

Fermi Questions Quiz 8-18-18

1. If the energy in a bolt of lightning could be completely harvested, how many bolts would need to be harvested in order to meet the United States' annual electricity demands?

Answer: the annual electricity demands of the US is $1.4E19$ joules. A bolt of lightning on average contains about $5E9$ joules. Dividing the two yields about $3E9$ bolts. FA=9.

2. If all bolts that strike the Earth were harvested, how many seconds would it take to harvest the bolts in the previous question?

Answer: according to the *Encyclopedia of World Climatology* (2005), lightning strikes the Earth at an average rate of approximately 45 bolts per second. Dividing the $3E9$ bolts by the rate of 45 bolts/second yields approximately $6E7$ seconds. FA=8.

3. A ship over the deepest point in the Great Lakes sends an acoustic pulse downwards to measure the depth. How many seconds does it take for the signal to return?

Answer: deepest is in Lake Superior at around 400 m. The signal would therefore have to travel 800 m. The speed of sound in (fresh)water is approximately 1,500 m/s. Therefore, the pulse would take a little over $5E-1$ seconds to return. FA=0.

4. How many newtons would an adult elephant weigh on Mars?

Answer: elephants generally have a mass of about 3,500 kg. On Earth's surface, the gravitational acceleration of about 10 m/s^2 results in a force of about 10 newtons for each kilogram. Therefore, the weight of an elephant on Earth is about 35,000 N. Mars' surface gravity is only approximately 40% of that of Earth, meaning the gravitational force is only 40% as strong, resulting in a weight of about 14,000 newtons. FA=4.

5. What is the momentum, in $\text{kg}\cdot\text{m/s}$, of a golf ball-sized hailstone?

Answer: a golf ball-sized hailstone has a terminal velocity of about 30 m/s. It has a diameter of about 4.5 cm, or a radius of about 2.3 cm, which gives a volume of about 45 cubic cm for the hailstone. With a density of about 0.93 g/cc for ice, the hailstone will have a mass of about 40 grams, or 0.040 kg. Multiply this mass by the velocity to find a momentum of about $1.2 \text{ kg}\cdot\text{m/s}$. FA=0.