

Problem Solving and Estimation Challenge Problems

Problem 1: *Fermi Problem*

One of the moons of Jupiter, Europa, is reported to have its surface covered by an ocean of water which is 100 km deep. The outermost 8 km are frozen as ice. The radius of Europa is approximately $\frac{1}{4}$ the radius of the earth. Estimate the pressure at the bottom of Europa's ocean. (Note: there is some speculation that the combination of internal heat and water makes the ocean of Europa the best candidate in the solar system outside the earth for organized life to evolve.)

Problem 2: Estimating Distances

- a) Hold a dime at arm's length. What angle in radians is subtended by the diameter of the dime?
- b) Using your result from part a), estimate the length of the infinite corridor at MIT. In order to do this, choose a reference height at one end of the corridor and estimate its height. Then go to the other end of the corridor and measure what fraction of the diameter of the dime corresponds to your reference height. You can now calculate the length of the corridor by using similar triangles. The length is published by MIT. Can you find the published value?
- c) Now use your dime and wait until the moon is out (the moon is full on Sept. 10) to try and estimate the angular diameter of the moon. Once you have this estimate, what additional information would you need in order to estimate the mass of the moon? Make some estimates regarding these additional quantities and then estimate the mass of the moon. Look up the actual value and compare it with your estimate. How did you do?

Problem 3: *Ice Age*

In a recent publication of *Nature*, Australian scientists determined that during the last ice age (22,000 to 19,000 years ago) the sea level reached its low point, 425 to 440 feet below the present level due to the change of seawater to glacial ice. What approximate volume of ice would this correspond to?

Please do not immediately search for the answer on the web (the problem will not be graded by the answer but by your approach). Outline a strategy for your estimation i.e. describe any assumptions that you make or estimations, identify any relevant quantities that you may need to make a reasonable estimate. The goal here is to base your estimates only on information that you already know without having to look anything up on the web or in some textbook. Then calculate your result. Decide by comparison to other volumes whether you think your estimate is reasonable.

Problem 4: *Estimation: average density of matter in galaxy*

Estimate the average density of matter (average mass per unit volume) in the Milky Way Galaxy. Please do not immediately search for the answer on the web (the problem will not be graded by the answer but by your approach). Outline a strategy for your estimation, describe any assumptions that you make, estimate or look up or search any relevant quantities that you may need, and calculate your result. Then search the web for a current estimate and compare with your estimate. How accurate were you? In particular try to identify how accurate your estimate was of each of your relevant quantities.

Problem 5: Mass in Universe

The density of luminous matter in the universe is currently estimated to be about $(5 \times 10^{-28} \text{ kg} \cdot \text{m}^{-3})$ which is about 1/10 the critical density necessary to keep the universe from expanding indefinitely. Estimate the total mass in the universe.

Problem 6: Circular Motion Estimation

- a) Estimate the speed of a MIT student in Room 26-152 undergoing circular motion about the earth's axis of rotation.
- b) Estimate the magnitude of that student's acceleration.
- c) Estimate the speed (in SI units) of the earth in orbit around the sun.

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8.01SC Physics I: Classical Mechanics

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