

# “Motivated” Numerical Science Problems: for GPT4 + Wolfram Alpha and GPT4 + Code Interpreter

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This document includes 21 college-level numerical math and physics problems with problems, answers, and outputs from GPT4 with the Wolfram Alpha plug-in (henceforth GPT4+WA) and with the Code Interpreter plug-in (henceforth GPT4+CI). The experiments on the two systems were carried out between July 27 and August ?? 2023.

1. If the earth collapsed to a black hole, how big would the black hole be? Please include all calculations.
2. If you fell into the black hole at the center of the Milky Way, how long would you have before hitting the singularity? Please include all calculations.
3. Consider the first binary black hole system discovered by LIGO. Roughly how close to that system would a person have to have been, before they were killed by the gravitational waves? Please include all calculations.
4. How far off from  $10!$  is Stirling’s approximation? Please include all calculations.
5. How high would an airplane have to be, before you could notice 10 degrees of the earth’s curvature when looking out the window? Please include all calculations.
6. Approximately how much time would a commercial airliner save in going from New York to Tel Aviv, if it could go in a straight line, through a tunnel in the earth, at the same speed as usual? Please include all calculations. Please include all calculations.
7. For what fraction of the lifetime of the universe has there been life in it? Give upper and lower bounds. Please include all calculations.
8. Approximately how long would it take to transmit an entire human genome over a standard WiFi connection? Please include all calculations.
9. Approximately how large would an asteroid have to be, in diameter (assume it’s approximately spherical), before an Olympic high jumper could no longer reach escape velocity by jumping off it? Please include all calculations.
10. What is the length of the  $y = x^2$  parabola in the region  $-1 \leq x \leq 1$ ? Please include all calculations.

11. Approximately how large a supply of antimatter would be needed, in order to propel a spacecraft with the mass of the International Space Station into orbit around Proxima Centauri, in one year as experienced by its crew? Please include all calculations.
12. Approximately how many errors will a standard laptop suffer over its lifetime, due to cosmic rays hitting the microchip? Please include all calculations.
13. What is the approximate probability that a randomly-chosen 100-digit integer is prime? Please include all calculations.
14. What is the probability that a randomly-chosen  $100 \times 100$  matrix, over the finite field  $F_2$ , is invertible? Please include all calculations.
15. How does the total weight of all the uranium that humans mined, compare to the total weight of all the gold that they've mined? Please include all calculations.
16. What is the Shannon entropy of a positive integer  $n$  that's chosen with probability  $\Pr[n] = 6/(\pi^2 * n^2)$ ? Please include all calculations.

**Revised version of problem:** On consideration, after running the above, we thought that perhaps the wording of the problem was unfair to GPT. After all, the answer probably has no elegant closed-form expression, and it is not easy to get a highly precise numerical answer (the convergence rate of the naïve summation is  $O(\log(n)/n)$ ). So here is an alternative formulation of the question:

Compute the Shannon entropy of a positive integer  $n$  that's chosen with probability  $\Pr[n] = 6/(\pi^2 * n^2)$  to 3 digit accuracy. Please include all calculations.

17. Assume that IQs are normally distributed, with a mean of 100 and a standard deviation of 15. For which  $n$  does the number of people with IQ  $n$  exceed the number of people with IQ  $n+1$  by the maximum amount? Please include all calculations.
18. Suppose a randomized algorithm outputs the correct answer (yes or no) with probability 0.9. If we take the majority answer out of 100 independent runs, with what probability will the answer be wrong? Please include all calculations.
19. In a Manhattan-like two-dimensional grid, how many distinct shortest paths are there that go from a fixed starting point to a fixed endpoint 5 blocks to the north and 5 blocks to the east? Please include all calculations.
20. When 3-dimensional spheres are packed in their densest possible configuration, what percentage of the space is empty? Please include all calculations.