

YEAH
Assignment 1
Getting your C++ Legs

Welcome to YEAH

- ❖ Your Early Assignment Help!
 - ❖ Conceived many moons ago to give students a boost when starting assignments early
 - ❖ Have also proved to be helpful for students starting later!
- ❖ We'll review the assignment, and I'll give helpful hints / tips – please ask questions!
- ❖ If you can (and are not a minor) please come to the **live** session!

Welcome to YEAH

- ❖ What I **can** do:

- ❖ Clarify funkiness (or try my best to do so) on the handout
- ❖ Give important insight / highlight common pitfalls on the assignment
- ❖ Memes

- ❖ What I **can't** do:

- ❖ Answer questions like “How exactly do I implement this?”
- ❖ Fly





Today's Agenda

1. Assignment logistics
2. Part I: Perfect Numbers
3. Part II: Soundex



Assignment 1 Logistics

- ❖ Due Tuesday, June 30th, 11:59PM (in your local time zone!)
 - ❖ This is in 6 days from now! Better get cracking!
 - ❖ The grace period for this assignment is 24 hours – late submissions will be accepted until June 31st, 11:59PM.
- ❖ You must complete this assignment **individually**. Please read more about what kinds of collaboration are and are **not** permitted on the course website.



Any Questions About Logistics?

Part 1: Perfect Numbers

- ◊ A warmup program to get your cpp bearings. You'll write an efficient algorithm that finds perfect numbers!

- ◊ A perfect number is a number whose factors add to the number!

$$\diamond 6 = 1 + 2 + 3;$$

$$28 = 1 + 2 + 4 + 7 + 14$$

- ◊ 2 fundamental pieces, **coding** and **short answer**.

- ◊ Designed to complement each other and help your understanding!

$$6 = 2^1(2^2 - 1) = 1 + 2 + 3,$$

$$28 = 2^2(2^3 - 1) = 1 + 2 + 3 + 4 + 5 + 6 + 7 = 1^3 + 3^3,$$

$$496 = 2^4(2^5 - 1) = 1 + 2 + 3 + \dots + 29 + 30 + 31 \\ = 1^3 + 3^3 + 5^3 + 7^3,$$

$$8128 = 2^6(2^7 - 1) = 1 + 2 + 3 + \dots + 125 + 126 + 127 \\ = 1^3 + 3^3 + 5^3 + 7^3 + 9^3 + 11^3 + 13^3 + 15^3,$$

$$33550336 = 2^{12}(2^{13} - 1) = 1 + 2 + 3 + \dots + 8189 + 8190 + 8191 \\ = 1^3 + 3^3 + 5^3 + \dots + 123^3 + 125^3 + 127^3.$$

Euclid discovered a pretty cool relationship about perfect numbers... we'll come back to this.

Part 1: Perfect Numbers

- ❖ The first thing that you'll do in this assignment is examine a pre-written algorithm that finds perfect numbers.

```
/* This function performs an exhaustive search for perfect numbers.  
 * It takes as input a number called 'stop' and searches for perfect  
 * numbers between 1 and 'stop'. Any perfect numbers that are found will  
 * be printed out to the console.  
 */  
  
void findPerfects(long stop)  
{  
    for (long num = 1; num < stop; num++) {  
        if (isPerfect(num)) {  
            cout << "Found perfect number: " << num << endl;  
        }  
        if (num % 10000 == 0) cout << "." << flush;  
    }  
    cout << "Done searching up to " << stop << endl;  
}
```

```
long divisorSum(long n) {  
    long total = 0;  
    for (long divisor = 1; divisor < n; divisor++) {  
        if (n % divisor == 0) {  
            total += divisor;  
        }  
    }  
    return total;  
}  
  
/* This function is provided a number n and returns a boolean  
 * (true/false) value representing whether or not the number is  
 * perfect. A perfect number is a non-zero positive number whose  
 * sum of its proper divisors is equal to itself.  
 */  
bool isPerfect (long n) {  
    return (n != 0) && (n == divisorSum(n));  
}
```

Part 1: Perfect Numbers

- ❖ isPerfect() calls a routine called divisorSum(). This approach is called an **Exhaustive Algorithm**. These algorithms attempt to find solutions by doing **all** computations without optimizations.

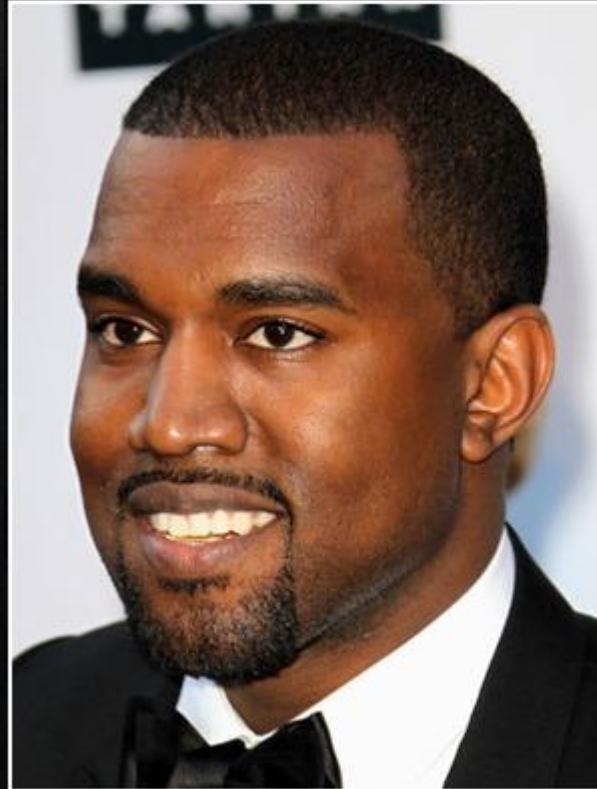
```
// Return sum of all divisors of n, excluding self
long divisorSum(long n)
{
    long total = 0;

    for (long divisor = 1; divisor < n; divisor++) {
        if (n % divisor == 0) {
            total += divisor;
        }
    }
    return total;
}
```

Part 1: Perfect Numbers

- ❖ Exhaustive algorithms get the job done, but they're not the fastest. We can do better!
- ❖ But first, it's time for...

Kanye StudentTest's Testing Overview!



That that don't break my computer can only make me stronger.

— *Kanye StudentTest*, CS106B alum and unit-testing pro

AZ QUOTES

Running Tests in CS106B

- ❖ An important part of CS106B is **testing**, the ability to write small pieces of functionality that you can test.
- ❖ There are 4 functions you'll be frequently using this quarter, TIME_OPERATION, EXPECT, EXPECT_EQUAL, and EXPECT_ERROR.
 - ❖ You will create STUDENT_TESTS and use TIME_OPERATION, EXPECT, EXPECT_EQUAL, and EXPECT_ERROR to verify the correctness of your functions!
- ❖ TIME_OPERATION (inputszie, operation) function call times how long it takes to perform function OPERATION on INPUTSIZE elements, and reports these numbers to the console.
- ❖ Check out the use of the EXPECT functions use on the next slide!

Running Tests in CS106B

```
int returnFive (int num) {
    if (num == -1) error ("Error, cannot process -1!");
    return 5;
}
// EXPECT tests the provided predicate.
STUDENT_TEST ("Verifies that returnFive returns five with EXPECT") {
    EXPECT (returnFive (0) == 5);
}
// EXPECT_EQUAL compares two values.
STUDENT_TEST ("Verifies that returnFive returns five with EXPECT_EQUAL") {
    EXPECT_EQUAL (returnFive (0), 5);
}
// EXPECT_ERROR passes if and only if the code it runs throws an error.
STUDENT_TEST ("Verifies that returnFive throws an error on bad input with EXPECT_ERROR") {
    EXPECT_ERROR (returnFive (-1));
}
```

Questions about testing?

```
int returnFive (int num) {
    if (num == -1) error ("Error, cannot process -1!");
    return 5;
}
// EXPECT tests the provided predicate.
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STUDENT_TEST ("Verifies that returnFive throws an error on bad input with EXPECT_ERROR") {
    EXPECT_ERROR (returnFive (-1));
}
```



Back to our algorithm!

Can we do better?

- ◊ After you write some tests for the existing code, your next step will be to **improve** the perfect number-finding algorithm!
- ◊ In its current state, the helper function that computes the sum of **all** divisors of a number loops through all values between 1 and $n - 1$.

```
// Return sum of all divisors of n, excluding self
long divisorSum(long n)
{
    long total = 0;

    for (long divisor = 1; divisor < n; divisor++) {
        if (n % divisor == 0) {
            total += divisor;
        }
    }
    return total;
}
```

Can we do better?

- ◊ It turns out, we only have to loop through numbers $1 \rightarrow \sqrt{n}$ to get all divisors of n !
 - ◊ Ex. For the number 6, who has perfect factors 1, 2, and 3, we only need to consider 1 and 2 (or $1 \rightarrow \sqrt{6}$); **we can get the complementary factor via ($n / \text{divisor}$) $\rightarrow 3 = 6 / 2$.**
 - ◊ Ex. $28 \rightarrow [1], [2 \text{ AND } 28 / 2], [4 \text{ AND } 28 / 4]$
- ◊ Suddenly, our work has gone from (n) computations to (\sqrt{n}) computations. Nice job!



Speed Racer
giving you a
thumbs-up!



SmarterSum

- ❖ You're going to write this into a program called `smarterSum()` that has the same functionality as `divisorSum`, but only loops through $\text{sqrt}(n)$ numbers!
- ❖ Some tips/tricks
 - ❖ There are a number of edge cases to consider now that you're not examining all numbers. Think about how you might handle negative values on n , 0, 1, or square roots! **This is the kind of thinking that you should always have when testing your code!**



Questions about smarterSum?

Mersenne Primes

梅森素数

- ❖ A Mersenne Prime is a special prime number that is **one less than a power of two.**
 - ❖ $31 = 2^5 - 1$.
- ❖ Euclid discovered a cool property of these numbers:
 - ❖ If $2^k - 1$ is prime, then $2^{(k - 1)} * (2^k - 1)$ is a **perfect number!**
- ❖ Can we make our perfect number algorithm even better?

findNthPerfectEuclid

- ❖ You're going to use Euclid's discovery to write a routine that finds the **nth** perfect number. More specifically, you'll be implementing the function

long findNthPerfectEuclid(long n)

that returns a **long** signifying the perfect number of order **n**.

findNthPerfectEuclid

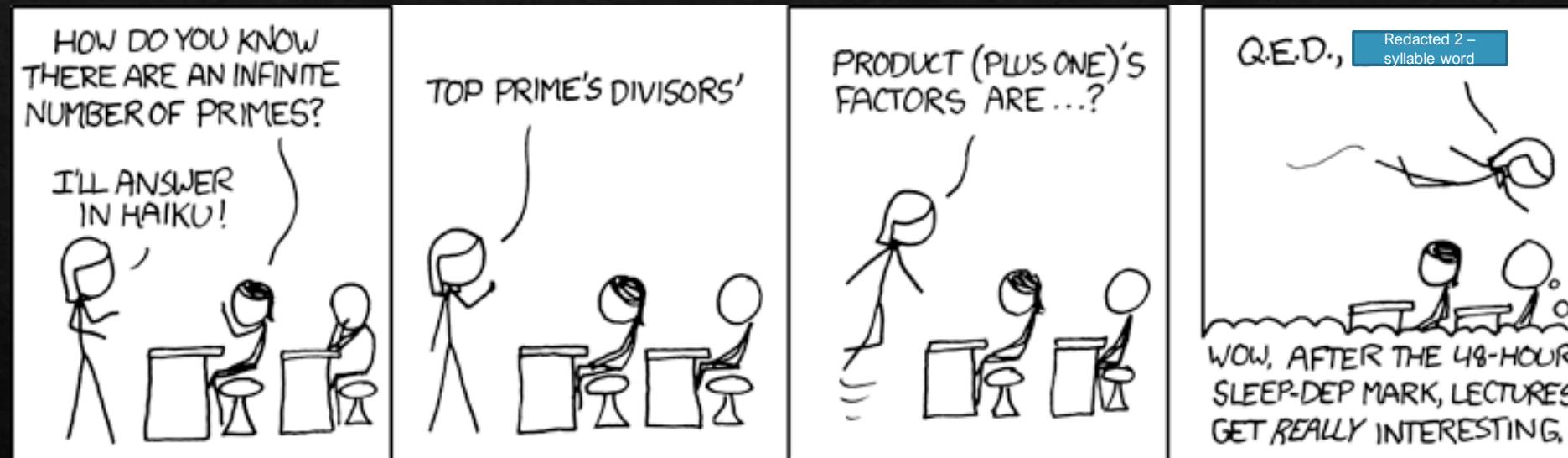
- ❖ Here's how we'd like you to approach this problem:
 1. Start by setting a variable $k = 1$
 2. Calculate $m = 2^k - 1$ (use cpp library pow() function!)
 3. Determine whether m is prime or composite (write an isPrime function that loops through possible divisors!)
 4. If m is prime, (it's a Mersenne Prime!!) calculate $2^{(k - 1)} * (2^k - 1)$. This is the associated **perfect number!**
 5. Increment k and repeat until you've found the **n th** perfect number!

(I'll wait here for a second ☺)

findNthPerfectEuclid

- ❖ A few things you should know:
 - ❖ We're using **long** instead of **int** here because these numbers can get really big!
 - ❖ If you're on a windows machine, you won't be able to find perfect numbers greater than ~6, but on mac you can find a few more!
 - ❖ Want to know why? Take CS107, or look up 32bit vs 64bit architectures!

Questions about findNthPerfectEuclid?



source, xkcd

That's Part II!

❖ Congrats! You made it past part I. Now it's time to do the big one!



source, google images

Part II, Soundex Search

- ❖ In this final part, you'll be writing an algorithm that takes a last name and turns it into a **soundex code**, which is a 4-digit pseudo-phonetic representation of a last name.
 - ❖ I say pseudo-phonetic because the soundex algorithm we're going to use is pretty crappy, and it doesn't account for most pronounciations.
 - ❖ That being said, the US census uses soundex codes! Wonder what that says about our language tolerance 😞

Soundex()

- ❖ Here are some examples of soundex conversions:
 - ❖ Zelenski -> Z452
 - ❖ Lee -> L000 (see what I mean?)

Soundex()

- ❖ The good news is, the **string soundex (string s)** routine is actually pretty straightforward. Here are the steps!
- 1. Discard all non-letters from the name. The `isalpha()` function will help with this!
- 2. Save the first letter of the name, and convert to uppercase if necessary.
- 3. Encode all letters using the depicted table.
- 4. Coalesce adjacent duplicate numbers (222025 would become 2025)
- 5. Replace the first number of the encoding with the **saved** first letter of the name.
- 6. Remove ALL zeroes from the code.
- 7. Format to length 4 by either truncating the code or padding zeroes at the end.

Digit	represents the letters
0	A E I O U H W Y
1	B F P V
2	C G J K Q S X Z
3	D T
4	L
5	M N
6	R

Soundex()

- ❖ Let's see an example with Zelenski!

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Zelenski

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Zelenski

Zelenski

Z

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Zelenski

Zelenski

Z

20405220

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Zelenski

Zelenski

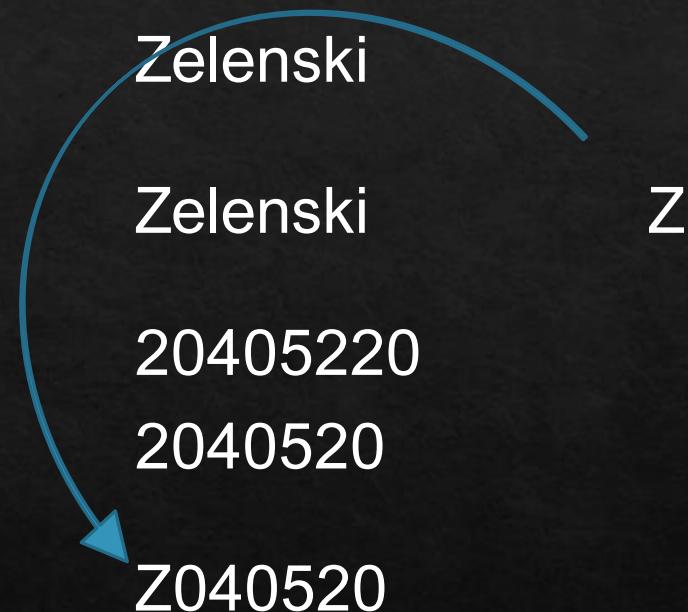
Z

20405220

2040520

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Zelenski

Zelenski

20405220

2040520

Z040520

Z452

Soundex()

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Zelenski

Zelenski

20405220

2040520

Z040520

Z452

Z452



Done!

Soundex()

- ◊ You'll implement this routine in the **string soundex(string s)** routine. You'll take a surname as a string and return the associated soundex code!
- ◊ To do this, **please** decompose! The aforementioned steps can each be their own functions, and that way you'll be able to **write tests for each helper function you write!**
- ◊ If you are able to test your helper functions, it will be much easier to pinpoint potential bugs in your program!

Soundex()

- ❖ Here are some tips for Soundex()
 - ❖ You'll be doing lots of work with **strings** and **chars** here. Know how to **index into** a string (like str[i]), but be wary that **strings** and **chars** are different types!
 - ❖ Strings use “double quotes” and chars use ‘single quotes.
 - ❖ In case you need to convert between the two, `strlib.h` includes conversion functions!
 - ❖ When converting chars to soundex numbers, ensure that your code is **case insensitive!**
 - ❖ If you ever need to convert a char to upper case, the **int toupper(int c)** function in `<cctype>` will **return** the uppercase version of the char you pass in.
 - ❖ wait... why does **int toupper(int c)** deal with integers then....



It's time for...

Charole Baskin's brief foray into char representation via the ASCII set!



-Charole Baskin, 106B alum
and mariticide suspect

How do we represent characters?

- ❖ Let's face it, there are a lot of unique chars out there. When you couple that with the existence of **fonts***, you get a data representation nightmare – **how do you represent chars?**
- ❖ The computing world decided to get together to create a **standard number representation for popular chars** (128 of them!). **Each char would correspond to an integer in a table called the ASCII set.**
- ❖ For example, 'A' -> 65, and 'a' -> 97.

*leave a comment if you know what font this is!

What does this code print?

```
string s = "apple";
cout << toupper(s[0]) << endl;
```

How do we represent characters?

- ❖ You need to be careful that you're not working directly with integers when you work with characters!
 - ❖ If a function returns an int, be sure **you're storing the data as a character** so that it can be read properly!

```
string s = "apple";
char firstLetter = toupper(s[0]);
cout << firstLetter << endl;
```

Soundex()

- ❖ Questions about soundex?
- ❖ Please remember to decompose the steps on this one ☺



source, xkcd, depicting me in a few years – I'm terrible with names

Soundex Search

- ❖ Now it's time to put your soundex function to the test! You will write the function **void soundexSearch(string filePath)**, that allows the **user** to find the soundex code for a given name, along with **other** names in the database represented by the filename **filePath** with the same soundex code.
- ❖ Your interaction with the user should match this exactly:

```
Read file res/surnames.txt, 26409 names found.  
Enter a surname (RETURN to quit): Zelenski  
Soundex code is Z452  
Matches from database: {"Zelenski", "Zelnick", "Zelnik", "Zelnis", "Zielonka"}  
  
Enter a surname (RETURN to quit): troccoli  
Soundex code is T624  
Matches from database: {"Therkelsen", "Torkelson", "Trakul", "Traxler", "Trisal", "Troc  
coli", "Trockel", "Troxel", "Troxell", "Trujillo", "Turkel"}  
  
Enter a surname (RETURN to quit):  
All done!
```

This line is done for you ☺

Soundex Search

- ◊ You've already been provided with the code that reads the provided file into a **vector**. If you're not familiar, a **vector** is like a Java **ArrayList** or a python **List**: we use it to store things!
- ◊ Here, the vector **lines** stores all names from the file!

```
void soundexSearch(string filepath)
{
    // The provided code opens the file with the given name
    // and then reads the lines of that file into a vector.
    ifstream in;
    Vector<string> lines;

    if (openFile(in, filepath)) {
        readEntireFile(in, lines);
    }
    cout << "Read file " << filepath << ", " << lines.size() << " names found." << endl;
```

Soundex Search

- ❖ You'll need to **repeatedly** prompt the user for a name (think while loop!)
 - ❖ If the user enters empty string, (return) break out of the loop!
- ❖ Once you get a string, compute and print its soundex code!
- ❖ Then, loop through the vector of strings, compute the soundex for each line, and store any whose soundex match yours into a new vector, which you will print after you've found all matches!

```
Read file res/surnames.txt, 26409 names found.

Enter a surname (RETURN to quit): Zelenski
Soundex code is Z452
Matches from database: {"Zelenski", "Zelnick", "Zelnik", "Zelnis", "Zielonka"}

Enter a surname (RETURN to quit): troccoli
Soundex code is T624
Matches from database: {"Therkelsen", "Torkelson", "Trakul", "Traxler", "Trisal", "Troc
coli", "Trockel", "Troxel", "Troxell", "Trujillo", "Turkel"}

Enter a surname (RETURN to quit):
All done!
```

Vector Semantics

```
Vector<string> names;

// Append to a vector
names += "Trip";
string str = "Kylie";
names.add(str);

// index-based for loop!
for (int i = 0; i < names.size(); i++) {
    string name = names [i];
}

// for-each loop!
for (string name : names) {

}
```



Soundex Search

- ❖ A few tips / tricks:
 - ❖ Use the `getline()` function from “`simpio.h`” to get user input!
 - ❖ You need to sort the names in the vector alphabetically. No need to fuss; before you print the vector, simply call `vector_name.sort()` (sorts in place)
 - ❖ You can cout vectors just like strings, and they’ll present themselves like you see in the example!
 - ❖ Give “Stanford string cpp” a google and take a foray through the Stanford cpp library for strings. There are some really helpful functions out there!



Questions About Soundex Search?