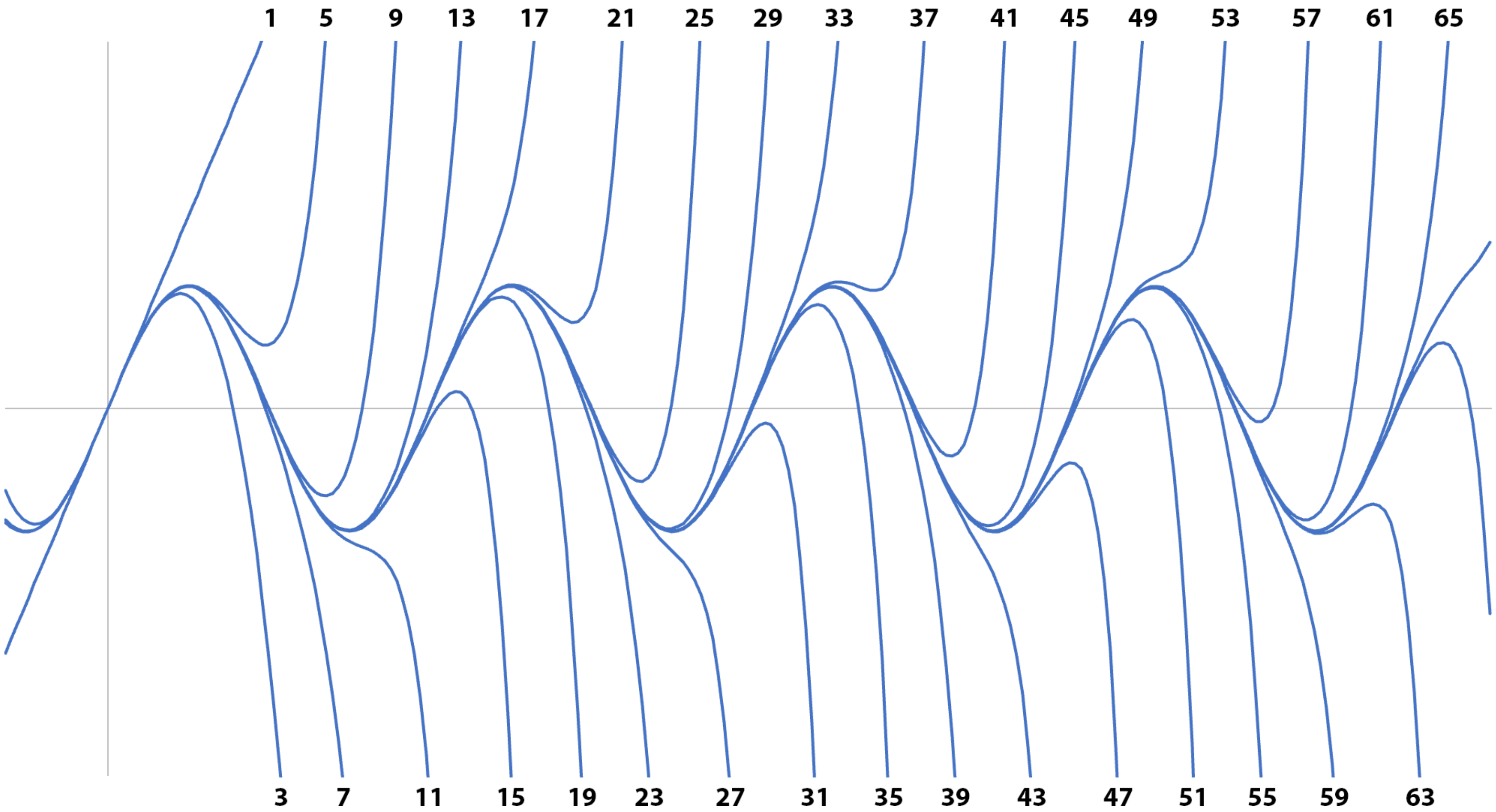
CSE 13S — Spring 2023



26 April 2023

Classroom information

Class time and location

M/W/F from 9:20 am – 10:25 am
Performing Arts M110 (Media Theater)

Final-exam day/time

Monday, June 12, 8:00 am – 11:00 am

Instructor

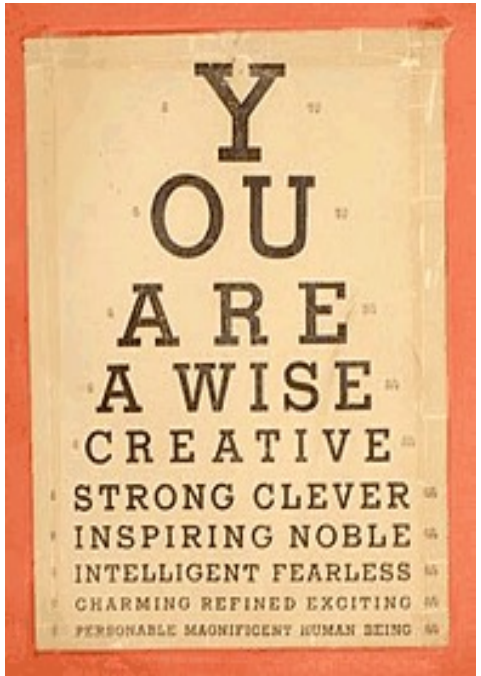
Dr. Kerry Veenstra
    veenstra@ucsc.edu

Engineering 2 Building, Room 247A
    (this is a shared office)

Office hours:
    Tuesday 10:30 am – 12:30 pm
    Thursday 2:00 pm – 4:00 pm

I'm totally supportive of DRC accommodations

- Bring me or email me your form ASAP
- Some folks need accommodations for the final only, some may need something for the quizzes: if so, we need to talk SOON!



So where does your grade come from?

- 20% Quizzes (top $n-1$ scores)
  - In class every Friday
  - I drop your lowest quiz score
- 50% Programming Assignments
- 30% Final Exam

I record the classes and post slides. **You** choose if you come to lecture—except for the quizzes.

NOTE: Assigned seats for the final exam

Canvas Web Site

- https://canvas.ucsc.edu/courses/62884

- Staff & Schedules (*still* under construction)
  - Office Hours
  - Discussion Section Times
  - Tutors & Times

Painless Way to Learn a Programming Language

<u>Write</u> a <u>series</u> of <u>tiny</u> <u>programs</u> to <u>verify</u> your <u>understanding</u> of what you <u>read</u>.

Assignment 2 — Preview

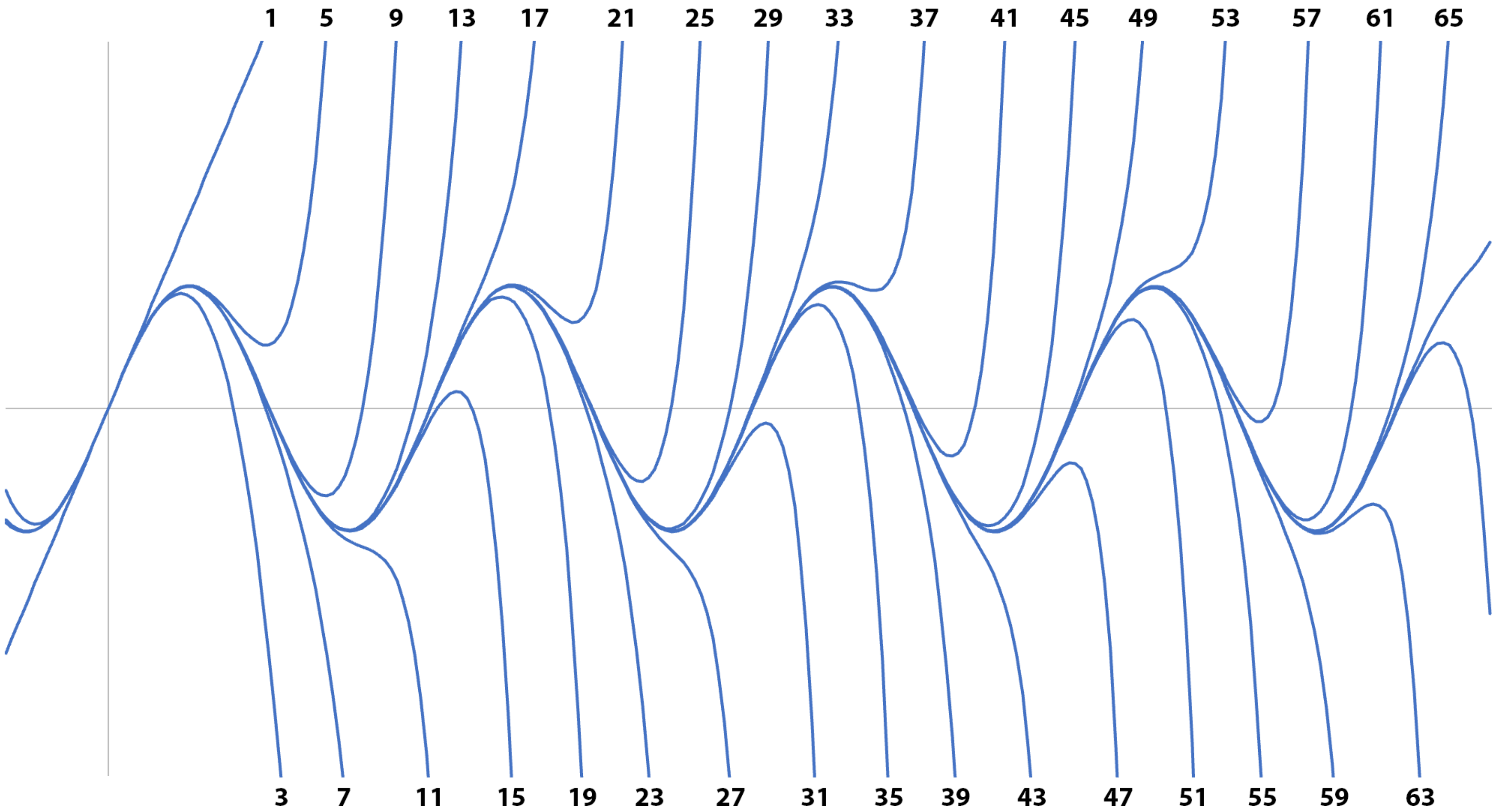
- Learning Objectives
  - Use command-line options

    ```
    $ my_program -a
    ```

  - Convert numeric series into C

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} + \cdots$$

"Maclaurin polynomials" for sin x through order 65



Converting Mathematical Series into C

$$\sum_{k=0}^{\infty} \frac{1}{(2k+1)(2k+2)} = \frac{1}{1 \times 2} + \frac{1}{3 \times 4} + \frac{1}{5 \times 6} + \frac{1}{7 \times 8} + \frac{1}{9 \times 10} + \cdots = \ln 2$$

1. Expand the first few iterations
2. Examine the equations for differences
   - Use these to compute the next iteration from the prior one
3. Create the for loop

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

ln(2)

```
/*
 * ln(2)
 *
 * Compute the result of n terms of
 *
 *      1 / (1 * 2)
 *    + 1 / (3 * 4)
 *    + 1 / (5 * 6)
 *    + 1 / (7 * 8)
 *    + 1 / (9 * 10)
 *    ...
 *
 */
```

ln(2)

```
double series_ln2B(int n) {
    double sum = 0.0;
    double d = 1.0;

    for (int k = 2; k <= n; ++k) {
        double term = 1.0 / (d * (d + 1));

        sum = sum + term;

        printf("%10d %.15f\n", k, sum);

        /*
         * compute d for k + 1
         */
        d += 2;
    }

    return sum;
}
```

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```

Converting Mathematical Series into C

$$\sum_{k=1}^{\infty} \frac{1}{2^k k} = \frac{1}{2} + \frac{1}{8} + \frac{1}{24} + \frac{1}{64} + \frac{1}{160} + \cdots = \ln 2$$

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Another ln(2)

```
double series_ln2C(int n) {
  double sum = 0.0;
  double two_to_the_k = 2.0;

  for (int k = 1; k <= n; ++k) {
    double term = 1.0 / (two_to_the_k * k);

    sum = sum + term;

    printf("%10d %.15f\n", k, sum);

    /*
     * Compute two_to_the_k for k + 1
     */
    two_to_the_k *= 2.0;
  }

  return sum;
}
```

```
/*
 * ln(2)
 *
 * Compute the result of n terms of
 *
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 *      + 1 / (2^3 * 3)
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 *      ...
 *
 */
```

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    sum = sum + term;

    printf("%10d %.15f\n", k, sum);

    /*
     * Compute two_to_the_k for k + 1
     */
    two_to_the_k *= 2.0;
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  return sum;
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$$\sum_{k=1}^{\infty} \frac{1}{2^k k} = \frac{1}{2} + \frac{1}{8} + \frac{1}{24} + \frac{1}{64} + \frac{1}{160} + \cdots = \ln 2$$

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    two_to_the_k *= 2.0;
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/*
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```

$$\sum_{k=1}^{\infty} \frac{1}{2^k k} = \frac{1}{2} + \frac{1}{8} + \frac{1}{24} + \frac{1}{64} + \frac{1}{160} + \cdots = \ln 2$$

Converting Mathematical Series into C

$$\sum_{k=1}^{\infty} \frac{1}{3^k k} + \sum_{k=1}^{\infty} \frac{1}{4^k k} = \left(\frac{1}{3} + \frac{1}{4}\right) + \left(\frac{1}{18} + \frac{1}{32}\right) + \left(\frac{1}{81} + \frac{1}{192}\right) + \left(\frac{1}{324} + \frac{1}{1024}\right) + \cdots = \ln 2$$

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

Alternating Series (alternating signs)

$$\sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{2^k k} + \sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{3^k k} = \left(\frac{1}{2} + \frac{1}{3}\right) \boxed{-} \left(\frac{1}{8} + \frac{1}{18}\right) \boxed{+} \left(\frac{1}{24} + \frac{1}{81}\right) \boxed{-} \left(\frac{1}{64} + \frac{1}{324}\right) \boxed{+} \cdots = \ln 2$$

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

Converting Mathematical Series into C

$$\sum_{k=1}^{\infty} \frac{1}{T_k} = \frac{1}{1} + \frac{1}{3} + \frac{1}{6} + \frac{1}{10} + \frac{1}{15} + \cdots = 2$$

$$\sum_{k=1}^{\infty} \frac{1}{Te_k} = \frac{1}{1} + \frac{1}{4} + \frac{1}{10} + \frac{1}{20} + \frac{1}{35} + \cdots = \frac{3}{2}$$

Converting Mathematical Series into C

$$\sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{2k-1} = \frac{1}{1} - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \cdots = \frac{\pi}{4}$$

$$\sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{k} = \frac{1}{1} - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \cdots = \ln 2$$

Converting Mathematical Series into C

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} + \cdots$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \frac{x^8}{8!} + \cdots$$

$$e^x = \sum_{k=0}^{\infty} \frac{x^k}{k!}$$

$$\frac{x^k}{k!} = \frac{x^{k-1}}{(k-1)!} \times \frac{x}{k}$$

Converting Mathematical Series into C

$$\pi = \sum_{k=0}^{\infty} \frac{1}{16^k} \left(\frac{4}{8k+1} - \frac{2}{8k+4} - \frac{1}{8k+5} - \frac{1}{8k+6} \right)$$

Watch out for integer division. Use floating-point constants in your C expressions to avoid integer division.

- **No**

```
4 / (8 * k + 1)
```

- **Yes**

```
4.0 / (8.0 * k + 1.0)
```

Converting Mathematical Series into C

$$\pi = \sum_{k=0}^{\infty} \frac{1}{16^k} \left(\frac{4}{8k+1} - \frac{2}{8k+4} - \frac{1}{8k+5} - \frac{1}{8k+6} \right)$$

$$\pi = 2 \prod_{k=1}^{\infty} \frac{4k^2}{4k^2 - 1}$$

$$\sum_{k=1}^{\infty} \frac{1}{k^2} = \frac{\pi^2}{6}$$

$$\pi = \sqrt{6 \sum_{k=1}^{\infty} \frac{1}{k^2}}$$

$$\pi = \sqrt{12} \sum_{k=0}^{\infty} \frac{(-3)^{-k}}{2k+1}$$

$$e^x = \sum_{k=0}^{\infty} \frac{x^k}{k!}$$

$$\frac{x^k}{k!} = \frac{x^{k-1}}{(k-1)!} \times \frac{x}{k}$$

$$\pi = \frac{4}{\sqrt{2}} \times \frac{4}{\sqrt{2+\sqrt{2}}} \times \frac{4}{\sqrt{2+\sqrt{2+\sqrt{2}}}} \cdots$$