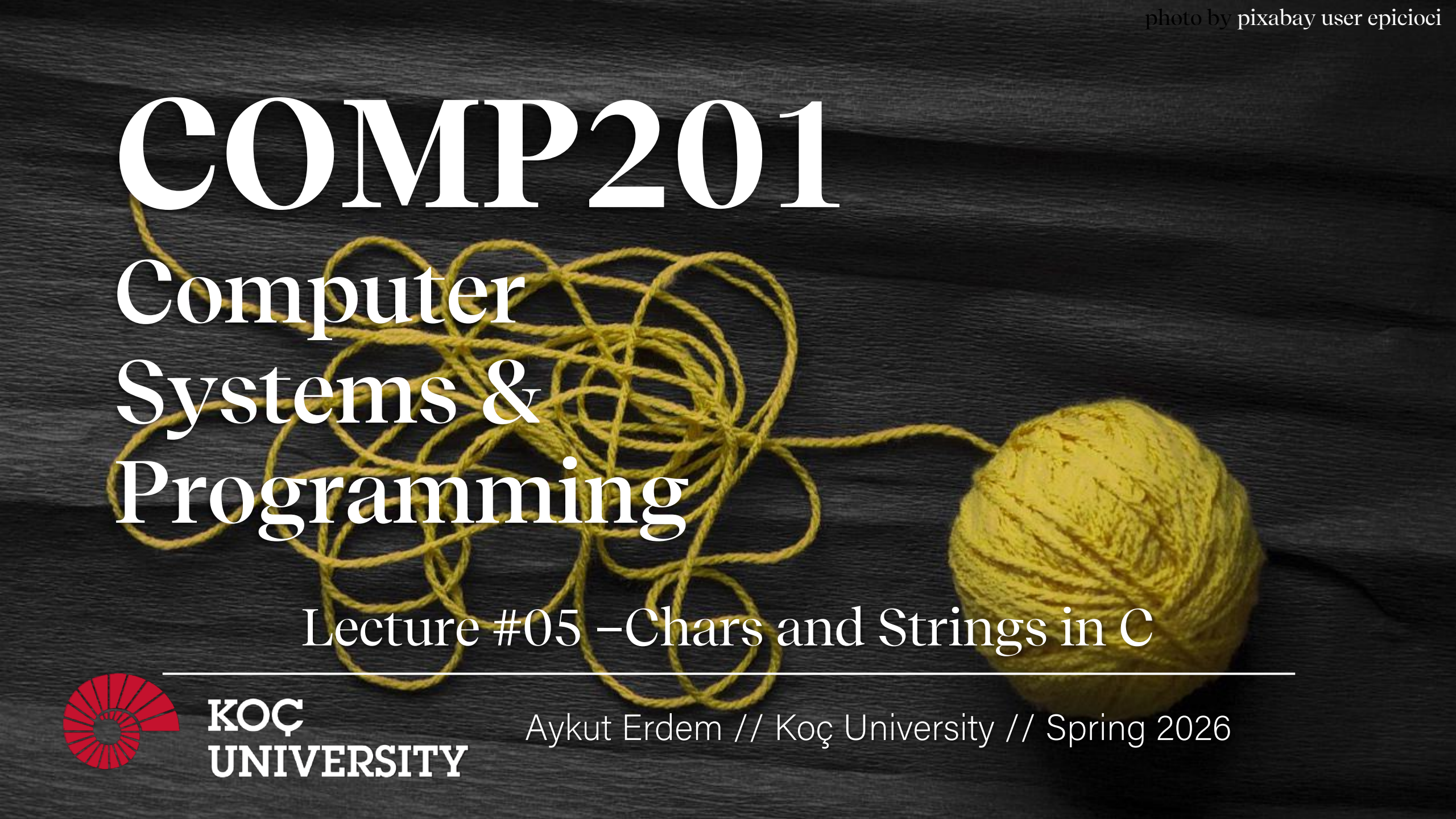


COMP201

Computer Systems & Programming

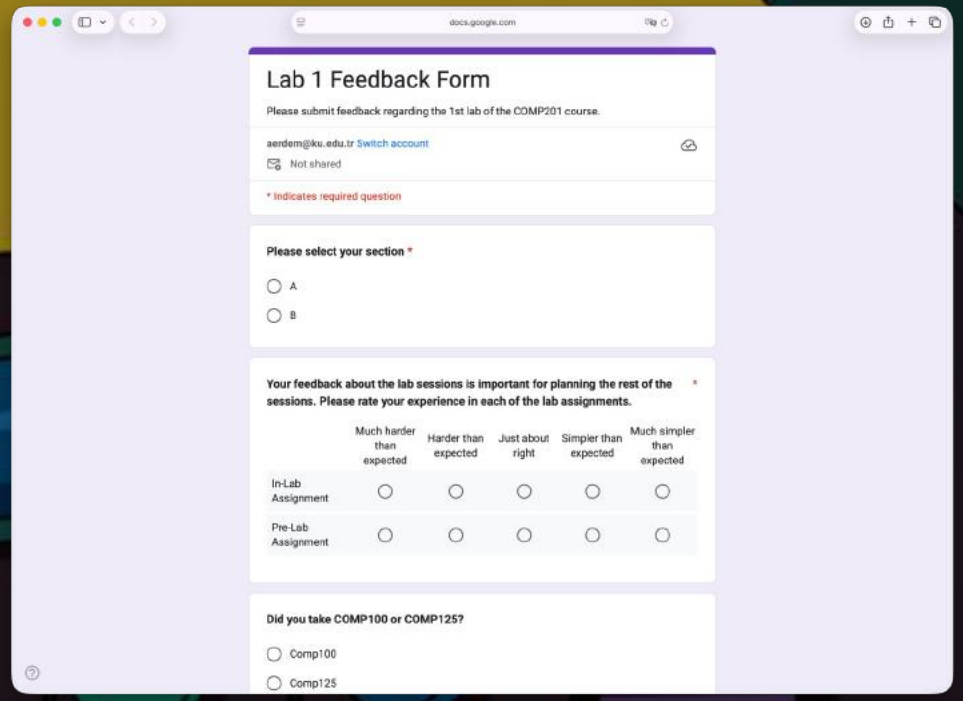
Lecture #05 –Chars and Strings in C

KOÇ UNIVERSITY

Aykut Erdem // Koç University // Spring 2026

Good news, everyone!

Image: Professor Farnsworth (Futurama)



Lab 1 Feedback Form

Please submit feedback regarding the 1st lab of the COMP201 course.

aerdem@ku.edu.tr Switch account

Not shared

* Indicates required question

Please select your section *

- A
- B

Your feedback about the lab sessions is important for planning the rest of the sessions. Please rate your experience in each of the lab assignments. *

	Much harder than expected	Harder than expected	Just about right	Simpler than expected	Much simpler than expected
In-Lab Assignment					
Pre-Lab Assignment					

Did you take COMP100 or COMP125?

- Comp100
- Comp125

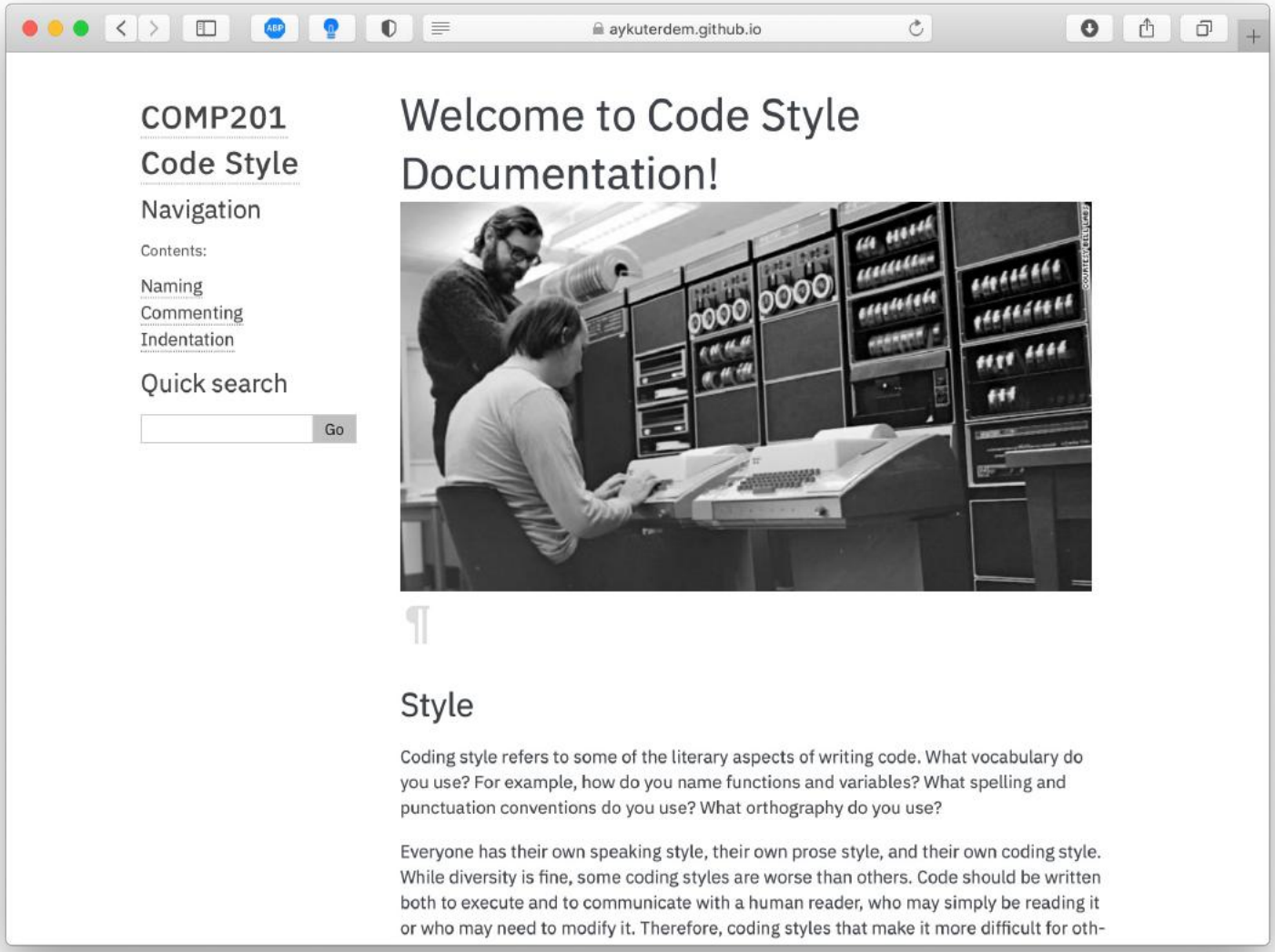
Good news, everyone!

Image: Professor Farnsworth (Futurama)

- Assg1 will be out this week! (due Mar 10)
- Lab2 this Friday
  - C-Strings and GDB
- Check out Lab Policy Guide for our rules!

COMP201 Coding Style Guide for C Programming

- Our guide serves as a brief introduction to C coding style.
- Following a formal style is very important to write a clean and easy to read code.
- There are many standards out there!



https://aykuterdem.github.io/classes/comp201/code-style/html/index.html

Recap: Real Numbers

Problem: unlike with the integer number line, where there are a finite number of values between two numbers, there are an *infinite* number of real number values between two numbers!

Integers between 0 and 2: 1

Real Numbers Between 0 and 2: 0.1, 0.01, 0.001, 0.0001, 0.00001,…

We need a fixed-width representation for real numbers. Therefore, by definition, *we will not be able to represent all numbers*.

Recap: Fixed Point

- **Idea:** Like in base 10, let's add binary decimal places to our existing number representation.

1 0 1 1 . 0 1 1

8s 4s 2s 1s 1/2s 1/4s 1/8s

- **Pros:** arithmetic is easy! And we know exactly how much precision we have.

Recap: Fixed Point

- **Problem:** we have to fix where the decimal point is in our representation. What should we pick? This also fixes us to 1 place per bit.

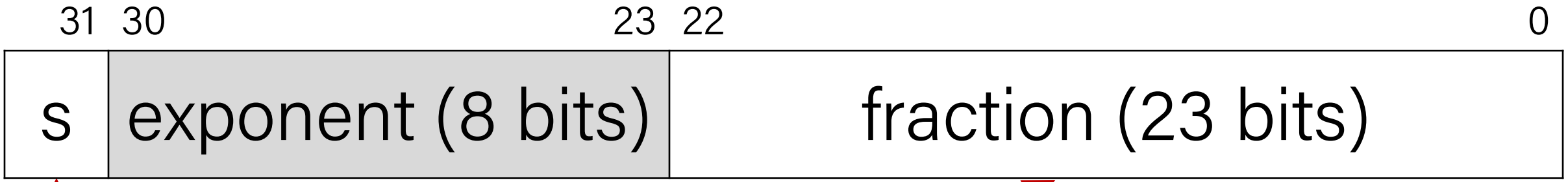
Base 10 Base 2

$5.07E30 = 10\underbrace{\ldots}_{\text{100 zeros}}0.1$

$9.86E\text{-}32 = 0.0\underbrace{\ldots}_{\text{100 zeros}}01$

To be able to store both these numbers using the same fixed point representation, the bitwidth of the type would need to be at least 207 bits wide!

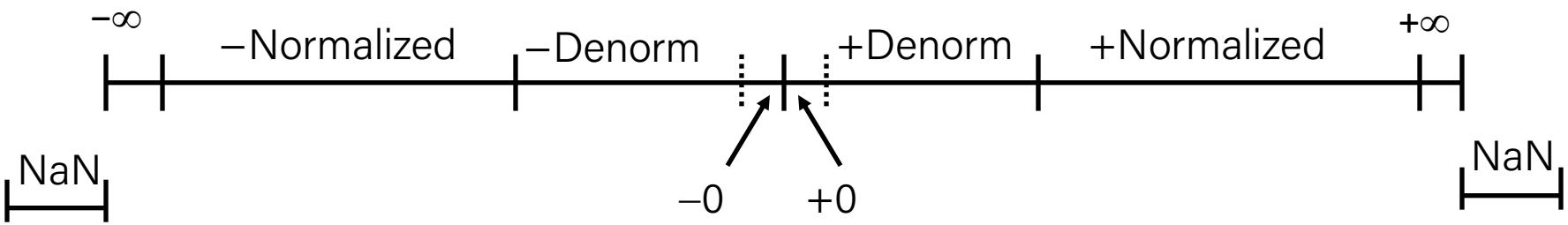
Recap: IEEE Single Precision Floating Point



Sign bit
(0 = positive)

$$x * 2^y$$

Recap: Floating Point Encodings

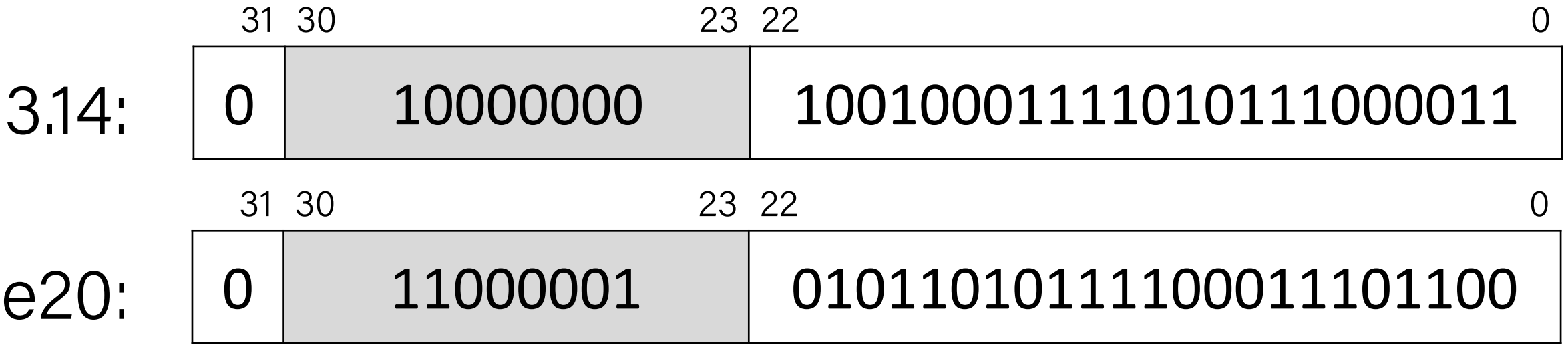


Recap: Floating Point Arithmetic

Is this just overflowing? It turns out it's more subtle.

```
float a = 3.14;
float b = 1e20;
printf("(3.14 + 1e20) - 1e20 = %g\n", (a + b) - b);  // prints 0
printf("3.14 + (1e20 - 1e20) = %g\n", a + (b - b));  // prints
3.14
```

Let's look at the binary representations for 3.14 and 1e20:



Recap: Floating Point Equality Comparisons

Equality comparison operations are often unwise!

```
double a = 0.1;
double b = 0.2;
double c = 0.3;
double d = a + b;
printf("0.1 + 0.2 == 0.3 ? %s\n", a + b == c ? "true" : "false");
printf("d: %.10lf\n", d);
```

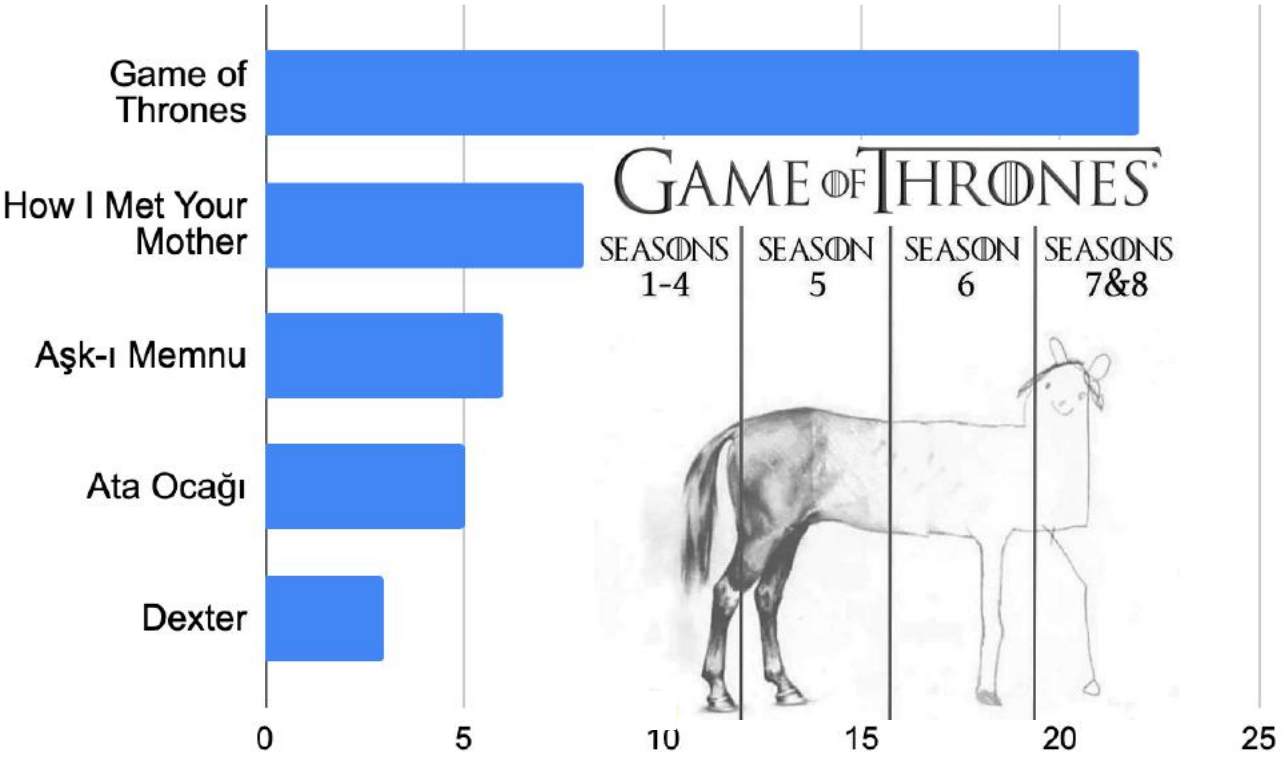
- Output:

```
0.1 + 0.2 == 0.3 ? false
d: 0.3000000000000004441
```

COMP201 Topic 3: How can a computer represent and manipulate more complex data like text?

Results of the Previous Attendance Question

Among the TV shows you watched, which one do you think has the worst ending?



Attendance Question

What is your all-time favorite movie? Just name one please!

Plan for Today

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

Disclaimer: Slides for this lecture were borrowed from

—Nick Troccoli and Lisa Yan's Stanford CS107 class

—Swami Iyer's Umass Boston CS110 class

Lecture Plan

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

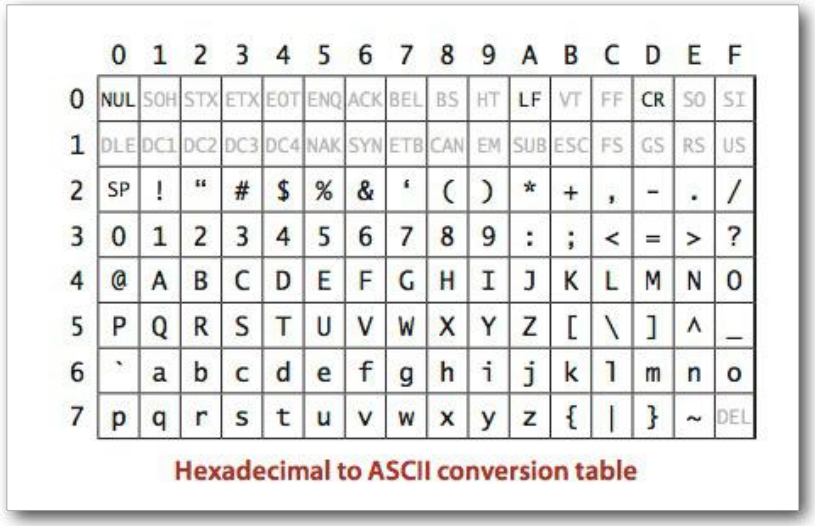
Char

A **`char`** is a variable type that represents a single character (aka a “glyph”).

```
char letter = 'A';
char plus = '+';
char zero = '0';
char space = ' ';
char newline = '\n';
char tab = '\t';
char quote = '\'';
char backSlash = '\\';
```

ASCII

Under the hood, C represents each **char** as an 8-bit *integer* (its "ASCII value").



	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2	SP	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL

Hexadecimal to ASCII conversion table

- Uppercase letters are sequentially numbered
- Lowercase letters are sequentially numbered
- Digits are sequentially numbered
- Lowercase letters are 32 more than their uppercase equivalents (bit flip!)

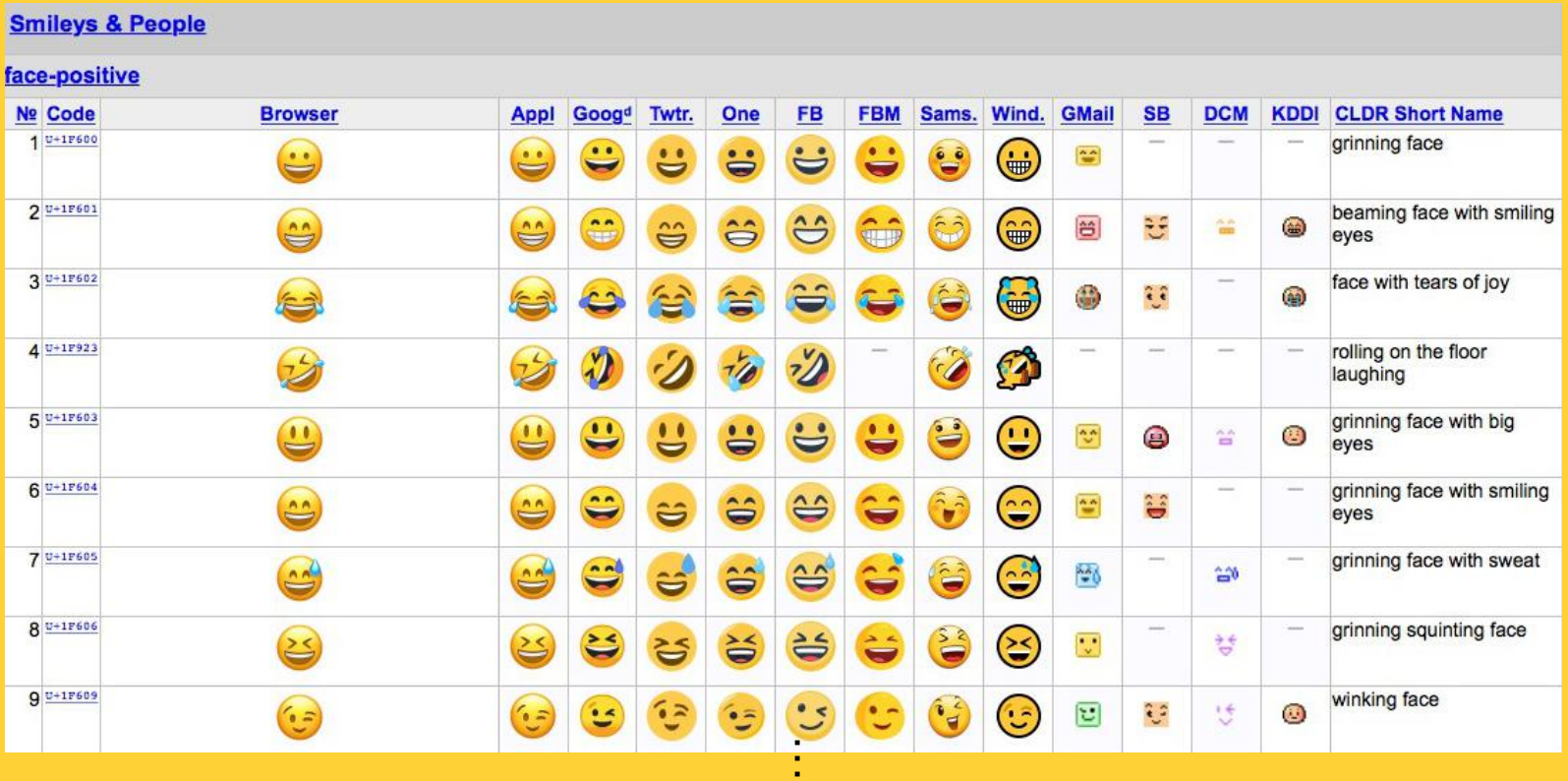
```
char uppercaseA = 'A';        // Actually 65
char lowercaseA = 'a';        // Actually 97
char zeroDigit = '0';         // Actually 48
```

Unicode Transformation Formats

- The International Standards Organization's (ISO) 16-bit Unicode system can represent every character in every known language, with room for more
- Unicode being somewhat wasteful of space for English documents, ISO also defined several "Unicode Transformation Formats" (UTF), the most popular being UTF-8

Emojis

- Emojis are just like characters, and they have a standard, too



Smileys & People

face-positive

№	Code	Browser	Appl	Goog	Twtr.	One	FB	FBM	Sams.	Wind.	GMail	SB	DCM	KDDI	CLDR Short Name
1	U+1F600														grinning face
2	U+1F601														beaming face with smiling eyes
3	U+1F602														face with tears of joy
4	U+1F923														rolling on the floor laughing
5	U+1F603														grinning face with big eyes
6	U+1F604														grinning face with smiling eyes
7	U+1F605														grinning face with sweat
8	U+1F606														grinning squinting face
9	U+1F609														winking face

- Full Emoji List, v17.0
  https://unicode.org/emoji/charts/full-emoji-list.html

ASCII

We can take advantage of C representing each **char** as an *integer:*

```
bool areEqual = 'A' == 'A';       // true
bool earlierLetter = 'f' < 'c';   // false
char uppercaseB = 'A' + 1;
int diff = 'c' - 'a';                    // 2
int numLettersInAlphabet = 'z' - 'a' + 1;
// or
int numLettersInAlphabet = 'Z' - 'A' + 1;
```

ASCII

We can take advantage of C representing each **`char`** as an *integer:*

```
// prints out every lowercase character
for (char ch = 'a'; ch <= 'z'; ch++) {
    printf("%c", ch);
}
```

Common `ctype.h` Functions

Function	Description
`isalpha(`***`ch`***`)`	true if *`ch`* is `'a'` through `'z'` or `'A'` through `'Z'`
`islower(`***`ch`***`)`	true if *`ch`* is `'a'` through `'z'`
`isupper(`***`ch`***`)`	true if *`ch`* is `'A'` through `'Z'`
`isspace(`***`ch`***`)`	true if *`ch`* is a space, tab, new line, etc.
`isdigit(`***`ch`***`)`	true if *`ch`* is `'0'` through `'9'`
`toupper(`***`ch`***`)`	returns uppercase equivalent of a letter
`tolower(`***`ch`***`)`	returns lowercase equivalent of a letter

Remember: these **return** a char; they cannot modify an existing char!

More documentation with `man isalpha`, `man tolower`

Common `ctype.h` Functions

```
bool isLetter = isalpha('A’);          // true
bool capital = isupper('f');           // false
char uppercaseB = toupper('b');
bool isADigit = isdigit('4');          // true
```

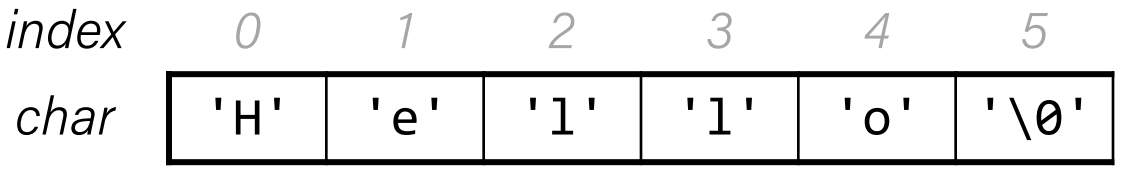
Lecture Plan

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

C Strings

C has no dedicated variable type for strings. Instead, a string is represented as an **array of characters** with a special ending sentinel value.

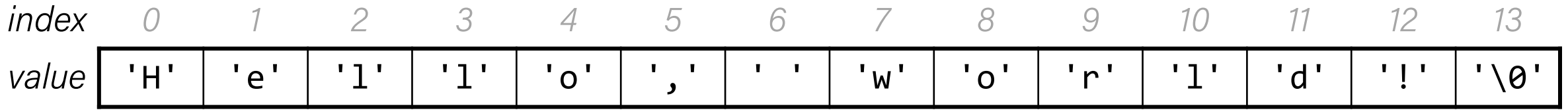
`"Hello"`



`'\0'` is the **null-terminating character**; you always need to allocate one extra space in an array for it.

String Length

Strings are **not** objects. They do not embed additional information (e.g., string length). We must calculate this!



We can use the provided **`strlen`** function to calculate string length. The null-terminating character does *not* count towards the length.

```
int length = strlen(myStr);        // e.g. 13
```

Caution: `strlen` is `O(N)` because it must scan the entire string! We should save the value if we plan to refer to the length later.

C Strings As Parameters

When we pass a string as a parameter, it is passed as a **`char *`**. C passes the location of the first character rather than a copy of the whole array.

```
int doSomething(char *str) {
    ...
}

char myString[6];
...
doSomething(myString);
```

C Strings As Parameters

When we pass a string as a parameter, it is passed as a **`char *`**. C passes the location of the first character rather than a copy of the whole array.

```
int doSomething(char *str) {
    ...
    str[0] = 'c'; // modifies original string!
    printf("%s\n", str);   // prints cello
}

char myString[6];
...  // e.g. this string is “Hello”
doSomething(myString);
```

We can still use a `char *` the same way as a `char[]`.

Lecture Plan

- Characters
- Strings
- Common String Operations
  - Comparing
  - Copying
  - Concatenating
  - Substrings
- Practice: Diamonds

Common `string.h` Functions

Function	Description
`strlen(`***`str`***`)`	returns the # of chars in a C string (before null-terminating character).
`strcmp(`***`str1, str2`***`),` `strncmp(`***`str1, str2, n`***`)`	compares two strings; returns 0 if identical, <0 if ***`str1`*** comes before ***`str2`*** in alphabet, >0 if ***`str1`*** comes after ***`str2`*** in alphabet. ***`strncmp`*** stops comparing after at most ***`n`*** characters.
`strchr(`***`str, ch`***`)` `strrchr(`***`str, ch`***`)`	character search: returns a pointer to the first occurrence of ***`ch`*** in ***`str`***, or ***`NULL`*** if ***`ch`*** was not found in ***`str`***. `strrchr` find the last occurrence.
`strstr(`***`haystack, needle`***`)`	string search: returns a pointer to the start of the first occurrence of ***`needle`*** in ***`haystack`***, or ***`NULL`*** if ***`needle`*** was not found in ***`haystack`***.
`strcpy(`***`dst, src`***`),` `strncpy(`***`dst, src, n`***`)`	copies characters in ***`src`*** to ***`dst`***, including null-terminating character. Assumes enough space in ***`dst`***. Strings must not overlap. **`strncpy`** stops after at most ***`n`*** chars, and <u>does not</u> add null-terminating char.
`strcat(`***`dst, src`***`),` `strncat(`***`dst, src, n`***`)`	concatenate ***`src`*** onto the end of ***`dst`***. **`strncat`** stops concatenating after at most ***`n`*** characters. <u>Always</u> adds a null-terminating character.
`strspn(`***`str, accept`***`),` `strcspn(`***`str, reject`***`)`	**`strspn`** returns the length of the initial part of ***`str`*** which contains <u>only</u> characters in ***`accept`***. **`strcspn`** returns the length of the initial part of ***`str`*** which does <u>not</u> contain any characters in ***`reject`***.

Common `string.h` Functions

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Many string functions assume **valid string** input; i.e., ends in a null terminator.

Comparing Strings

We cannot compare C strings using comparison operators like ==, < or >. This compares addresses!

```
// e.g. str1 = 0x7f42, str2 = 0x654d
void doSomething(char *str1, char *str2) {
     if (str1 > str2) { …    // compares 0x7f42 > 0x654d!
```

Instead, use **`strcmp.`**

The string library: `strcmp`

`strcmp(str1, str2)`: compares two strings.

- returns 0 if identical
- <0 if ***`str1`*** comes before ***`str2`*** in alphabet
- >0 if ***`str1`*** comes after ***`str2`*** in alphabet.

```
int compResult = strcmp(str1, str2);
if (compResult == 0) {
      // equal
} else if (compResult < 0) {
      // str1 comes before str2
} else {
      // str1 comes after str2
}
```

Copying Strings

We cannot copy C strings using =. This copies addresses!

```
// e.g. param1 = 0x7f42, param2 = 0x654d
void doSomething(char *param1, char *param2) {
      param1 = param2;    // copies 0x654d.  Points to same string!
      param2[0] = 'H';    // modifies the one original string!
```

Instead, use **`strcpy`**.

The string library: `strcpy`

`strcpy(dst, src)`: copies the contents of **`src`** into the string **`dst`**, including the null terminator.

```
char str1[6];
strcpy(str1, "hello");

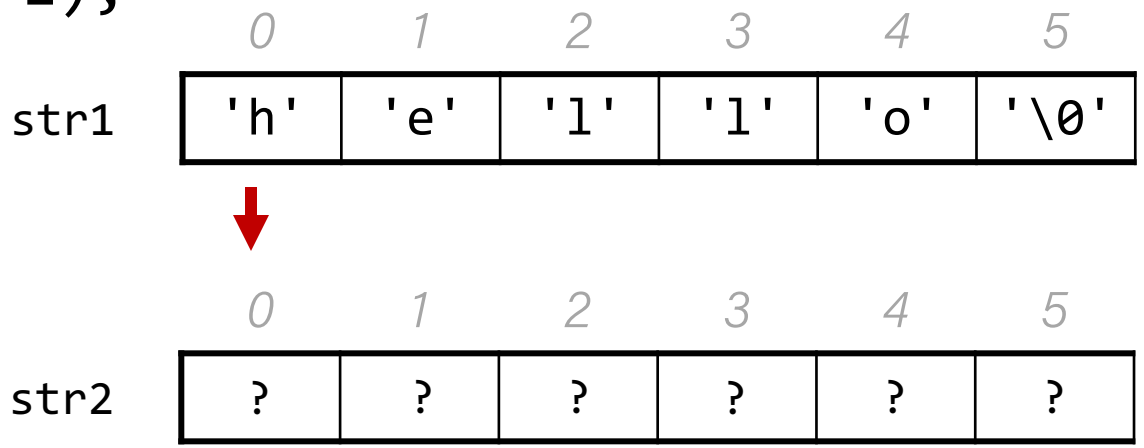
char str2[6];
strcpy(str2, str1);
str2[0] = 'c';

printf("%s", str1);       // hello
printf("%s", str2);       // cello
```

Copying Strings – `strcpy`

```
char str1[6];
strcpy(str1, "hello");

char str2[6];
strcpy(str2, str1);
```



Copying Strings – `strcpy`

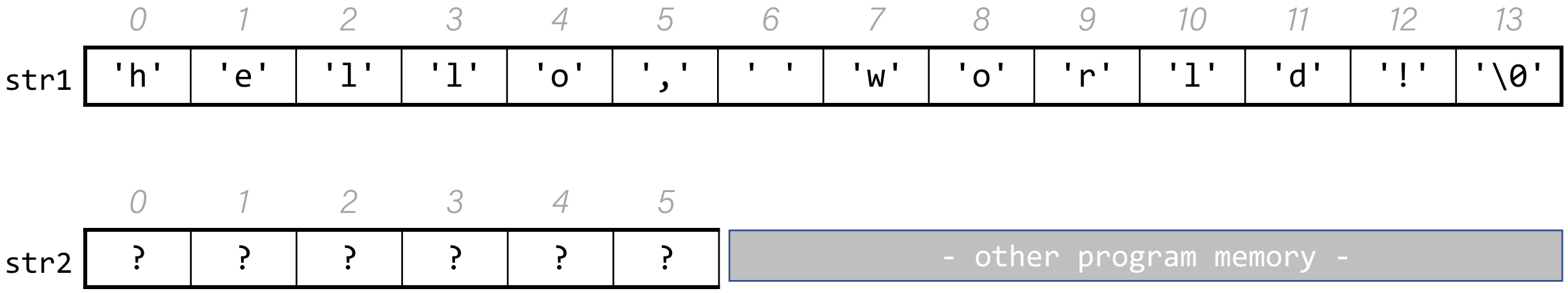
We must make sure there is enough space in the destination to hold the entire copy, *including the null-terminating character*.

```
char str2[6];                       // not enough space!
strcpy(str2, "hello, world!");      // overwrites other memory!
```

Writing past memory bounds is called a “buffer overflow”. It can allow for security vulnerabilities!

Copying Strings – Buffer Overflows

```
char str1[14];
strcpy(str1, "hello, world!");
char str2[6];
strcpy(str2, str1);   // not enough space - overwrites other
memory!
```



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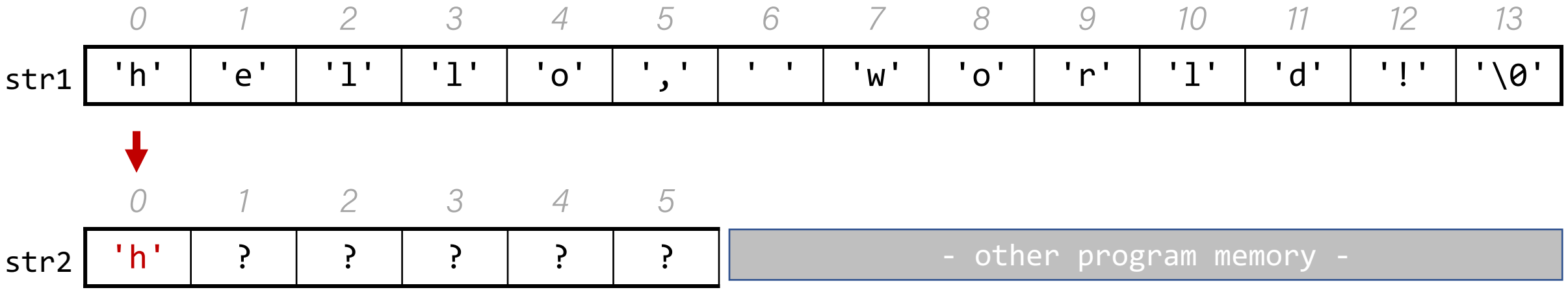

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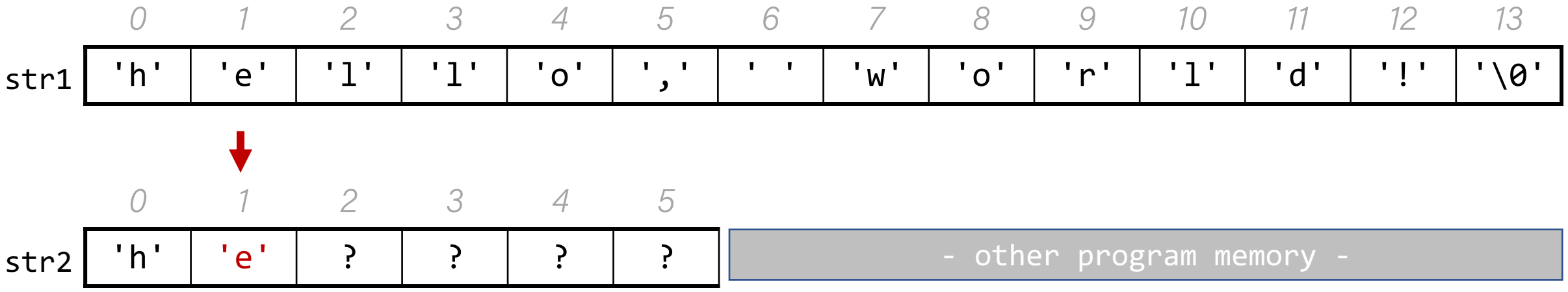

Copying Strings – Buffer Overflows

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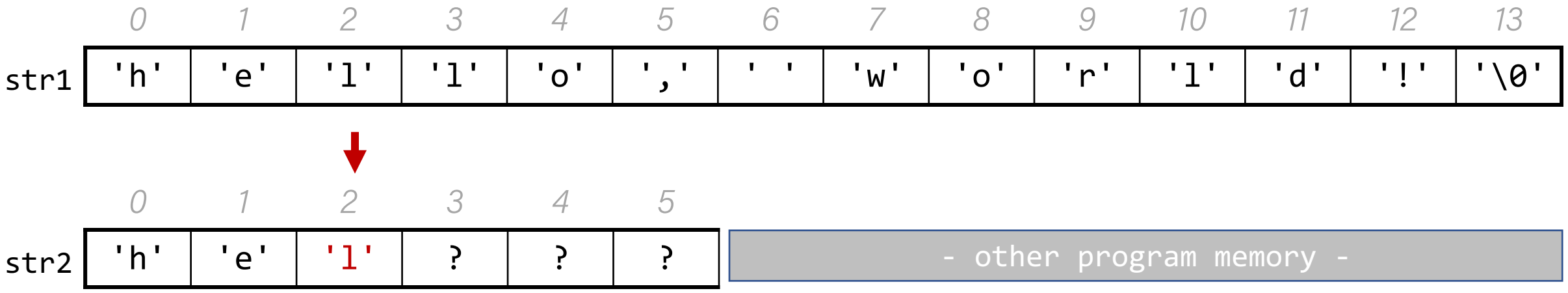

Copying Strings – Buffer Overflows

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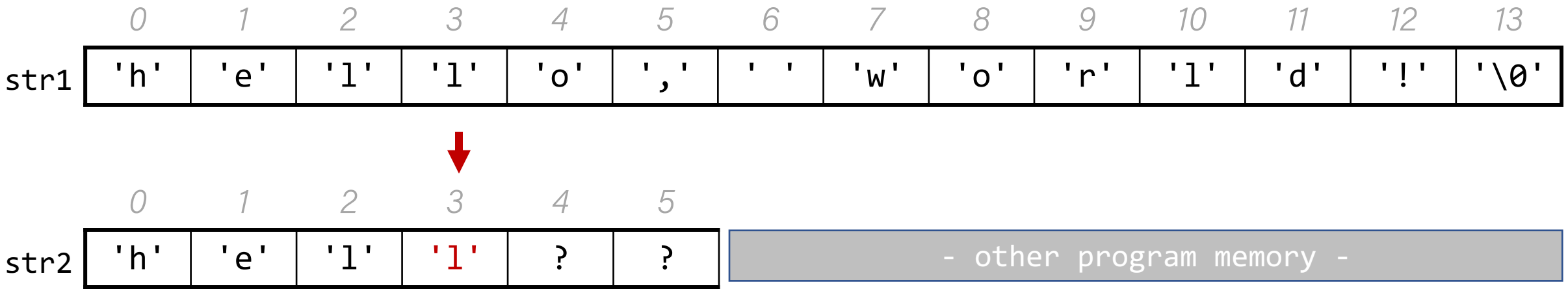

Copying Strings – Buffer Overflows

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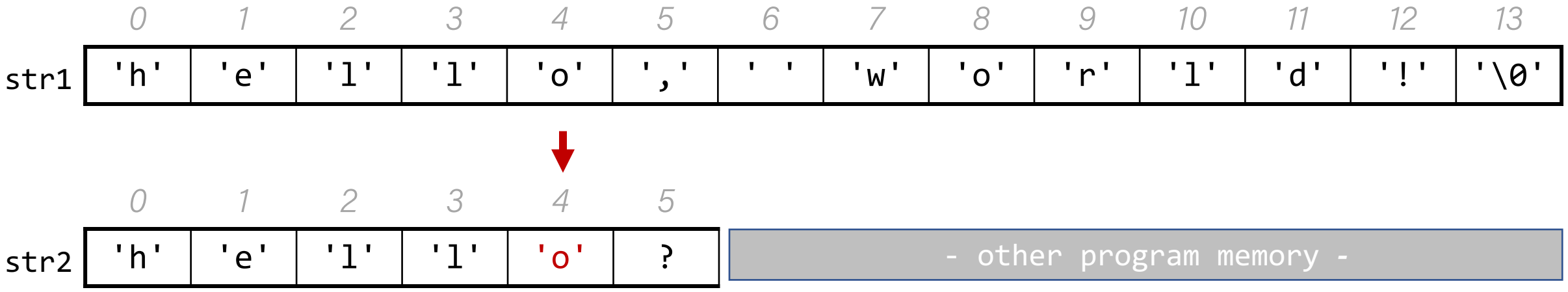

Copying Strings – Buffer Overflows

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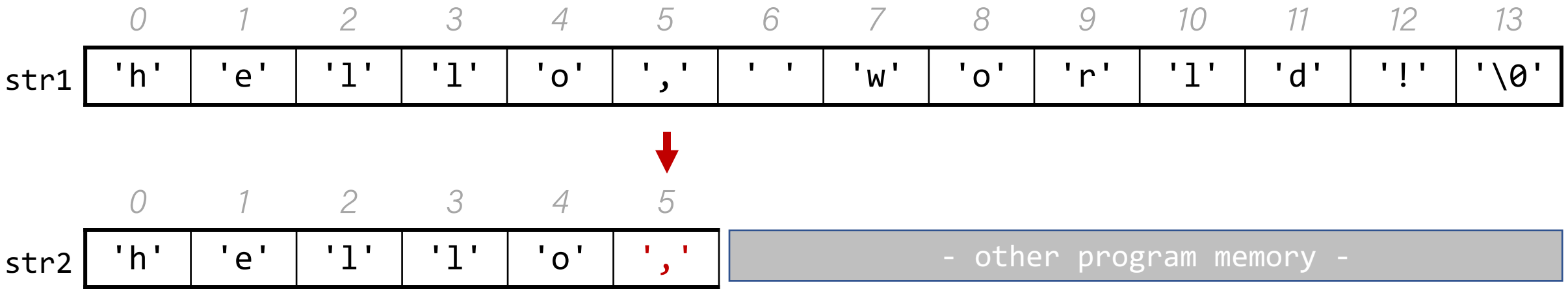

Copying Strings – Buffer Overflows

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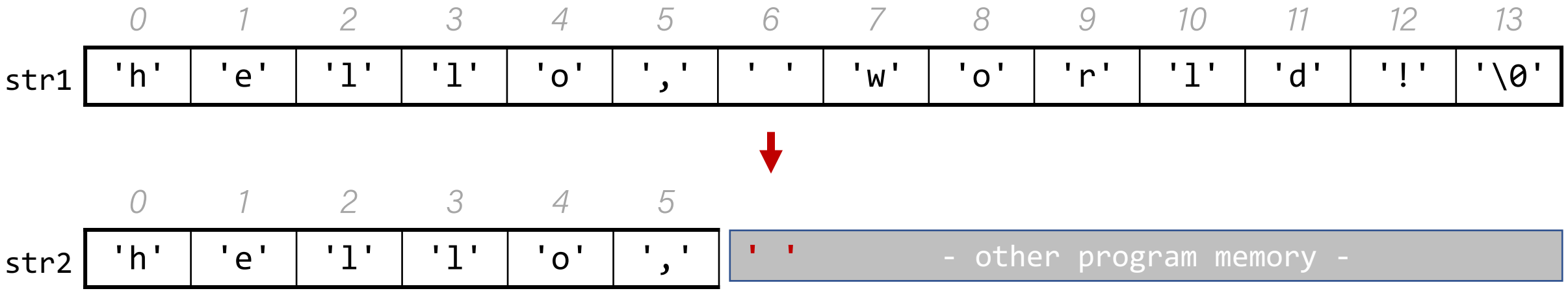

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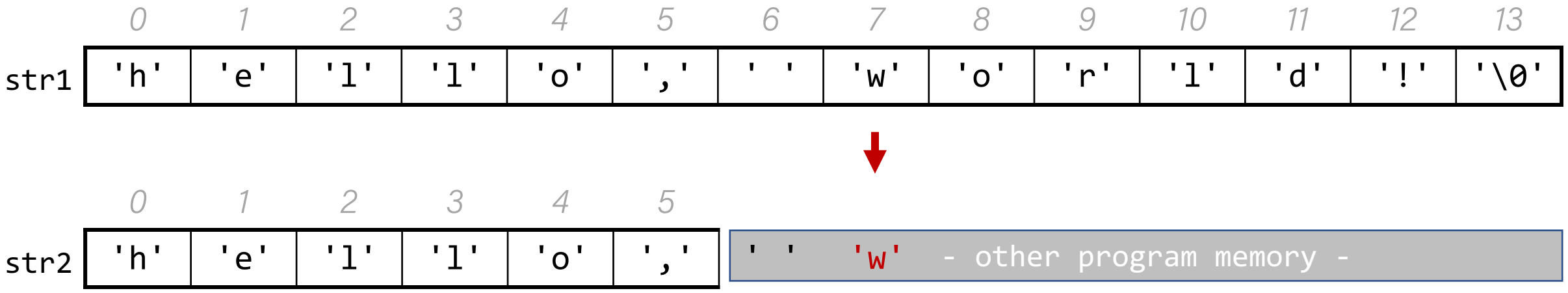

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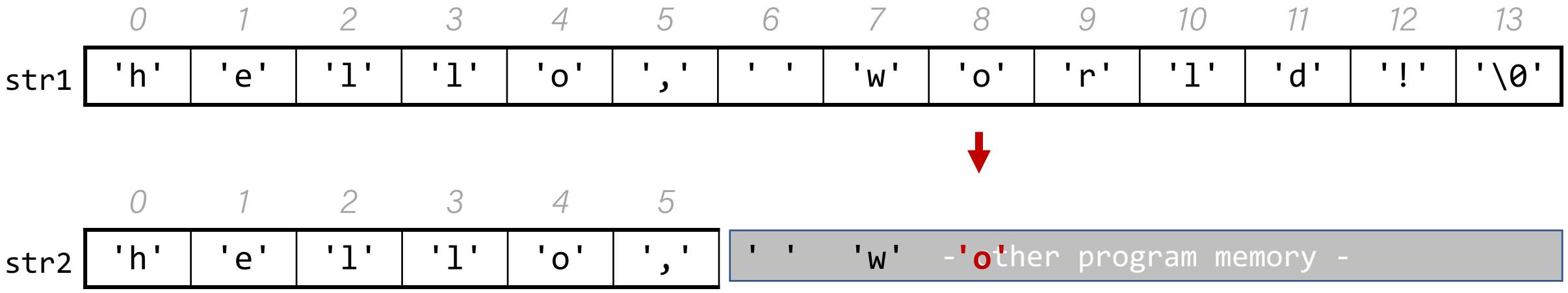

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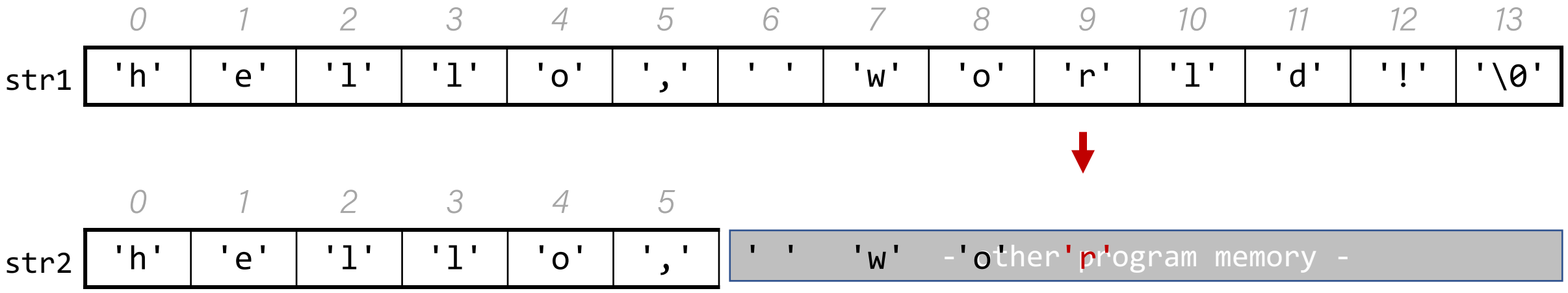

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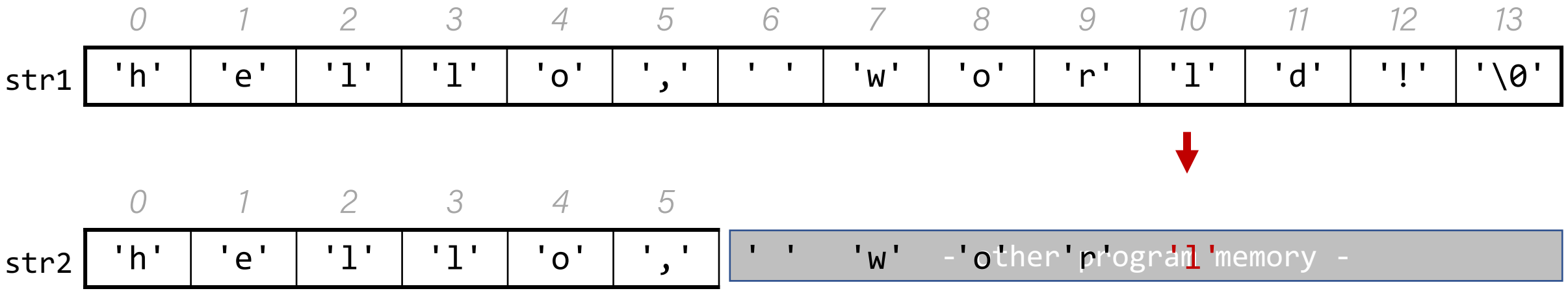

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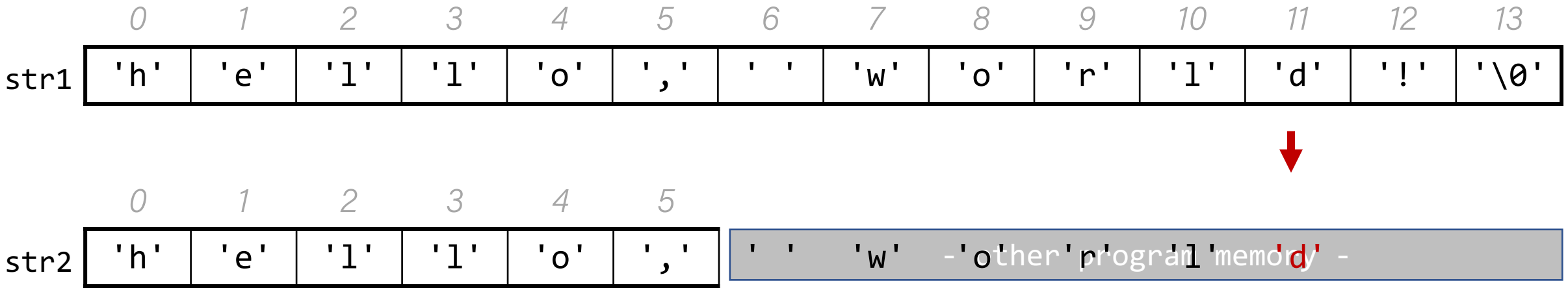

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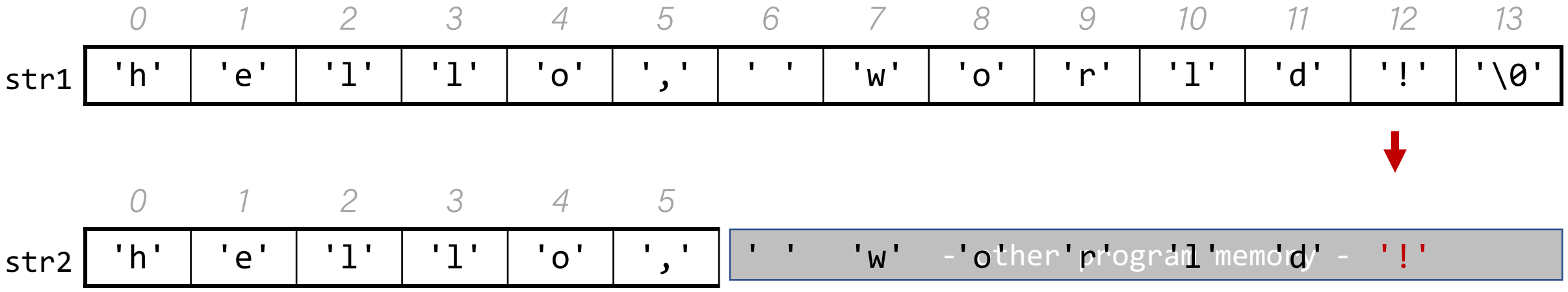

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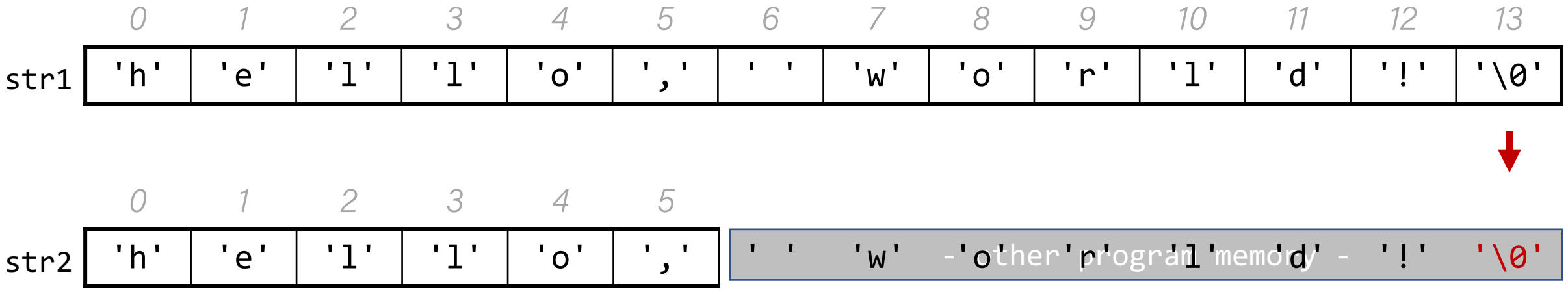

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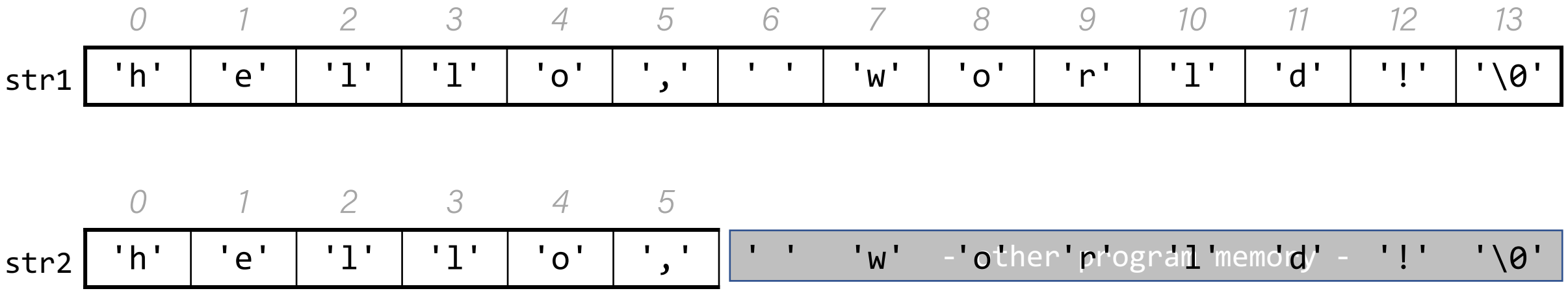

String Copying Exercise

What value should go in the blank at right?

A. `4`

B. `5`

C. `6`

D. `12`

E. `strlen("hello")`

F. Something else

```
char str[_____];
strcpy(str, "hello");
```

slido

Please download and install the Slido app on all computers you use

What value should go in the blank at right?

ⓘ Start presenting to display the poll results on this slide.

String Exercise

What is printed out by the following program?

```
1  int main(int argc, char *argv[]) {
2      char str[9];
3      strcpy(str, "Hi earth");
4      str[2] = '\0';
5      printf("str = %s, len = %lu\n",
6             str, strlen(str));
7      return 0;
8  }
```

A. `str = Hi, len = 8`
B. `str = Hi, len = 2`
C. `str = Hi earth, len = 8`
D. `str = Hi earth, len = 2`
E. None/other

slido

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What is printed out by the following program?

ⓘ Start presenting to display the poll results on this slide.

Copying Strings – `strncpy`

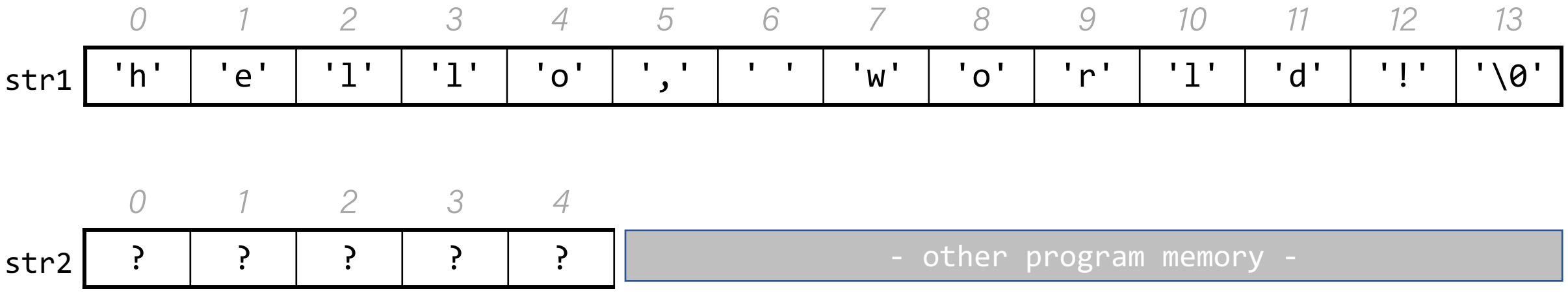
`strncpy(dst, src, n)`: copies at most the first n bytes from **src** into the string **dst**. If there is no null-terminating character in these bytes, then **`dst`** will *not be null terminated*!

```
// copying "hello"
char str2[5];
strncpy(str2, "hello, world!", 5);    // doesn't copy '\0'!
```

If there is no null-terminating character, we may not be able to tell where the end of the string is anymore. E.g. **`strlen`** may continue reading into some other memory in search of `'\0'`!

Copying Strings – strncpy

```
char str2[5];
strncpy(str2, "hello, world!", 5);
int length = strlen(str2);
```



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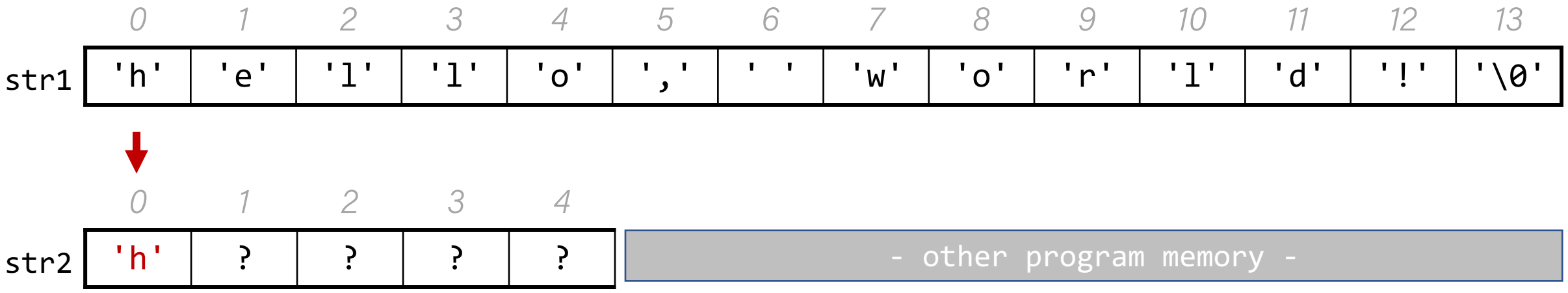

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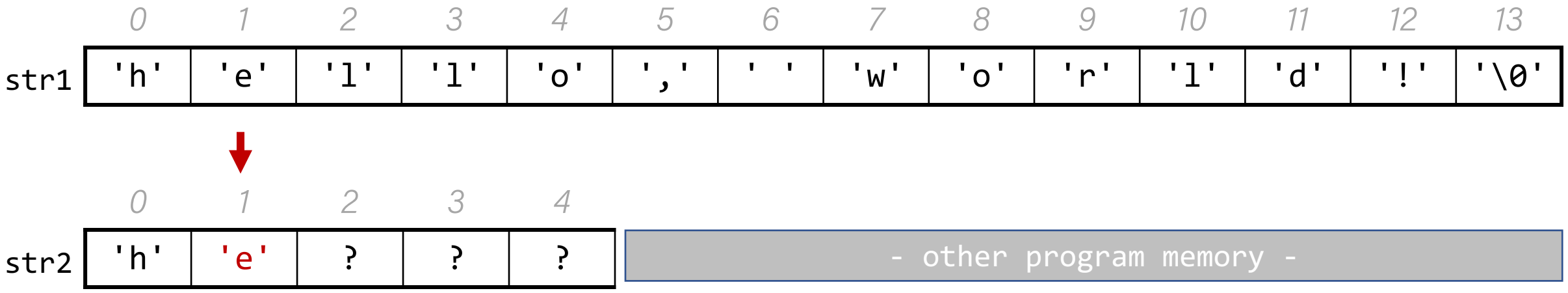

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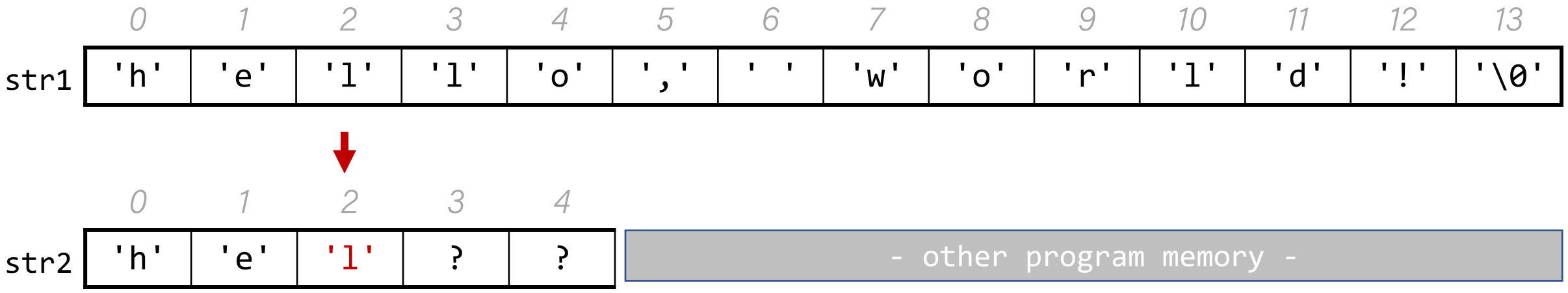

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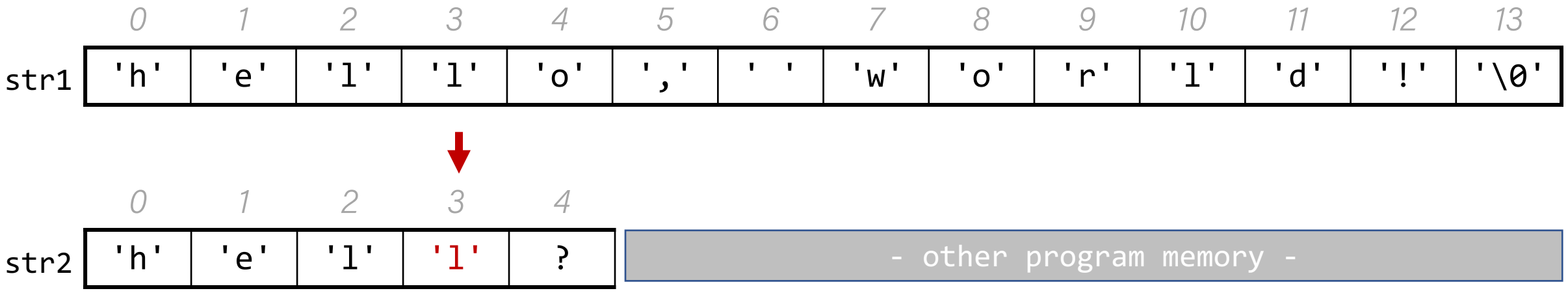

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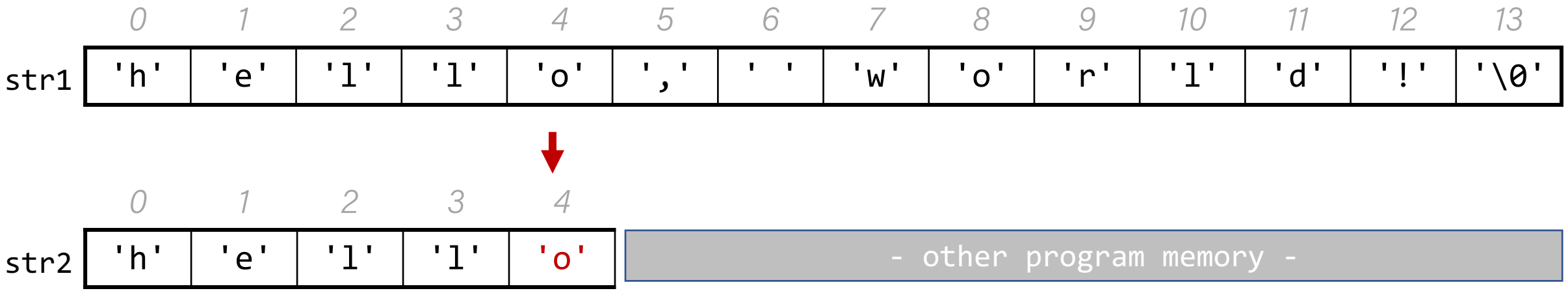

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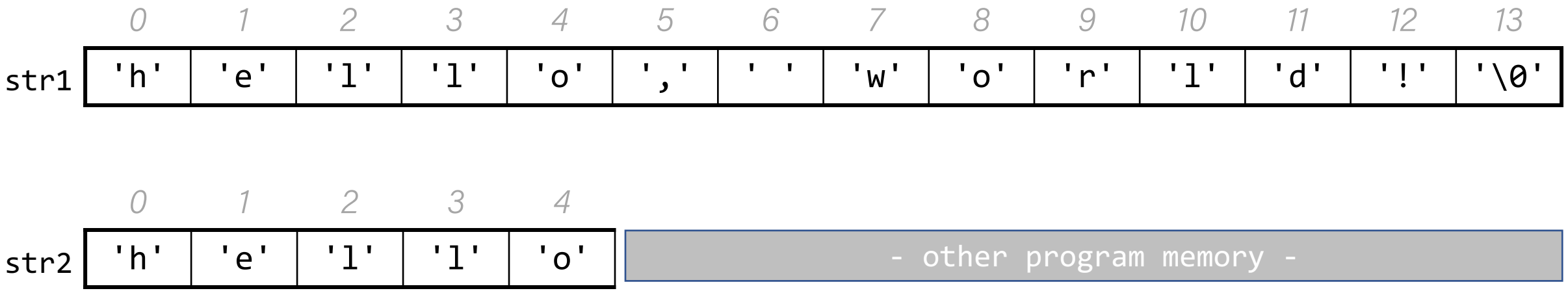

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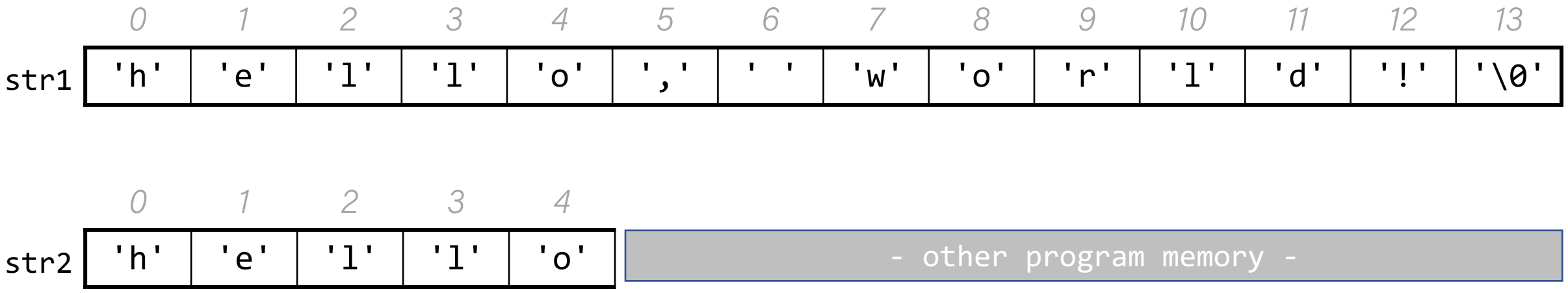

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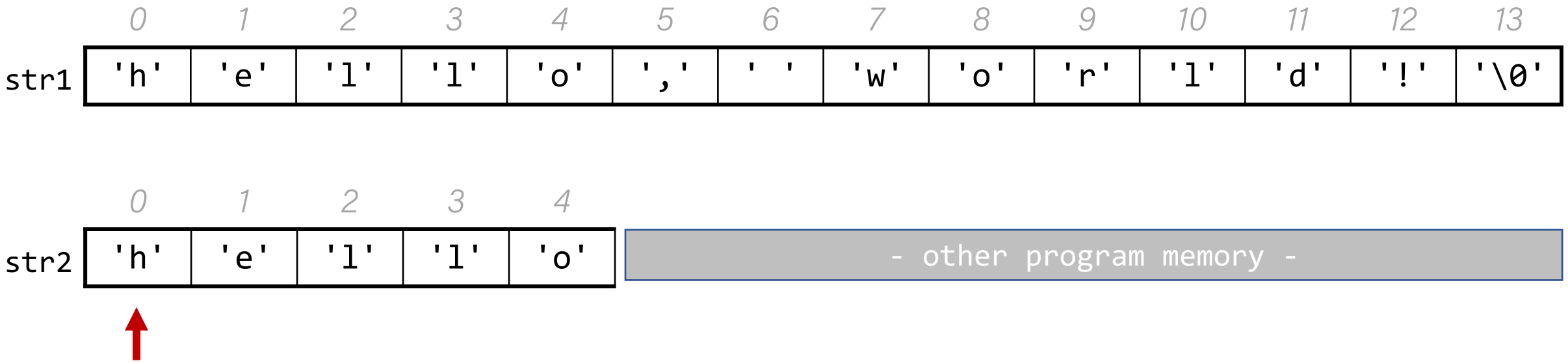

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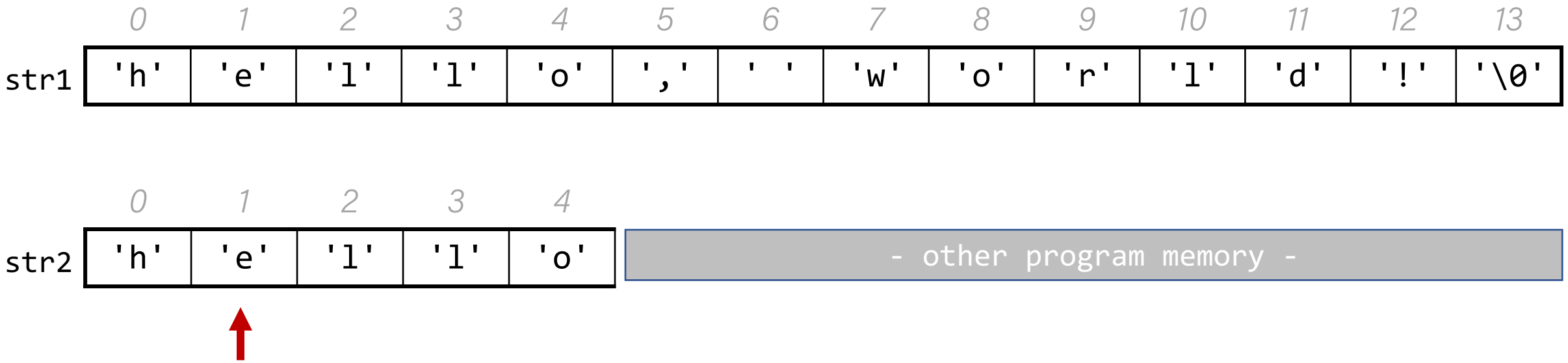

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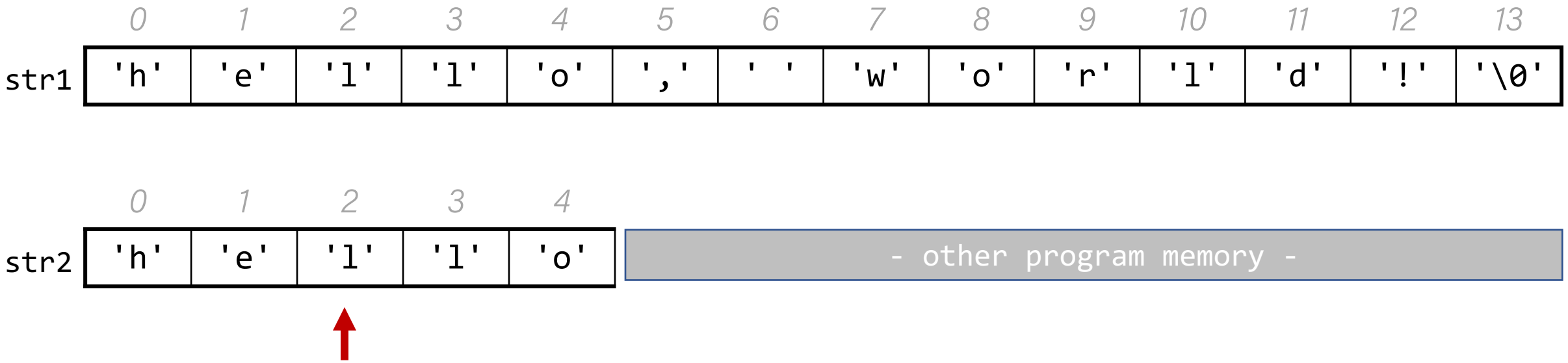

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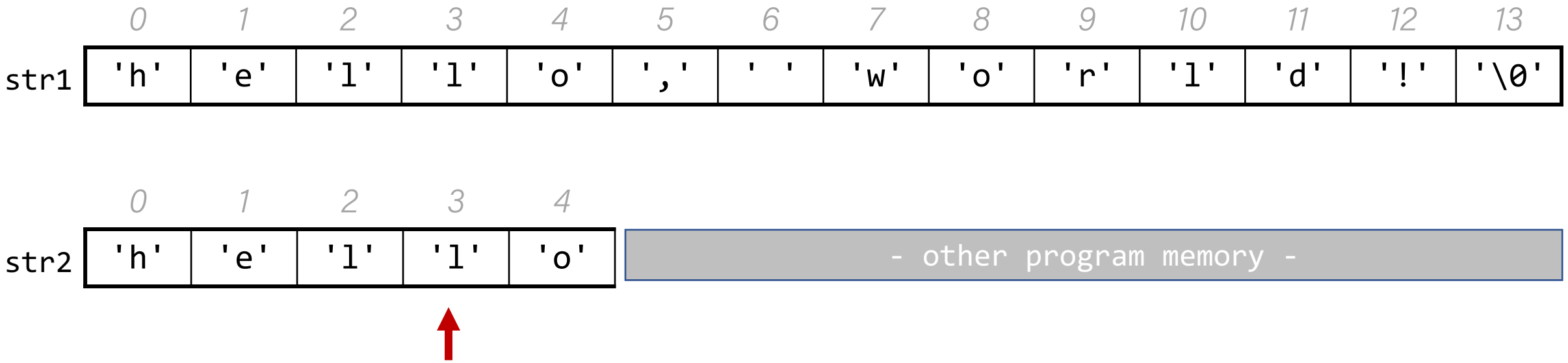

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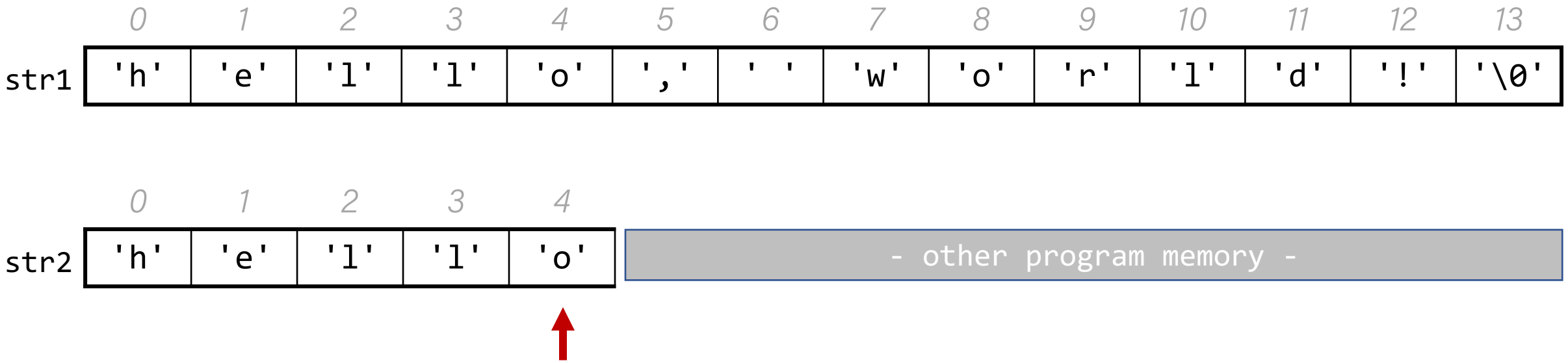

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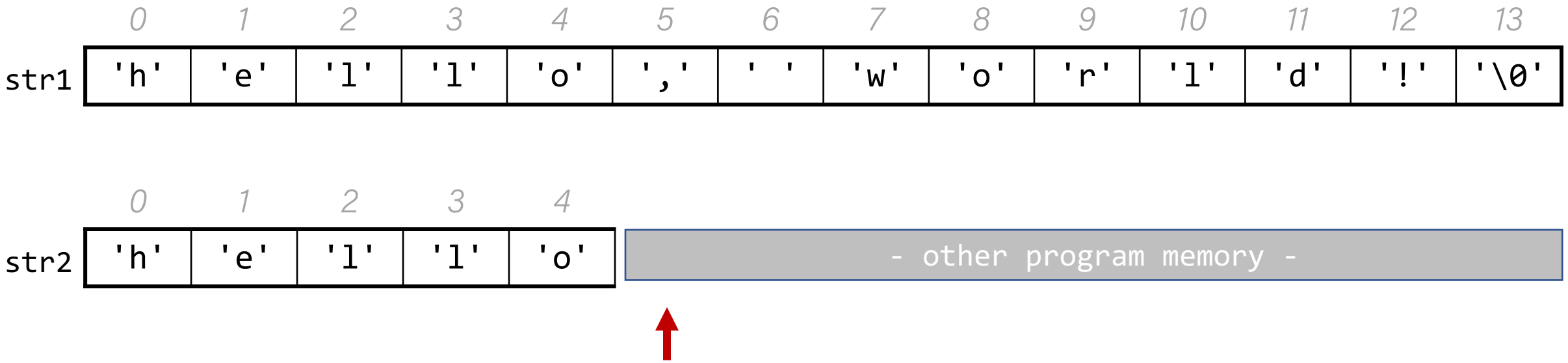

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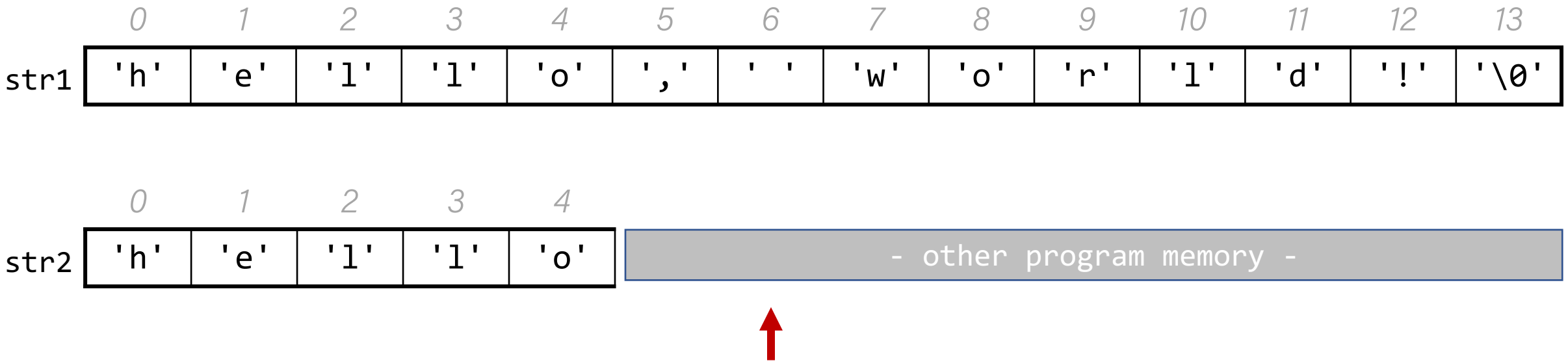

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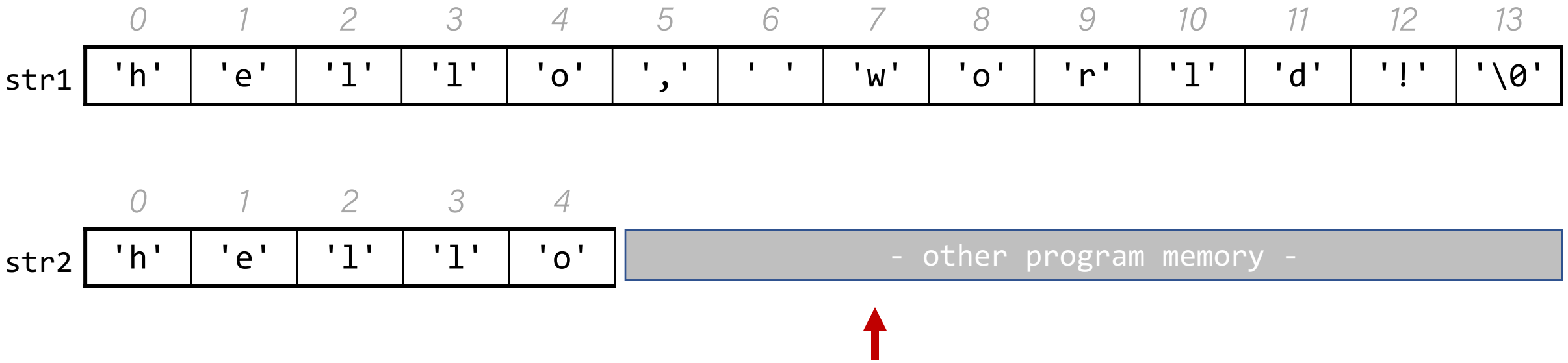

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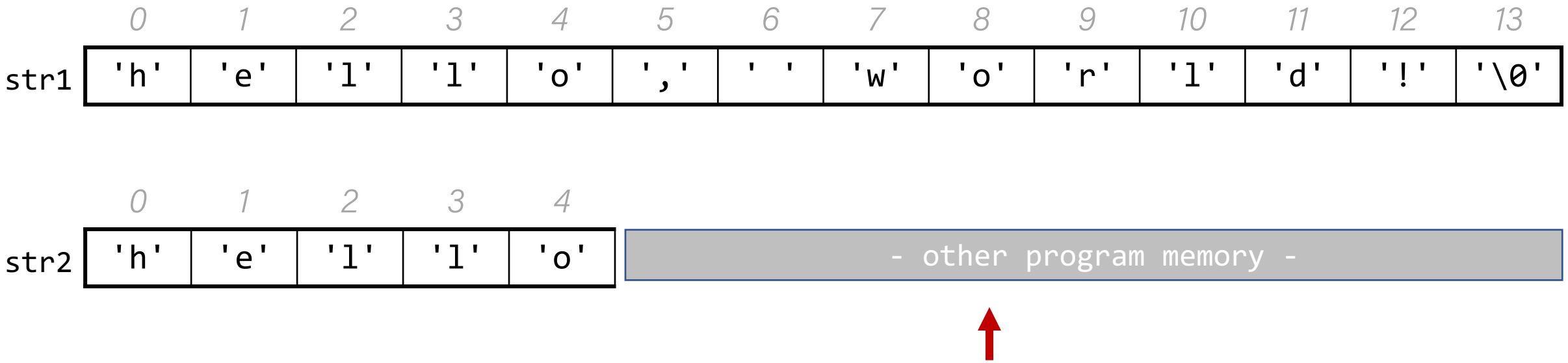

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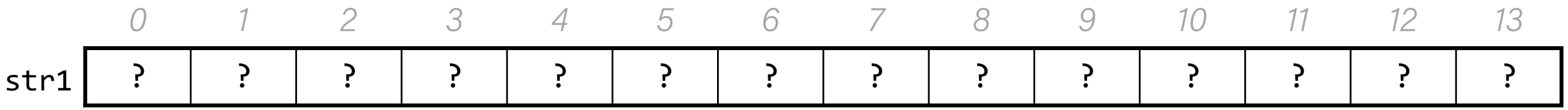

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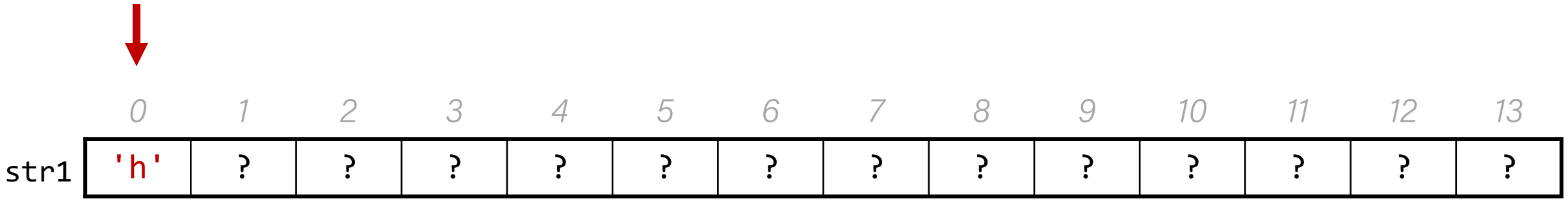

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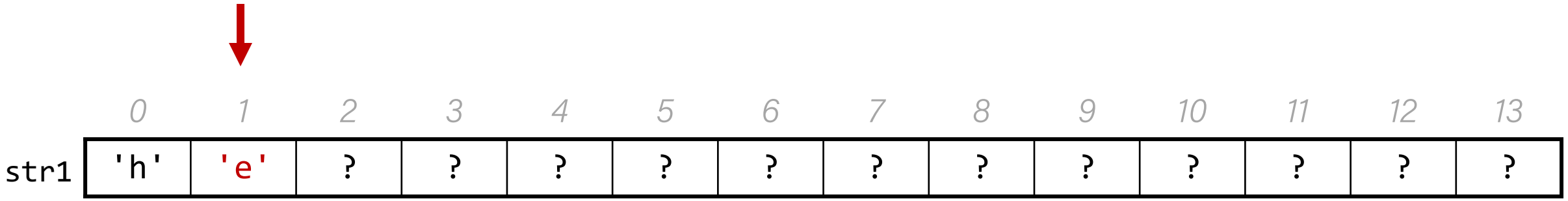

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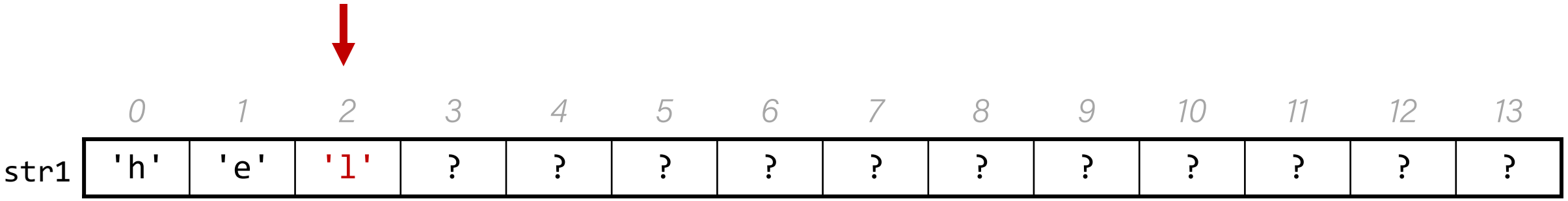

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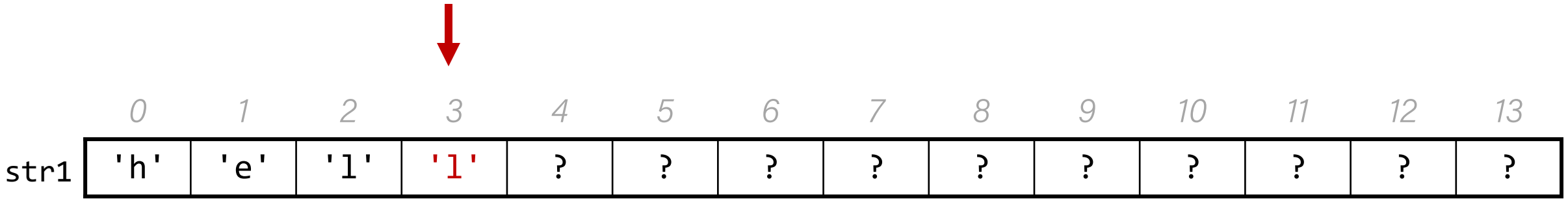

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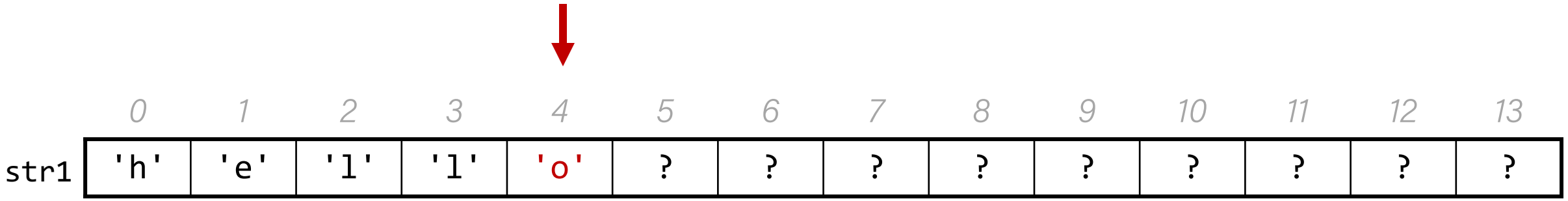

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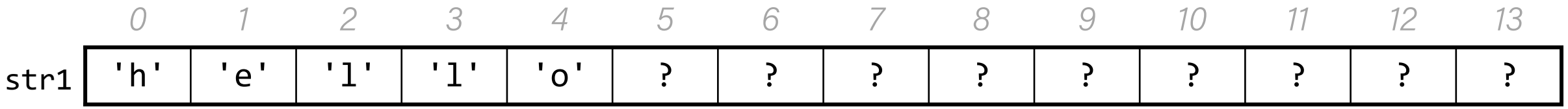

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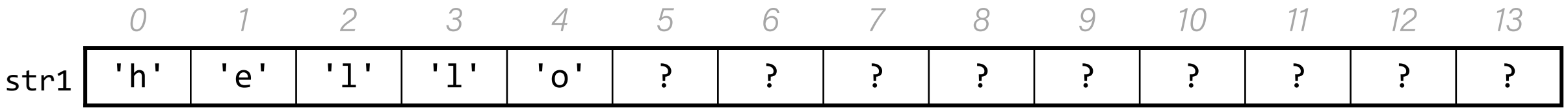

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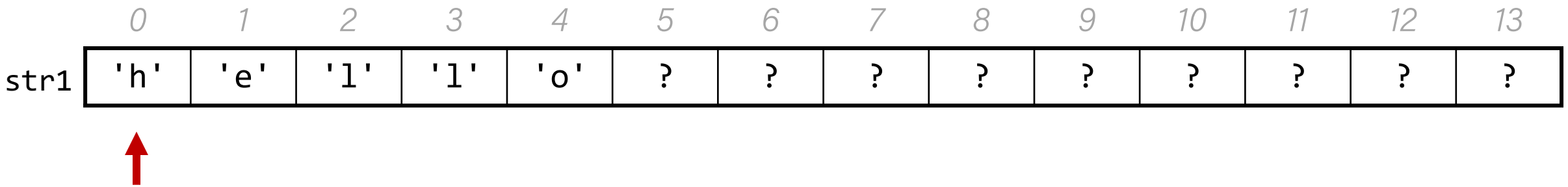

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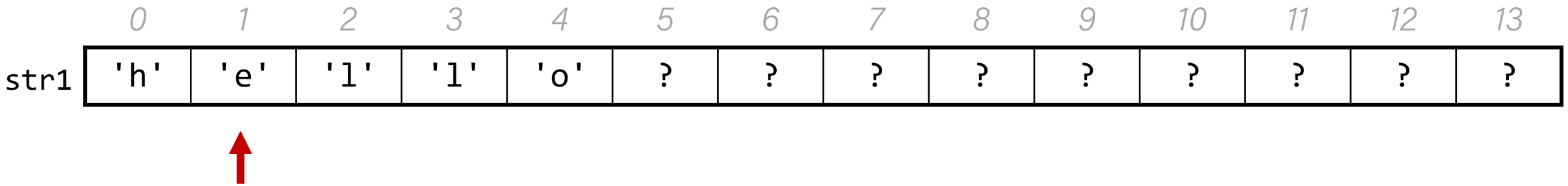

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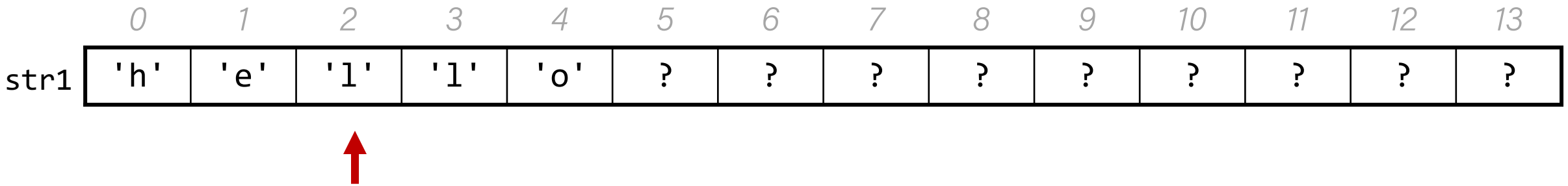

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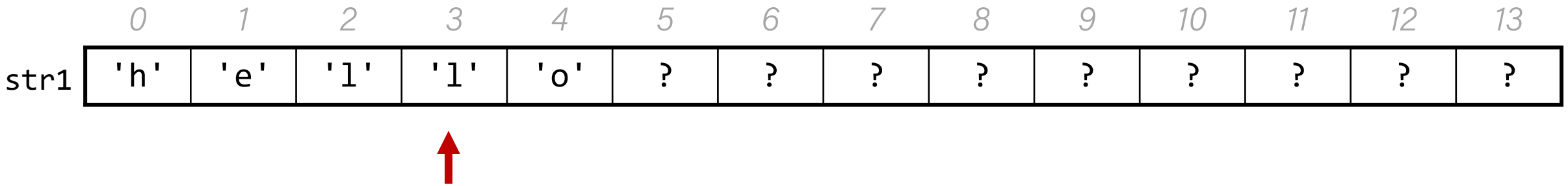

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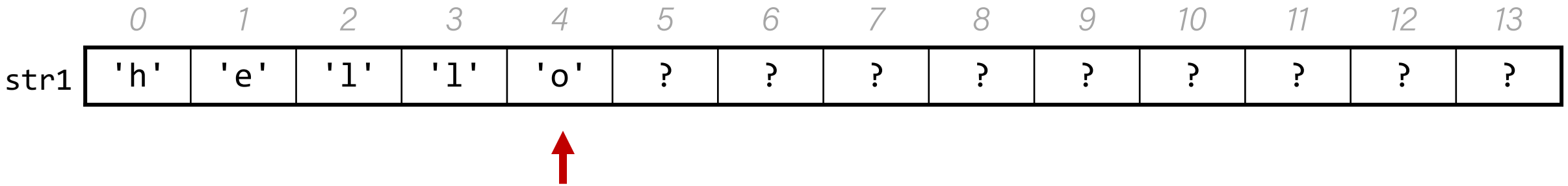
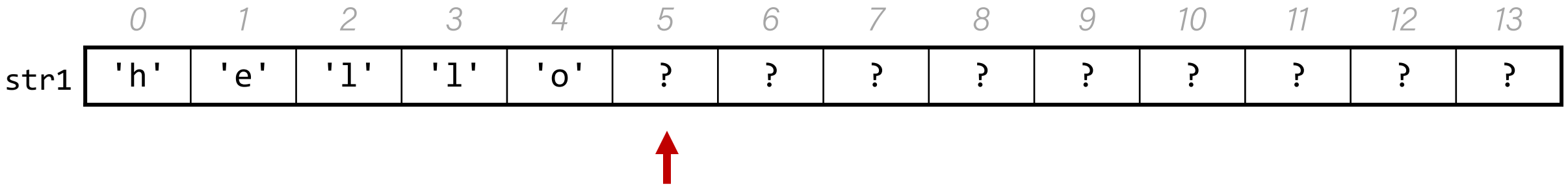


Copying Strings – `strncpy`

```
char str1[14];
strncpy(str1, "hello there", 5);
printf("%s\n", str1);
```



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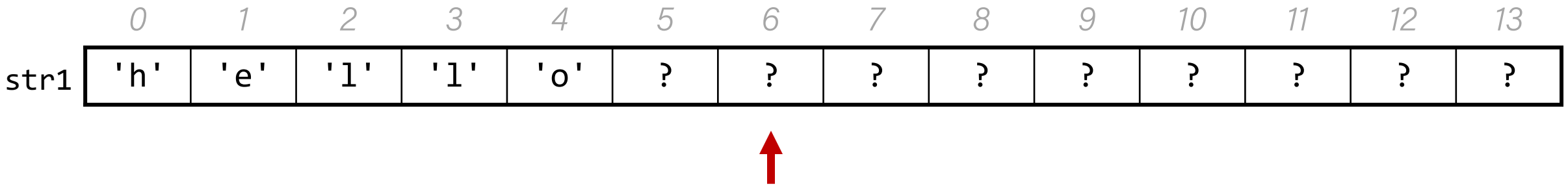

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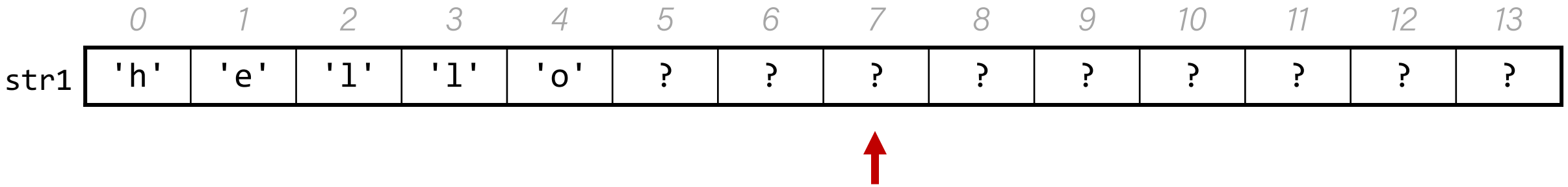

Copying Strings – `strncpy`

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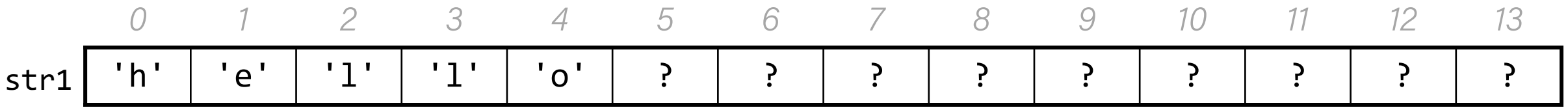



```
hello? ?J? ? ?
```

Copying Strings – `strncpy`

If necessary, we can add a null-terminating character ourselves.

```
// copying "hello"
char str2[6];                          // room for string and '\0'
strncpy(str2, "hello, world!", 5);     // doesn't copy '\0'!
str2[5] = '\0';                        // add null-terminating char
```

Concatenating Strings

We cannot concatenate C strings using **+**. This adds addresses!

```
// e.g. param1 = 0x7f, param2 = 0x65
void doSomething(char *param1, char *param2) {
     printf("%s", param1 + param2);   // adds 0x7f and 0x65!
```

Instead, use **`strcat`**.

The string library: `str(n)cat`

`strcat(dst, src)`: concatenates the contents of **src** into the string **dst**.

`strncat(dst, src, n)`: same, but concats at most **n** bytes from **src**.

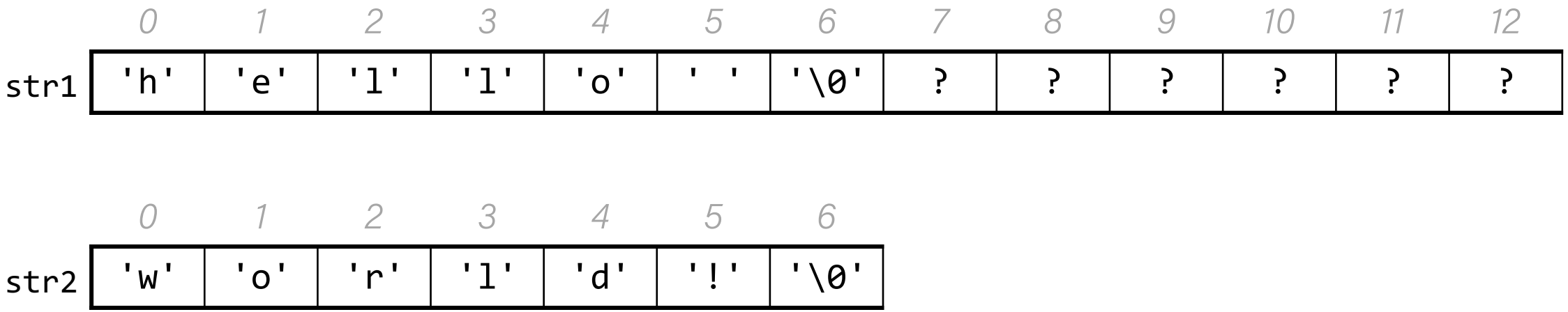
```
char str1[13];                  // enough space for strings + '\0'
strcpy(str1, "hello ");
strcat(str1, "world!");         // removes old '\0', adds new '\0' at end
printf("%s", str1);             // hello world!
```

Both **`strcat`** and **`strncat`** remove the old `'\0'` and add a new one at the end.

Concatenating Strings

```
char str1[13];
strcpy(str1, "hello ");
char str2[7];
strcpy(str2, "world!");

strcat(str1, str2);
```



Concatenating Strings

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char str2[7];
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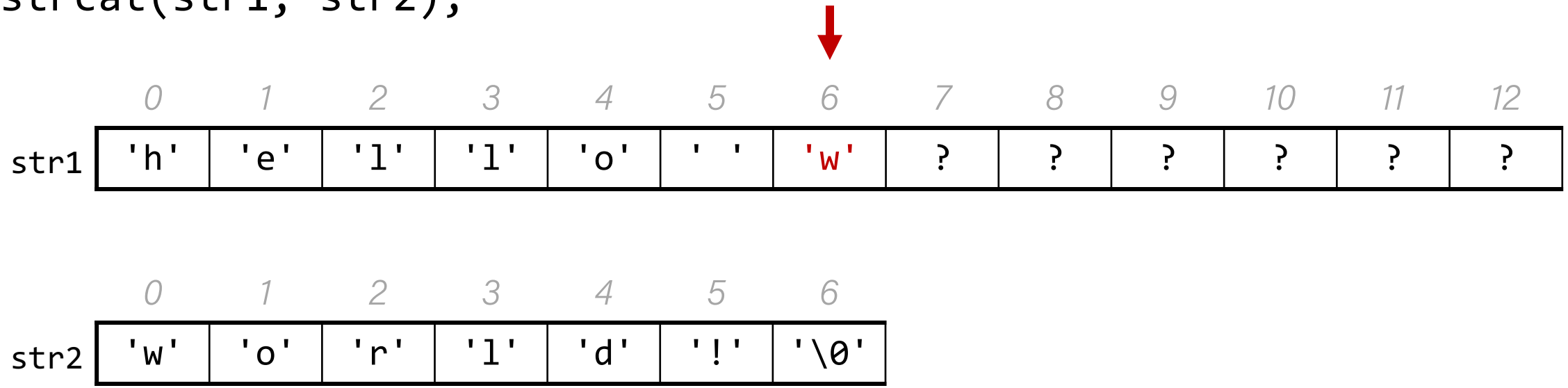

Concatenating Strings

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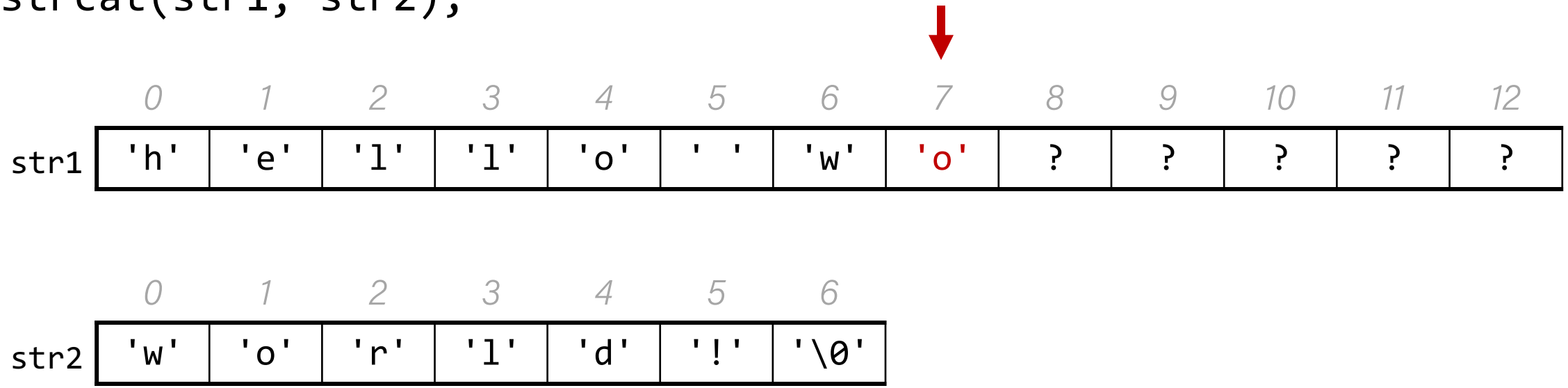
char str2[7];
strcpy(str2, "world!");

strcat(str1, str2);
```



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strcpy(str2, "world!");

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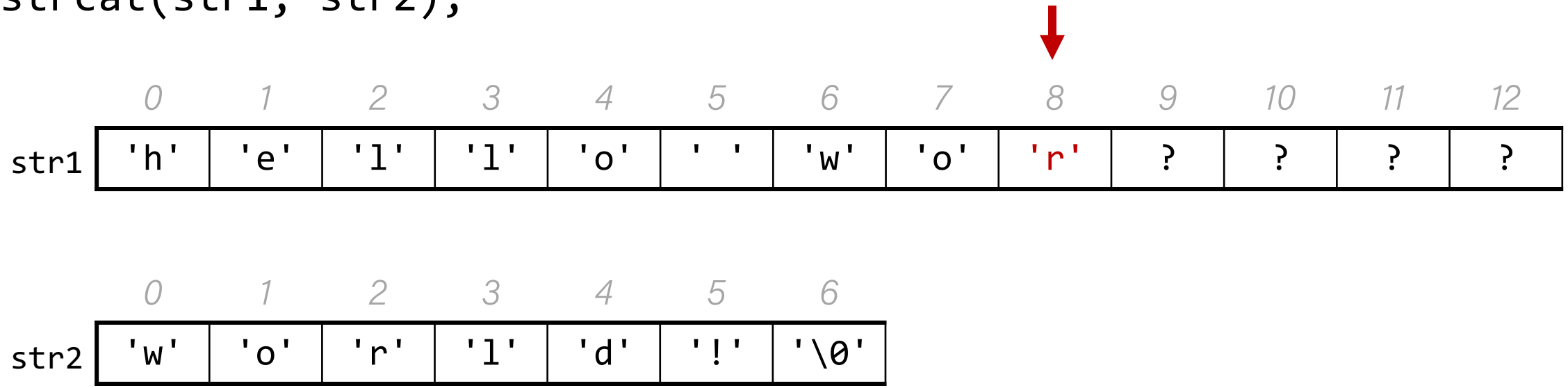

Concatenating Strings

```
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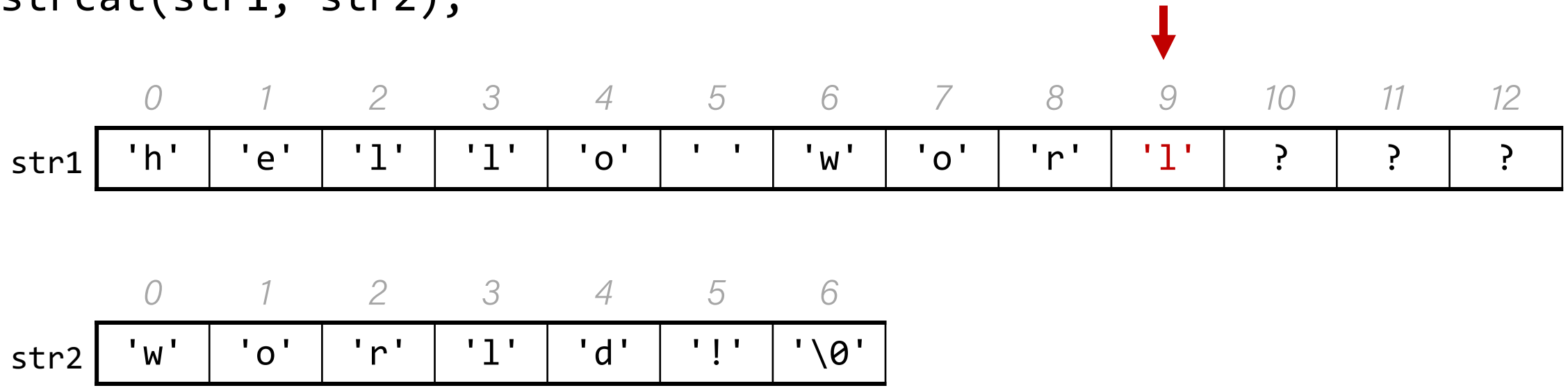
strcpy(str1, "hello ");
char str2[7];
strcpy(str2, "world!");

strcat(str1, str2);
```



Concatenating Strings

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char str2[7];
strcpy(str2, "world!");

strcat(str1, str2);
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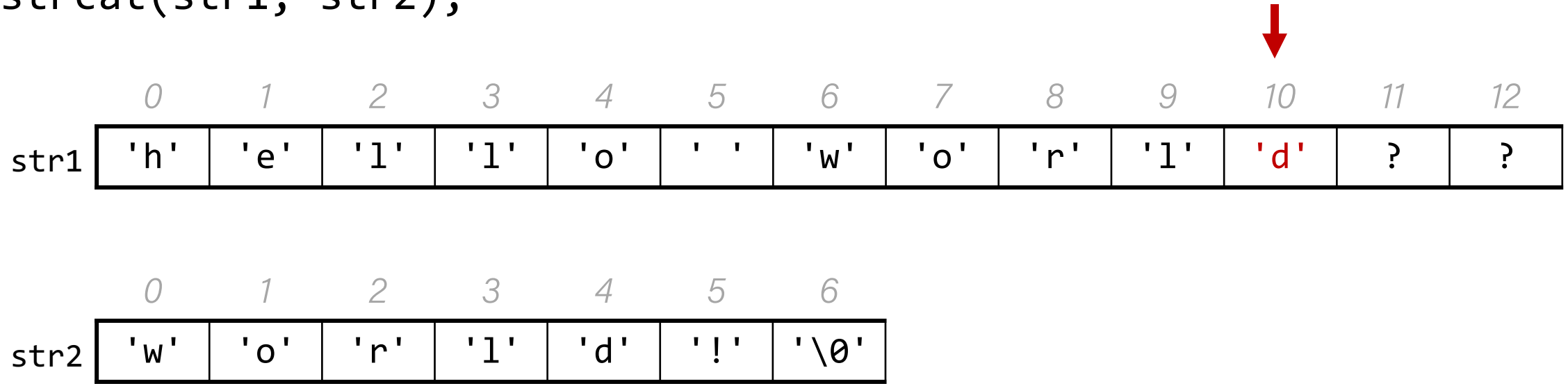

Concatenating Strings

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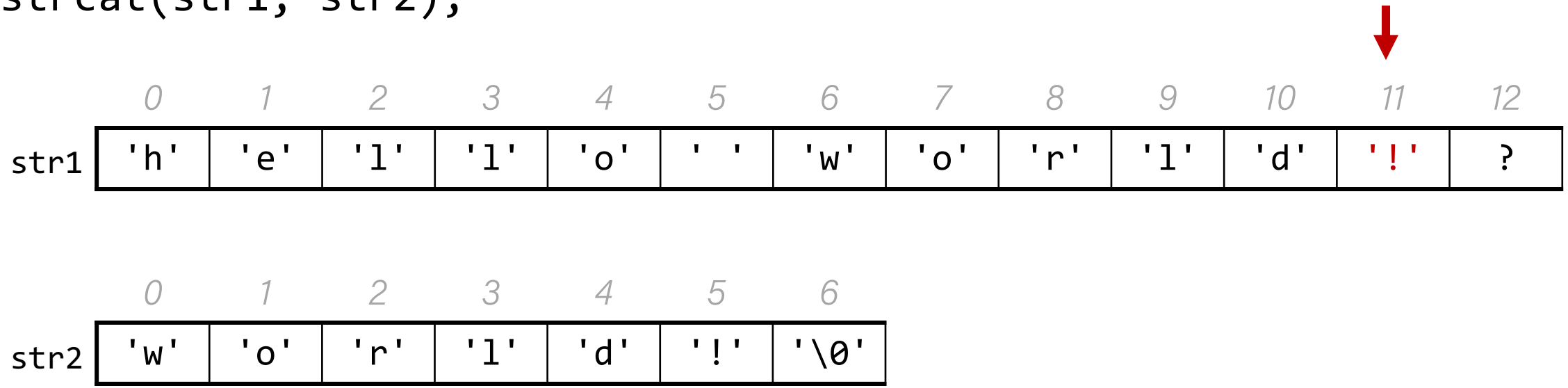

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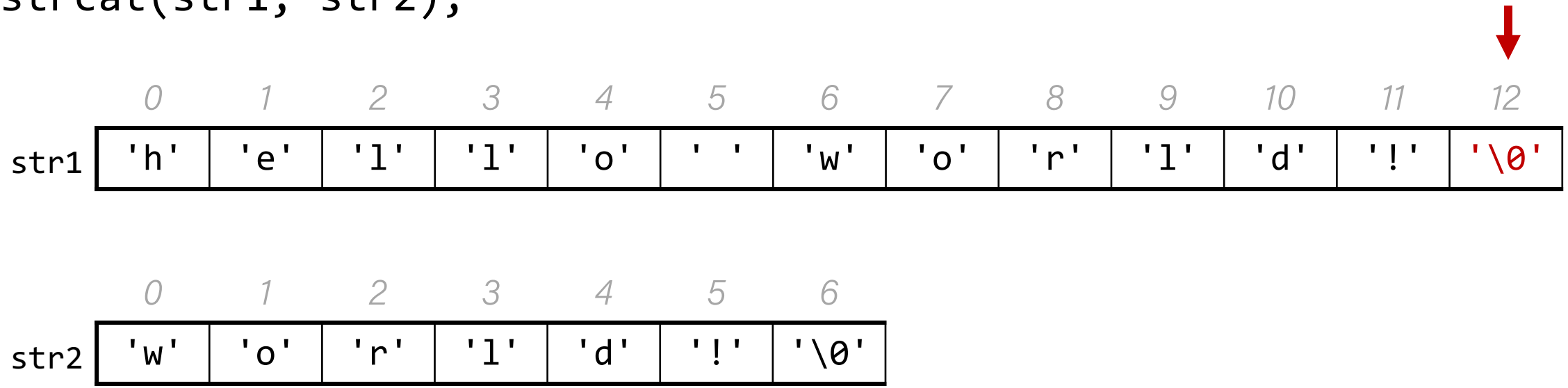

Concatenating Strings

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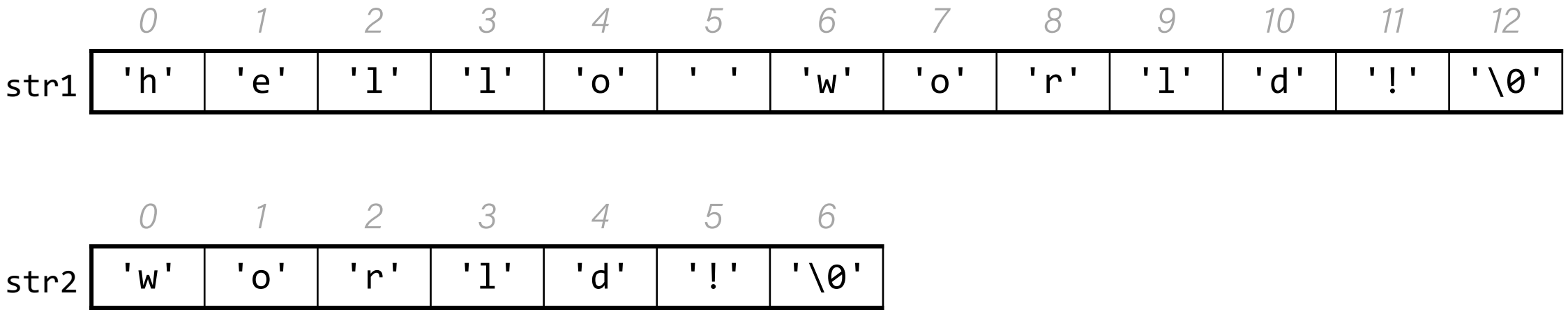


Substrings and `char *`

You can also create a `char *` variable yourself that points to an address within in an existing string.

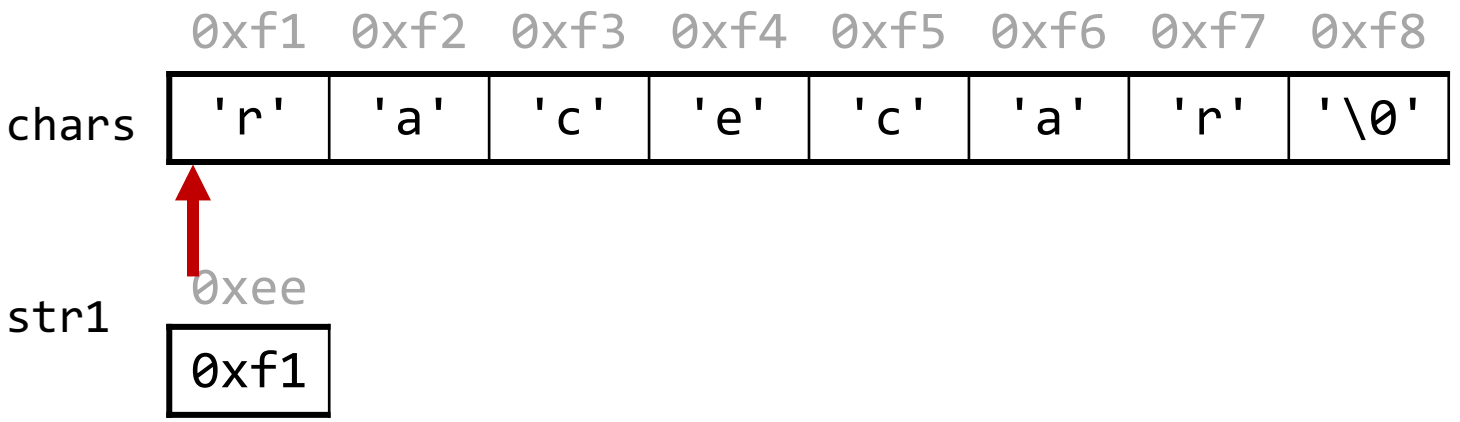
```
char myString[3];
myString[0] = 'H';
myString[1] = 'i';
myString[2] = '\0';

char *otherStr = myString;  // points to 'H'
```

Substrings

char ***s are pointers to characters. We can use them to create substrings of larger strings.

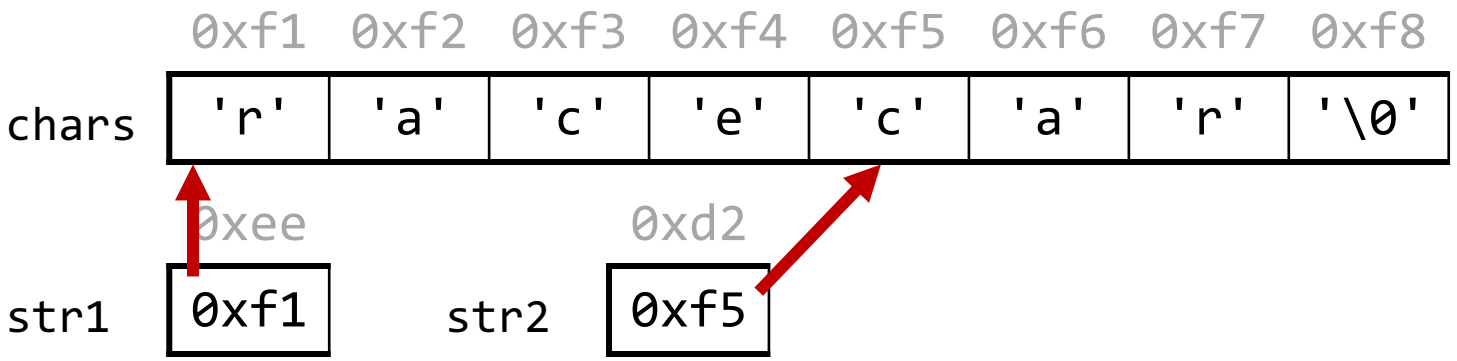
```
// Want just "car"
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning.

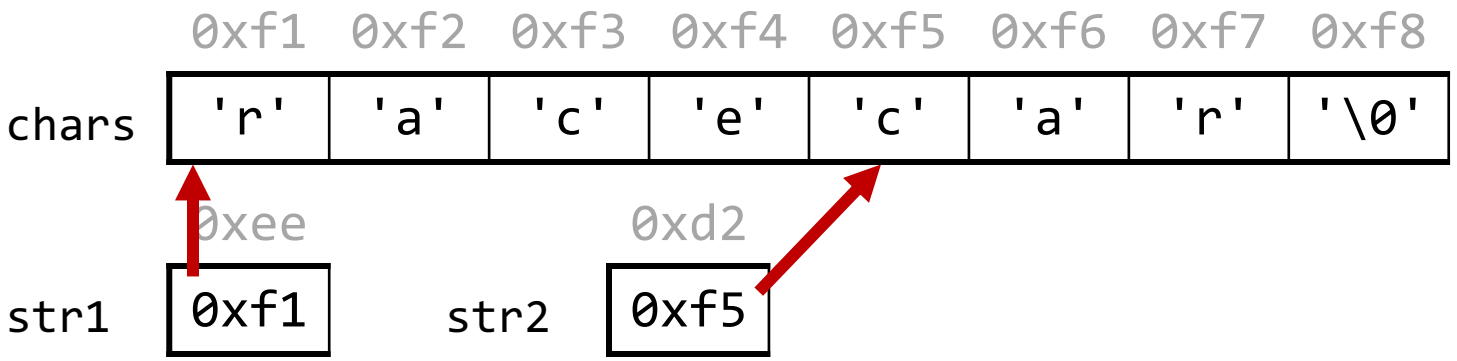
```
// Want just "car"
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning.

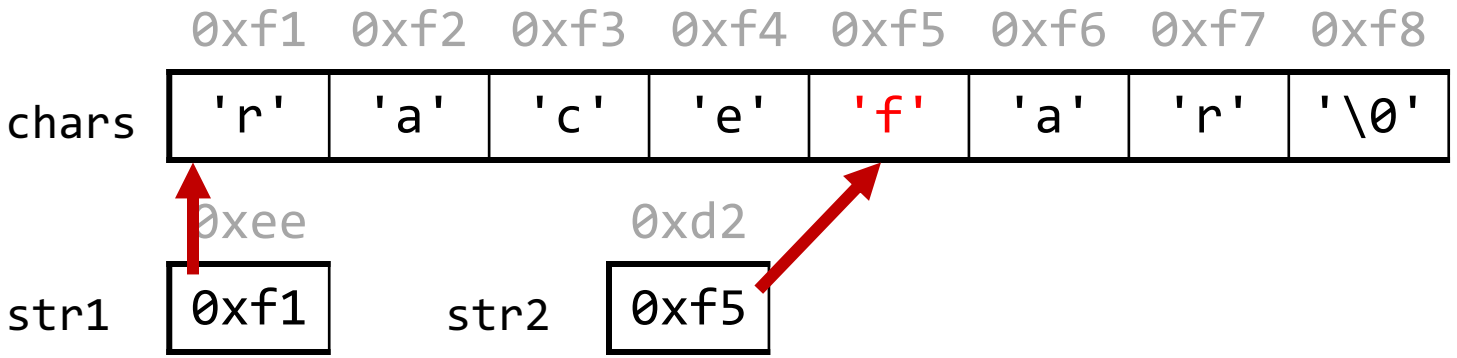
```
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
printf("%s\n", str1);           // racecar
printf("%s\n", str2);           // car
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning. **NOTE:** the pointer still refers to the same characters!

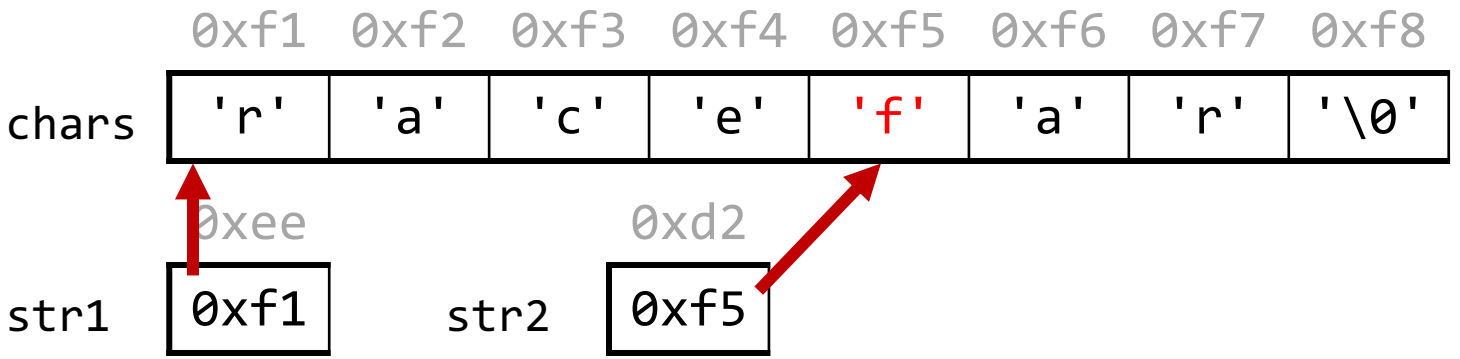
```
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
str2[0] = 'f';
printf("%s %s\n", chars, str1);
printf("%s\n", str2);
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning. **NOTE:** the pointer still refers to the same characters!

```
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
str2[0] = 'f';
printf("%s %s\n", chars, str1);        // racefar racefar
printf("%s\n", str2);                  // far
```



String copying exercise

```
1  char buf[____];
2  strcpy(buf, "Potatoes");
3  printf("%s\n", buf);
4  char *word = buf + 2;
5  strncpy(word, "mat", 3);
6  printf("%s\n", buf);
```

Line 1: What value should go in the blank?

A. `7`
B. `8`
C. `9`
D. `12`
E. `strlen("Potatoes")`

slido

Please download and install the Slido app on all computers you use

Line 1: What value should go in the blank?

ⓘ Start presenting to display the poll results on this slide.

String copying exercise

```
1  char buf[____];
2  strcpy(buf, "Potatoes");
3  printf("%s\n", buf);
4  char *word = buf + 2;
5  strncpy(word, "mat", 3);
6  printf("%s\n", buf);
```

Line 1: What value should go in the blank?

A. `7`
B. `8`
C. `9`
D. `12`
E. `strlen("Potatoes")`

Line 6: What is printed?

A. `matoes`
B. `mattoes`
C. `Pomat`
D. `Pomatoes`
E. Something else
F. Compile error

slido

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Line 6: What is printed?

ⓘ Start presenting to display the poll results on this slide.

char * vs. char[]

`char myString[]`

vs

`char *myString`

You can create `char *` pointers to point to any character in an existing string and reassign them since they are just pointer variables. You **cannot** reassign an array.

```
char myString[6];
strcpy(myString, "Hello");
myString = "Another string";                    // not allowed!
---
char *myOtherString = myString;
myOtherString = somethingElse;                  // ok
```

Substrings

To omit characters at the end, make a new string that is a partial copy of the original.

```
// Want just "race"
char str1[8];
strcpy(str1, "racecar");

char str2[5];
strncpy(str2, str1, 4);
str2[4] = '\0';
printf("%s\n", str1);          // racecar
printf("%s\n", str2);          // race
```

Substrings

We can combine pointer arithmetic and copying to make any substrings we'd like.

```
// Want just "ace"
char str1[8];
strcpy(str1, "racecar");

char str2[4];
strncpy(str2, str1 + 1, 3);
str2[3] = '\0';
printf("%s\n", str1);          // racecar
printf("%s\n", str2);          // ace
```

Lecture Plan

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

String Diamond

- Write a function **`diamond`** that accepts a string parameter and prints its letters in a "diamond" format as shown below.
  - For example, `diamond("COMP201")` should print:

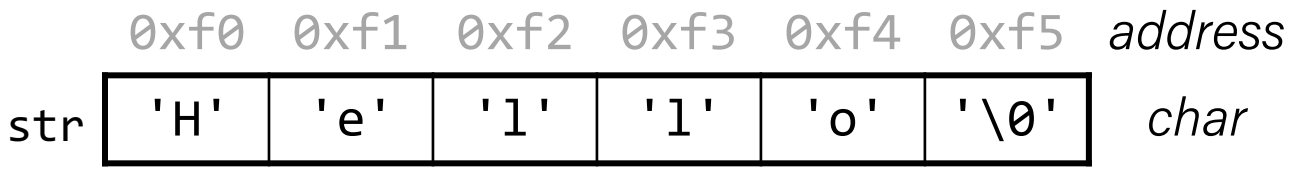
```
C
CO
COM
COMP
COMP2
COMP20
COMP201
 OMP201
  MP201
   P201
    201
     01
      1
```

Practice: Diamond

`diamond.c`

Key takeaways

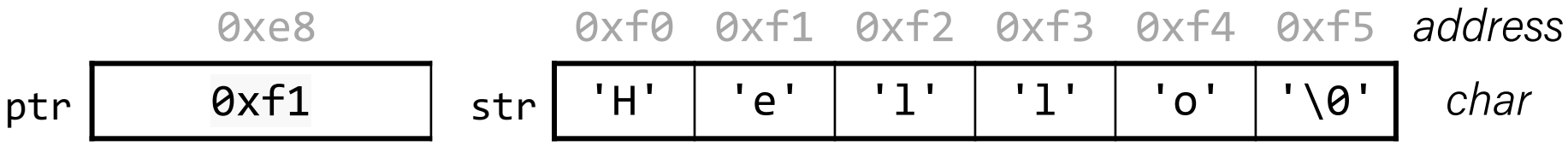
1. Valid strings are null-terminated.




```
char str[6];
strcpy(str, "Hello");
int length = strlen(str);  // 5
```

Key takeaways from this time

1. Valid strings are null-terminated.
2. An array name (and a string name, by extension) is the address of the first element.




```
char str[6];
strcpy(str, "Hello");
int length = strlen(str);   // 5
char *ptr = str + 1;        // 0xf1
printf("%s\n", ptr);        // ello
```

Key takeaways from this time

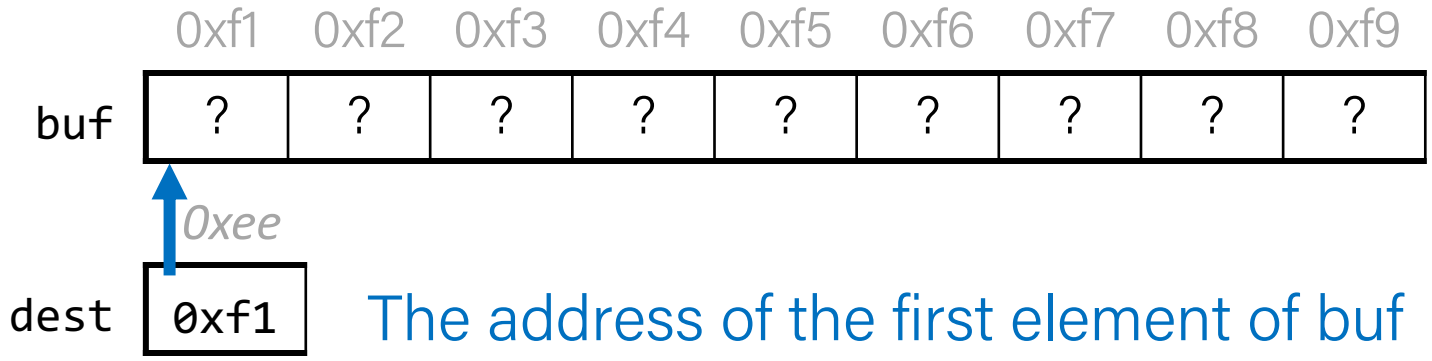
1. Valid strings are null-terminated.
2. An array name (and a string name, by extension) is the address of the first element.
3. When you pass a `char[]` as a parameter, it is automatically passed as a `char *` (pointer to its first character)

Why did C bother with this representation?

- C is a powerful, **efficient** language that requires a solid understanding of computer memory.
- We'll hone this understanding over these next two weeks!

Takeaway #3 : `man strcpy`

```
1 char buf[6];
2 strcpy(buf, "Hello");
3 printf("%s\n", buf);
  …
```



The address of the first element of buf

```
STRCPY(3)                  Linux Programmer's Manual

NAME
       strcpy, strncpy - copy a string

SYNOPSIS
       #include <string.h>

       char *strcpy(char *dest, const char *src);
```

- Lecture 6: where string constants like `"hello"` are stored.
- Lecture 12: what `const` means

Recap

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

Next time: *More strings, pointers*