Columbia Science Olympiad
2024 Fermi Questions Exam

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Student Name(s): _____

Team Name: _____ **Team Number**: _____

School Name: _____

INSTRUCTIONS

- You have **50 minutes** to complete this exam. There are **35 questions** total. The questions are not in any particular order of difficulty. You are not expected to finish.
- No additional resources are allowed other than **pencils and scratch paper**.
- **Only the answer sheet will be graded.** It is the last page. Please fill out the identification information on the answer sheet as well. It is okay to detach the answer sheet, as you will need to when turning in your exam anyways.
- Recall that answers should just be the degree of the exponent (power of ten). Round your answers (e.g. if you calculate $3.67 * 10^7$, your round your answer to 10^7, and you should write down **7**. If you estimate $5 * 10^2$, you round to 10^3, then you should write down **3**).
- Incorrectly formatted answers may not be graded (e.g. 10^5, 4000)!
- Scoring will work as normal – you will be awarded 1 point for a ± 2 order of magnitude, 3 points for ± 1, and 5 points for the correct order of magnitude approximation.

Section 1. Real-world cases (15 problems)

1. (5 points) Thousands of tourists visit the Grand Canyon each year. **How many pounds of water are required to fill the entire canyon?**

2. (5 points) Selfies are one of the most common types of photographs. **How many selfies are estimated to be taken globally in one day?**

3. (5 points) I've never understood why chocolate is associated with love... **How many pounds of chocolate were bought during Valentine's Day week in 2023?**

4. (5 points) India has one of the lowest rates of meat consumption per capita, while the U.S. has one of the highest. **On average, how many people from India would you need to match the yearly meat consumption of the entire US population?**

5. (5 points) Columbia recently made a gaming lounge, outfitted with some of the newest and fastest PC hardware on the market (all the more reason to come to Columbia)! **How many operations does an NVIDIA RTX 4090 TI GPU (the top-end consumer available GPU as of 2023) perform per second?**

6. (5 points) 2023 was a big year for Taylor Swift – TIME person of the year, a billion-dollar tour, and Spotify's top artist, to name some achievements. **What is the product of all of Taylor Swift's ex and current boyfriends' heights (in meters)?**

7. (5 points) Did you know chinchillas have the densest fur (in terms of number of hairs per unit area) out of all mammals? **How many more times dense is a chinchilla's fur compared to the average human head?**

8. (5 points) Chess is far from being a "fully solved" game, but we're slowly making progress. In 2018, computer scientists finally finished tabulating all possible positions with 7 or fewer pieces left on the board. **How many legal chess positions can be created using 7 or fewer pieces?** Remember that a "legal position" must contain two kings, pawns can't be on the first or last rank, etc.

9. (5 points) 2024 means another U.S. presidential election year! **If you took all U.S. presidents that have an "e" somewhere in their full name and multiplied their number n together (where they are the n-th president), what number would you get?** – e.g. Thomas Jefferson $\times$ Joe Biden $= 3 * 46 = 138$.

10. (5 points) The speedrunning community loves the original 1985 *Super Mario Bros.* game, on Nintendo's NES console. **How many frames (ran on original NES) does it take to complete *Super Mario Bros.*, based on the current world-record fastest speedrun?**

11. (5 points) You ever think about how physics-defying Carl's house is in the movie *Up*? He always managed to keep exactly the right number of balloons attached to the house for it to float one foot off the ground. **How many standard balloons, filled with helium, would you need to lift the Empire State Building?**

12. (5 points) Did you know that it's a kicker that holds the all-time high for career points in the NFL? **What is the product of the highest number of career points scored in the NBA, career goals scored in the NHL, career points scored in the NFL, and career runs scored in the MLB?** (By career points, we mean the number of points scored across a single player's entire playing career).

13. (5 points) Spider silk is remarkably strong – however, we haven't quite figured out how to create web fluid, so no swinging around like Spiderman yet. **How many times greater is the tensile strength of spider silk compared to that of steel?** Note that tensile strength is measured by stretching a material until it breaks.

14. (5 points) Many people dream of traveling the world, and some of them also dream of trying every item on the McDonald's menu... people have different tastes I guess. **How many times could you go around Earth's circumference, by lining all of the burgers that McDonald's sells (globally) in one year?** Assume the burgers are placed along the equator.

15. (5 points) In *Percy Jackson*, Delphi Strawberry Service is the cover name for Camp Half-Blood. The cost of constructing a temple dedicated to one god at the camp requires selling a 16-wheeler truckload of strawberries. **If each of the major Greek gods were to receive a temple, how many pounds of strawberries would the camp have to sell?**

Section 2. Columbia (5 problems)

16. (5 points) In 1946, Enrico Fermi was awarded an honorary degree of Doctor of Science by Columbia for his discovery of nuclear reactions. **Since 1896, how many degrees has Columbia University awarded in total?**

17. (5 points) Some of you have traveled from very far to come to today's Science Olympiad! **If you summed all of the direct distances ("as the crow flies") between Columbia and each school at today's invitational, what would the total distance be in kilometers?**

18. (5 points) Low Library (the big domed building in the middle of campus) isn't actually library anymore! In 1934, all books were removed and moved to Butler Library. **At full capacity, how many books was Low Library expected to accommodate?**

19. (5 points) Columbia's campus is very small - I can walk to any of my classes in less than 5 minutes! **If you combined the land across all Ivy League school *main* campuses (exclude any land owned outside of the main campuses), how many of Columbia's main campus could fit in this area?**

20. (5 points) Do you all think the Columbia classroom chairs are comfy? **How many chairs are there within all the registrar-managed classrooms on Columbia's campus?**

Section 3. Science (5 problems)

21. (5 points) (Physics) A common joke about particle physics research is how we keep needing to construct bigger particle accelerators to make any new discoveries. **How many times more powerful is the Large Hadron Collider at CERN compared to the first cyclotron ever made by Ernest Lawrence back in 1931?**

22. (5 points) (Physics) Brian and I were lucky enough to watch *Oppenheimer* at an IMAX 70mm theatre last summer. **Assuming you only account for the projector and sound system, how many times could an IMAX movie theatre play *Oppenheimer* using solely the energy from the 1945 Trinity nuclear test's explosion?**

23. (5 points) (Astronomy) Did you know there will be a total solar eclipse that goes directly through the continental US on April 8, 2024? **If you witnessed a solar eclipse, about how many blue moons (the 2nd full moon occurrence in a calendar month) would you see until you saw another solar eclipse, still standing at the exact same spot?**

24. (5 points) (Chemistry) Have you seen the famous Mentos and Soda experiment? If you dump Mentos into a bottle of soda, the carbon dioxide bubbles expand rapidly, creating a geyser. **If you put a single Mento into a 2 liter bottle of Diet Coke, how many bubbles are produced in the resulting geyser?**

25. (5 points) (Biology) Villains are always saying creepy things like, "this sword was forged from the blood my enemies." **Assuming perfect extraction, how many human men would you need to extract enough iron to create a full medieval broadsword?**

Section 4. Mathematics (5 problems)

26. (5 points) **How many digits in pi do you need to get the first instance of 123456789?**

27. (5 points) **A rabbit is traveling from** $(0, 0)$ **to** $(24, 24)$ **by hopping one unit in the positive** x **or positive** y **direction each step. However, there is a snake at each lattice point where both coordinates are odd, e.g.** $(1, 1)$ **or** $(1, 3)$**. How many paths can the rabbit take without encountering a snake?**

28. (5 points) Let's talk about telescoping. **What is** $\sqrt{1\sqrt{5\sqrt{25\sqrt{125\ldots}}}}$**?**

29. (5 points) **The prime factorization of 2024 is $2^3 \times 11 \times 23$. What is the sum of all positive numbers less than 2024^2 that are divisible by all of 2, 11, and 23?**

30. (5 points) **What is the maximum number of regions that a circle can be partitioned into by drawing 100 lines?**

Section 5. Meta questions (5 problems)

DEFINITION: the *raw value* of your answer is 10 to the power of the number you write down. For example, if you write "-2" on the answer sheet, the *raw value* is $10^{-2} = \frac{1}{100}$.

31. (5 points) **EXCLUDING section 5, what number do you get if you divide the GREATEST *raw value* any team answered on the exam by the SMALLEST *raw value* any team guessed on the exam?** e.g. if the largest guess was 23 and the least was 3, then the correct answer is $\frac{10^{23}}{10^3} = 10^{20}$, written as 20.

32. (5 points) **If we multiplied all of the *correct* answers' raw values of the test together (EXCLUDING section 5) and converted this number to binary, how many 1's would there be in our result?** e.g. if the correct answers were $\{3, 4, 5\}$, the product is $10^3 \times 10^4 \times 10^5 = 10^{12} = 1110100011010100101001010001000000000000_2$, which has 13 1's in it, so our final answer would be 1.

33. (5 points) The mode never gets as much love as the mean or the median... **EXCLUDING section 5, across all of the guesses that all teams wrote down on the exam, what is the mode of the guesses' raw values?** e.g. If all guesses were $\{3, 3, 4, 6, 10, 3, 5, 3\}$, the mode would be 10^3, so the correct answer is 3.

34. (5 points) **If we put the final scores (EXCLUDING points from section 5) of all the teams in a list, how many non-degenerate triangles could we create whose side lengths are chosen from this list (without replacement)?** By non-degenerate triangle, we mean the sum of the lengths of the two smaller sides must be greater than the length of the longest side. By without replacement, we mean you cannot use the same score twice in one triangle.

35. (5 points) Your guess for this question will influence the correct answer - tread carefully! **We start with $x = 1$. If the *raw value* of your answer to this question is < 1, we will divide x by 10, and if it's ≥ 1 we will multiply x by 10. The correct answer to this question will be the final value of x, operated upon by all the team's guesses!**

36. (1 point) **Please rate this exam on a scale from 10^0 to 10^{10}.** Any answer (or even no answer) will be rewarded 1 free point. You can leave feedback below as well!

Congratulations on finishing the test! We hope you enjoyed solving these questions as much as we enjoyed crafting them. Regardless of how well you think you did, know that we designed this to be a difficult exam; you should be proud of even completing such a challenge! :)

Answer Sheet

Student Name(s): _____

Team Name: _____ **Team Number**: _____

School Name: _____

1. _____	2. _____	3. _____	4. _____	5. _____
6. _____	7. _____	8. _____	9. _____	10. _____
11. _____	12. _____	13. _____	14. _____	15. _____
16. _____	17. _____	18. _____	19. _____	20. _____
21. _____	22. _____	23. _____	24. _____	25. _____
26. _____	27. _____	28. _____	29. _____	30. _____
31. _____	32. _____	33. _____	34. _____	35. _____

36. Feedback appreciated as well!