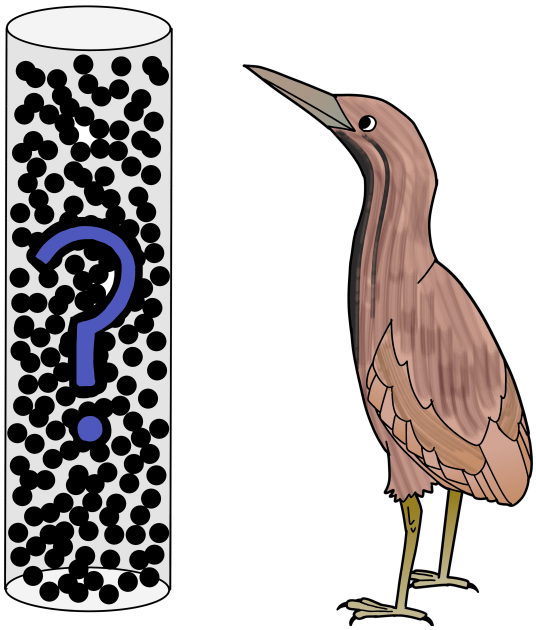
Science Olympiad
Fermi Questions C
BirdSO Invitational

March 7-13, 2021



Solutions

Written by:
Andrew Zhang, *azhang941@gmail.com*
Caleb Chiang, *calebrong@gmail.com*
Robert Lee, *robertyl@ucla.edu*

Feedback? **Test Code**: *2021BirdSO-FermiQuestionsC-Chickadee*

1. How many nanoseconds did it take you to read this sentence?

   $\boxed{9}$ 11 words $/250$ wpm $\cdot\, 60 \times 10^9$ ns min^{-1}.

2. Compute (Larry Bird's Jersey #)^{100}.

   $\boxed{152}$ This is 33^{100}. We compute $100(\log 3 + \log 11)$, which gives the answer after rounding.

3. How many years would it take to walk from the SF Bay in California ... to New York Island?

   $\boxed{-1}$ according to Google Maps.

4. How many Sonic Chili Dogs (Chili Cheese Coney) would Klebb have to eat in order to replenish all the calories he burned while walking to New York?

   $\boxed{3}$ Travel $\sim$ 3000 miles $\cdot$ 100 kcal per mile / 420 kcal per chili dog.

5. How many words are on the Wikipedia page for "Bird"?

   $\boxed{4}$ It's about 21000.

6. What is the population of China minus the population of the United States?

   $\boxed{9}$ $1.398 \times 10^9 - 328.2 \times 10^6 = 1.0698 \times 10^9$.

7. What is the average number of windows in a house?

   $\boxed{1}$ It is definitely less than 50 windows but more than 5.

8. How many ways can 15 unique books be arranged on a three-shelf bookcase? Assume 5 books can fit on each shelf.

   $\boxed{12}$ 15 ways to arrange the books, so $15! = 1307674368000$. The three shelves are a red herring.

9. How many atoms of gold are in one carat of 24-karat gold?

   $\boxed{21}$ $0.200\,\text{g}/196.966\,\text{g mol}^{-1} \cdot 6.022 \times 10^{23}\,\text{atoms/mol} = 6.11 \times 10^{20}\,\text{atoms}$

10. On average, how many packages did Amazon deliver everyday in 2019?

    $\boxed{7}$ Amazon delivered 3.5×10^9 packages in 2019. Dividing by 365 days gives 9589041.1 packages a day.

11. What is the distance to the sun in meters?

    $\boxed{11}$ $1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$

12. How many kilograms of gold can you buy with Elon Musk's net worth?

    $\boxed{6}$ 162.4 billion dollars / 56323 dollars per kg of gold $= 2.88 \times 10^6$ kg of gold

13. How many helium balloons do you need to lift a human being?

    $\boxed{4}$ Helium can lift an average of $30\,\text{g}/\text{ft}^3$. An average 12 inch latex party balloon can hold about $850\,\text{in}^3$, or $0.492\,\text{ft}^3$. The average American male, over 20 years of age, weighs 196 pounds, or 88 900 g. $88\,900\,\text{g}/30\,\text{g}/\text{ft}^3/0.492\,\text{ft}^3 = 6026$ balloons.

14. How many πgeons are there worldwide?

    $\boxed{8}$ From Google, it's more than 400 million.

15. How many questions are there on this test?

    $\boxed{2}$ There are 60.

16. Klebb generates a string of 10 letters, with each letter having a probability of being generated equal to that letter's relative frequency in English. What is the probability of Klebb generating the string `meadowlark`?

    $\boxed{-14}$ This is $0.0253 \times 0.1251 \times 0.0804 \times 0.0399 \times 0.076 \times 0.0192 \times 0.0414 \times 0.0804 \times 0.0612 \times 0.0067$.

17. How many feathers weigh a slug?

    $\boxed{6}$ A feather weighs about 0.01 grams, or about 6×10^{-7} slugs.

18. How many KFC buckets filled with 12 pieces of chicken would fit inside the Earth?

    $\boxed{23}$ Assume the KFC bucket is about a cylinder with radius 10 cm and height 20 cm, and the Earth's volume is approximately $10^{12}\,\mathrm{km}^3$.

19. How long is a footlong in furlongs?

    $\boxed{-3}$ by definition.

20. How many fortnights of Fortnite have been played, ever?

    $\boxed{8}$ Apparently it's about 10 million years, which gives the answer when converted for fortnights.

21. What is the probability of having a negative IQ, assuming IQ's distribution is indeed normal centered at 100?

    $\boxed{-11}$ This is cumulative on the normal distribution for $z-$scores $z \leq \frac{-100}{15}$.

22. How loud, in $\mathrm{W/m}^2$, would the Sun be to you if all of the Sun's total power output were converted completely to sound energy and you decided to stand on Mercury? Assume that empty space suddenly got filled with air ... somehow.

    $\boxed{4}$ The calculation, by the inverse square law, is about $3.8 \times 10^{26}\,\mathrm{W}/(4\pi \cdot (6.8 \times 10^{10}\,\mathrm{m})^2)$.

23. On a perfect scale, one side is occupied by a blue whale. How many blue jays would have to sit on the other side to make the scale balanced?

    $\boxed{6}$ This is about $10^5\,\mathrm{kg}$ / $0.085\,\mathrm{kg}$.

24. Tall Vincent stands on top of Mount Everest, and he is confused about where he is. Is he dreaming? Or is the air just so thin that he's getting lightheaded? He screams, for he does not know. His scream can be abstracted as a point source emitting sound. Assuming the Earth is completely flat aside from the mountain and he can scream loud enough, how many seconds would it take for his scream to reach the ears of his friends in New York City?

    $\boxed{4}$ This is about $1.2 \times 10^7\,\mathrm{m}$ / $331\,\mathrm{m\,s}^{-1}$.

25. How many 500-mL bottles of water would be needed to fill a tub the size of Bangladesh up to 1 cm?

    12 This is about $1.5 \times 10^{15}\,\text{cm}^2 \cdot 1\,\text{cm} \,/\, 500\,\text{mL}$.

26. How many grams of potassium permanganate can be produced from the potassium in one apple? Assume there is infinite permanganate.

    0 0.195 grams of potassium in an apple. The molar masses of potassium and potassium permanganate are $39.0983\,\text{g}\,\text{mol}^{-1}$ and $158.034\,\text{g}\,\text{mol}^{-1}$ respectively. $0.195 \,/\, 39.0983 \cdot 158.034 = 0.788\,\text{g}$.

27. How many *Universe* superyachts are needed to span the observable universe?

    25 The diameter of the Universe is $8.8 \times 10^{26}\,\text{m}$ and the length of the *Universe* superyacht is 74 m. Dividing the two results in 1.189×10^{25}.

28. How many atoms of gold are on the James Webb Space Telescope?

    23 There are 48 grams of gold on the telescope and the molar mass of gold is $197\,\text{g}\,\text{mol}^{-1}$. Dividing the two and multiplying by Avogadro's number gets 1.5×10^{23} atoms.

29. A 1 cm cube of Jell-O is smacked by a typical spoon. What is the frequency at which it vibrates, in hertz?

    1 One can imagine smacking a small piece of Jello. In one second, it should jiggle at least 5 times, but less than 50 times.

30. How many vegetable slices are in one serving of ratatouille in the movie *Ratatouille*?

    1 It's definitely less than 50 and more than 5.

31. How many pinheads can you glue on the surface of a pinball?

    3 The radius of a pinball is 27 mm and the radius of the flat end of a pinhead is 1.5 mm. $(4\pi \cdot 27^2)/(\pi \cdot 1.5^2) = 1296$.

32. What is π^{19}?

    9 It's about 2.8×10^9.

33. If an AA battery is collected from every person in California, how many milligrams of aluminum can be electrolyzed from molten aluminum oxide with the total charge?

    10 There are 39.51×10^6 people in California and 5000 coulombs per AA battery. There are 96500 coulombs per mole of electrons and it takes 3 electrons to electrolyze one atom of aluminum. Finally, the molar mass of aluminum is $27\,\text{g}\,\text{mol}^{-1}$. $39.51 \times 10^9 \cdot 5000/96500/3 \cdot 27 \times 10^3 = 1.84 \times 10^{10}\,\text{mg}$.

34. What is the number of shirts on the shelves of a typical Walmart?

    3 Somewhere around 500 to 5000 shirts seems reasonable.

35. How many practicing orthodontists are in Iowa?

    2 The population of Iowa is about 3.155 million, and there are about 3.27 orthodontists per 100,000 people in the US. $31.55 \cdot 3.27 = 103.1685$ orthodontists.

36. How many Sverdrups is the entire global input of fresh water from rivers to the oceans?

    $\boxed{0}$ According to the Wikipedia page of Sverdrup, 1.2.

37. Shuckle is a weak pokemon ... or is it? Under optimal conditions in a triple battle, how much damage could shuckle theoretically do in one attack?

    $\boxed{9}$ A level 100 Shuckle, two Helping Hands, use of metronome, power trick, skill swap to pure power, ice type conversion, +6 attack, -6 defense on the opponent, sunny weather, both allies with flower gift, the use of defense curl, 5th turn of ice ball, perfect IVs and nature for both Shuckle and the opponent, and forest's curse being applied on opponent against a level 1 Noibat results in 721,899,685 damage.

38. How many molecules are there in Earth's atmosphere?

    $\boxed{44}$ From Google, 1.04×10^{44}.

39. How many miles of interstate highways are there in the US?

    $\boxed{4}$ From Google, 46,876 miles

40. My friend Aidan and I decide to play rock-paper-scissors. Assuming the results are truly random, find the probability that I do not lose a single game to Aidan after 100 games.

    $\boxed{-18}$ $(2/3)^{100} = 2.45 \times 10^{-18}$

41. Find Hubble's constant in units of hertz.

    $\boxed{-18}$ Convert $67.4\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ to $\mathrm{m\,s^{-1}\,m^{-1}}$, which is the same as $\mathrm{s^{-1}}$ or Hz): 2.18×10^{-18}

42. By what factor is the electrostatic force between a proton and electron greater than the gravitational force between the proton and electron?

    $\boxed{39}$ $\frac{kq_1q_2/r^2}{Gm_1m_2/r^2} = \frac{kq_1q_2}{Gm_1m_2} = \frac{8.99 \times 10^9 \cdot 1.6 \times 10^{-19} \cdot 1.6 \times 10^{-19}}{6.67 \times 10^{-11} \cdot 1.67 \times 10^{-27} \cdot 9.11 \times 10^{-31}} = 2.27 \times 10^{39}$

43. How many barns (units) would it take to cover the floor of a barn (building)?

    $\boxed{30}$ An average barn is around $300\,\mathrm{m^2}$ and a barn is $10 \times 10^{-28}\,\mathrm{m^2}$ so about 3×10^{30} unit barns are needed.

44. What is $10^{10^{10^{10^{-100}}}}$?

    $\boxed{10}$ Using a calculator, we get 10^{10}.

45. The Richter scale measures the strength of an earthquake, where the magnitude scales logarithmically with energy. The equation is $\log E = 11.8 + 1.5M$ where E is in ergs and M is the magnitude. How many tons of TNT would it take to release the same amount of energy as a 100 magnitude earthquake?

    $\boxed{145}$ $10^{161.8}$ erg after plugging in 100 into magnitude, one erg is 10^{-7} J so $10^{154.8}$ J. A ton of TNT is 4.184×10^9 J or about $10^{9.62}$. Subtracting the powers results in $10^{145.18}$ or about 1.6×10^{145}.

46. How many prime numbers p are there less than 10^{2020} such that $p+2$ and $p+4$ are also prime?

    $\boxed{0}$ Considering mod 3, notice that $p,\ p+2,\ p+4 \equiv p,\ p+2,\ p+1 \bmod 3$. Thus the only possibility is $(3, 5, 7)$.

47. Compute (10!)!

    $\boxed{22228104}$ Good luck.

48. How many possible teams of six Pokémon are possible made up of only Smogon's Red/Blue/Yellow OU Pokémon, considering species and four-move movesets?

    $\boxed{8}$ There are 15 mons, with an average of 31.8 moves each, so the answer is $\binom{31.8}{4} \times \binom{15}{6}$.

49. How many trees would you have to chop in order to create enough sheets of paper folded into paper airplanes that equal the mass of the US Air Force's personnel?

    $\boxed{6}$ 1 tree = 8000 sheets = 36000 g = 36 kg and 330000 people · 70 kg = 23100000 kg. Dividing gives the answer.

50. An unfair coin lands on heads a third of the time. What is the probability to flip it 50 times and get 15 tails and 35 heads, in percent?

    $\boxed{-5}$ $\binom{50}{15} \cdot (1/3)^{35} \cdot (2/3)^{15} \cdot 100 = 1.0274 \times 10^{-5}\,\%$.

51. How many Straits of Gibraltar are needed to equal their net flow to the volumetric production rate of Coca-Cola drinks?

    $\boxed{-4}$ Coke produces 1.8×10^9 coke drinks per day and each drink has a volume of $0.355 \times 10^{-3}\,\mathrm{m}^3$. Multiplying gives a flow rate of $6.39 \times 10^5\,\mathrm{m}^3\,\mathrm{d}^{-1}$. The average flow rate of the Strait of Gibraltar is $0.038 \times 10^6\,\mathrm{m}^3\,\mathrm{s}^{-1}$ and multiplying gives a flow rate of $3.28 \times 10^9\,\mathrm{m}^3\,\mathrm{d}^{-1}$. Dividing the two gives 1.95×10^{-4}.

52. Your friend George has come up with an ingenious plan to create sustainable energy. He develops the Gravitational Energy Collector (GEC) which collects 100% of the potential energy of a falling object. Since he wants this to be sustainable, he decides to use the GEC in a mango orchard. How many mango trees are needed to power the entire Western Interconnection?

    $\boxed{15}$ The Western Interconnection has a energy consumption of 883 TWh and mulitplying by 3600 gives $3.2 \times 10^{18}\,\mathrm{J\,yr}^{-1}$. Estimating that each mango tree produces 150 mangoes a year, each mango is 200 g, and that each one falls a distance of 5 m, we get a production of 1471.5 J per year per tree. Dividing gets 2.160×10^{15} trees.

53. Cellulose is an extremely strong polymer. A rod of pure cellulose is fabricated with a length of 2 m and a diameter of 5 cm. If a compressive force of 7 kN is applied to its ends, how much does it contract by, in meters?

    $\boxed{-4}$ Young's modulus of cellulose is 130 GPa, which gives:

$$\frac{7000 \cdot 2}{130 \times 10^9 \cdot (\pi/4 \cdot 0.05^2)} = 5.5 \times 10^{-5}\,\mathrm{m}.$$

54. In a different universe, the speed of light is ten thousand times greater than the speed of light. With everything else staying the same, what is the Planck length of the other universe, in meters (from this universe)?

    $\boxed{-41}$ Planck length is 10^{-35} and it's proportional to $c^{-3/2}$, so it's modified by a factor of 10^{-6}.

55. 1, 3, 3, 9, 27, 243, 6561 ... Find the 20th number in this sequence.

    1994 The pattern is 3^{F_n}, where F_n is the sequence of Fibonacci numbers.

56. According to the holographic principle, the maximum amount of information (in bits) that can be stored in a system is proportional to the surface area. Hawking found that the maximum entropy (or information) can be found by $S = kA/4$, where k is the Boltzmann's constant (1.3×10^{-23} JK) and A is the surface area in Planck areas. Using this equation, how many times more information can a human body theoretically hold than the human body already holds through the storage of DNA? Assume there are 40 trillion human cells that contain DNA.

    24 Equation source. The conversion of m^2 to Planck area is 3.828×10^{69}. $1.9\,\mathrm{m}^2$ is the average surface area of a human. There's 1.5×10^9 bytes of data in a human cell and 8 bits in a byte.

$$\frac{1.3 \times 10^{-23} \cdot 1.9 \cdot 3.828 \times 10^{69}/4}{1.5 \times 10^9 \cdot 40 \times 10^{12} \cdot 8} = 4.92 \times 10^{22}$$

57. If human beings give off infrared light with a wavelength of 1 mm, how many photons will the entire current population of the earth give off in 1 galactic year?

    49 The average person gives off 100 W. Infrared photons are around 1 mm wavelength and has about 1.99×10^{-22} J of energy per photon. The world population is 7.67×10^9 and 1 galactic year is 250 Myr. $100 \cdot 7.67 \times 10^9 \cdot 3 \times 10^7 \cdot 2.5 \times 10^8 / 1.99 \times 10^{-22} = 2.89 \times 10^{49}$ photons.

58. Given: Schwarzschild radius, $r = \frac{2GM}{c^2}$ where G is the gravitational constant, M is the mass of the black hole, c is the speed of light, and r is the radius of the black hole. Calculate the volume in liters of a perfect sphere of water so that there is just enough water to form a black hole. Assume that the density stays constant.

    38 Density is mass divided by volume, so:

$$\rho = \frac{M}{\frac{4\pi}{3}\left(\frac{2GM}{c^2}\right)^3} = \frac{3Mc^6}{32\pi G^3 M^3} = \frac{3c^6}{32\pi G^3 M^2}.$$

    Density of water is $1\,\mathrm{g\,cm^{-3}}$, $1\,\mathrm{kg\,L^{-1}}$, or $1000\,\mathrm{kg\,m^{-3}}$. Equating these two, we get $7.33 \times 10^{79}/M^2 = 1000$, so $M = 2.7 \times 10^{38}$ kg. From the density of water, there must be 2.7×10^{38} L of water.

59. A dumb hole (or a sonic black hole) is a type of black hole where phonons rather than photons are unable to escape. After expanding/compressing the universe's radius to create a dumb hole, what is the radius of the new universe (in meters)? Take into account baryonic matter, dark matter, and dark energy. Assume the dumb hole to be surrounded by dry air at 20 degrees Celsius.

    39 Use $\frac{2GM}{c^2}$ but replace c^2 with the speed of sound squared. The mass of the Universe without dark energy or matter is 1.5×10^{53} kg and the universe is 4% baryonic matter, so total mass-energy is 3.75×10^{54} kg. $2 \cdot 6.67 \times 10^{-11} \cdot 3.75 \times 10^{54}/343^2 = 4.25 \times 10^{39}$ m.

60. Pick an integer from 1 to 300 inclusive. The answer will be the product of the answers to this question from all teams that answer this question.

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