
D9HXT

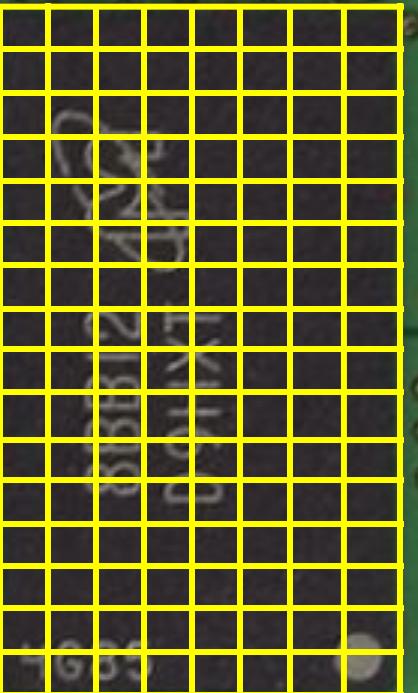
8BB12  
D9HXT

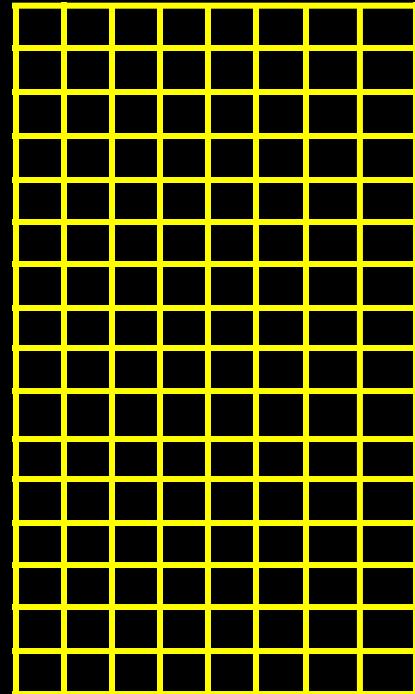
4G85

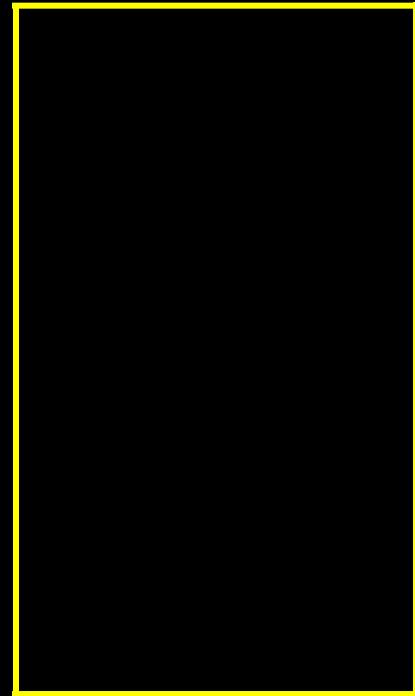
4G85

8BB12  
D9HXT

4G85



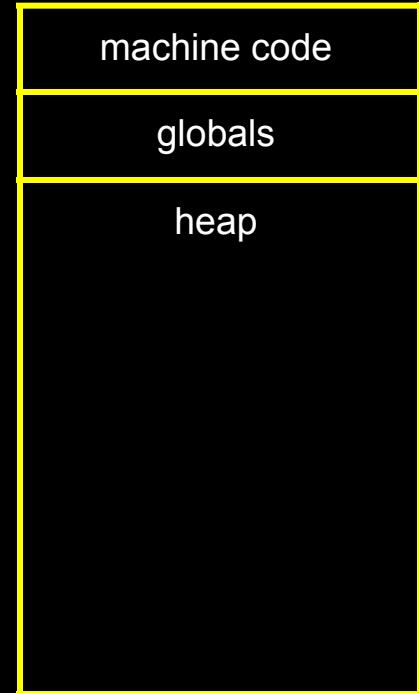


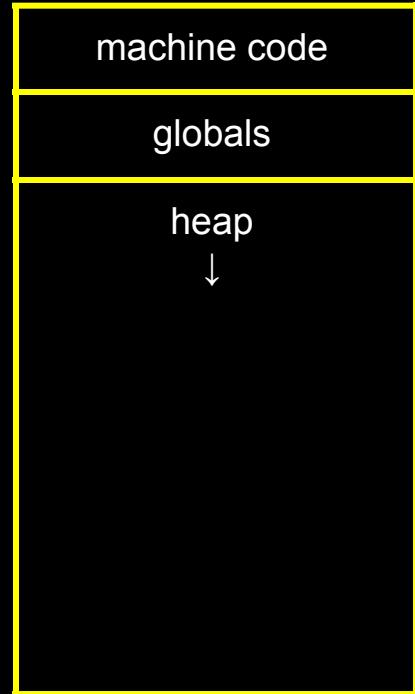


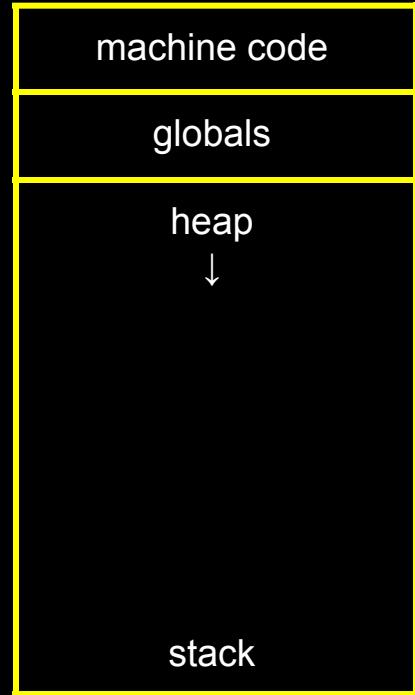
machine code

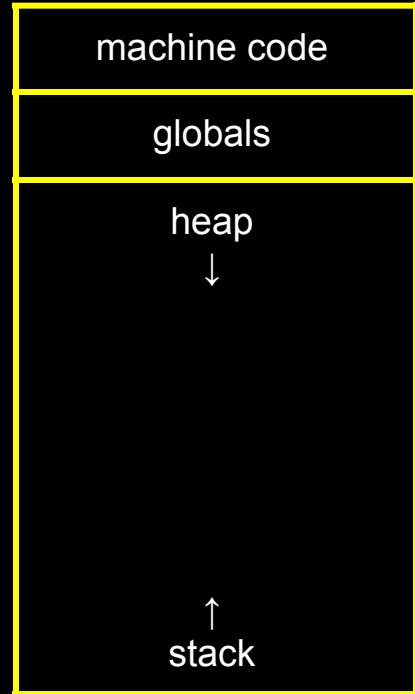
machine code

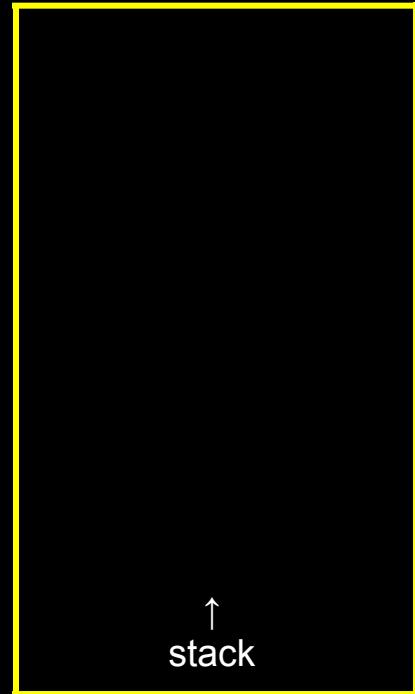
globals



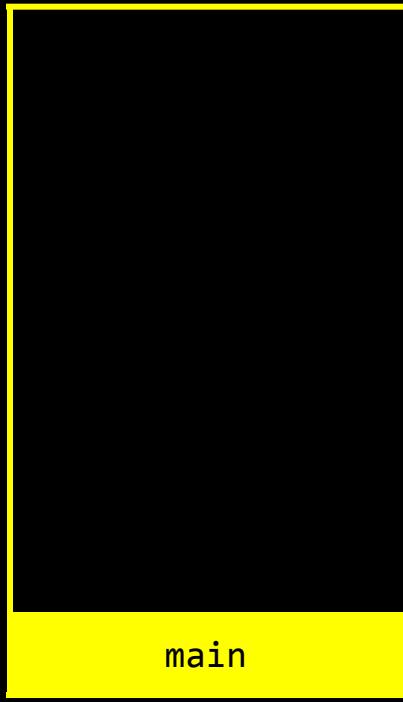




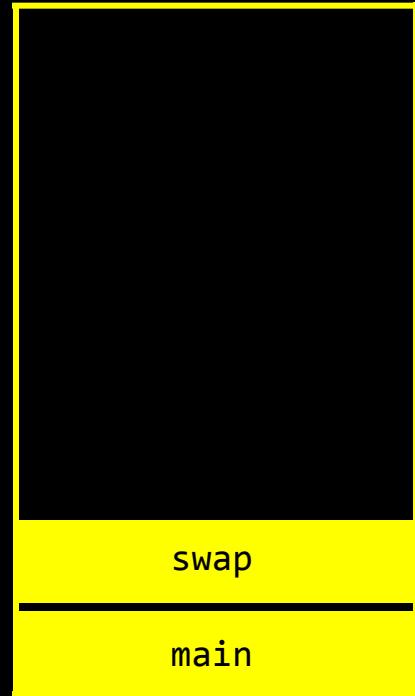


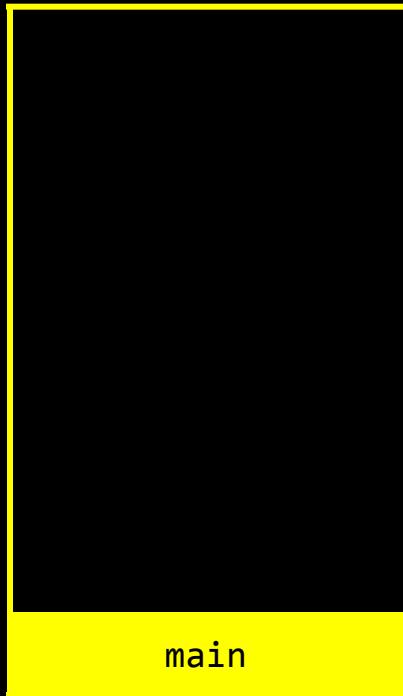




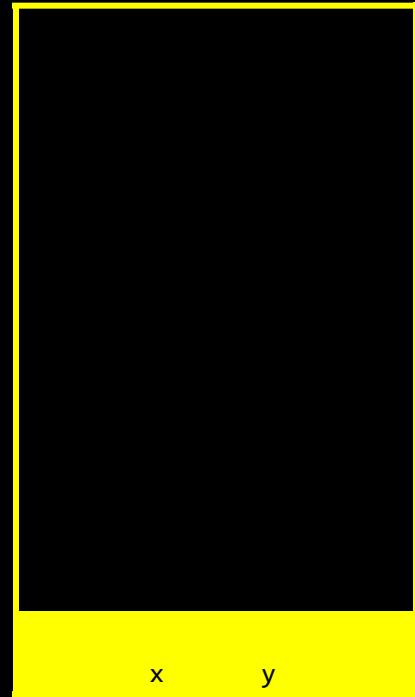


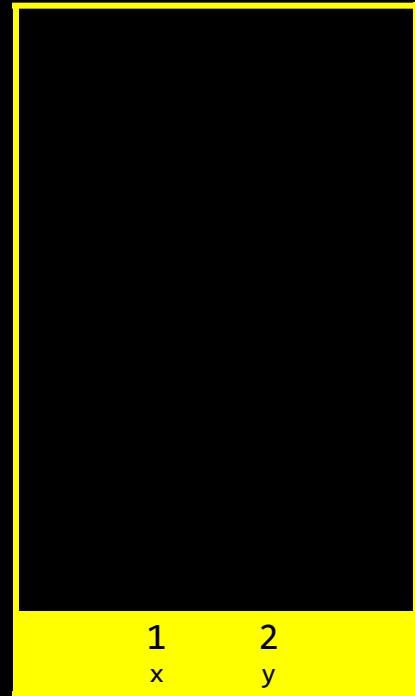
main

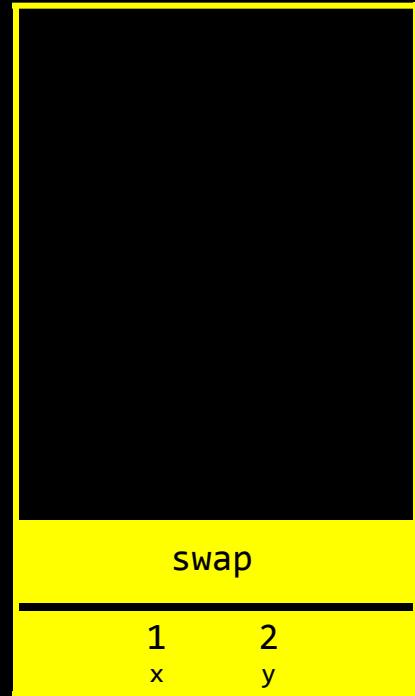


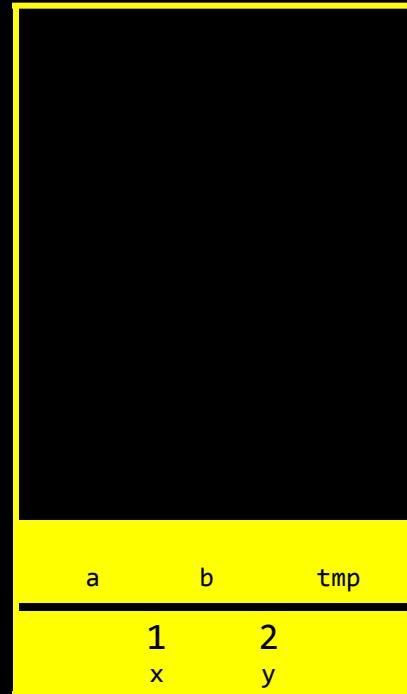


main



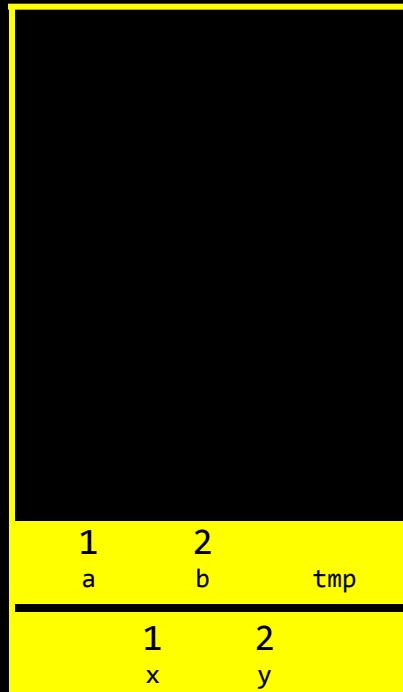




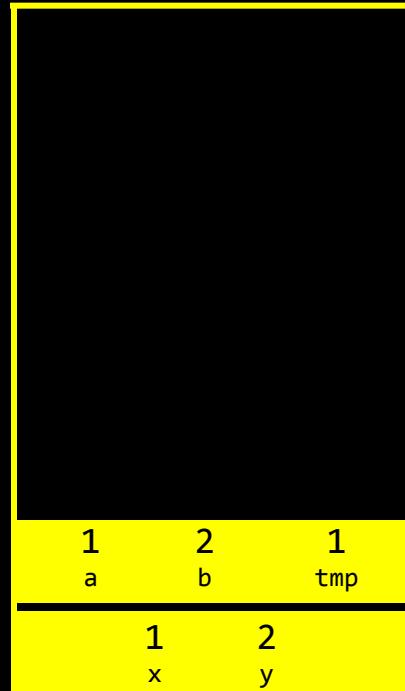


1 a	2 b	tmp
1 x	2 y	

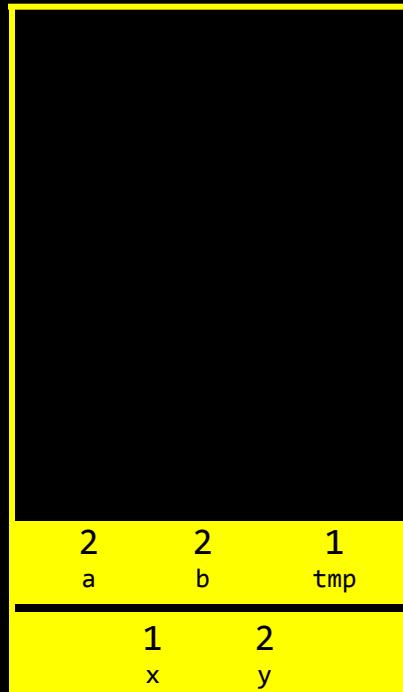
```
int tmp = a;  
a = b;  
b = tmp;
```



```
int tmp = a;  
a = b;  
b = tmp;
```



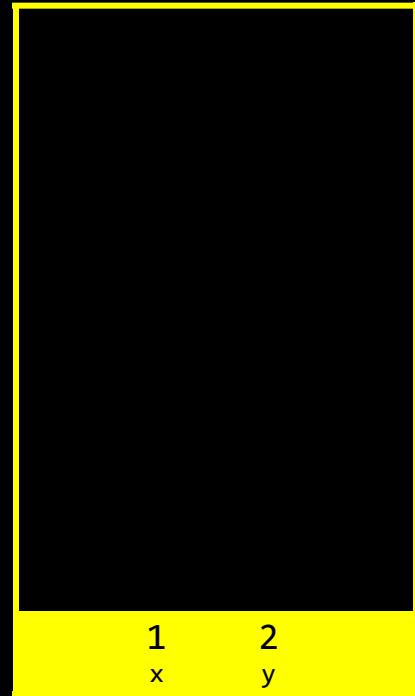
```
int tmp = a;  
a = b;  
b = tmp;
```



```
int tmp = a;  
a = b;  
b = tmp;
```

2	1	1
a	b	tmp
<hr/>		
1	2	
x	y	

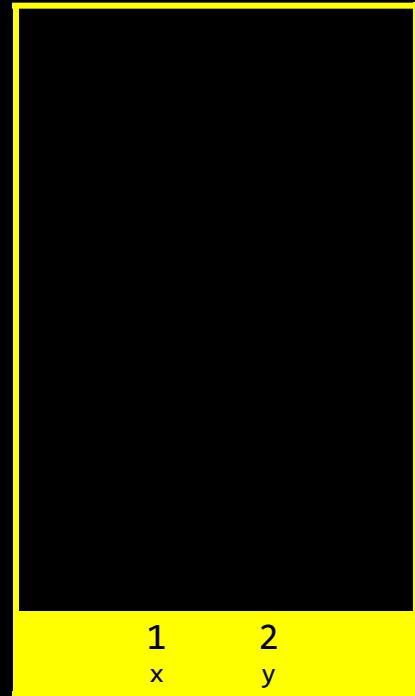
2 a	1 b	1 tmp
1 x	2 y	

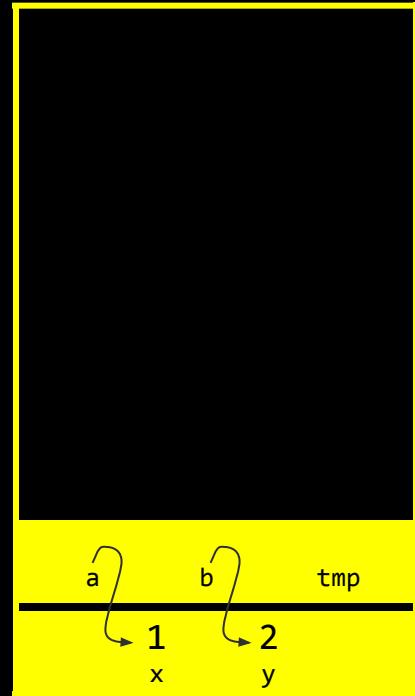


passing by reference

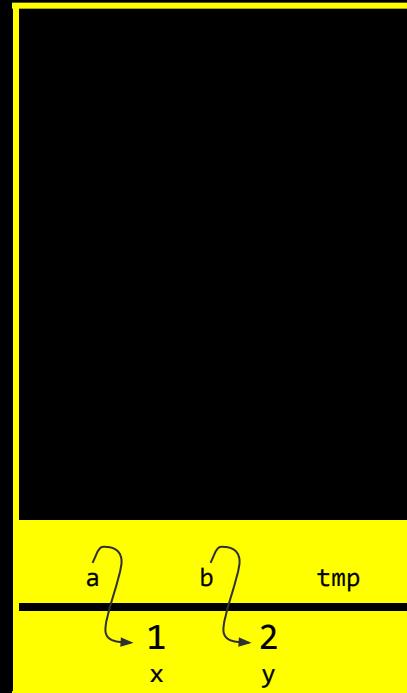


```
void swap(int *a, int *b)
{
    int tmp = *a;
    *a = *b;
    *b = tmp;
}
```

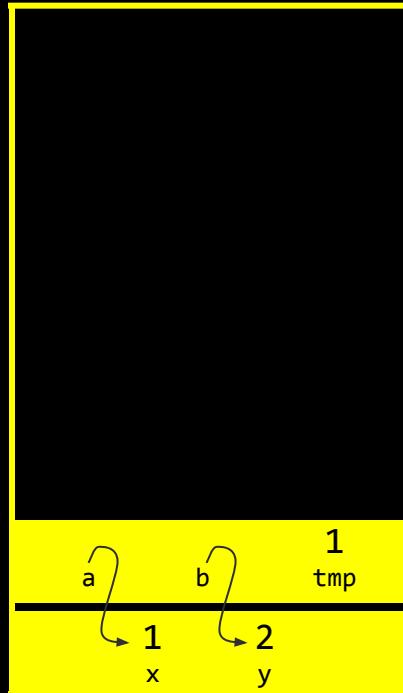




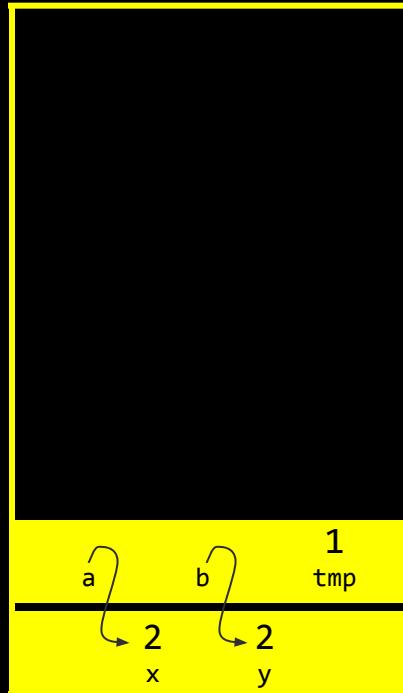
```
int tmp = *a;  
*a = *b;  
*b = tmp;
```



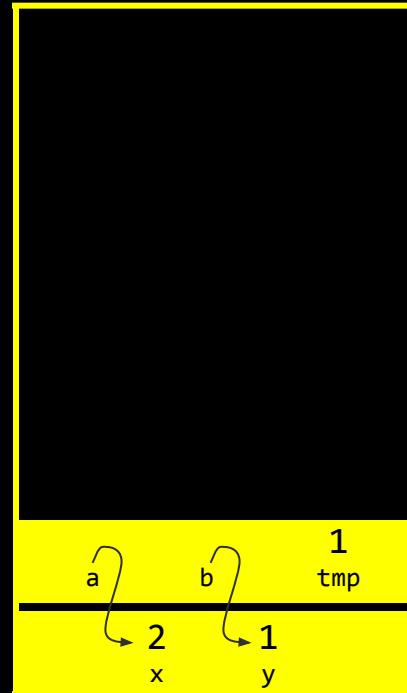
```
int tmp = *a;  
*a = *b;  
*b = tmp;
```

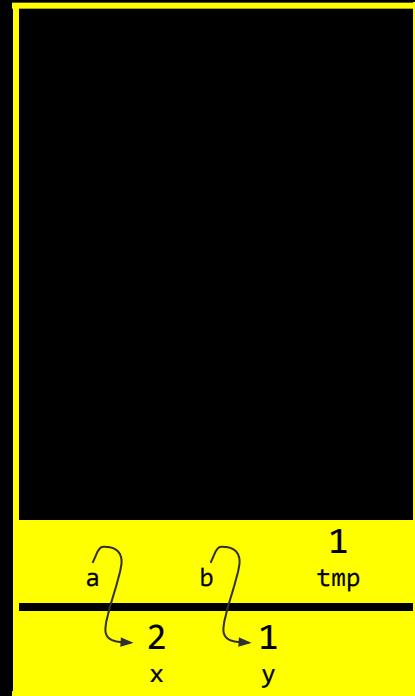


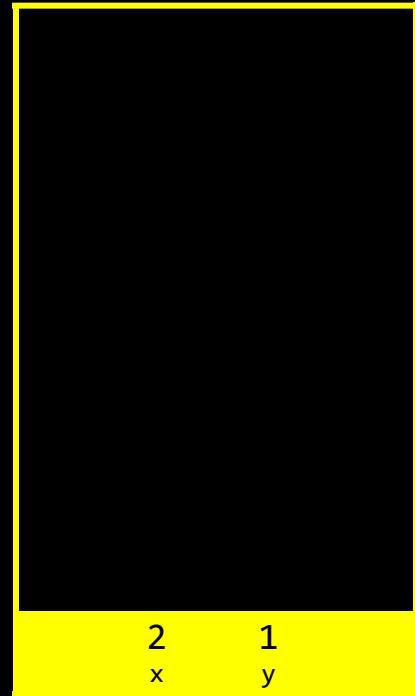
```
int tmp = *a;  
*a = *b;  
*b = tmp;
```



```
int tmp = *a;  
*a = *b;  
*b = tmp;
```

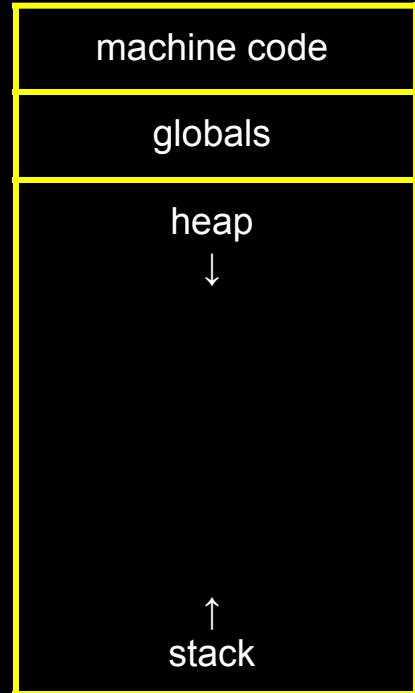








```
void swap(int *a, int *b)
{
    int tmp = *a;
    *a = *b;
    *b = tmp;
}
```



heap



stack



heap overflow

stack overflow

buffer overflow

`get_char`

`get_double`

`get_float`

`get_int`

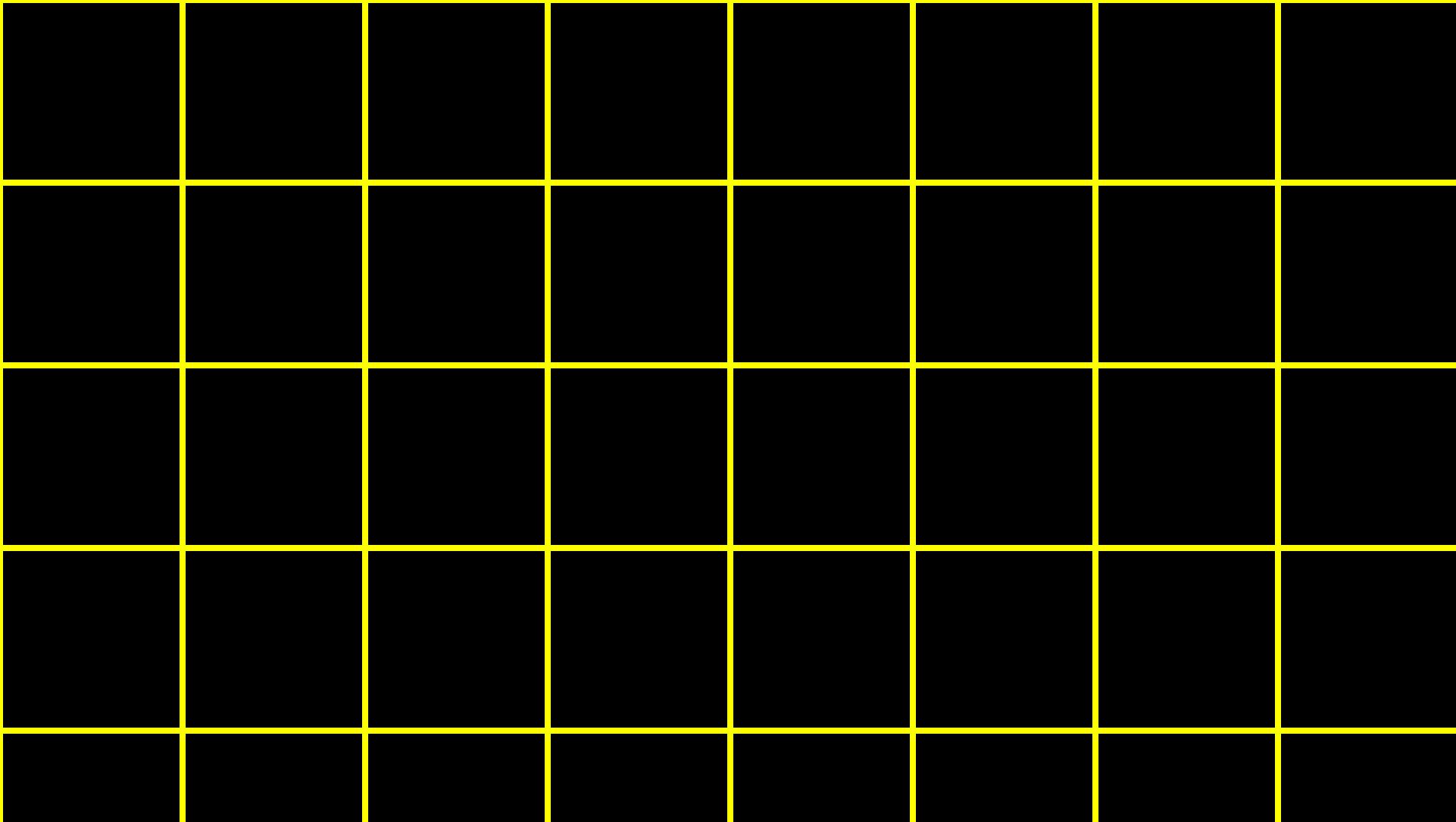
`get_long`

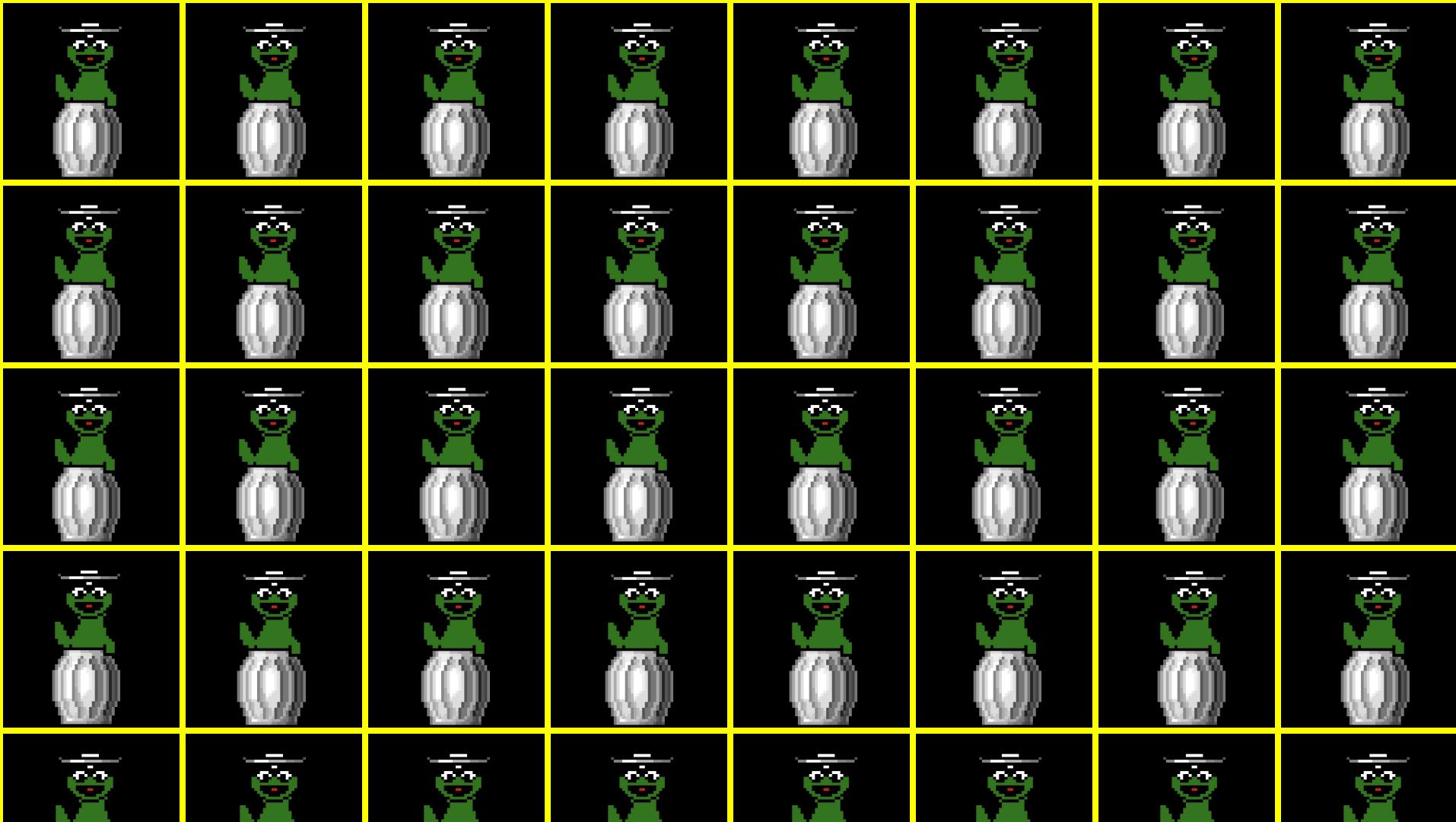
`get_string`

`...`

`scanf`

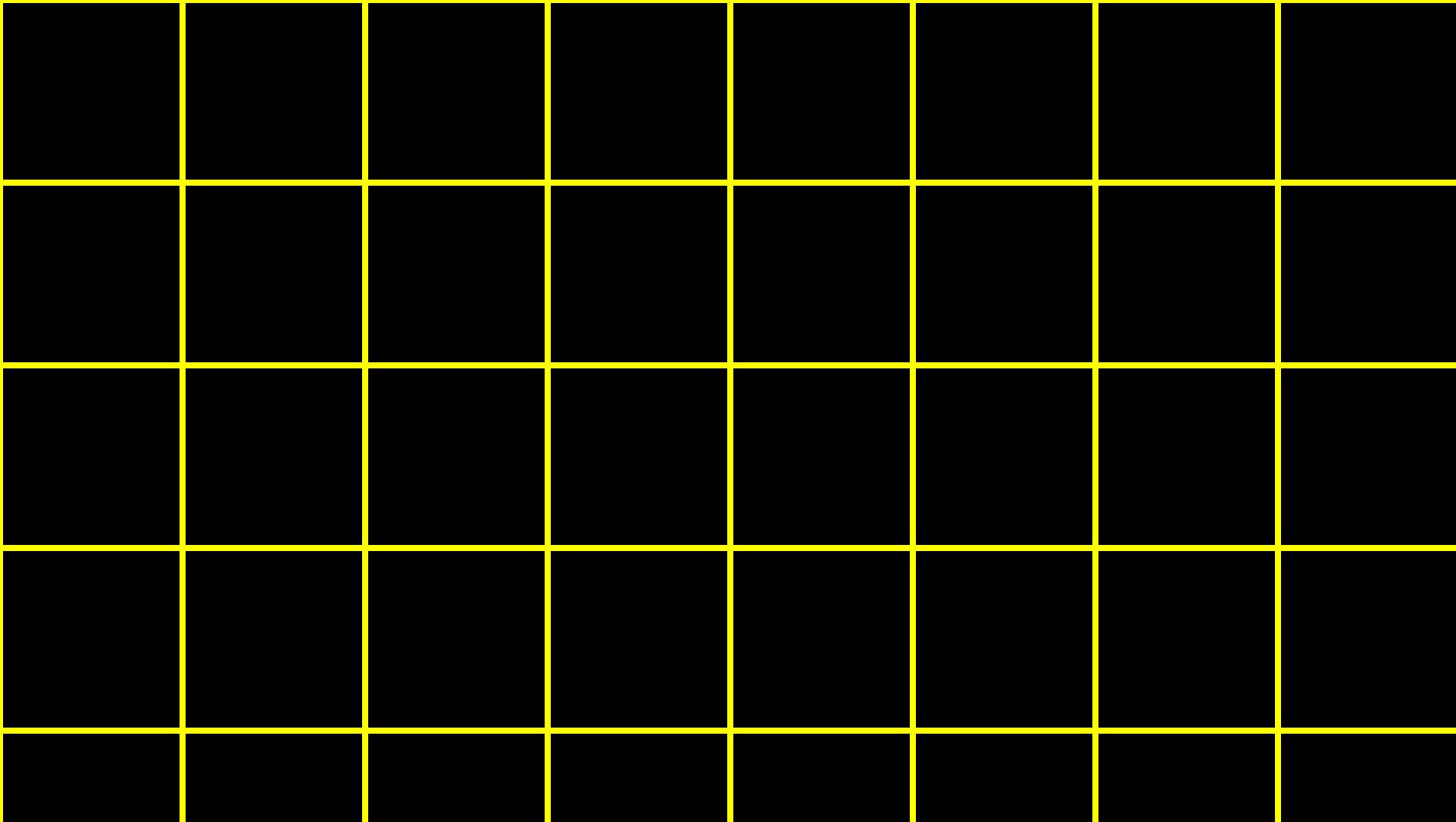
...

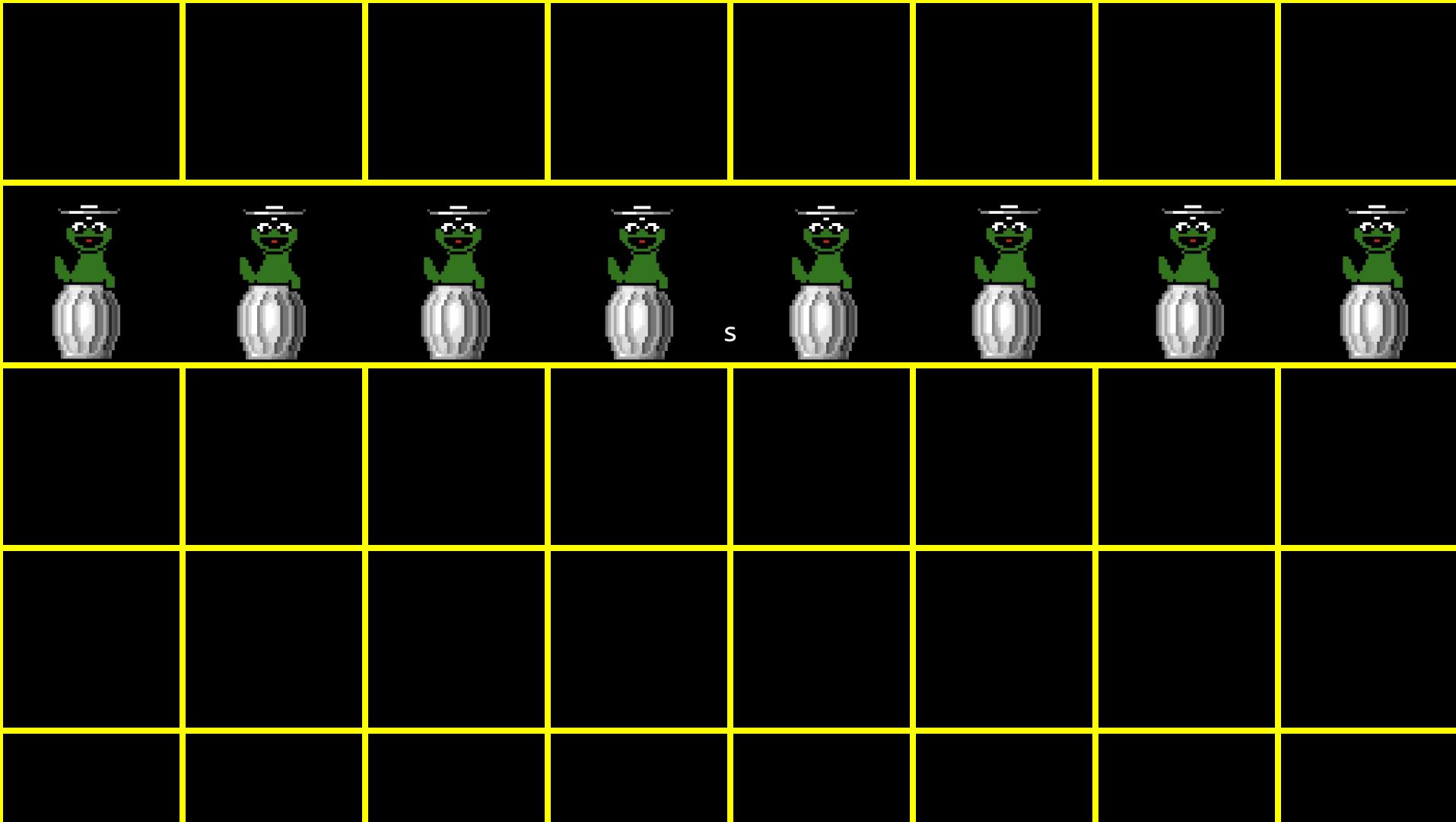


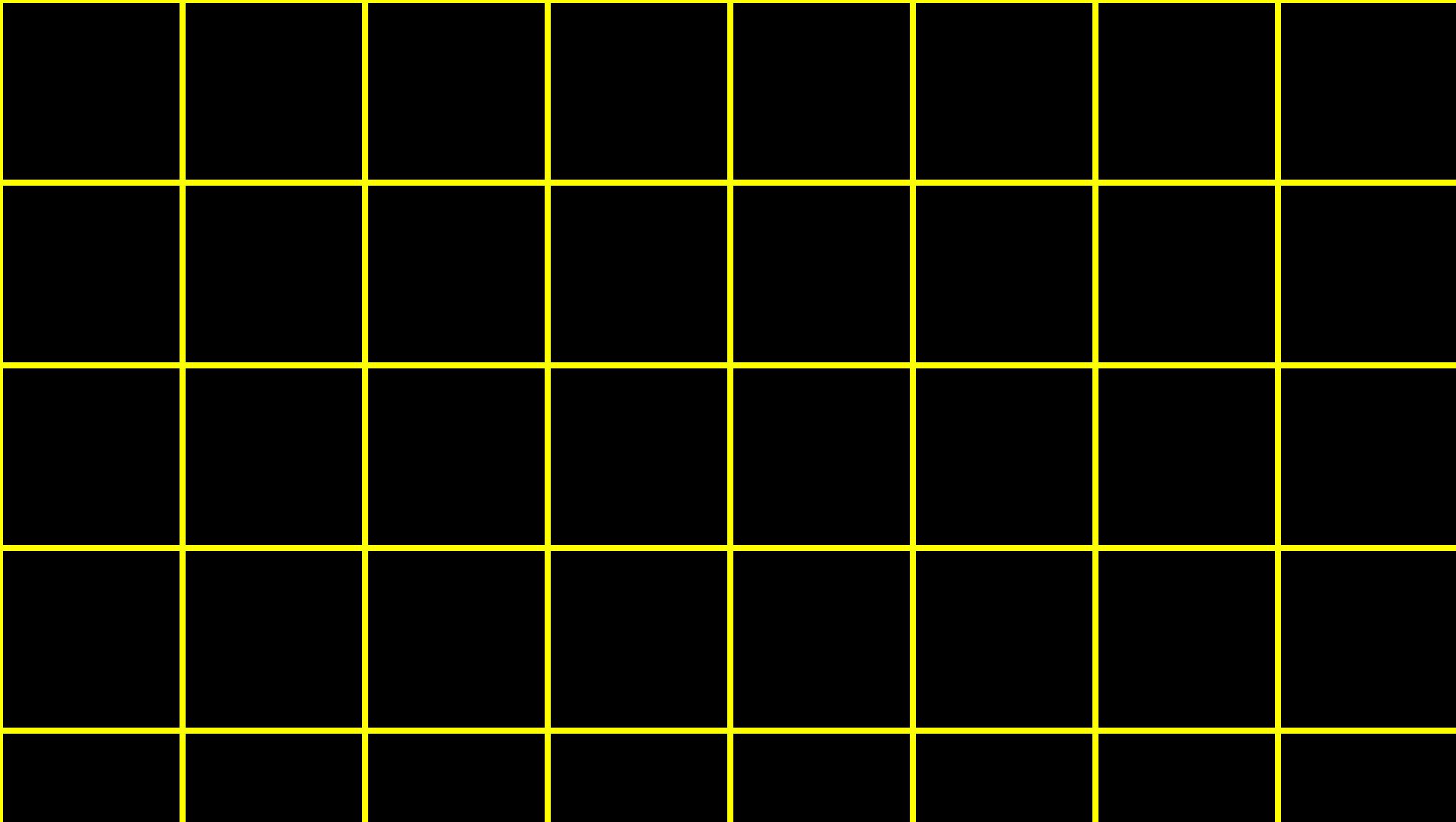


50

*n*







$s$

# file I/O

**fopen**

**fclose**

**fprintf**

**fscanf**

**fread**

**fwrite**

**fseek**

...

**BMP**









UNIVERSITY OF MASSACHUSETTS





MAN, I SUCK AT THIS GAME.  
CAN YOU GIVE ME  
A FEW POINTERS?

|  
0x3A28213A  
0x6339392C,  
0x7363682E.

I HATE YOU.



This is CS50