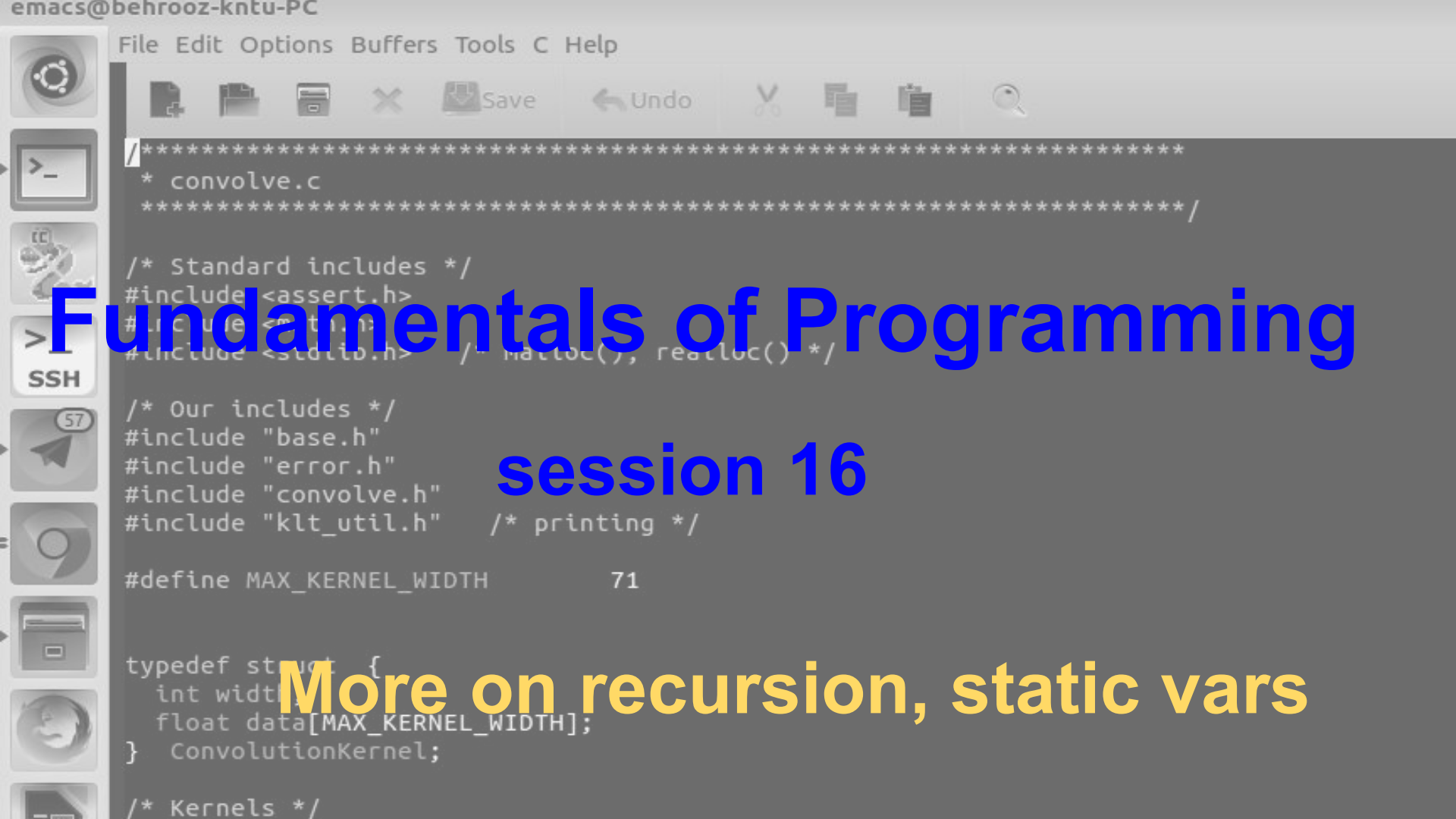

emacs@behrooz-kntu-PC
File Edit Options Buffers Tools C Help
Save
Undo
/* Standard includes */
/* Our includes */
#include "base.h"
#include "error.h"
#include "convolve.h"
#include "klt_util.h" /* printing */
#define MAX_KERNEL_WIDTH 71
float data[MAX_KERNEL_WIDTH];
} ConvolutionKernel;
/* Kernels */
SSH
Fundamentals of Programming
session 16
More on recursion, static vars

Recursion

recursive definition:

- `0! = 1`
- `n! = n * (n-1)!`

```c
#include <stdio.h>

int fact(int);


int main() {
  int n;

  scanf("%d", &n);

  printf("%d\n", fact(n));

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  // ???
```

Recursion

recursive definition:

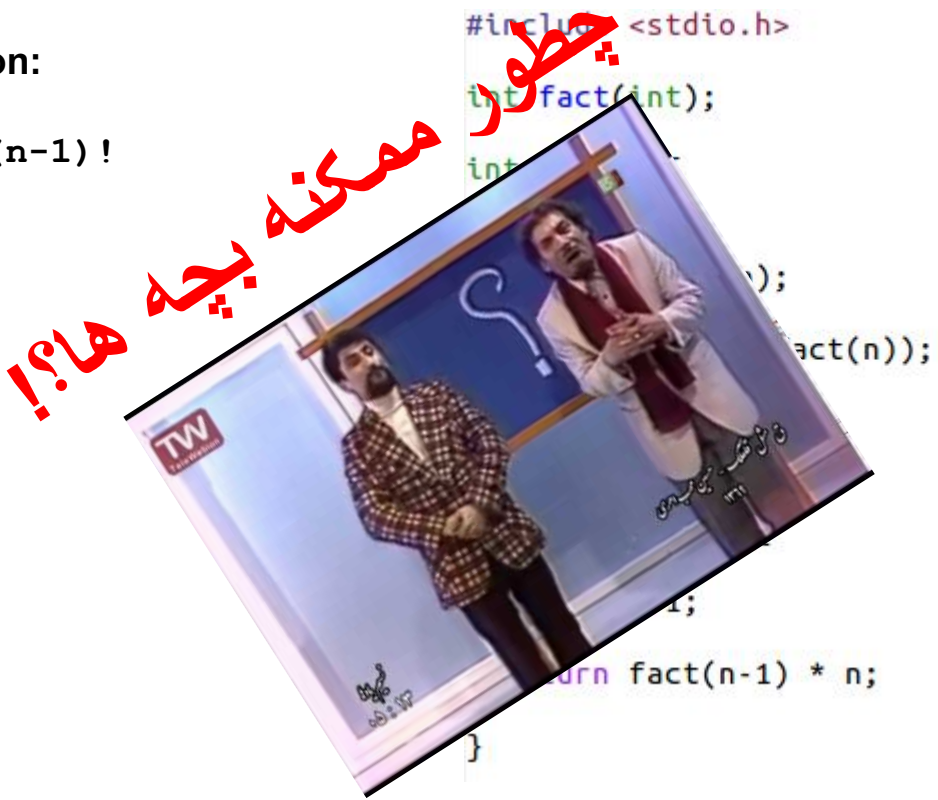
- `0! = 1`
- `n! = n * (n-1)!`

```c
#include <stdio.h>

int fact(int);

int main() {
  int n;

  scanf("%d", &n);

  printf("%d\n", fact(n));

}


int fact(int n) {
  if (n == 0)
    return 1;

  return fact(n-1) * n;

}
```

Recursion

recursive definition:

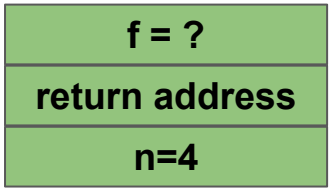
- `0! = 1`
- `n! = n * (n-1)!`



Call stack

```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;

  printf("%d\n", fact(m));

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

stack frame:

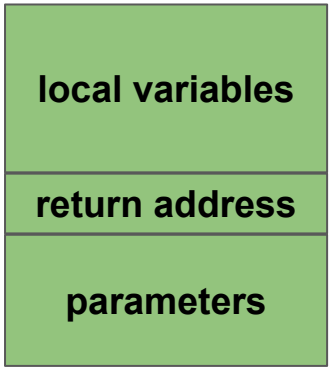


Call stack

```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;

  printf("%d\n", fact(m));

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

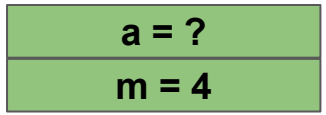
stack frame:

- **parameters (arguments)**
- **return address**
- **local variables**

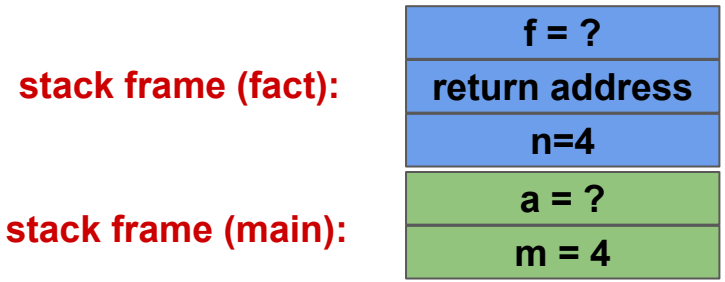


```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

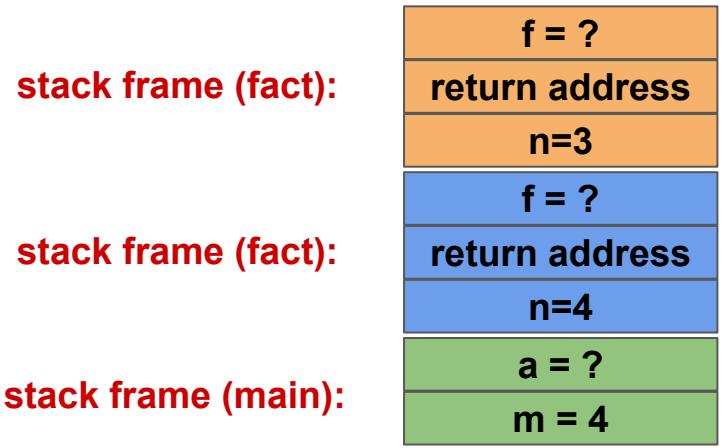
stack frame (main):



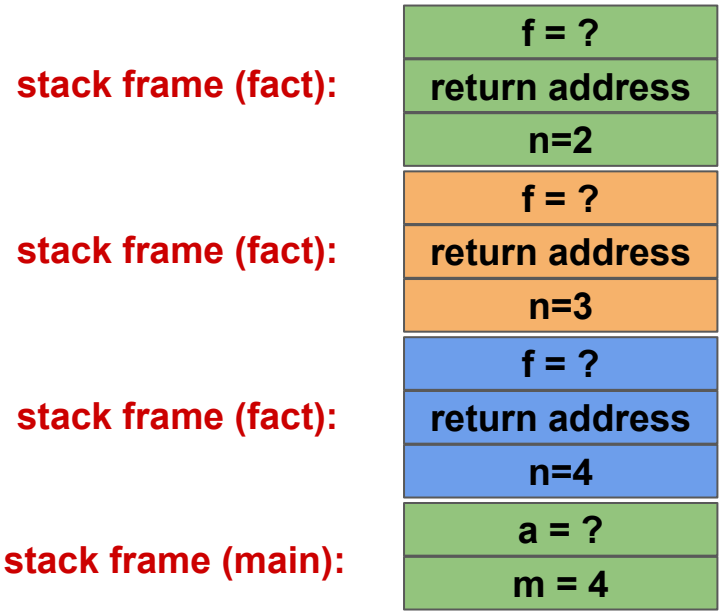
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;
                    int f;
  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



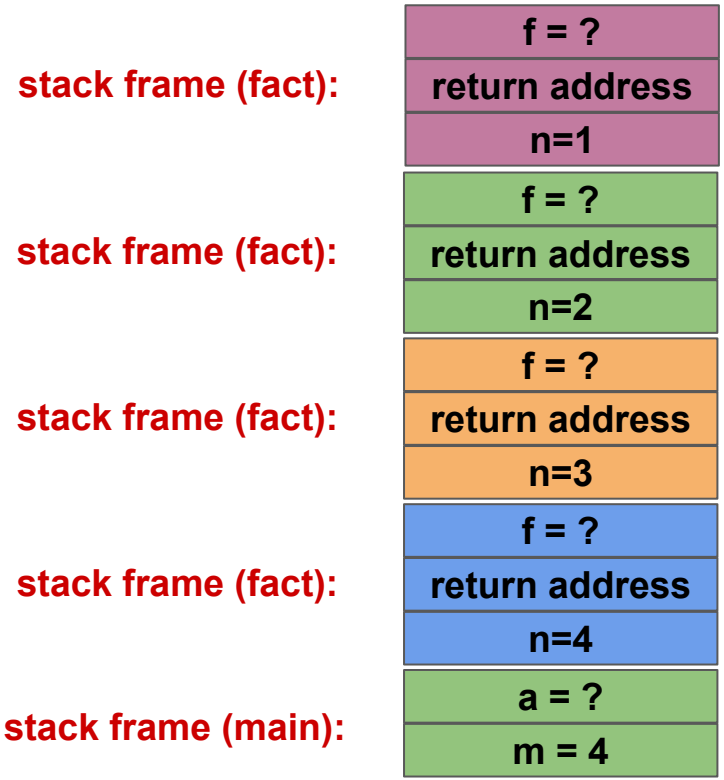
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



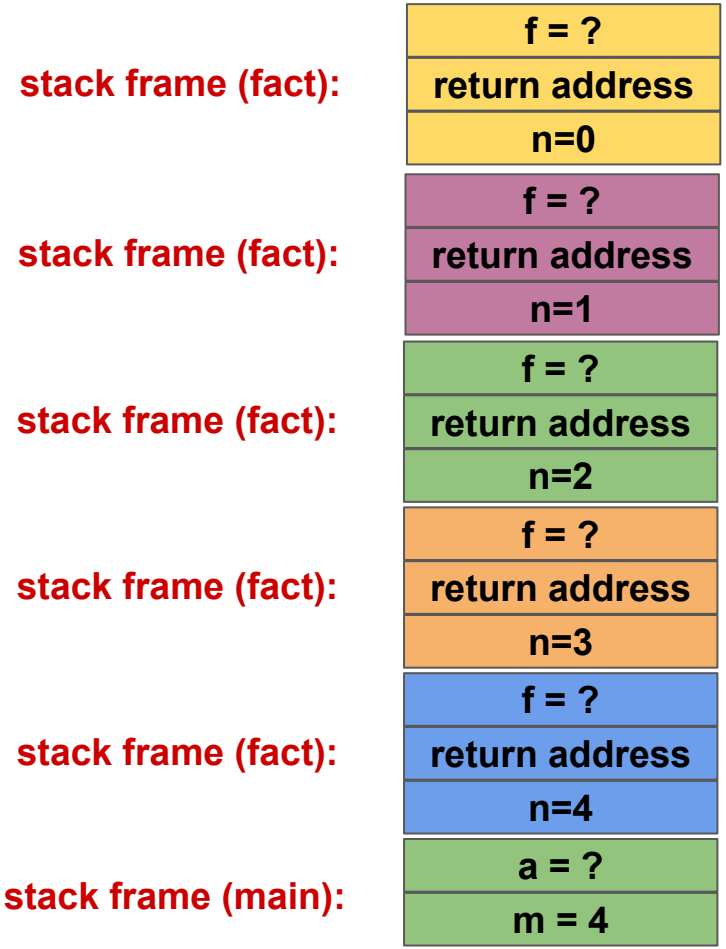
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



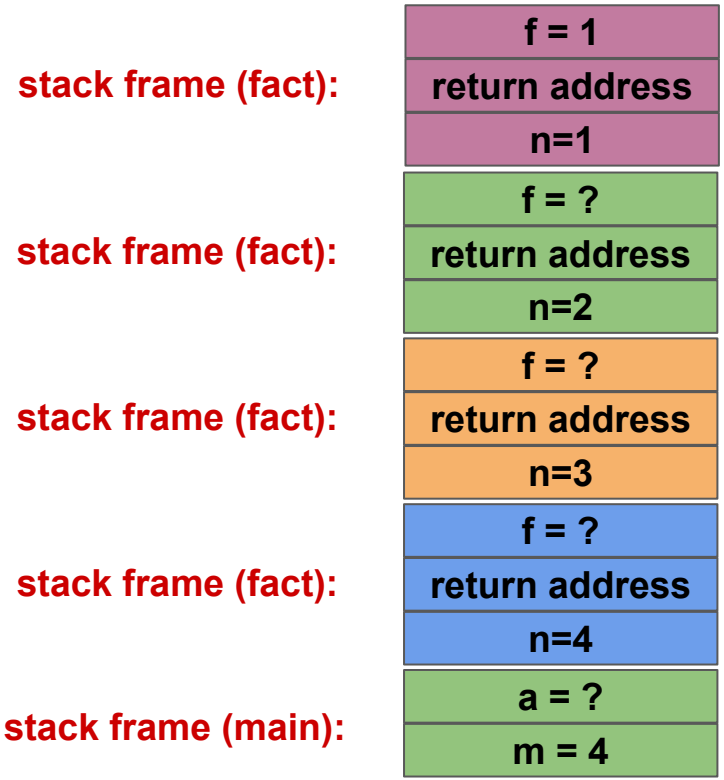
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



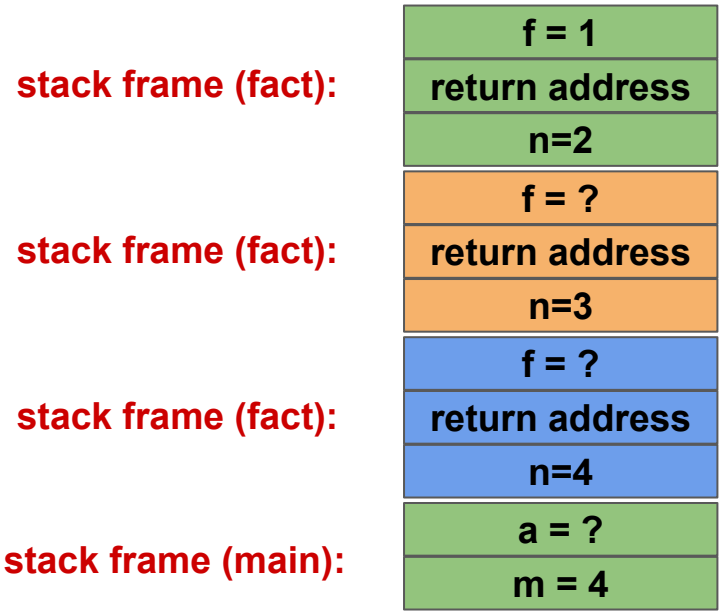
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



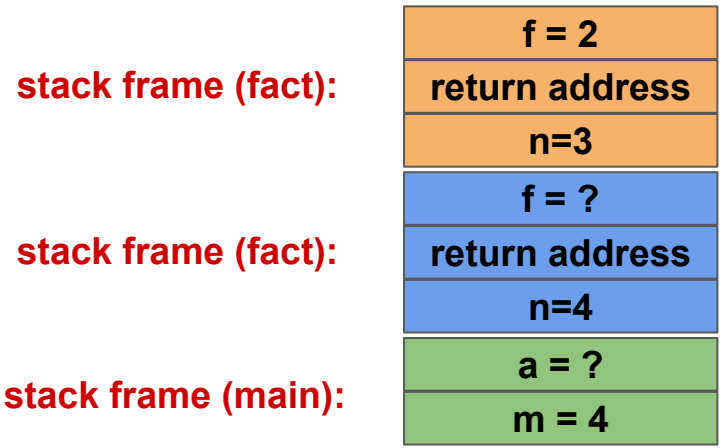
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



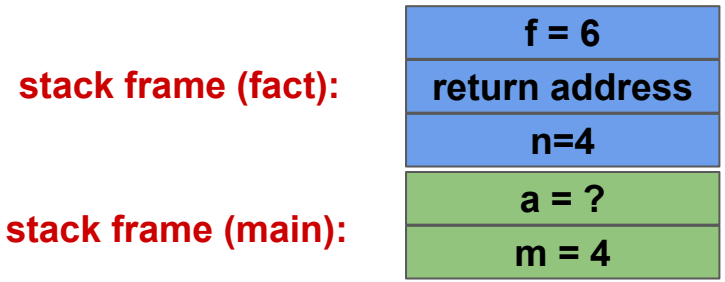
```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

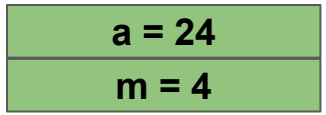


```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```



```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

stack frame (main):



```c
#include <stdio.h>

int fact(int);


int main() {
  int m = 4;
  int a = fact(m);

  printf("%d\n", a);

}


int fact(int n) {
  double f;

  if (n == 0)
    return 1;

  f = fact(n-1);

  return n*f;

}
```

what if n < 0?

The ? : conditional operator

- `a = (i > 10 ? 1 : 0)`
- `ternary operator`

Category	Operator	Associativity
Postfix	() [] -> . ++ - -	Left to right
Unary	+ - ! ~ ++ - - (type)* & sizeof	Right to left
Multiplicative	* / %	Left to right
Additive	+ -	Left to right
Shift	<< >>	Left to right
Relational	< <= > >=	Left to right
Equality	== !=	Left to right
Bitwise AND	&	Left to right
Bitwise XOR	^	Left to right
Bitwise OR	|	Left to right
Logical AND	&&	Left to right
Logical OR	||	Left to right
Conditional	?:	Right to left
Assignment	= += -= *= /= %=>>= <<= &= ^= |=	Right to left
Comma	,	Left to right

https://www.tutorialspoint.com/cprogramming/c_operators_precedence.htm

The ? : operator

- `a = (i > 10 ? 1 : 0)`
- `a = i > 10 ? 1 : 0`
-

The ? : operator

- `a = (i > 10 ? 1 : 0)`
- `a = i > 10 ? 1 : 0`
- `a = b >= 0  ? b : -b`

The ? : operator

- `a = (i > 10 ? 1 : 0)`
- `a = i > 10 ? 1 : 0`
- `a = b >= 0  ? b : -b` `// a = abs(b)`

The ? : operator

- `a = (i > 10 ? 1 : 0)`
- `a = i > 10 ? 1 : 0`
- `a = b >= 0  ? b : -b` `// a = abs(b)`
- `z = x >= y  ? x : y`

The ? : operator

- `a = (i > 10 ? 1 : 0)`
- `a = i > 10 ? 1 : 0`
- `a = b >= 0  ? b : -b` `// a = abs(b)`
- `z = x >= y  ? x : y` `// z = max(x,y)`
- `z = x >= y ? 2*x+y : y*x;`

The ? : operator

```
int fact(int n) {
   return n > 0 ? n * fact(n-1) : 1;
}
```

Recursion

Fibonacci series

- `f(1) = 1`
- `f(2) = 1`
- `f(n) = f(n) + f(n-1)`

Recursion

Fibonacci series

- `f(1) = 1`
- `f(2) = 1`
- `f(n) = f(n) + f(n-1)`

```c
int fibo(int n) {
  if (n <= 2)
    return 1;

  return fibo(n-1) + fibo(n-2);
}
```

fibo.c

Recursion

```c
int fibo(int n) {
  if (n <= 2)
    return 1;

  return fibo(n-1) + fibo(n-2);
}
```

fibo.c

```c
int fibo(int n) {
  int a=1, b=1;

  for (int i=2; i < n; i++) {
    b = a+b;
    a = b-a;
  }

  return b;

}
```

fibo2.c

automatic vs static local variables

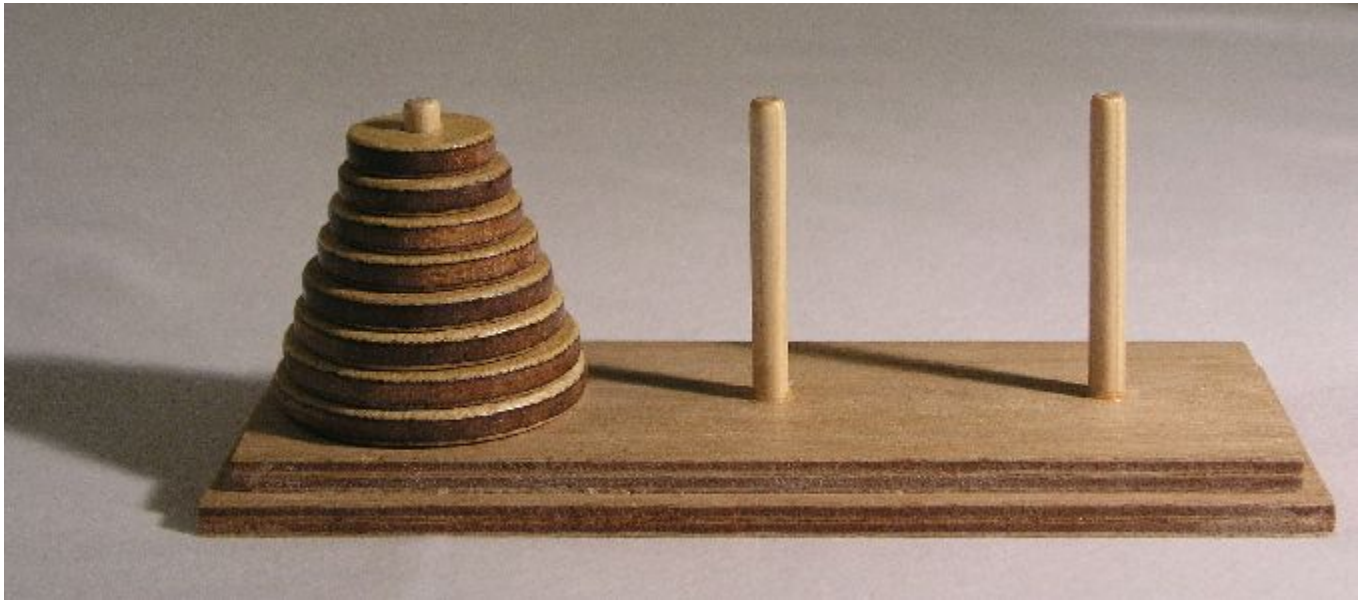
```c
#include <stdio.h>

void testfunc(void);

int main() {

  for (int i = 1; i <= 10; i++)
    testfunc();
}

void testfunc() {
  int a = 1;
  static int b = 1;

  printf("a=%d, b=%d\n",a,b);

  a++;
  b++;


}
```

automatic vs static local variables

```c
#include <stdio.h>

void testfunc(void);

int main() {

  for (int i = 1; i <= 10; i++)
    testfunc();
}

void testfunc() {
  int a = 1;
  static int b = 1;

  printf("a=%d, b=%d\n",a,b);

  a++;
  b++;


}
```

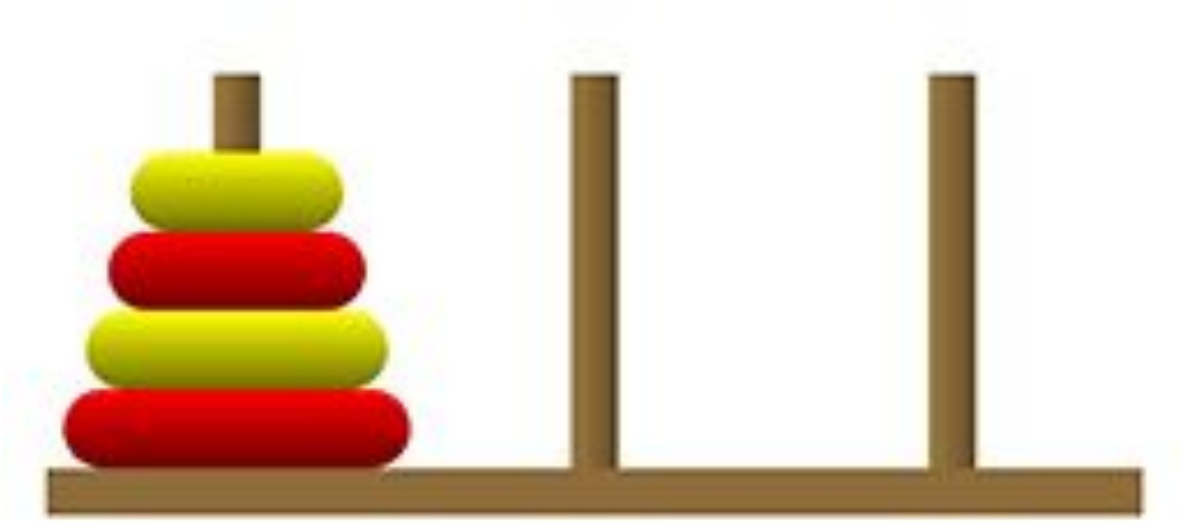
```
a=1, b=1
a=1, b=2
a=1, b=3
a=1, b=4
a=1, b=5
a=1, b=6
a=1, b=7
a=1, b=8
a=1, b=9
a=1, b=10
```

Tower of Hanoi



https://en.wikipedia.org/wiki/Tower_of_Hanoi

Tower of Hanoi



http://larc.unt.edu/ian/TowersOfHanoi/activelearning.html

Tower of Hanoi

```c
#include <stdio.h>

void hanoi(int, int, int, int);

int main() {
  int n;

  scanf("%d", &n);

  hanoi(n, 1, 2, 3);

}

void hanoi(int n, int from, int to, int aux) {
  if (n == 1) {
    printf("%d -> %d\n", from, to);
    return;
  }

  hanoi(n-1, from, aux, to);
  printf("%d -> %d\n", from, to);
  hanoi(n-1, aux, to, from);

}
```

Tower of Hanoi

```c
#include <stdio.h>

void hanoi(int, int, int, int);

int main() {
  int n;

  scanf("%d", &n);

  hanoi(n, 1, 2, 3);

}

void hanoi(int n, int from, int to, int aux) {
  if (n == 0)
    return;


  hanoi(n-1, from, aux, to);
  printf("%d -> %d\n", from, to);
  hanoi(n-1, aux, to, from);

}
```