Lecture Topics

Lecture 1

1. Opening comments
2. Nigeria-Exxon comparison fallacy
3. Volume of a pyramid
   - Checking dimensions
   - Checking easy cases
4. Integral of $\int_{-\infty}^{\infty} e^{-3x^2} \mathrm{d}x$
   - Discussion of dimensions
   - Discussion of exponents

Lecture 2

1. Questions from Lecture 1
2. Integral of $\int_{-\infty}^{\infty} e^{-3x^2} \mathrm{d}x$
   - Introduction of dimensions into integral
   - Calculating the constant: use easy cases
3. Method of easy cases: Volume of a truncated pyramid
   - What are some easy cases?

Lecture 3

1. Questions from Lecture 2
2. Method of easy cases: Volume of a truncated pyramid
3. Drag on two falling cones
   - What are some dimensionless groups?
   - How can they be related?

Lecture 4

1. Questions from Lecture 3
2. Drag on two falling cones
   - Is this low Reynolds number or high Reynolds number flow?
   - How does the drag depend on Reynolds number at each limit?

Lecture 5

1. Skipped Questions from Lecture 4 (will be posted)
2. Discretization: How many births in the United States per year?
3. Discretization and easy cases: Evaluate the integral of $\int_0^\infty e^{-at}\mathrm{d}t$
4. Discretization and dimensions: How high is the atmosphere?
5. Historical discussion of the pendulum clock, latitude, and longitude
   - Is $\pi^2 \approx g$ by coincidence or by design?

Lecture 6

1. Questions from Lecture 5
2. Pendulum
   - How does the period depend on θ_0?

Lecture 7

1. Questions from Lecture 6
2. Picture proofs: What is the sum of n odd numbers starting with 1?
3. Picture proofs: Show the arithmetic mean is greater than the geometric mean with equality when $a = b$
4. Picture proofs: What is the shortest path for bisecting an equilateral triangle?

Lecture 8

1. Questions from Lecture 7
2. Picture proofs: $\ln n!$
3. Taking out the big part and picture proofs: Calculate 8.4^2
4. Taking out the big part: Calculating energy consumption increase when speed limit rises from 55 mph to 65 mph
5. Taking out the big part: Calculate $\sqrt{5}$
6. Taking out the big part: What is the general rule for $(1+x)^n$?
7. Taking out the big part: Is $(1+0.1)^{10} \approx 2$? Why or why not?

Lecture 9

1. Questions from Lecture 8
2. Taking out the big part and picture proofs: Evaluate $\int_{-\pi/2}^{\pi/2}(\cos t)^{100}\mathrm{d}t$ to within 5% in less than 5 minutes
3. Analogy: Into how many regions will 5 planes divde 3-dimensional space?
   - Find patterns between Dots on a Line, Lines on a Plane, and Planes in Space

Lecture 10

1. Analogy: Planes in space creating regions
   - Find the general expression for the number of regions formed by lines in a plane
   - Find the general expression for the number of regions formed by planes in space
2. Analogy: A derivative is like a fraction
   - Another way to look at the chain rule: $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}t} / \frac{\mathrm{d}x}{\mathrm{d}t}$
3. What does $e^{\mathrm{d}/\mathrm{d}x}$ mean?
   - What does $e^{\mathcal{D}}$ mean when $\mathcal{D} = \mathrm{d}/\mathrm{d}x$? Answer: $e^{\mathcal{D}} = \mathcal{L}$ when $\mathcal{L}$ is the left shift operator ($e^{-\mathcal{D}} = \mathcal{R}$)
   - Definition of the right shift operator: $\mathcal{R}$
   - What does summation mean? Answer: $\Sigma = \frac{1}{1-\mathcal{R}} = \frac{1}{1-e^{-\mathcal{D}}}$

Lecture 11

1. Questions from Lecture 10
2. Recapitulation of summation operator derivation
3. Analogy: Approximation of logarithms using musical intervals