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Solutions for Fermi Questions, March 2021

Larry Weinstein
Old Dominion University, lweinste@odu.edu

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Fermi Questions

Larry Weinstein, Column Editor
Old Dominion University, Norfolk, VA 23529
weinstein@odu.edu

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► Question 1: Flat screens

How much total space did we save by switching to flat screen TVs and monitors? (*Thanks to Jalopnik via Robert Friedhoffer for suggesting the question.*)

Answer: To estimate this we need to estimate the number of TVs and monitors in the U.S. and the volume saved per screen. Everybody in the U.S. has at least one and at most 10 screens, so we will take the geometric mean and estimate 3 per person. At a U.S. population of 3×10^8 , this gives 10^9 total screens in the U.S.

In the far distant past when we used cathode ray tubes for TV screens and computer monitors, they were a lot thicker and heavier than modern flat screens. At the time, a large screen would have been 2 ft across. At an aspect ratio of 4:3, it would have been 1.5 ft tall, and therefore about 1.5 ft deep, giving it a volume

$$V = lwh = (2 \text{ ft})(1.5 \text{ ft})(1.5 \text{ ft}) = 5 \text{ ft}^3.$$

Those are horrible units. Let's switch to metric. 2 ft is a bit more than 0.5 m and 1.5 ft is a bit less, giving a per-screen volume of

$$V = lwh = (0.5)^3 \approx 0.1 \text{ m}^3,$$

or 0.3 m^3 per person. Since flat screens are, um, flat, we will neglect their volume. Thus, switching to flat-screen TVs and monitors saved the average person 0.3 m^3 . That does not seem like much.

This means that the total space saved in the U.S. is

$$V_{\text{tot}} = (3 \times 10^8 \text{ people})(3 \text{ screens/person})(0.1 \text{ m}^3/\text{screen}) \\ = 10^8 \text{ m}^3,$$

which is rather a lot. Of course it is a lot. Most numbers become large when multiplied by country-sized populations.

However, volume is probably not the best metric. The screens take up more volume than they actually displace, because they need to be supported from below and because it is hard to place things over them. Therefore we will consider area instead. The area saved per screen is about $3 \text{ ft}^2 = 0.3 \text{ m}^2$. The cost of a house is typically more than \$100 and less than \$1000 per square foot, giving an estimate of \$300 per square foot. This means that the three screens per person occupy 10 ft^2 , at a capital cost of \$3000.

That is a lot.

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► Question 2: Volleyball travel

How far does a volleyball travel during a typical volleyball game?

Answer: To estimate this we need to estimate how far the ball travels during each trip over the net, how many times it crosses the net for each point, and how many points per game. The ball travels about 30 feet per trip (more than 10 ft and less than 60 ft) and crosses the net about five times per point (more than once and less than 20 times). This gives a total distance traveled of 150 ft or 50 m.

The first team to get to 25 points wins, but the winning team must win by two points. Thus, the minimum number of points in a game is 25 and there is no maximum. We will ignore the extra points of close games and use 48 points as the maximum. This gives a practical average of 40 points per game.

Thus, the volleyball travels a total distance of

$$d = (40 \text{ points})(50 \text{ m/point}) \\ = 2 \times 10^3 \text{ m} \\ = 2 \text{ km}$$

No wonder it's tired.

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