Section 9: Cosmos

1. Density Comparison

Instead of just stating the difference, calculate the average density of the Solar System (mass $\approx M_{Sun}$, volume within Pluto's orbit ≈ 40 AU) versus the Milky Way galaxy (mass $\approx 10^{12} M_{Sun}$, volume $\approx$ disk 100kly $\times$ 1kly). Compare the orders of magnitude.

2. Galactic Geometry

The Milky Way galaxy has a diameter of about 100,000 light-years and a thickness of about 1,000 light-years. What is the ratio of its diameter to its thickness?

3. Cosmic Timeline

How long after the Big Bang did the Cosmic Microwave Background (CMB) radiation originate? What temperature did the universe cool to at that moment (approx.)?

4. Fermi Estimation

The Milky Way contains approximately 200 billion stars. If these were distributed equally among Earth's 8 billion people, how many stars would each person get?

5. Space Travel Kinetics

The minimum distance from Earth to Mars is about 55 million km. How long would it take a spacecraft traveling at a constant speed of 40,000 km/h to reach Mars?

6. Galactic Collision

The Andromeda galaxy is about 2.5 million light-years away and is moving towards our Milky Way at about 110 km/s. Estimate how long it will be until the two galaxies collide.

7. Light Delay

A message is sent from Earth to a probe orbiting Jupiter, which is 600 million km away. How long does the message take to arrive? (Use the speed of light, $c \approx 3 \times 10^8$ m/s).

8. Astronomical Units

What is an "Astronomical Unit" (AU)? Express the average distance from Earth to the Sun in kilometers and light-minutes.

9. Expansion Evidence

What specific observation of distant galaxies (redshift) made by Edwin Hubble led to the conclusion that the universe is expanding?

10. Solar Light Time

How long does it take for light from the Sun to reach Earth?