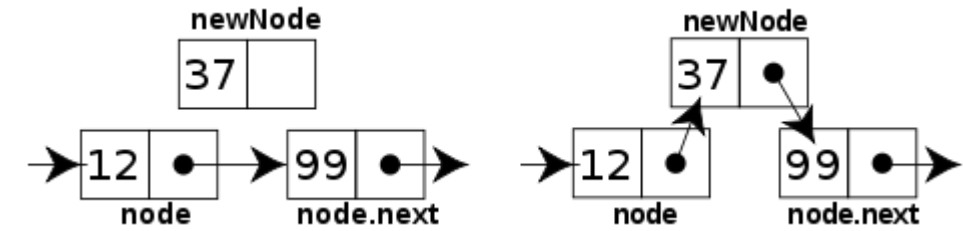


```

INSERTION-SORT(A)
1  for j = 2 to A.length
2    key = A[j]
3    // Insert A[j] into the sorted
   sequence A[1..j-1].
4    i = j - 1
5    while i > 0 and A[i] > key
6      A[i + 1] = A[i]
7      i = i - 1
8    A[i + 1] = key

```

| cost | times |
|-------|--------------------------|
| c_1 | n |
| c_2 | $n - 1$ |
| c_3 | $n - 1$ |
| c_4 | $n - 1$ |
| c_5 | $\sum_{j=2}^n t_j$ |
| c_6 | $\sum_{j=2}^n (t_j - 1)$ |
| c_7 | $\sum_{j=2}^n (t_j - 1)$ |
| c_8 | $n - 1$ |



WELCOME TO CS 24!

Problem Solving with Computers-II

Instructor: Diba Mirza

C++

```

#include <iostream>
using namespace std;

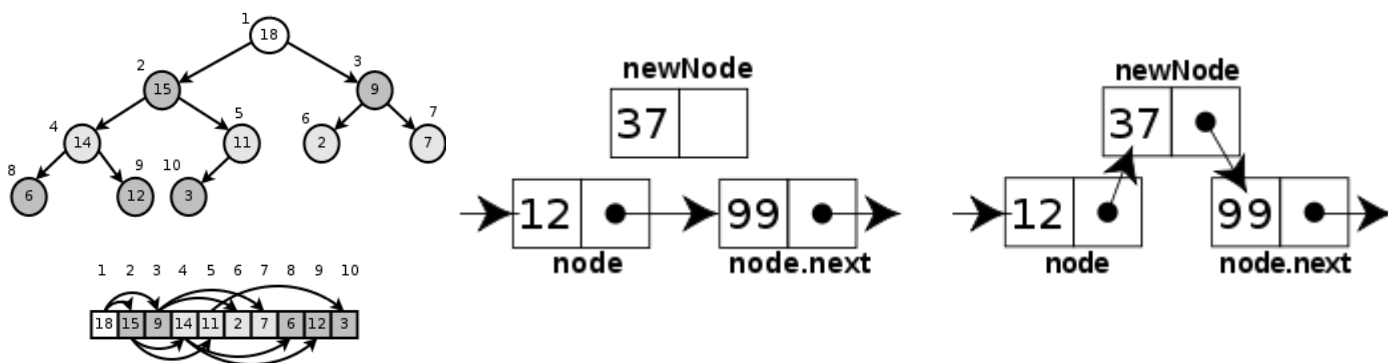
int main() {
    cout << "Hola Facebook!\n";
    return 0;
}

```

Read the syllabus. Know what's required. Know how to get help.

About this course

- Design and implement **larger programs** that **run fast**
- Organize **data** in programs using **data structures**
- **Analyze** the **complexity** of your programs
- Understand what goes on **under the hood of programs**



```

INSERTION-SORT(A)
1  for j = 2 to A.length
2    key = A[j]
3    // Insert A[j] into the sorted
      sequence A[1 .. j - 1].
4    i = j - 1
5    while i > 0 and A[i] > key
6      A[i + 1] = A[i]
7      i = i - 1
8    A[i + 1] = key
  
```

| <i>cost</i> | <i>times</i> |
|-------------|--------------------------|
| c_1 | n |
| c_2 | $n - 1$ |
| 0 | $n - 1$ |
| c_4 | $n - 1$ |
| c_5 | $\sum_{j=2}^n t_j$ |
| c_6 | $\sum_{j=2}^n (t_j - 1)$ |
| c_7 | $\sum_{j=2}^n (t_j - 1)$ |
| c_8 | $n - 1$ |

Data Structures and C++

Complexity Analysis

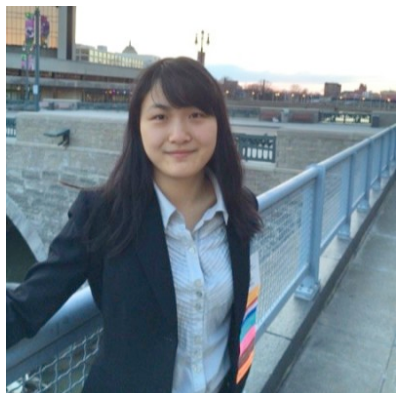
About the team



Diba Mirza

- Prof. Mirza's Office hours:
M 2:30-3:30p, HFH 1155, or by appointment
- Communication with staff via **Piazza**
- Include [CS24] in the subject line of any email communication with me
- Sections start this week
- Office hours start next week

Ask questions about class examples, assignment questions, or other CS topics.



TA Sherry

TA Mehak

TA Jeffrey



LA Zack



LA Karanina



LA Torin

Course Logistics

- Course website: <https://ucsb-cs24.github.io/f23>
- Read the syllabus
- If you have a section conflict, you may informally switch your section time.
- No makeup on exams unless its a real emergency!
- To complete the labs you need a college of engineering account. If you don't have one yet, send an email to help@engineering.ucsb.edu

About lectures

- I will not be a talking textbook
- Ask questions anytime!
- I'll ask you questions too! Be ready to discuss with the people near you and respond to multiple-choice questions (using the clickers).
- Take a moment to introduce yourself to the people sitting near you.
 - Talk about...
 - your background,
 - experience in CS so far, and
 - what you hope to get out of this class!

iClicker Cloud

- Join the class CMPSC24: Problem Solving with Computers-2:

<https://join.iclicker.com/HFXE>

Recommended textbook

- Problem Solving with C++, Walter Savitch, Edition 9

About you: When did you take CS16 or an equivalent course?

- A. Summer 2023
- B. Spring 2023
- C. Winter 2023
- D. Fall 2022 or earlier

About you...

What is your familiarity/confidence in C++?

- A. Know nothing or almost nothing about it.
- B. Used it a little, beginner level.
- C. Some expertise, lots of gaps though.
- D. Lots of expertise, a few gaps.
- E. Know too much; I have no life.

About you...

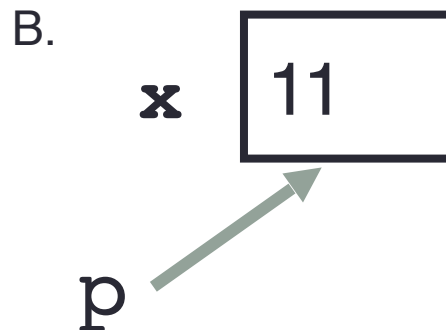
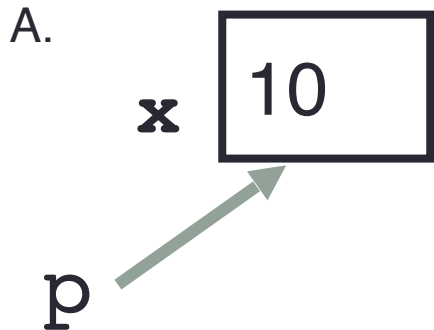
What is your familiarity/confidence with using git or any version control system?

- A. Know nothing or almost nothing about it.
- B. Used it a little, beginner level.
- C. Some expertise, lots of gaps though.
- D. Lots of expertise, a few gaps.
- E. Know too much; I have no life.

Review: Tracing code involving pointers

```
int* p;  
int x = 10;  
p = &x;  
*p = *p + 1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

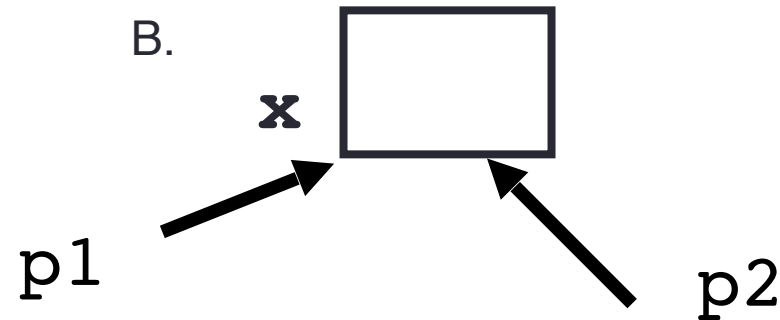
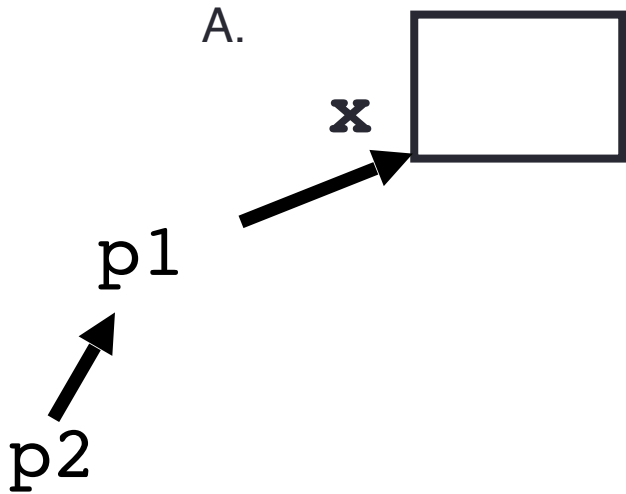


C. Neither, the code is incorrect

Review: Pointer assignment

```
int* p1, *p2, x;  
p1 = &x;  
p2 = p1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?



C. Neither, the code is incorrect

Two important facts about Pointers

1) A pointer can only point to one type –(basic or derived) such as `int`, `char`, a `struct`, a `class` another pointer, etc

2) After declaring a pointer: `int *ptr;`
`ptr` doesn't actually point to anything yet.

We can either:

- make it point to something that already exists, OR
- allocate room in memory for something new that it will point to

Review: Heap vs. stack

```
1 #include <iostream>
2 using namespace std;
3
4 int* createIntArray(int len){
5
6     int arr[len];
7     return arr;
8
9 }
```

Where does the above function create the array of integers?

A. Stack

B. Heap

C. Don't know, what do you mean by stack and heap?

Review: C++ Program's Memory Regions

```
#include <iostream>
using namespace std;

// Program is stored in code memory

int myGlobal = 33;    // In static memory

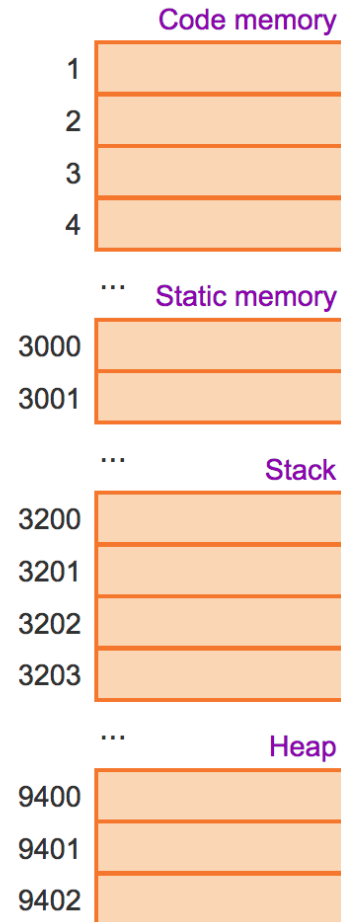
void MyFct() {
    int myLocal;      // On stack
    myLocal = 999;
    cout << " " << myLocal;
}

int main() {
    int myInt;         // On stack
    int* myPtr = nullptr; // On stack
    myInt = 555;

    myPtr = new int;    // In heap
    *myPtr = 222;
    cout << *myPtr << " " << myInt;
    delete myPtr; // Deallocated from heap

    MyFct(); // Stack grows, then shrinks

    return 0;
}
```



The code regions store program instructions. `myGlobal` is a global variable and is stored in the static memory region. Code and static regions last for the entire program execution.

Review: C++ Program's Memory Regions

```
#include <iostream>
using namespace std;

// Program is stored in code memory

int myGlobal = 33;    // In static memory

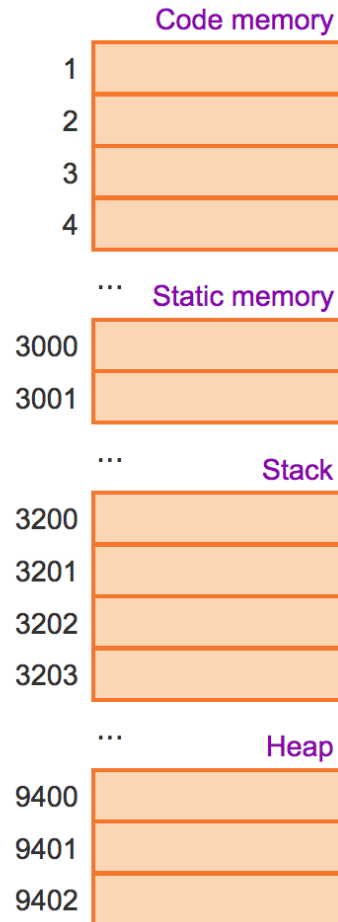
void MyFct() {
    int myLocal;      // On stack
    myLocal = 999;
    cout << " " << myLocal;
}

int main() {
    int myInt;         // On stack
    int* myPtr = nullptr; // On stack
    myInt = 555;

    myPtr = new int;    // In heap
    *myPtr = 222;
    cout << *myPtr << " " << myInt;
    delete myPtr; // Deallocated from heap

    MyFct(); // Stack grows, then shrinks

    return 0;
}
```



- Stack: Segment of memory managed automatically using a Last in First Out (LIFO) principle.
- Heap: Segment of memory managed by the programmer
 - Data created on the heap stays there
 - FOREVER or
 - until the programmer explicitly deletes it

The code regions store program instructions. myGlobal is a global variable and is stored in the static memory region. Code and static regions last for the entire program execution.

Review: Heap vs. stack

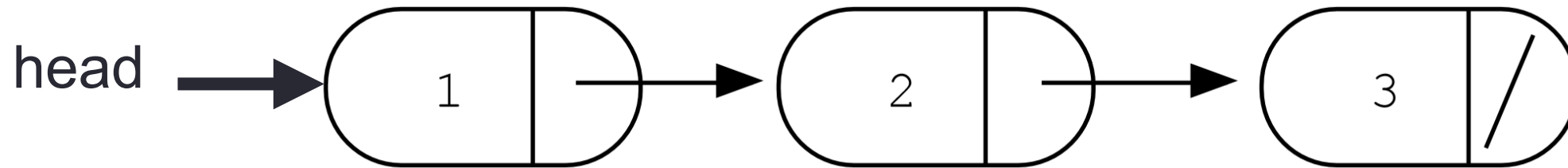
```
#include <iostream>
```

```
int main() {  
    int* x = new int[3];  
    x[1] = 20;  
    int* p = &x[1];  
    const char** fruit = new const char*[3];  
    fruit[1] = "bananas";  
    std::cout << "Yum " << *p << " " << fruit[1];  
    return 0;  
}
```

What is the output?

What data structure does the diagram represent?

```
struct Node {  
    int data;  
    Node *next;  
};
```

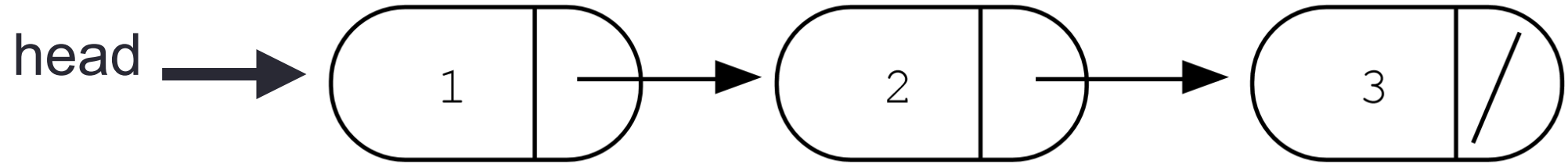


Evaluate each of the following expressions?

1. head->data
2. head->next->data
3. head->next->next->data
4. head->next->next->next->data

- A. 1
- B. 2
- C. 3
- D. nullptr
- E. Run time error

Write a C++ function to add a node to the head of the list



```
struct Node {  
    int data;  
    Node *next;  
};
```

Next time

- Intro to Object Oriented Programming in C++