Order of Magnitude Questions

Integrals are not allowed!

You will be randomly assigned a problem from the list of questions below. You'll have 30 minutes to prepare an answer, then about 15 minutes to present your answer within a group of 3. Please write up your answer and your critique of the answers of your other group members. In your writeup, talk about what assumptions you've made. Talk about what physics is important, what physics might be important but you haven't had time to investigate, and what you think isn't important. If you've had to make up a number, admit it and explain where your guess comes from. If you had more time, what would be the first thing or two you looked up. In your reviews, write up how well you think they did at this, what effects (if any) they didn't consider or didn't treat properly. Are the units correct?

You may freely use Purcell's sheet of useful numbers:
`https://spinlab.me/2023/09/01/purcell-cards-order-of-magnitude-physics/`
Unless otherwise specified, no googling except via instructor/TA.
PLEASE SUBMIT WRITEUPS AS PDFS!

1. **Armored Car Robbery:** How big was the largest robbery of an armored car in history?
2. **Taylor-Sedov:** See picture of the Trinity nuclear test. It has both a size scale and a time stamp. How big was the explosion?
3. **Kursk Explosion:** The Russian nuclear submarine *Kursk* exploded at a depth of 100m in August, 2000. Seismometers detected the explosion via an oscillation at 1.45 Hz. How much energy did the explosion release?
4. **The Law of Urination:** It has been seen observationally that all mammals take about the same length of time to urinate. Estimate this time, and how it depends on the size of the animal.
5. **Hanging Cables:** You want to dangle a very long cable from a very high perch. What's the longest cable you can dangle before it snaps under its own weight?
6. **Bell Centre HVAC:** What are the minimum relevant specifications for the HVAC system at the Bell Centre?
7. **Cyclist Efficiency:** How many miles-per-gallon (or litres/100 km) does a bicyclist get?
8. **Manicouagan Asteroid:** Manicouagan Reservoir is in an asteroid crater in northern Quebec. How big was the asteroid that caused the crater? (you may consult a map of Quebec)
9. **Where the Rubber Meets the Road:** How quickly does a layer of rubber build up on freeways?

10. **U235 Refinement:** Design a centrifuge system that enriches concentrates U235 enough to build a nuclear bomb (natural uranium is 1% U235).

11. **Red Skies:** How long does it take dust from a volcanic eruption to settle out of the atmosphere?

12. **Tay-Sachs:** Until the advent of antibiotics, tuburculosis was a major cause of death in cities. Two copies of the gene that causes Tay-Sachs disease is fatal, but a single copy protects against tuburculosis. Certain populations were not allowed to own land in medieval times, and hence were forced to live in cities. Estimate the incidence rate of Tay-Sachs in such a population, and estimate how long it takes to reach that rate.

13. **Top Gear:** Passenger cars need to be able to safely merge into freeways. What is the typical top speed a car can reach?

14. **Winged Migration:** What's the furthest a bird can fly without stopping?

15. **Go With the Flow:** What is the total flow rate of all the world's rivers? How big is the drainage basin of the Saint Lawrence?

16. **Planetary Defense:** Design a planetary defense laser that can protect the Earth from getting hit by asteroids.

17. **Moonwalking:** Can you run on water on the Moon?

18. **Plowie McPlowface:** What mileage does a snowplow get during a storm?

19. **The Unfriendly Skies:** What are the odds that someone has died on a flight you've taken?

20. **Surf's Up!:** Surfers know that waves come in sets typically of a half-dozen or so, and that the size of the waves changes from day-to-day. The surf report for Oahu's North Shore is 8-10 foot waves at 3 PM on Tuesday Jan. 14, and 4-6 foot waves at 3 PM on Thursday Jan. 16. How big and how far away was the storm that gave rise to these waves? NB - waves heights never exceed 1/7 of their wavelength or they quickly collapse.

21. **Feed Me, Seymour:** You want to water your houseplants while travelling, but don't want to find someone to come into your house. Design a setup that keeps your plants happy by running a thin glass tube from a raised bucket of water.

22. **Hydrogen Atom Size:** Estimate the radius of a $j = 0$ (ground-state) hydrogen atom using only the Heisenberg Uncertainty Principle.

23. **Excited Hydrogen Size:** Estimate the radius of a $j = 1$ (first excited state) hydrogen atom using quantization of angular momentum.

24. **Fighting Fire with Water:** In the Pacific Palisades fire recently, some fire hydrants ran dry while fighting the fires. How many hydrants could be used simultaneously?

25. **Everyone's a Star. Or a Planet.** A few years ago, there was a planned reality-TV show that was going to be Big Brother on Mars. Design a system to broadcast an HDTV stream back to the Earth from Mars.