

Section 10: Astronomy and Astrophysics

1. Scale Comparison

How many times farther is the Sun from Earth compared to the Moon from Earth? (Sun-Earth distance $\approx 150 \times 10^6$ km; Moon-Earth distance $\approx 384,000$ km).

2. Angular Size

Calculate the angular size (in degrees) of the Sun and the Moon as seen from Earth. Sun's diameter $\approx 1.39 \times 10^6$ km; Moon's diameter $\approx 3,474$ km. Why do they appear to be roughly the same size?

3. Rotational Velocity

Calculate the linear speed (in km/s) of a point on the Earth's equator due to its rotation. Earth's radius ≈ 6378 km.

4. Orbital Mechanics

Calculate the orbital speed of the International Space Station (ISS), which orbits at an altitude of approximately 400 km above the Earth's surface. (Earth's mass $M_E \approx 5.97 \times 10^{24}$ kg).

5. Microgravity

What is the acceleration due to gravity (g) at the altitude of the ISS (400 km)? Why do astronauts experience a state of "weightlessness" despite this gravity?

6. Geostationary Orbit

Satellites in geostationary orbit remain above the same point on Earth. What must their orbital period be? Calculate the altitude of a geostationary orbit above the Earth's surface.

7. Escape Velocity

What is the escape velocity from the surface of the Moon? (Moon's mass $M_M \approx 7.35 \times 10^{22}$ kg; Moon's radius $R_M \approx 1,737$ km).

8. Solar Gravity

Calculate the acceleration due to gravity on the surface of the Sun. By what factor would your weight increase if you could stand on its surface? (Sun's mass $M_S \approx 2 \times 10^{30}$ kg; Sun's radius $R_S \approx 6.96 \times 10^8$ m).

9. Stellar Density

A white dwarf star has a mass roughly equal to the Sun's mass but a radius similar to the Earth's radius (~ 6371 km). What is the average density of such a white dwarf?

10. Megastructures

A "Dyson Sphere" is a hypothetical megastructure that completely encompasses a star to capture its energy output. If the mass of Mercury (3.3×10^{23} kg) were used to build a solar panel sphere with a surface density of 10 kg/m^2 , what would be the radius of the sphere?