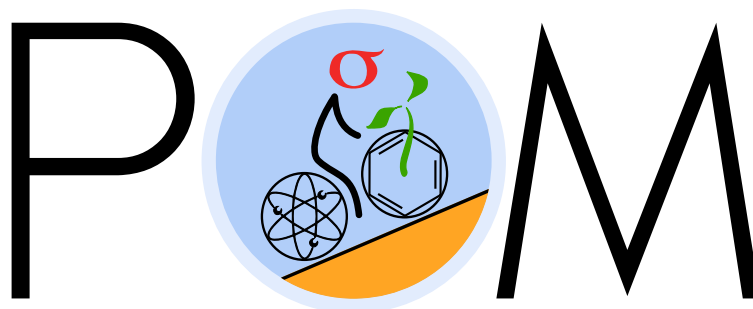




SigmaCamp's Problem of the Month Contest

OCTOBER 2026

Welcome to the **Problem of the Month (POM)**! Before you get started, here are some instructions and pointers. Each POM month consists of a **project**, which is worth **30 points**, and pairs of **problems**, which are worth **5 and 10 points**.

You do not need to solve all of the questions.

You can solve as many or as few of the problems or projects as you wish. For admission to SigmaCamp, SigmaWest or SigmaNext through POM, we only count your top few problems for points, based on your age and the camps you are eligible to apply for. **You don't need to solve all problems to be competitive for camp admission.** See the full POM rules for details at sigmacamp.org/pom/rules.

Videos are optional for problems, and mandatory for the project.

Submitting a video for a 5/10pt problem will add a **20% bonus to the problem's score** only if the video adds to your solution: reading your PDF will not give you the boost. Videos must be at most **3 minutes long for 5pt/10pt problems**, and at most **6 minutes long for projects**. **Your solution must be narrated, but you do not need to show your face.** Acceptable formats include narrating while screensharing a slides presentation or drawing app, or narrating with a whiteboard, paper, or easel. Upload your video to Google Drive, YouTube, Dropbox, or another hosting service and submit it as a link. **Make sure that you can access your video using your link in an incognito/private window.**

The deadline to submit October POM is October 31, 2026.

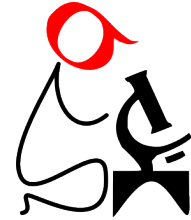
Please submit at sigmacamp.org/pom/upload.

If you have any questions, please email us at pom@sigmacamp.org.

Please see sigmacamp.org/pom/rules for full details regarding the POM format and rules.

Project – Biology & Linguistics (30pt)

Birds use different calls and songs for different reasons: attracting mates, warning others, defending territory, keeping in contact with a group, and more. For this project, you will be given several examples of birdsong, and will analyze them. The following Google Drive folder contains eight recordings of birdsong:



[Link to audio recordings](#)

Note that there is no single correct answer for many of the following questions. Try to address as many of the points below as you can, and also feel free to include anything that you find interesting that we don't explicitly ask for. Have fun, and enjoy the bird calls!

Part 1: Patterns

First, let's look for patterns in the recordings.

- Pay attention to things like pitch, repetition, rhythm, length, and the order of different sounds.
- Try to group the recordings to determine what kind of situation each one might be used in, e.g., mating, warning, territorial behavior, or social communication.

Part 2: Communication System

Now, let's look at how the birds' communication system is structured.

- What are the smallest units that repeat?
- In what ways can these units be combined into longer sequences?
- Does changing the order of these units or repeating sounds seem to change the message?
- Why might some communication use short sounds, while other is longer and continuous?

Part 3: Birdsong and Human Language

Next, let's compare the songs of birds to the languages that humans use.

- What parts of birdsong are similar to human language, and which are different? Think about things like sound units, sequences, meaning, syntax, learning, and dialects.

Part 4: How Sounds are Made

Finally, let's think about how the sounds are produced.

- How do humans produce sound, and how does this sound stay consistent enough to create recognizable words?
- How does this compare to birds?

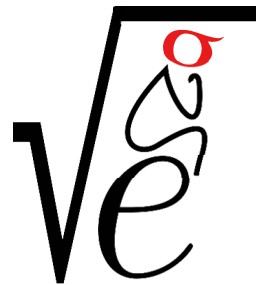
Submission Requirements

Be sure to include these in your submission:

- A **PDF** containing your answers to the above parts. Support your answers with evidence from specific recordings (specify the filename), list the sources you used (which books, which webpages, etc.), and indicate any help you received.
- A **video** (up to 6 minutes total) that summarizes your main findings for the parts above. We encourage you to play (parts of) the recordings to support your argument and convey your points. See the first page of this document for details about the video. **For the project, the video is mandatory with the PDF.**

Mathematics

For all mathematics problems, please provide full justification. **Do not include any code** in your submission unless specified otherwise — all code submissions will be awarded no points.



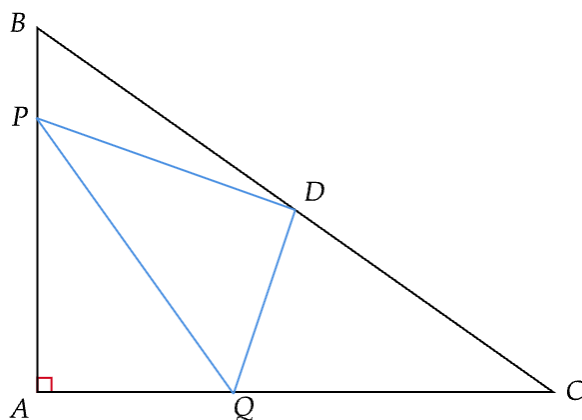
5 points:

Alice and Bob are playing a game. Starting from an empty (standard 8×8) chessboard, they take turns placing bishops on the board so that none of the bishops attack each other. Alice starts. The player who cannot place a bishop so that it is not under attack, loses. Does Alice or Bob have a winning strategy?

Alice and Bob never run out of bishops. The color of bishops does not matter, so even bishops of the same color count as “attacking” each other under the usual rule: they share a diagonal and there are no other pieces between them.

“Having a winning strategy” means that there is a rule for one of the players that allows this player to choose a move based on the current position on the board, and that by following this rule this player will always win, regardless of what the other player might do. If you think that Alice or Bob have a winning strategy, you must explain what the rule is, and why following this rule will guarantee a win under any circumstances.

10 points:



Anatoly folds right triangle ABC along the line PQ by holding it at the vertex A and bringing A over to the point D , which is the midpoint of BC . Given that $AQ = 2$ and $AP = 3$, find the length of AB .

Submission Requirements

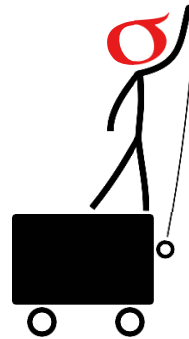
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Physics

5 points:

A key aspect of calculations in physics is that they deal with dimensionful quantities. This means that quantities in physics have associated units. For example, the average distance from the Earth to the Moon is 384 399 km or 238 854 miles, a day is 24 hours or 86400 seconds etc.



The three fundamental dimensions in classical mechanics are mass, length and time. Dimensions of all quantities in classical mechanics can be expressed in terms of some combination of mass, length and time. This alone is a surprisingly powerful idea, which can be used to deduce how some equations should look like. Use this idea to answer the following questions. *Hint: You may find the sample problem below useful.*

- (a) Black holes are very dense objects, with a gravitational field so strong that light cannot escape it. The relevant constants are M (the mass of the black hole), c (the speed of light) and G (Newton's gravitational constant with units $\frac{\text{length}^3}{\text{mass} \cdot \text{time}^2}$). What should the radius of the black hole be (up to dimensionless constants)?
- (b) A meteor crashes into the ground leaving an impact crater. Estimate the diameter of the crater given that the kinetic energy of the meteor is E , the density of the surface is ρ and the acceleration on the surface due to gravity is g .

Sample Problem: A ball is thrown from the ground, directly upwards with speed v . The relevant constants in the problem are the initial speed of the ball v and the acceleration of the ball downward due to gravity g which has units of $\frac{\text{length}}{\text{time}^2}$. How long does it take for the ball to return to the ground?

Solution: We look at the units of the constants involved. We need to make something with units of time. This can be achieved via:

$$\frac{v}{g} = \frac{\frac{\text{length}}{\text{time}}}{\frac{\text{length}}{\text{time}^2}} = \text{time}$$

From this, we can conclude that the time t it takes for the ball to return to the ground is proportional to:

$$t \propto \frac{v}{g}$$

Even though we don't know the constant of proportionality, this already contains a lot of useful information. For example: if you want the ball to have twice the air time, you can throw it twice as fast.

10 points:

Consider the xkcd comic in Figure 1. A person is trying to heat up their room with a “manual heat pump”. They have a closed expandable box that they can cool down outside. When they go inside, they compress it, heating up the gas inside. Then it radiates heat, increasing the room’s temperature.

- (a) How many trips does the person have to make to heat up the room by 1 degree Celsius?

Suppose the dimensions of the room are $4 \times 4 \times 2$ meters, the initial room temperature is 20 degrees Celsius, and the volume of the bellows (heat pump) ranges between 0.025 and 0.1 cubic meters when it is compressed or expanded. You can assume the room is perfectly insulated, the temperature outside is constant at 10 degrees Celsius and no heat is lost when the person goes in and out of the room.

- (b) How does your estimate compare with what you may expect intuitively? Identify any assumptions you make that may lead the estimate to be inaccurate and comment on the efficiency of the manual heat pump.

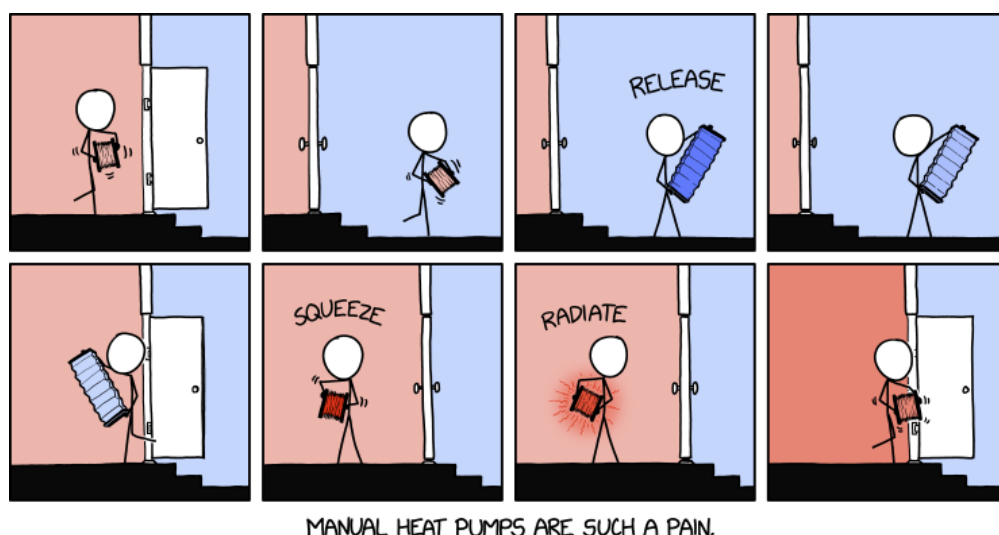


Figure 1: Comic taken from <https://xkcd.com/2790/>

Note: For both parts of the problem, you may find it helpful to learn about the *ideal gas law* and the *pressure-volume work*.

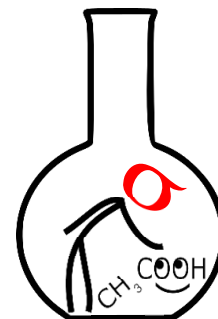
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Chemistry

Reminder: You are encouraged to use external resources for POM. If you encounter a term or concept you are unfamiliar with, feel free to Google it or ask a teacher. You also do not need to fully complete a problem to get points. Your final solution must be written entirely in your own words.



5 points:

Note: For the following problem, we are only asking only for a **theoretical solution**. Some materials sold by Home Depot can be dangerous, and any experiments with them must be done under the supervision of a trained professional. **Please do not try this experiment yourself.**

A young chemist found a metal rod. He measured its density, which appeared to be very low (less than 3 g/cm^3), so the chemist had good reason to suspect that the strange metal was aluminum, magnesium, or an aluminum-magnesium alloy. To find out, he took it to his home laboratory, which he had stocked with basic equipment from a nearby convenience store and Home Depot. He also had a few simple chemicals, like muriatic acid or Crystal Lye Drain Cleaner.

Can he determine the composition of the rod? What experiment should he perform to verify if the rod is pure magnesium or aluminum? If the experiment shows the metal is an alloy, how can he determine the percentage of each metal? What setup does he need to assemble?

10 points:

Bob, an undergraduate student, came to see Alice, a young postdoc, and they had the following conversation.

Bob: Hi Alice, I have a problem and I need your help.

Alice: What is the matter?

Bob: I need to prepare a series of iodinated hydrocarbons with the empirical formula $\text{C}_5\text{H}_{11}\text{I}$, and I know that the best way to do this is to take the corresponding bromo derivative, dissolve it in acetone, add sodium iodide and heat the mixture for several hours. Under these conditions the iodide ion replaces the bromine, and I obtain an iodo compound in which the iodine sits at exactly the same position where the bromine was. Last year I prepared iodoethane from bromoethane by this method.

And Bob wrote the equation shown in Figure 2 on the whiteboard:



Figure 2: Preparation of iodoethane from bromoethane

Alice: Yes, that is correct. But what is the problem?

Bob: Alice, some of the reactions simply do not work. I took five isomeric bromo compounds of formula $\text{C}_5\text{H}_{11}\text{Br}$ (and Bob wrote their structures on the whiteboard, see Figure 3), but only three of them reacted. Compounds 4 and 5 did not.

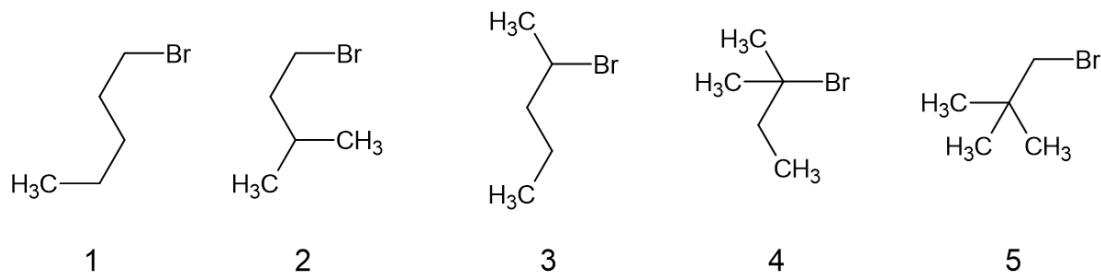


Figure 3: The brominated alkanes Bob used in his experiments

Alice: But that is no surprise...

Bob: Alice, it IS a surprise to me, and if you think I do not know any chemistry, you are wrong. I know the rules, and I know that when the carbon bearing the chlorine or bromine also carries three substituents (bigger than a hydrogen atom), as in compound 4, the replacement reaction with iodide does not proceed under these conditions. That is why the poor reactivity of compound 4 does not surprise me. The behavior of compound 5, however, contradicts the rule: it looks just like compound 1, since only one group is attached to the carbon bearing the bromine, yet it is completely unreactive. Why does this compound break the rules of chemistry?

Alice: Bob, chemistry is not just a collection of empirical rules, and memorizing them is not enough to understand the subject. You should always make sure that you understand the mechanistic principles behind an empirical rule, because they are what tell you whether the rule applies to a particular case. For example, do you understand why the rules say that compound 4 is unreactive while compound 1 is reactive?

Bob: No. I was taught the rule, but it was never explained to me.

Alice: To understand the rule we are discussing, you must first understand the mechanism of the reaction, which is the following. (*And Alice wrote the mechanism shown in Figure 4 on the whiteboard.*)

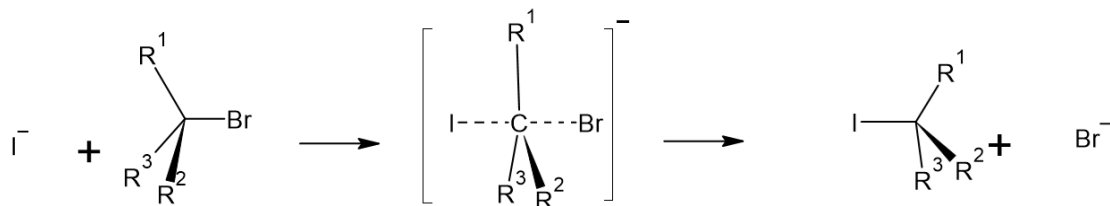


Figure 4: The mechanism of halogen substitution in organic molecules

As you can see, the iodide ion attacks the carbon atom from the side opposite to the bromine, which then leaves the molecule as an ion as well. In my scheme, R^1 , R^2 and R^3 denote arbitrary groups: each of them may be a hydrogen atom, a methyl group (CH_3), or something else. When all three of them (R^1 , R^2 and R^3) are bulky, methyl groups for instance, the iodide ion simply cannot get close enough, because there is no space left around the central carbon atom. This kind of effect is called a *steric effect*.

Bob: But Alice, look: in compound 5 only one of the groups is bulky, the other two are just hydrogen atoms!

Alice: Yes, but our aim is to find out whether steric effects operate here, not to count bulky groups. Empirical rules such as the one you quote are helpful in simple cases, but sometimes they fail, and that is precisely why we need to know the real chemistry behind them. To understand why compound 5 is unreactive, go home, build a simple model of the molecule from clay or from a plastic model kit, and see for yourself whether an iodide ion can reach the carbon atom and displace the bromine.

Help Bob understand why compound 5 is not reactive in a reaction with sodium iodide in acetone.

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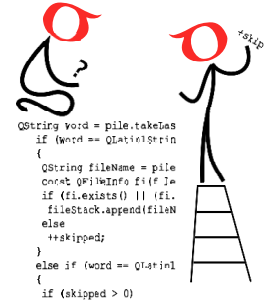
Computer Science

5 points:

The Sigma messaging service allows any pair of counselors to send messages to each other. Currently Alex, Boris, Cormac, and Deniz are the only users of the service. The server through which these messages pass records the receiver and timestamp of every single message on Monday:

08:30: Alex received a message	13:43: Deniz received a message
08:33: Boris received a message	13:44: Cormac received a message
08:34: Alex received a message	13:47: Deniz received a message
08:37: Boris received a message	15:50: Alex received a message
10:00: Deniz received a message	15:53: Boris received a message
10:56: Boris received a message	17:05: Deniz received a message
11:30: Cormac received a message	17:13: Alex received a message
11:35: Deniz received a message	17:18: Deniz received a message
11:36: Alex received a message	17:19: Alex received a message
11:37: Cormac received a message	18:30: Boris received a message
11:37: Deniz received a message	19:30: Deniz received a message
11:38: Deniz received a message	19:32: Cormac received a message
11:39: Alex received a message	19:33: Deniz received a message
11:40: Cormac received a message	19:34: Boris received a message
11:40: Deniz received a message	19:35: Cormac received a message
12:30: Boris received a message	21:30: Alex received a message
13:40: Cormac received a message	21:33: Boris received a message

Based on this messaging history, which 3 pairs of counselors are likely to be talking to each other? Describe your method, and explain how you would generalize it to identify peoples' contacts in a setting with more people and messages.



10 points:

After the opening ceremony, a group of n campers standing close to the campfire may have been exposed to the Sigma Spirit: potentially all, some, or none of the campers now have the Sigma Spirit. However, the only person who can actually tell if a camper has the Sigma Spirit is Mark, who will only answer yes/no questions. To figure out if they have the Sigma Spirit, the campers prepare a list of questions in advance and ask Mark to answer all of them at once. The questions can be repeated, and may be any yes/no questions about which campers have the Sigma Spirit.

- (a) If Mark answers every question truthfully, what is the smallest possible number of questions that n campers can ask to determine who has the Sigma Spirit?
- (b) If there is only one camper and Mark answers incorrectly at most once, what is the smallest possible number of questions the camper needs to ask to figure out if they have the Sigma Spirit?
- (c) If there are 4 campers and Mark answers incorrectly at most once, how can the campers figure out who has the Sigma Spirit using at most 7 questions?

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