# CS 33

## Introduction to C
### Part 6

# The String Library

```
#include <string.h>

char *strcpy(char *dest, char *src);
  // copy src to dest, returns ptr to dest
char *strncpy(char *dest, char *src, int n);
  // copy at most n bytes from src to dest
int strlen(char *s);
  // return the length of s (not counting the null)
int strcmp(char *s1, char *s2);
  // returns -1, 0, or 1 depending on whether s1 is
  // less than, the same as, or greater than s2
int strncmp(char *s1, char *s2, int n);
  // do the same, but for at most n bytes
```

# The String Library (more)

```
size_t strspn(const char *s, const char *accept);
      // returns length of initial portion of s
      // consisting entirely of bytes from accept

size_t strcspn(const char *s, const char *reject);
      // returns length of initial portion of s
      // consisting entirely of bytes not from
      // reject
```

# Quiz 1

```
#include <stdio.h>
#include <string.h>

int main() {
  char s1[] = "Hello World!\n";
  char *s2;
  strcpy(s2, s1);
  printf("%s", s2);
  return 0;
}
```

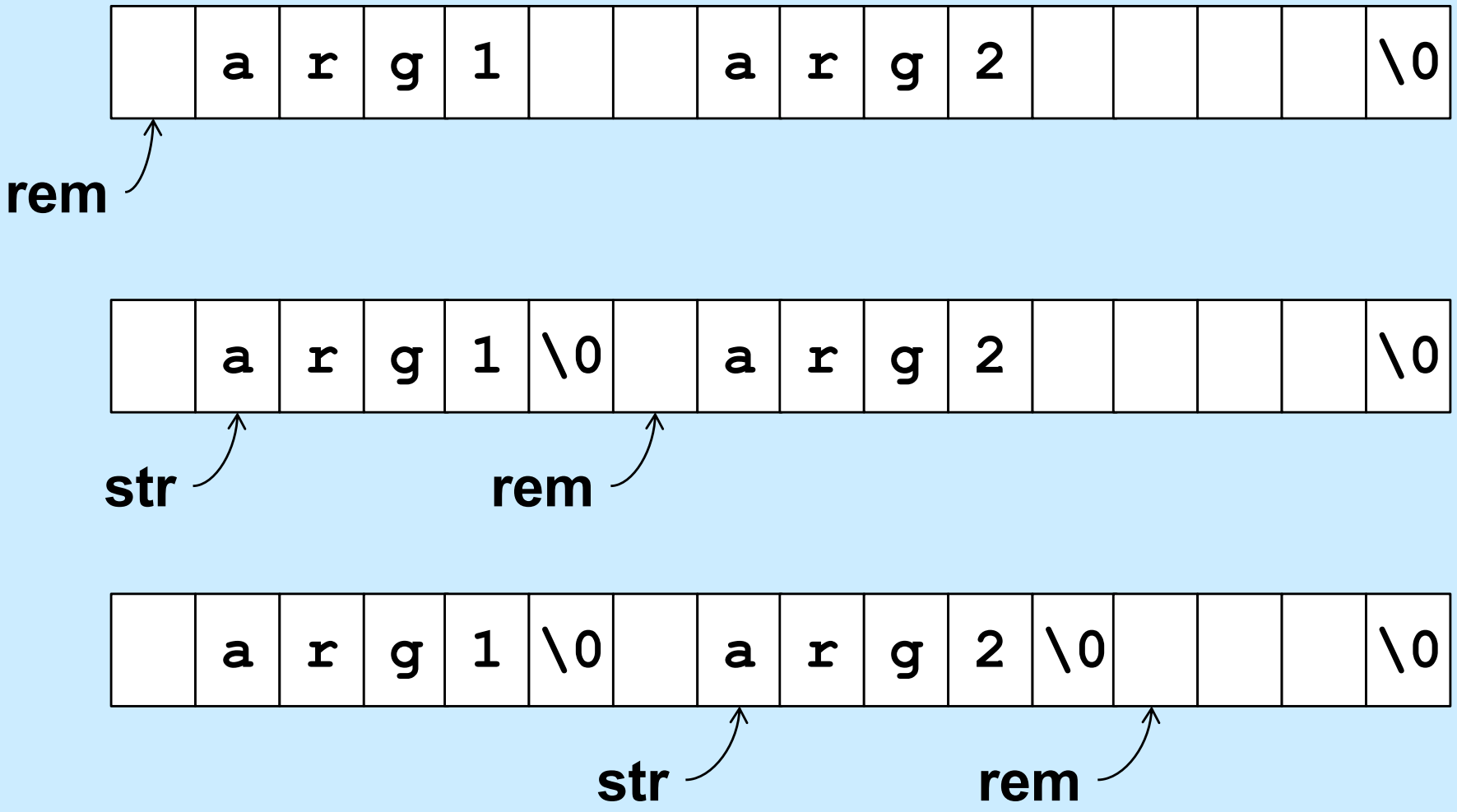
**This code:**

a) **is a great example of well written C code**

b) **has syntax problems**

c) **might seg fault**

# Parsing a String

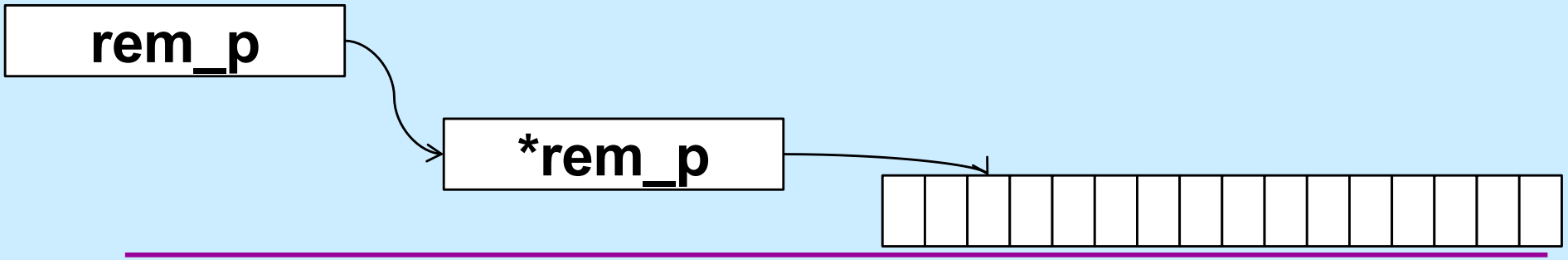


# Design of *getfirstword*

- char *getfirstword(char **rem_p)
  - returns
    - » pointer to null-terminated first word in *rem_p

    or
    - » NULL, if *rem_p is a string entirely of whitespace
  - *rem_p modified to
    - » point to character following first word in *rem_p if within bounds of string

    or
    - » NULL if next character not within bounds



# Using *getfirstword*

```
int main() {
  char line[] = "  arg0   arg1 arg2   arg3   ";
  char *rem = line;
  char *str;
  while ((str = getfirstword(&rem)) != NULL) {
    printf("%s\n", str);
  }
  return 0;
}
```

**Output:**

```
arg0
arg1
arg2
arg3
```

# Code

```
char *getfirstword(char **rem_p) {
  char *str = *rem_p;
  if (str == NULL)
    return NULL;
  int len = strlen(str);
  int wslen =
    strspn(str, " \t\n");
      // initial whitespace
  if (wslen == len) {
    // string is all whitespace
    return NULL;
  }
  str = &str[wslen];
    // skip over whitespace
  len -= wslen;
  int wlen =
    strcspn(str, " \t\n");
      // length of first word
  if (wlen < len) {
    // word ends before end of
    // string: terminate
    // it with null
    str[wlen] = '\0';
    *rem_p = &str[wlen+1];
  } else {
    // no more words
    *rem_p = NULL;
  }
  return str;
}
```

# Numeric Conversions

```
short a;
int b;
float c;

b = a;    /* always works */
a = b;    /* sometimes works */
c = b;    /* sort of works */
b = c;    /* sometimes works */
```

# Implicit Conversions (1)

```
float x, y=2.0;
int i=1, j=2;

x = i/j + y;
  /* what's the value of x? */
```

# Implicit Conversions (2)

```
float x, y=2.0;
int i=1, j=2;
float a, b;

a = i;
b = j;
x = a/b + y;
  /* now what's the value of x? */
```

# Explicit Conversions: Casts

```
float x, y=2.0;
int i=1, j=2;

x = (float)i/(float)j + y;
  /* and now what's the value of x? */
```

# Purposes of Casts

- **Coercion**

```
int i, j;
float a; //sizeof(float) == 4
a = (float)i/(float)j;
```

**do something sensible**

- **Intimidation**

```
float x, y;
swap((int *)&x, (int *)&y);
```

**just do it**

# Quiz 2

- **Will this work?**

```
double x, y; //sizeof(double) == 8

...
swap((int *)&x, (int *)&y);
```

a) **yes**

b) **no**

# Nothing, and More …

- ***void* means, literally, nothing:**

```
void NotMuch(void) {
   printf("I return nothing\n");
}
```

- **What does *void* * mean?**
  - **it's a pointer to anything you feel like**
    - » **a generic pointer**

# Rules

- **Use with other pointers**

```
int *x;
void *y;
x = y; /* legal */
y = x; /* legal */
```

- **Dereferencing**

```
void *z;
func(*z); /* illegal!*/
func(*(int *)z); /* legal */
```

# Swap, Revisited

```
void swap(int *i, int *j) {
  int tmp;
  tmp = *j; *j = *i; *i = tmp;
}
/* can we make this generic? */
```

# An Application: Generic Swap

```
void gswap (void *p1, void *p2,
        int size) {
  int i;
  for (i=0; i < size; i++) {
      char tmp;
      tmp = ((char *)p1)[i];
      ((char *)p1)[i] = ((char *)p2)[i];
      ((char *)p2)[i] = tmp;
  }
}
```

# Using Generic Swap

```
short a=1, b=2;
gswap(&a, &b, sizeof(short));

int x=6, y=7;
gswap(&x, &y, sizeof(int));

int A[] = {1, 2, 3}, B[] = {7, 8, 9};
gswap(A, B, sizeof(A));
```

# Fun with Functions (1)

```
void ArrayDouble(int A[], int len) {
  int i;
  for (i=0; i<len; i++)
      A[i] = 2*A[i];
}
```

# Fun with Functions (2)

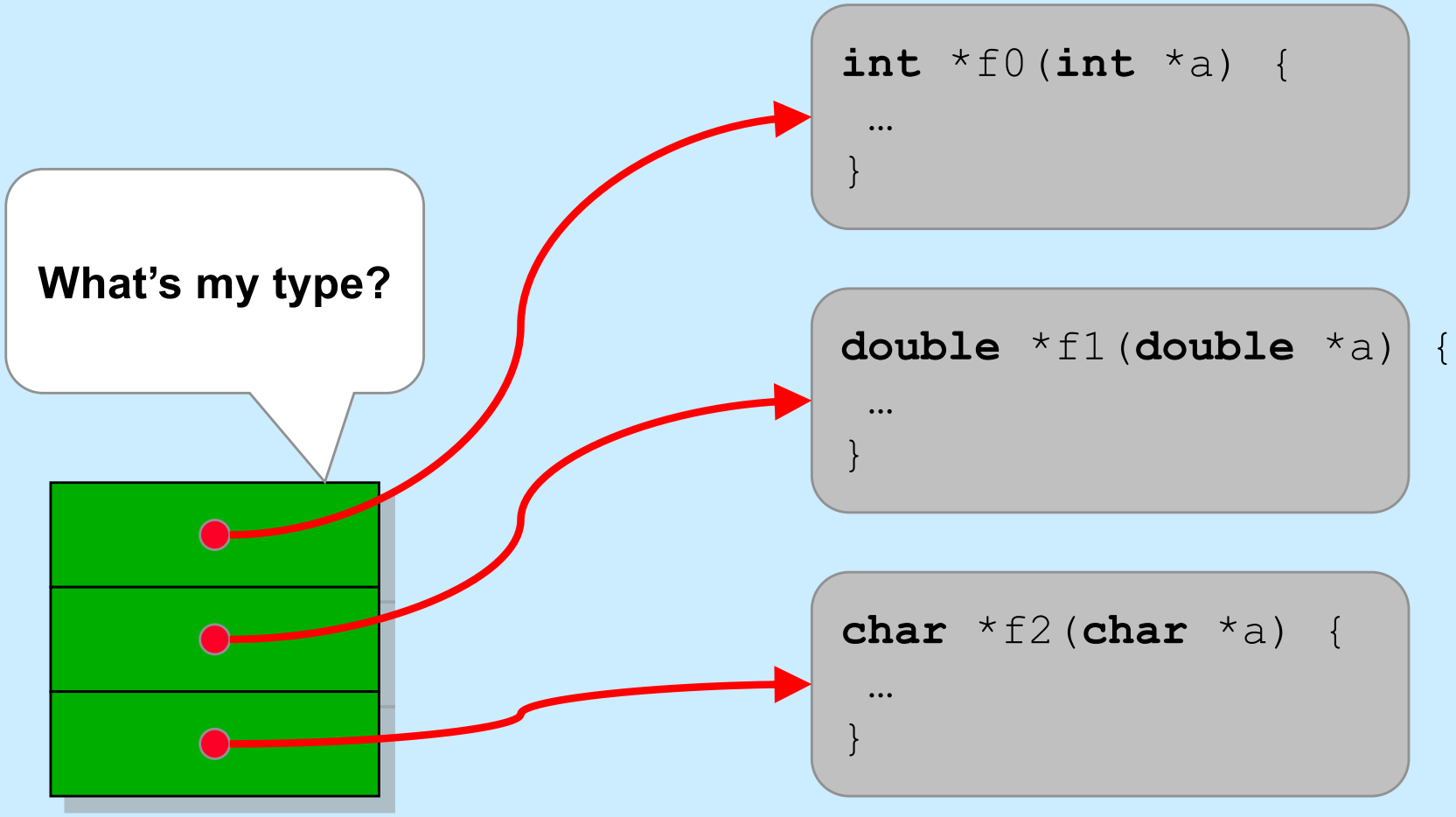
```
void ArrayBop(int A[],
     int len,
     int (*func)(int)) {
  int i;
  for (i=0; i<len; i++)
     A[i] = (*func)(A[i]);
}
```

# Fun with Functions (3)

```
int triple(int arg) {
  return 3*arg;
}

int main() {
  int A[20];
  … /* initialize A */
  ArrayBop(A, 20, triple);
  return 0;
}
```

# For Our Next Trick …



# Working Our Way There …

- An array of 3 ints
  - `int A[3];`
- An array of 3 int *s
  - `int *A[3];`
- A func returning an int *, taking an int *
  - `int *f(int *);`
- A pointer to such a func
  - `int *(*pf)(int *);`

# There …

- **An array of func pointers**
  - `int *(*pf[3])(int *);`
- **An array of generic func pointers**
  - `void *(*pf[3])(void *);`

# Using It

```
int *f0(int *a) { *a += 1; return a; }
double *f1(double *a) { *a += 1; return a; }
char *f2(char *a) { *a += 1; return a; }
int main() {
  int x = 1;
  int *p;
  void *(*pf[3])(void *);
  pf[0] = (void *(*)(void *))f0;
  pf[1] = (void *(*)(void *))f1;
  pf[2] = (void *(*)(void *))f2;
  p = pf[0](&x);
  printf("%d\n", *p);
  return 0;
}
```

```
$ ./funcptr
2
$
```

# Casts, Yet Again

- **They tell the C compiler: "Shut up, I know what I'm doing!"**
- **Sometimes true**

```
pf[0] = (void *(*)(void *))f0;
```

- **Sometimes false**

```
long f = 7;
(void(*)(int))f(2);
```

# Laziness …

- **Why type the declaration**

```
void *(*f)(void *, void *);
```

- **You could, instead, type**

```
MyType f;
```

- **(If, of course, you can somehow define *MyType* to mean the right thing)**

# typedef

- **Allows one to create new names for existing types**

```
typedef int *IntP_t;
```

```
IntP_t x;
```

– **means the same as**

```
int *x;
```

# More typedefs

```
typedef struct complex {
  float real;
  float imag;
} complex_t;

complex_t i, *ip;
```

# And ...

```
typedef void *(*MyFunc_t)(void *, void *);

MyFunc_t f;

// you must do its definition the long way

void *f(void *a1, void *a2) {
  …
}
```

# Quiz 3

- **What's A?**

```
typedef double X_t[M];
X_t A[N];
```

**a) an array of N doubles**
**b) an MxN array of doubles**
**c) an NxM array of doubles**
**d) a syntax error**

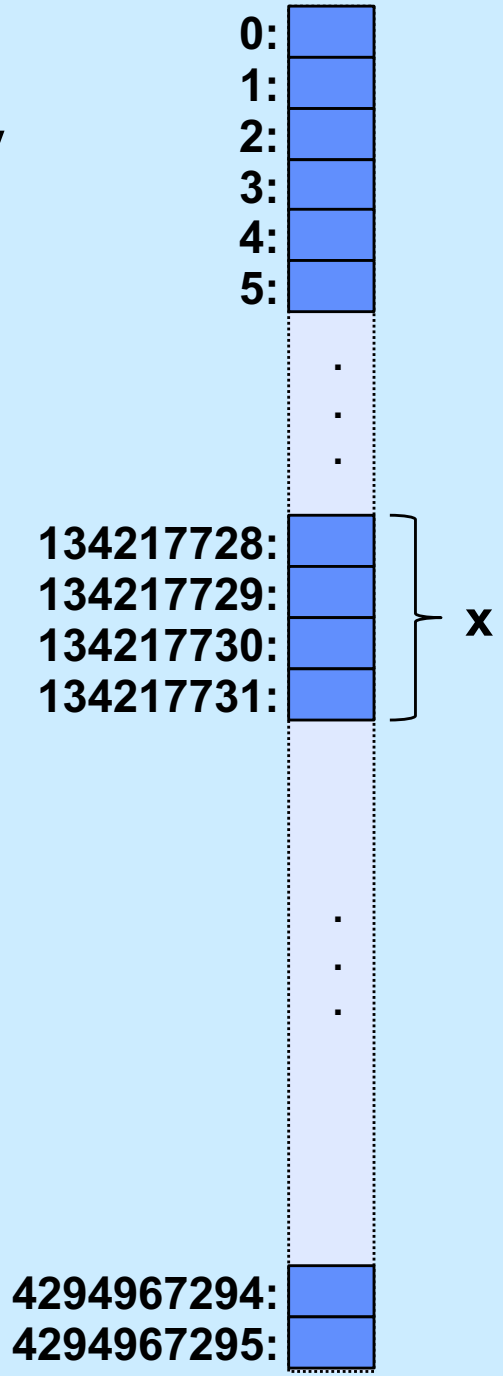
# CS 33

## Data Representation

### Part 1

# Representing Data in Memory

- x is a 4-byte integer
  - how do the 32 bits represent its value?

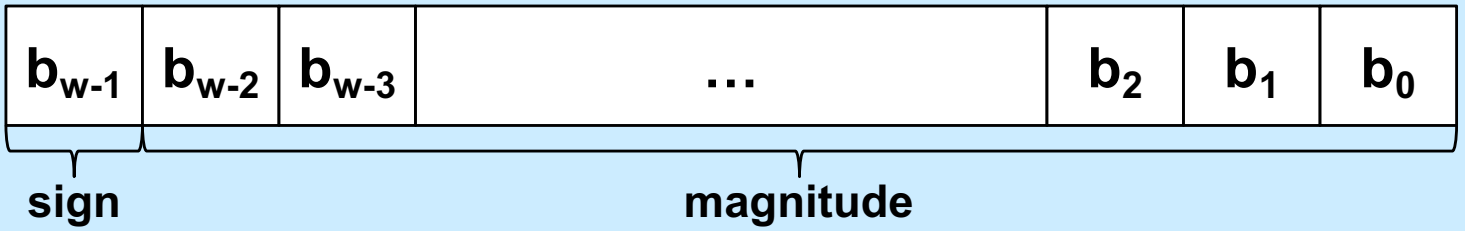


# Unsigned Integers


$$\text{value} = \sum_{i=0}^{w-1} b_i \cdot 2^i$$

# Signed Integers

- **Sign-magnitude**




$$\text{value} = (-1)^{b_{w-1}} \cdot \sum_{i=0}^{w-2} b_i \cdot 2^i$$

- two representations of zero!
  - computer must have two sets of instructions
    - one for signed arithmetic, one for unsigned

# Signed Integers

- **Ones' complement**
  - **negate a number by forming its bit-wise complement**
    - » **e.g., (-1)·01101011 = 10010100**

**$b_{w-1}$ = 0 ⇒ non-negative number**

$$\text{value} = \sum_{i=0}^{w-2} b_i \cdot 2^i$$

**$b_{w-1}$ = 1 ⇒ negative number**

$$\text{value} = \sum_{i=0}^{w-2} (b_i - 1) \cdot 2^i$$

**two zeros!**

# Signed Integers

- **Two's complement**

  **$b_{w-1} = 0 \Rightarrow$ non-negative number**

  **value =** $\sum_{i=0}^{w-2} b_i \cdot 2^i$

  **$b_{w-1} = 1 \Rightarrow$ negative number**

  **value =** $(-1) \cdot 2^{w-1} + \sum_{i=0}^{w-2} b_i \cdot 2^i$

  **one zero!**

# Example

- **w = 4**

```
0000: 0        1000: -8
0001: 1        1001: -7
0010: 2        1010: -6
0011: 3        1011: -5
0100: 4        1100: -4
0101: 5        1101: -3
0110: 6        1110: -2
0111: 7        1111: -1
```