POM

SigmaCamp's *Problem of the Month* Contest

SEPTEMBER 2026

Need help with a problem?

The **POM Office Hour** is on **Sunday, September 27th** at **1:00 PM EST**.

Come ask us about the problems! See sigmacamp.org/pom/office-hours for details.

You can also ask your teachers at school, or consult the internet. You can use the internet and books for research and learning, as long as your final solution is written in your own words.

Collaboration with other POM participants, including siblings, is prohibited.
Using LLMs or AI to solve problems is not allowed.

Welcome to the **September 2026 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.

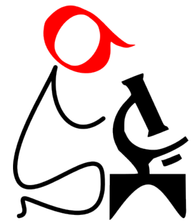
You can **solve as many or as few of the problems or projects as you wish**. For admission to SigmaCamp, SigmaWest or SigmaNext through POM, we only count your top few problems for points, based on your age and the camps you are eligible to apply for. **You don't need to solve all problems to be competitive 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 September POM is September 30, 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 – Applied Sciences (30pt)

For September's project, you will design, build, and test a family of devices made of household materials that keep a chicken egg in the air for as long as possible after being released from 2 meters above the ground, without the egg breaking.

This project is divided into three parts: a design stage, a build and test stage, and an analysis. Submission requirements are denoted with a square (☐). **Have fun and be careful!**

Part 1: Design

Before you start gluing things together, think like an engineer: change one variable at a time so you can tell *why* a design works, not just *whether* it works.

- Propose between 3 and 6 distinct designs for your egg-carrying device.
- Your set of designs should change one or two variables at a time. For example, if your design includes cardboard wings, you could experiment with different wingspans, different wing shapes, or both. Building several unrelated contraptions does not satisfy this requirement. The goal is to see how these variables change the airborne time of your device.
- For each design:
  - ☐ Draw a **well-labeled** diagram (by hand or digitally) showing its structure and all components, dimensions, and the egg itself.
    - ∗ If several of your designs share the same main body, you only have to draw that body once, but draw the component that changes for each design.
    - ∗ Looking for a tutorial on how to make good engineering drawings? We recommend this design handbook from MIT or this guide from Fractory.
  - ☐ Write 1-2 paragraphs explaining the building process. You don't need to re-explain your blueprint.

  The diagram and description together should contain enough detail for someone else to reproduce your designs from them.
- ☐ Write a paragraph explaining why you chose to test the variables that you did, and what effect you predict each will have.

Part 2: Build and Test

Have fun, but be careful. For example, if you are using sharp objects to cut cardboard, have an adult supervise you.

- Build all of your proposed designs. Note that you can reuse components between designs. For example, if you are testing differently shaped cardboard wings, you can reuse the same box to house the egg across all of them.
- Test each design by dropping it from a height of exactly 2 meters (measured from the bottom of the egg-holding device to the ground or landing surface), timing the fall with a stopwatch or your phone's timer from release to the moment it first touches the ground.
  - – Test each design at least 2 times if you have 5–6 designs, at least 3 times if you have 4 designs, and at least 4 times if you have 3 designs.
  - ☐ Report all times and calculate the average time for each design. Organize your data in a table.
- ☐ Record a short video of at least one drop per design, showing the release, the fall, and the landing.

Part 3: Explain Your Results

☐ Write a short summary (1-2 paragraphs) that:

- States your best design and its average airborne time that you measured.
- Explains why you think it outperformed your other designs, tying the result back to the variable(s) you changed in Part 1.
- Discusses anything unexpected (a design that flipped, spun off course, oscillated, or otherwise didn't behave as predicted) and what you think caused it.

☐ Write down any websites or books you used, if any, to think of design ideas or understand why some of your designs worked better than others.

A few notes:

- You may use only ordinary household materials. For example, cardboard, toilet paper, tape, and bed-sheets are allowed. Objects with batteries, electrical wires and combustion engines are not permitted.
- The egg must be a **raw chicken egg** that is medium, large, or extra-large.
- **Fifteen of the thirty points** will be based on the explanations and diagrams of your designs, your written analysis, and the quality of your documentation of the testing process.
- **Three points** will be awarded if at least one of your designs protected the egg in each one of its tests, with **two additional points** if *every* design protected the egg in every test.
- **Ten points** will be awarded based on the performance of the design with the best average airborne time *among those that protected their egg in all tests.* You cannot earn these ten points if none of your designs protected their egg in every test.

Submission Requirements

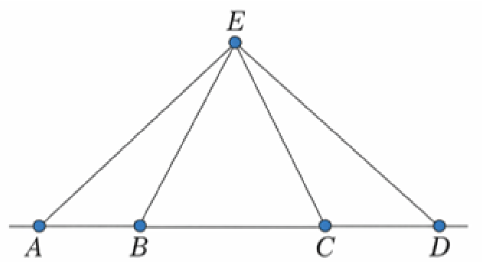
In the parts above, requirements are denoted with a square (☐). **Even if you skipped some of the requirements, you can get credit for others.** Be sure to include these in your submission:

- A **PDF** containing your diagrams, your predictions, your recorded drop times for every design, and your written explanation of results.
- A **video** (up to 6 minutes total, per the POM project rules) that shows the drop test of each of your designs and narrates your results and explanation. **For this 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:



In this diagram, 4 points A, B, C, D are on the same line, and there are 6 triangles. Is it possible for all 6 triangles to be isosceles? Remember to fully justify your answer.

10 points:

(a) [3 points] By considering the numbers of the form $2027! + k$ for different values of k, show that you can find 2026 consecutive composite numbers. Will your proof still work if you replace $2027! + k$ with $2026! + k$?

Note: $n!$ is pronounced "n factorial" and is equal to $n! = 1 \cdot 2 \cdot 3 \cdot \ldots \cdot n$. For example, $5! = 120$. A composite number is a number with more than 2 divisors. Also, the number 1 is neither prime nor composite.

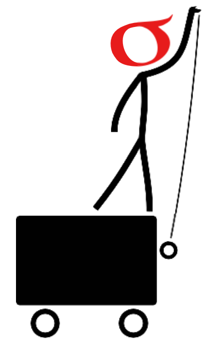
(b) [7 points] Show that there must exist 2026 consecutive natural numbers such that exactly 26 of them are prime.

General note: This problem deals with two questions about distribution of prime numbers and gaps between primes. The part of number theory that deals with these questions includes both well-understood and relatively easy results like Prime Number Theorem and famously unproven Riemann Hypothesis and Twin Prime Conjecture.

Submission Requirements

For both the 5pt and 10pt problems, submit separate PDF files with your solution. Do not put your solutions for both problems in one file.

For both problems, **you may optionally submit a video solution** along with the PDF to receive a **20% score increase** for that problem. **The video must be up to 3 minutes long**. Your video must add to your solution — reading from the PDF will not qualify you for the score increase. See the first page of this document for details about the video.



Physics

5 points:

There is a simple and well-known experiment in momentum transfer: hold a small ball just above a basketball, and let both drop and hit the ground. After the collision, the small ball is sent sky high. See this video for a demonstration.

Suppose you conduct two experiments — one with a lacrosse ball above a basketball, and one with a golf ball above a basketball. Which ball will go higher? Justify your answer, perhaps even with more than one physical effect. You do not necessarily need to show explicit calculations, although you are welcome to, so long as you demonstrate solid physical reasoning. You are encouraged to google the properties of each type of ball.

10 points:

A tennis ball is dropped from a height of one meter. Suppose that with every collision with the ground, it loses 70% of its kinetic energy. Assume that each bounce is instantaneous, so that you may ignore the amount of time the ball spends in contact with the ground. How long will it take the ball to stop bouncing entirely? Ignore air resistance. Report your answer to the nearest hundredth of a second.

You may find the following resources helpful when solving the problem: resource on kinetic energy and resource on geometric series. You may also need to consider the kinematics equations of motion.

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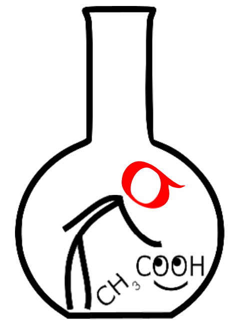

Chemistry

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. Your final solution must be written entirely in your own words.

5 points:

Imagine you have access to a chemistry laboratory with any standard equipment you want, and you have water, SO_3, and one additional chemical of your choice (a pure substance, not a mixture). Using these chemicals, prepare as many different substances as you can. Draw equations of these reactions.

10 points:

In an ordinary molecule, every atom is bonded to the rest of the molecule. However, chemists have managed to build molecules where two separate pieces do not share a bond, yet cannot be pulled apart, as they are locked together like links in a chain. One example is shown in Figure 1.

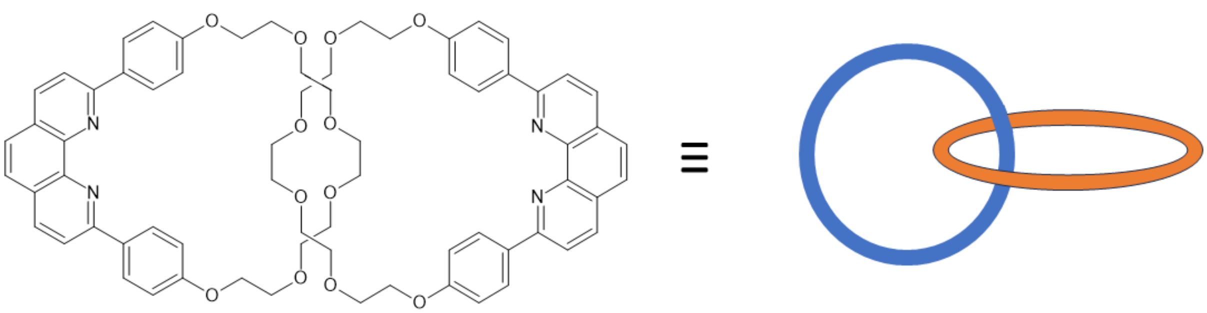

Figure 1: An example of a molecule in which two parts are held together like two links in a chain.

In this problem, you will investigate how small the rings can get in such two-ring molecules, where both rings are *saturated* and *aliphatic*. A molecule is *saturated* if it contains only single bonds, and is *aliphatic* if it contains no benzene rings. Find the smallest ring size for which such a molecule can exist.

To answer this question, you need to determine the ring size at which the molecule can avoid clashes between its different parts without distorting the bond geometry. Keep in mind that every carbon atom in a saturated aliphatic hydrocarbon has tetrahedral geometry, so the angle between two carbon–carbon bonds is approximately 109.5°. You can do this by building a model from toothpicks and modeling clay, or with one of the many inexpensive plastic model kits available (plastic kits may be useful for solving future Chemistry POM problems this season). Please provide photos of your models.

During modeling, keep in mind that the true shape of hydrocarbon molecules is not like that shown in Figure 2, but rather like that shown in Figure 3.

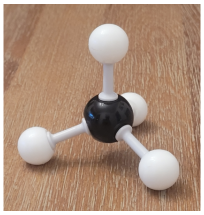

Figure 2: In this model, the bonds are unrealistically long.

Figure 3: This model represents the shape of the molecule fairly realistically.

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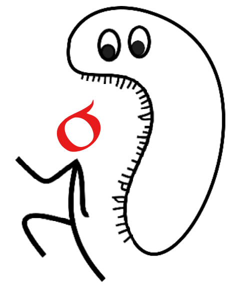

Biology

5 points:

Tropical coral reefs support an extraordinary amount of life. Although they cover well under 0.1% of the ocean floor, they harbour roughly a quarter of all marine species, including more than 4,000 species of fish, along with corals, crustaceans, molluscs and much else.

Yet reefs appear to flourish in a nutritional desert. In other highly productive parts of the ocean, for example, Georges Bank off Cape Cod, or the Dogger Bank in the North Sea, the water is green and turbid, clouded by the dense plankton that abundant dissolved nitrogen and phosphorus sustain. Around a coral reef, the water is famously crystal clear, with no visible trace of such a bloom. Part of the reason is that tropical surface waters are oligotrophic: they are chronically poor in the nutrients that fuel plankton growth. This fact only sharpens the puzzle because reefs are found only in these transparent, nutrient-starved waters, and they build the most productive aquatic ecosystem there.

In your own words, explain why the water around a coral reef is so clear, and how the reef ecosystem, nevertheless, manages to thrive in it.

10 points:

Nematodes and elephants differ in size enormously, and yet their cells are roughly similar in size, barring a few exceptions (primarily specialized cells, like neurons and ova, which can grow much larger than typical cells but have unusual structures and functions). This suggests that there are some limits on how large most cells can become. Some single-celled protists, like amoebas, however, can become much larger than typical animal cells. What adaptations allow these organisms to overcome the usual limits on cell size, and why have large multicellular organisms generally evolved by increasing cell number rather than cell size?

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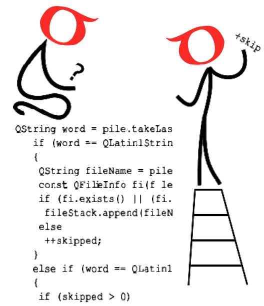


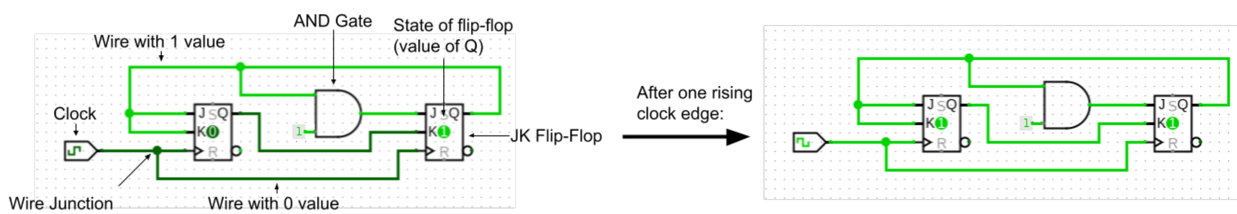
Computer Science

In a circuit, a clock is a digital signal that oscillates between 0 and 1 forever (0, 1, 0, 1, etc. changing every few milliseconds). A JK flip-flop is a 1-bit memory that holds an output Q (0 or 1) and only ever changes Q when the clock is on a rising edge (increasing from 0 to 1). The way Q changes depends on the value of the inputs to the JK flip flop at the rising edge, following the table below:

J	K	what Q changes to at the rising edge of the clock
0	0	Q (stays the same)
0	1	0
1	0	1
1	1	$\overline{Q}$ (inversion, so if it was 0 it changes to 1 and vice-versa)

When several flip-flops share one clock, they all update their Q values at the same instant. Note that things other than a clock can be connected to the clock input of a JK flip-flop; the transitions described above will occur whenever the wire connected to the clock input goes from a 0 to a 1.

For example, a transition from one clock cycle to the next, might look like:



5 points:

A chip has three JK flip-flops sharing one clock, and its stored values are Q_2, Q_1, and Q_0. The chip's overall state is the 3-bit number $Q_2Q_1Q_0$. The control inputs are wired as follows:

- $J_0 = \overline{Q_2}, K_0 = 1$
- $J_1 = Q_0$, $K_1 = Q_0$
- $J_2 = Q_1$ AND Q_0, $K_2 = 1$

At each rising edge, the J and K inputs are determined by the Q values immediately before that rising edge, and then all three flip-flops update simultaneously.

The chip powers on in the state $Q_2Q_1Q_0 = 110$, meaning that after one rising edge of the clock it is in the state $Q_2Q_1Q_0 = 010$ and after two rising edges it is in the state $Q_2Q_1Q_0 = 011$. What state is it in after 100 rising edges of the clock?

10 points:

The Sigma M&M dispenser is peculiarly configured so that every 3rd M&M dispensed is red, every 5th M&M is blue, every 15th M&M is purple, and the rest of the M&Ms are brown.

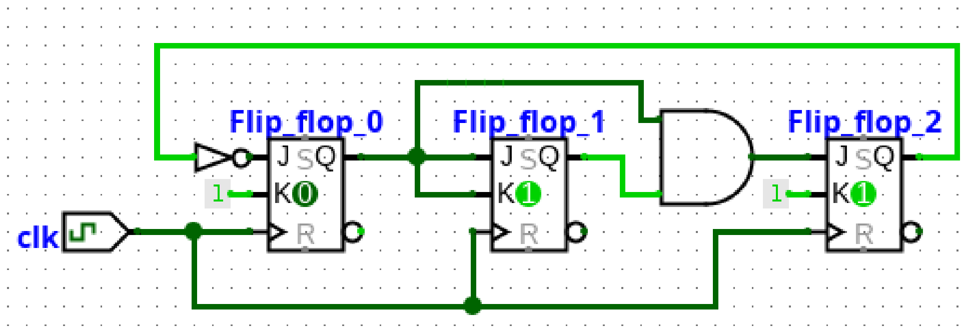


Figure 4: A diagram of what the circuit described above looks like initially.

To dispense an M&M, someone must press the "Dispense" button. A press lasts for at least one clock cycle and possibly more. If a press lasts multiple clock cycles, it still only counts as one press; the button must be unpressed before a new M&M can be dispensed.

Complete the following circuit to show which color the M&M machine is currently being dispensed (if a button is pressed for multiple clock cycles, then that particular M&M is being 'dispensed' for all of them). If no M&M is being dispensed on a given clock cycle, all of these should be 0. A 1 on the "Dispense" pin indicates it being pressed, a 0 indicates that it is not pressed. You may only add wires, logic gates, constants (values always set to 0 or 1), and any number of JK flip-flops. Assume that at the start, 0 M&Ms have been dispensed so far. You may choose the starting Q value for each of your JK flip-flops, but make sure to indicate this in your diagrams.

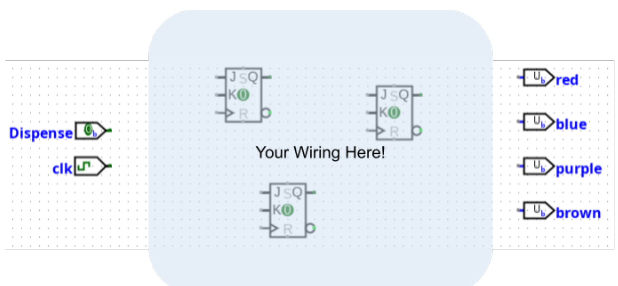


Figure 5: A template for what your solution could contain.

Explain why your circuit correctly models Sigma's M&M dispenser.

Note: Our diagrams were made using logisim-evolution. For your own, feel free to use paper and pencil or any software that you like, but do make sure your components are clearly identifiable. Label the "J", "K", clock ("R"), and output ("Q") of your flip-flops, label your clocks ("clk" in our diagrams), and label what your input and output bits correspond to.

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