Collaborating with other applicants on the QQ is prohibited.

Using LLMs or AI (ChatGPT, Claude, Gemini, etc.) to solve QQ problems is also prohibited.

Violation of either of these rules will affect your admission.

SigmaCamp & SigmaWest Qualification Quiz 2026

Please carefully read this page, as it has important information.

This Qualification Quiz (QQ) is only one part of your application to SigmaCamp and SigmaWest. For full instructions, check https://sigmacamp.org/2026/apply and https://sigmacamp.org/2026west/apply.

Note that **the QQ does not count towards SigmaNext applications**. For details about how to apply to SigmaNext, please see https://sigmacamp.org/2026next/apply.

The Qualification Quiz contains two problems from each of the six main disciplines at Sigma – math, physics, chemistry, biology, computer science, and linguistics & applied sciences. The second problem in each category is designed to be more challenging than the first. **You are not expected to solve all the problems.** We evaluate your submission based on your approach to the problems and the quality of reasoning.

You can use the Internet, books and even help from someone (who is not another applicant), but **state precisely what sources you have used to solve each problem**. Note that you cannot post the problems to the Internet or other public forums. **You are also not allowed to use any LLMs (ChatGPT, Claude, Gemini, etc.) to solve any of the problems.**

If you were admitted to either SigmaCamp or SigmaWest through the Problem of the Month (POM), you do not need to submit the QQ for that camp. If you were not admitted to either SigmaCamp or SigmaWest through POM, or if you are applying to the other camp (SigmaCamp/SigmaWest), your POM work will still count: **30% of your total POM score will be added to your QQ score, capped at 20 points**.

You cannot collaborate with other applicants.

Video and PDF submissions are required for all problems.

- Videos must be at most **2.5 minutes long** for each problem. Submit one video per problem.
- **Solutions must be narrated**, but you do not need to show your face. Acceptable formats include:
  - Screensharing slides or a drawing app (e.g., MS Paint) with narration.
  - Recording a whiteboard, paper, or easel with narration (contents may be pre-written).
  - Speaking directly to the camera.
- **Submit videos as links** (Google Drive, Youtube, Dropbox, etc.). Other files must be submitted as a single PDF file per problem. **Make sure that the video is viewable and accessible with the link.**

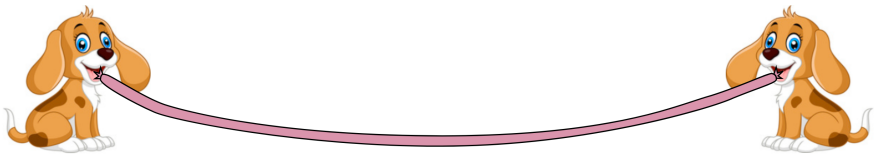
The application deadline for SigmaCamp and SigmaWest is March 15, 2026 – all your materials (Qualification Quiz, essay, letter of recommendation) must be submitted by that date. We will notify all applicants no later than April 5, 2026.

Good luck with your application!

Mathematics

5 points:

Lena's dog gave birth to a litter of a dozen adorable identical puppies, and Lena is feeding them long, thin sausages (kabanos). It takes exactly one hour for one puppy to eat one sausage. If two puppies start eating the sausage, one at each end, they will finish it faster (how fast?). Note that the sausages are uneven, so the puppies will not necessarily meet at the middle of the sausage. No more than two puppies can be eating a sausage at a time, or utter chaos will erupt.



(a) Lena has two sausages. How can she measure a 45 minutes interval by feeding them to her puppies?

(b) What lengths of time is it possible to measure using two sausages? Provide a complete list of all options, and explain how they work.

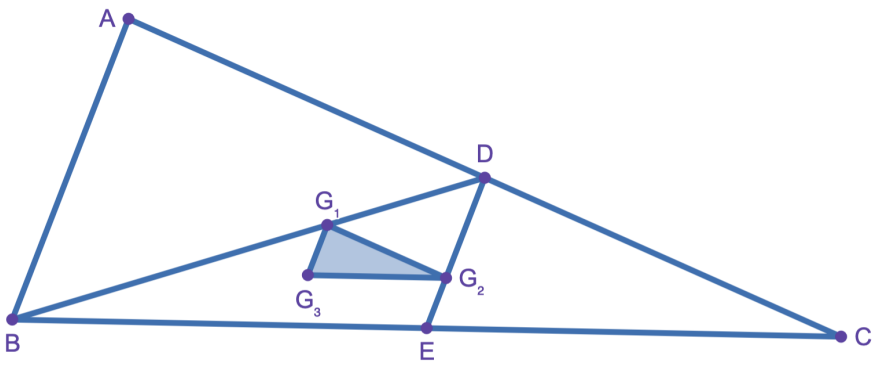
Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution.

  Include a clear explanation of what happens in each method in both parts (a) and (b).

- **PDF:** Make a list of all time length options for part (b) with a short explanation of what happens in each option.

10 points:



In the figure above, the points G_1, G_2 and G_3 are the centroids of triangles ABC, BDC and BDE, respectively.

(a) Prove that in any triangle the centroid divides each median in the ratio of $2:1$.

(b) If the area of $\triangle G_1G_2G_3 = 12$, find area of $\triangle ABC$.

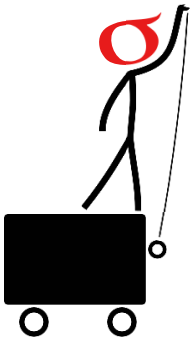
Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution.

  Explain your solutions for both parts. Make sure to refer to all shapes, lines, and points by their full names, e.g. "line AB".

- **PDF:** Draw diagrams for both parts, make sure to name all the points you need to refer to, and provide an outline of your solution to part (b) that includes all relevant computations.

Physics



5 points:

A frictionless circular ramp of radius R is made out of a strip of metal and held fixed in a vertical plane. A spring with spring constant K and equilibrium length L is attached to the bottom of the ramp (where $L > 2R$). At the bottom of the ramp, the spring is compressed to zero length and then released, pushing the bead up. Assume that the spring always remains straight. When the bead reaches the top of the ramp, it is released and hits the floor some time later. Assuming that air resistance is negligible, what is the distance X that the bead travels?

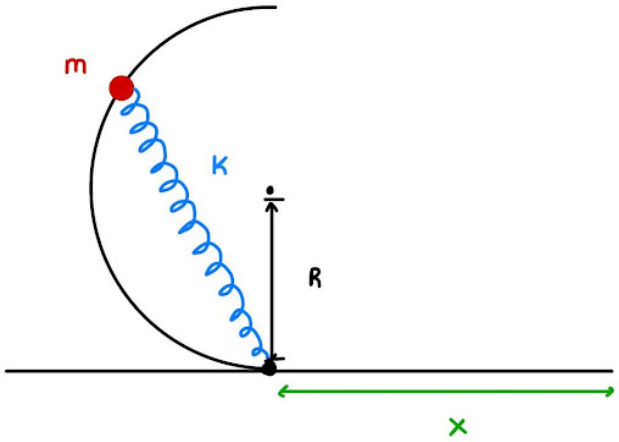


Figure 1

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. State your answer and explain how you derived it.
- **PDF:** Include all of your detailed computations, and any drawings and diagrams that you use in your video or in your computations.

10 points:

(a) A student of mass m was climbing a large conical structure with base radius R and angle at base θ. All of a sudden the cone started rotating about its vertical axis at a constant angular speed ω. Afraid to fall off, the student stopped and was able to hold onto the cone without slipping. If the student's friction coefficient with the cone is μ_s, what is the minimal height they must have climbed to not fall off?

(b) Some time later, the operators of the cone finally notice the student. They reduce the speed of the cone's angular rotation uniformly over time Δt, until the cone is at rest. What is the shortest time Δt, over which the cone needs to be slowed such that the student does not fly off the cone?

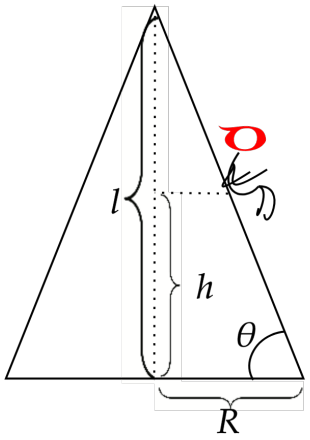


Figure 2

Supplemental Information

Suppose an object of mass m is moving along a circular trajectory of constant radius r. Then its force in the radial and tangential directions must be

$$F_r = \frac{mv^2}{r} \qquad F_\varphi = mr\alpha$$

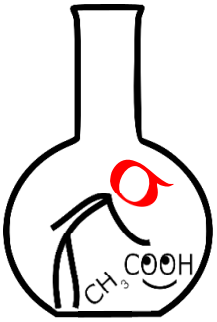
where v is the speed of the object, r is the radius of the trajectory and α is the angular acceleration (how quickly the angular speed is changing).

Note that the equations above mean that if the object is moving in a circle around at a constant speed, then the net force on it must be pointing directly towards the center of the circle.

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. State your answer and explain how you derived it.
- **PDF:** The PDF solution should include a set of diagrams that encapsulate the problem. Your final answer should be expressed as an equation in terms of the given variables. Please include all relevant steps of your derivations.

Chemistry



5 points:

When certain compounds, such as the one shown in Figure 3 (a chloro-substituted compound in which R_1, R_2, and R_3 are different groups or atoms), react with a nucleophile (e.g., iodide), chlorine is substituted in a way that inverts the configuration at the stereogenic carbon atom. In this type of structural formula, a solid wedge denotes a bond projecting out of the plane of the page toward the viewer, a dashed wedge denotes a bond projecting behind the plane, and bonds drawn as simple lines lie in (or are parallel to) the plane of the page.

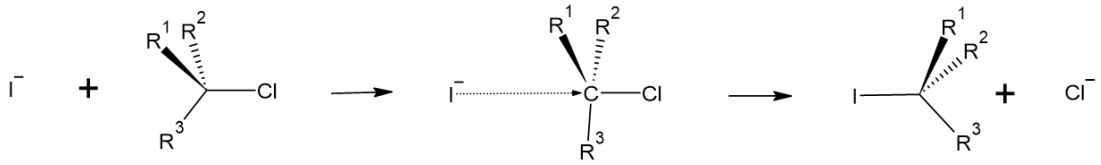


Figure 3

If the molecular structure prevents the iodide ion from readily approaching from the required side, the inversion proceeds slowly or may not occur at all.

How many distinct compounds can be formed in the reaction of the substances shown in Figure 4? Draw the structures of those that form quickly, and then those whose formation requires a longer time.

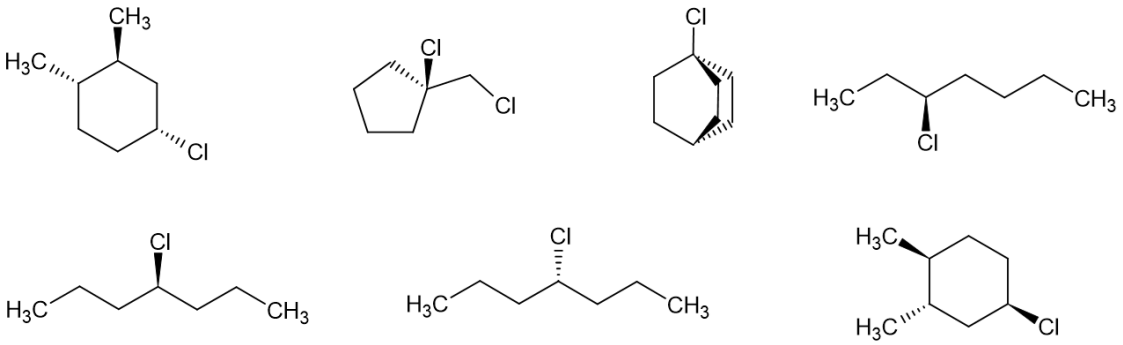


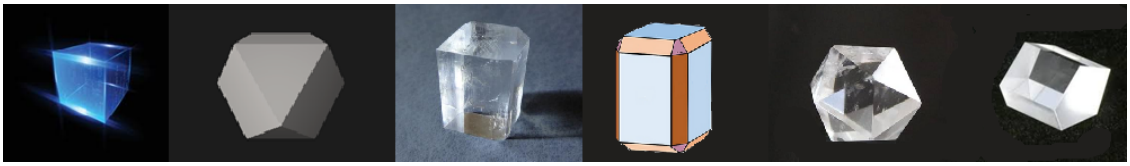
Figure 4

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. State your final answer and explain why it is correct. For structures that form quickly, explain why, and similarly for structures that form slowly.
- **PDF:** Include drawings of all compounds that you find.

10 points:

We know that the shape of crystals in a given material depends on the structure of its crystal lattice. For example, substances with a simple cubic lattice tend to form crystals with cubic symmetry. The figure 6 shows several bodies that resemble crystals. Based on shape alone—and, in particular, on symmetry (noting that some symmetries are permitted only in certain crystal systems, while others are forbidden altogether)—please indicate which bodies are likely crystalline metals, which are more likely inorganic or organic salts, and which are probably man-made, crystal-like objects (i.e., arbitrarily shaped bodies fabricated by humans). Please, focus exclusively on geometry and symmetry, and note that some bodies are rendered transparent solely for clarity.



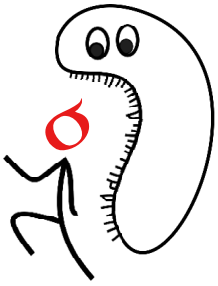
Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution.

  State your answer and explain why it is correct. Explain how you arrived at your solution.

- **PDF:** Include all of your detailed explanations, and any drawings and diagrams that you use in your video or explanations.

Biology



5 points:

Two laboratories, A and B, study the same human neurological disorder. Lab A uses mice, and Lab B uses zebrafish embryos. Both observe mutations in a gene responsible for the creation and maintenance of complex brain circuits, which are essential for normal neural development. This gene is similar among these organisms, but not identical. Only the mouse model reproduces the full disease phenotype. Which explanation best accounts for this difference?

A third laboratory (Lab C) starts to work with this gene and has findings similar to those of one of the other labs. What is an example of another commonly used model organism that Lab C could be using?

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. Answer all parts of the problem and provide explanation.
- **PDF:** Include a more detailed description of the third model organism of your choosing.

10 points:

Planarian worms are unique in the animal kingdom because they are some of the only animals that can regenerate. In an experiment, a planarian worm is trained to associate light with food. After training, it is cut into two pieces, each of which regenerates into a complete organism.

(a) Would both pieces still equally respond to behavioral training?

(b) What about if the planaria were cut along the sagittal plane/transverse plane? Which part of the cut planaria would remember the behavior best? Describe all possible options.

(c) What features of planaria's physiology explain the behavior of the regenerated animals in the situation described in questions 1 and 2?

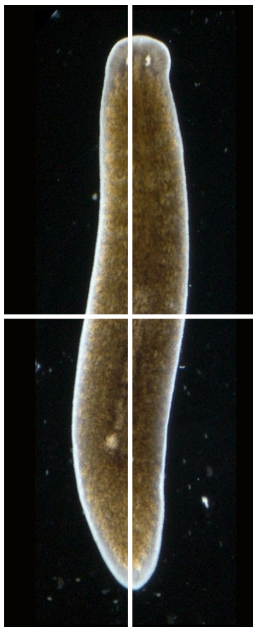
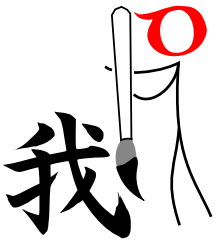


Figure 1: Planarian worm with a line dividing the sagittal plane and the transverse plane

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. Answer all parts of the problem and provide explanation.
- **PDF:** Include a drawing of the nervous system of planarian worms compared to another organism with a different nervous system that shows the difference in physiology (part (c)).

Linguistics & Applied Sciences



5 points:

In natural languages, the frequency of words follows a pattern known as Zipf's Law. If the words of a text are ranked by decreasing frequency, then the number of occurences, or $f(r)$ of the word with rank r ($r = 1$ for the most common word) is often modeled by the power law

$$f(r) = C\, r^{-s},$$

where C is the approximate frequency of the most common word, and s is the Zipf exponent.

Last month, a tome of an unknown language was found in the depths of Silver Lake. The frequency of words in the tome was measured, and data for the 100 most common words has been prepared in CSV format, containing two columns: rank and frequency. Use the provided data to estimate the Zipf exponent s for the newly discovered language.

The data can be found at:

https://drive.google.com/file/d/1PZC_5Vjelps6MkqjF0jvrucBloTiXdw2/view?usp=sharing

You may import the CSV file into a spreadsheet program such as Google Sheets or Excel, or any other program of your choice, such as Python with the `pandas` library. You may use your tool of choice to transform the data in any way you see fit as well as use the program's trendline or linear regression tools to find a line of best fit. **The only regression or trendline tool you are permitted to use is linear regression or trendline.** To find the line of best fit with Google Sheets:

1. Create a scatter plot with the data highlighted.
2. In the *Chart Editor*, go to *Customize*, then *Series*, and toggle the *Trendline* checkbox.
3. In the *Trendline* options, change *Label* to *Use Equation* to see the equation of the line of best fit.

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution.

  Describe your approach, its motivation, and summarize your findings.
- **PDF:** Describe in detail how you processed the data, including but not limited to equations and screenshots of the plots.

10 points:

Here are sentences in an unknown language and their English translations, **not in matching order**:

A. Sisia idia mahuta	1. *They sit down*
B. Kekeni ia raka	2. *He knows me*
C. Kito ese manu ia lulua	3. *You jump*
D. Lau ese oi lau doria	4. *The dogs are sleeping*
E. Manu lau ese lau kamonai	5. *The girl sees the dog*
F. Idia helai	6. *I push you*
G. Ia ese lau ia diba	7. *The cat chases the bird*
H. Oi paudobi	8. *The girl walks*
I. Sisia kekeni ese ia itaia	9. *I hear the bird*

Match each sentence to its translation.

What is an alternate way to write sentence 5 in the unknown language?

Translate the following sentences into the language and explain your process:

- *The cats know me*
- *She chases the dog*

Submission Instructions: Video + PDF Required

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. Clearly explain the answer to each part of the problem including how you arrived at a solution.
- **PDF:** Include a clear list of the matches you made and legible copies of the sentences you wrote.

Computer Science

5 points:

Exploring the basement of an abandoned facility, you discover a vault door with four lights in some initial configuration. In order to unlock the door, all lights must be on. However, you discover that the wiring is cross-linked: pressing on a light (which toggles it) will also toggle the lights to the left and right of it. You decide to represent each light as 1 if it is on, and 0 if it is off.

Given the initial configuration of the lamps, write a program that determines the *minimum number of presses* needed to turn all four lamps on to open the vault door. Your program should read the first line of a file `input.txt` for input, which contains a string of four space-separated 0s and 1s, e.g. "`1 1 0 1`", and write the output to a file `output.txt` as an integer. If it is impossible to turn on all four lamps from the starting configuration, instead write "`impossible`" in the output file.

Submission Instructions: Video + Code + PDF Required

Unlike other problems on the QQ, this problem requires a **code submission, a video, and a PDF**.

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution. Give an overview of how your code works. Describe your approach, its motivation, and any issues you had to overcome.
- **PDF:** Describe how you implemented your code. Document any external resources you used when writing your code — what websites you read, along with other external resources that you used.
- **Code:** Submit a Python (`.py`) or Java (`.java`) file containing your code for the problem. Ensure that your code reads from a file called "`input.txt`" and writes to a file called "`output.txt`".

Python Input/Output Tips

In this section, we briefly describe how to read and write to a `.txt` file using Python. You can also check out this cheatsheet for reading/writing to Python files, or search for more guides on the internet. For input/output in Java, you can refer to this online guide.

To read from a text file in Python, use the `open()` function with the `"r"` (read) setting. Suppose your `input.txt` file consists of a single line of space-separated integers, such as "`1 3 5`". You can read these numbers and put them into a list as follows:

```
with open("input.txt", "r") as file:  # Open in read mode
    integers = [int(x) for x in file.readline().strip().split()]
    print(integers)
```

The function `strip()` will remove any white-space, `split()` will break the string up into a list using the spaces as dividers, and `int()` will convert them from strings to integers. To write to a text file in Python, use the `open()` function with the `"w"` (write) setting, and use the `write()` function:

```
with open("output.txt", "w") as f:
    f.write("Hello World!")
```

10 points:

Once SigmaCamp ends, campers return home, scattered across the globe. To keep the SigmaSpirit alive throughout the year, you decide to create a social network called SigmaNet consisting of n campers. You are studying how long it takes for the SigmaNet community to reach "social health" in order to plan for its development. To simulate the growth of the network, you consider the following experiment: starting with an empty network (with n campers and zero connections), you **connect a random pair of unconnected campers every hour**. You track the following two times as the network evolves:

- T_E : The number of hours it takes for each camper to have at least one connection (when the very last camper finally makes their first connection).
- T_C : The number of hours it takes for the network to become so well-linked that every camper is reachable from everyone else through a chain of connections (i.e. friend of a friend of a friend, etc.).

In this problem, you will experimentally investigate how T_E and T_C are related to n (the number of campers).

(a) Will T_E always, sometimes, or never happen before T_C? Explain your answer.

(b) Write a program that performs the experiment described above.

For several values of n (e.g. $n = 100, 500, 5000, \ldots$), run the experiment 100 times. Collect and plot the values of T_E and T_C that you find. From your plots, hypothesize how the two quantities typically grow as you increase n. That is, how do they grow with relation to n?

Express T_E and T_C as functions of n (e.g. $10n^2$, $7e^n$, $0.3n\log(n)$, etc.), and explain your answer.

Submission Instructions: Video + Code + PDF Required

Unlike other problems on the QQ, this problem requires a **code submission, a video, and a PDF**.

- **Video (max 2.5 minutes total):** Do not introduce the problem — jump straight to your solution.

  For part (a), state and explain your answer. For part (b), give an overview of how your code works. Describe how you implemented the simulation, and any issues that you had to overcome. Explain your hypothesis about the growth of T_E and T_C. How do your experiments support your hypothesis?

- **PDF:** Include your plots of T_E and T_C as functions of n, your hypothesized expressions for T_E and T_C in terms of n, and any other critical observations.

  Describe how you implemented your code. Document any external resources you used when writing your code — what websites you read, along with other external resources that you used. Lastly, include instructions on how to run your code and replicate the results of your experiment.

- **Code:** Submit a Python (`.py`) or Java (`.java`) file containing your code for your simulation.