

- **Speed of light** is constant in all frames of reference. It is denoted by c and is approximately 3×10^8 m/s.
- **Time dilation** occurs when an object moves at a significant fraction of the speed of light. Time appears to pass slower for the moving object relative to a stationary observer. The formula for time dilation is $\Delta t = \gamma \Delta t_0$, where $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$.
- **Length contraction** occurs when an object moves at a significant fraction of the speed of light. The length of the object appears to contract in the direction of motion. The formula for length contraction is $L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$.
- **Relativity of simultaneity** states that events that are simultaneous in one frame of reference are not simultaneous in another frame moving relative to the first.
- **Mass-energy equivalence** is expressed by the equation $E = mc^2$, where E is energy, m is mass, and c is the speed of light.
- **General Relativity** extends the principles of special relativity to include gravity. It describes gravity as the curvature of spacetime caused by mass and energy.
- **Gravitational time dilation** occurs because time passes slower in a stronger gravitational field. This is a consequence of the curvature of spacetime.
- **Gravitational redshift** occurs when light waves are stretched as they escape a gravitational well, resulting in a shift towards longer wavelengths (lower frequencies).
- **Black holes** are regions of spacetime where gravity is so strong that nothing, not even light, can escape. They are formed by the collapse of massive stars.
- **Event horizons** are the boundaries of black holes. Once an object crosses the event horizon, it is inevitably drawn towards the center.
- **Gravitational waves** are ripples in the fabric of spacetime caused by the acceleration of massive objects, such as merging black holes.
- **Dark matter** is a form of matter that does not interact with electromagnetic radiation, making it invisible. It is inferred from its gravitational effects on visible matter.
- **Dark energy** is a mysterious form of energy that is thought to be driving the accelerated expansion of the universe.
- **Big Bang theory** describes the origin and evolution of the universe, starting from a hot, dense state and expanding over time.
- **Cosmic Microwave Background (CMB)** is the remnant radiation from the Big Bang, providing a snapshot of the early universe.
- **Redshift** is the increase in wavelength (or decrease in frequency) of light as it moves away from the observer. It is used to measure the distance of galaxies.
- **Hubble's Law** states that the distance to a galaxy is proportional to its redshift, indicating that the universe is expanding.
- **Galaxies** are large systems of stars, gas, and dust held together by gravity. They come in various shapes and sizes, including spiral, elliptical, and irregular.
- **Galaxy clusters** are groups of galaxies bound together by gravity. They are the largest gravitationally bound structures in the universe.
- **Superclusters** are large-scale structures consisting of multiple galaxy clusters.
- **Large-scale structure** refers to the overall distribution and organization of matter in the universe on the largest scales.
- **Dark matter halos** are the extended regions of dark matter that surround galaxies and galaxy clusters, providing the gravitational scaffolding for visible matter.
- **Lambda-CDM model** is the current standard model of cosmology, which includes dark matter and dark energy.
- **Future of the universe** depends on the amount of dark energy and dark matter. Possible scenarios include a "Big Freeze" (heat death), a "Big Crunch" (collapse), or a "Big Rip" (tearing apart).

Questions for Oral Answers

1. **What is the speed of light and why is it important in relativity?**
2. **How does time dilation occur and what is the formula for it?**
3. **What is the difference between special relativity and general relativity?**

