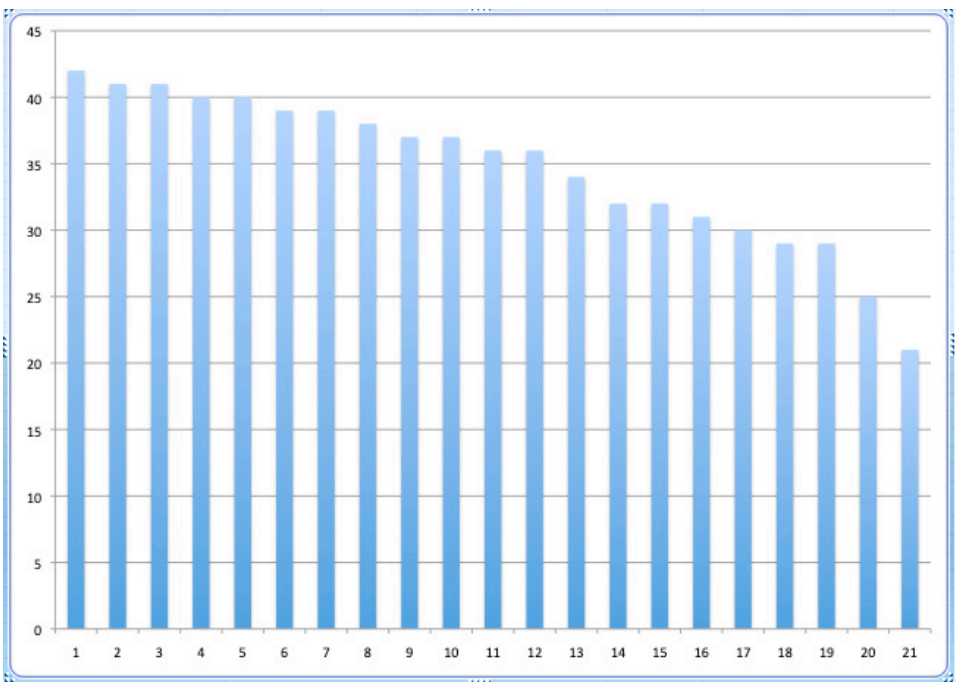
Problem set 2 solutions

A number of people are still evidently uncertain about how bits and bytes relate to how many of them are required to count or store numbers. In particular, if you didn't get close to 15 points on question 3, you 're not yet in command of this part of the material. Make sure you've got this under control – come talk to me or Abby or Francisca soon.

Related: if you did a long series of divisions to find the number of bits in a big number, you're doing it the hard way. Use the powers of 2 / powers of 10 relationships to convert these into basically mental arithmetic.

Lots of arithmetic errors, mostly being off by some power of 10. A surprising number of people slipped up on the number of seconds in an hour. Hint: it's not 60. In general, watch out for careless arithmetic.

Point totals: 18 + 9 + 15 = 42



Problem 1: [6 x 3 pts each]

(a) Hours to send 50 PB at 100 GBps?

50 PB = 50 * 10^15 B = 50 * 10^6 GB. At 100 GB/sec, takes 50 * 10^6 / 10^2 or 50 * 10^4 = 500,000 sec.

There are 3,600 seconds in an hour, so 500,000/3600 ~ **140 hours.**

(b) Transfer rate for sending 50 PB from San Francisco to NYC?

If you assume it takes 35 hours to drive across the country, the rate must be 4 times faster than the 100 GB/sec used above, so **400 GB/sec** is plausible. You could also compute this independently, of course. Either way, since the driving time is a rough estimate, the answer can't have more than a couple of significant figures.

(I realized in retrospect that the capacity of the SD cards was irrelevant here – not intended to confuse.)

(c) How many tractor trailers to hold the 256 GB SD cards?

You could put 10 cards in a cubic inch, and there are (roughly) 2000 cubic inches in a cubic foot, and a typical truck is 50 x 8 x 10 = 4000 cubic feet, so a truck would hold about 10 * 2000 * 4000 = 8 x 10^7 cards; call it 10^8 cards.

10^8 cards x 256 x 10^9 B/card = 250 x 10^17 which is well over 50 x 10^15.
One truck should do it.

(d) Cost of the SD cards?

50 x 10^15 B / (250 x 10^9) = 2 x 10^5 cards at $40 each is $40 x 2 x 10^5 or $4 x 2 x 10^6 or about **$8 million**.

(e) How many DVDs for 50 PB?

50 x 10^15 / 5 x 10^9 = 10 x 10^6 = **10 million.**

(f) How high is the stack of DVDs?

10^7 x 1 mm = **10^4 meters.**

Problem 2: [3 x 3 pts]

(a) How many times do you need to fold the map?

4000 km is 4 million meters = 2^22 meters. But we have to fold it on both x and y axes, so **44 folds.** A fair number of people only folded on one axis, or didn't double the other axis, properly leading to answers like 22 and 34.

(b) How thick will the folded map be?

2^44 x 0.1 mm = 0.1 x 2^4 x 2^40 = 1.6 x 10^12 mm ~
1.6 x 10^9 meters = 1.6 x 10^6 km

(c) Is 0.1mm right for paper thickness, and why?

A standard ream of 500 sheets of paper is about 5 cm or 50 mm, so this is **about right.**

Problem 3: [5 x 3 pts each]

(a) (i) How many bits for a unique id for each US car, and why?

330M Americans, probably somewhat fewer cars. 2^27 is about 130M, 2^28 is over 250 M, 2^29 is over 500M. **28 is reasonable.**

(ii) How many bytes for this number?

4 bytes (no fractions)

(iii) How many bytes if we add Canadian cars?

Canada is about 1/10 of the US population, so it would probably be **28 or 29 bits and thus still 4 bytes.**

(b) (i) What range of digits on your fingers and thumbs?

2^10 possibilities, **so 0 to 1023.** I really wanted to see 1023, to remind you that there are 1024 values, but as numbers they go from 0 to 1023.

(ii) What range if you can also use toes?

0 .. 2^20-1. No need to spell out the exact power.