

CSC 400 Estimation Questions

September 7, 2005

Document your sources and describe your reasoning and assumptions in answering the following questions.

1. It has been proposed that an efficient way to transport material into space would be by a “space elevator”. Basically you place a mass just beyond the geosynchronous orbit point and tether it to the earth with a very strong cable. The centrifugal force of the mass swinging around with earth (once per day) keeps the cable taut and supports its weight. You then run an elevator up and down the cable. The main issue in designing such a device is supporting the weight of the cable. Estimate the cable tensile-strength to mass density factor required to construct such an artifact. Show the calculations - don't just look up someone's answer. What is the strongest steel cable available? By what factor is it too weak? Recently there have been published statements that carbon nanotubes are strong enough to build a space elevator. How strong are carbon nanotubes? Are these statements plausible? Hint: A useful material concept is the longest uniform-diameter cable of that material that could be self-supporting in a uniform gravitational field equal to that at the earth's surface.
2. Estimate the amount of water (per unit area, per crop) to grow wheat in the Sahara desert. If this water came from desalinization plants, what would be its cost using the most efficient available technology? How does this cost compare to the wholesale value of the wheat that could be grown?
3. How many raindrops fall to earth in a year? How long would it take the the world's water supply to be cycled through the atmosphere via rain and snow assuming uniform remixing? What percent of the world's water is retained in reservoirs that have a turnover time significantly exceeding this average?
4. Suppose that in 2030 NASA wants to build a starship that will get one or more astronauts to a nearby star and back within a human lifetime. This means getting the ship up to a significant fraction of the speed of light (say .25 c or so). Suppose that the DOE projects have managed to get fusion working as a practical energy source (i.e. the deuterium/tritium/lithium/helium3 sort) What are the prospects for using this technology to power a rocket vehicle to the required velocity? The critical factor is the ultimate payload to mass ratio needed to achieve a certain rocket velocity change given the energy per unit mass of the propellant. What is the required factor, and is it at all practical to achieve? Remember that the astronauts have to start and stop, and get back. Does stranding the astronauts there, or assuming they can refuel at their destination change anything?