

CSS-2016

What is Tsunami? How the tsunamis are generated and what are their characteristics.

Ans:

Tsunami

Tsunami is a Japanese word which means "Harbour wave". According to NOAA (National Oceanic and Atmospheric Administration):

"A tsunami is a series of extremely long waves caused by a large and sudden displacement of the ocean, usually the result of an earthquake below or near the ocean floor."

Formation of Tsunami

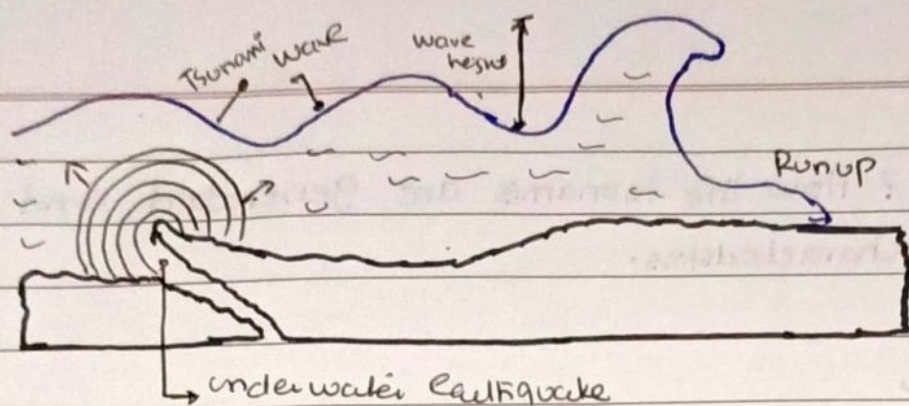
The formation of tsunami involves several stages - Following are the stages which produce tsunami -

(i) Triggering Event:

It is the event which initiates the process of tsunami - It could be an underwater earthquake, volcanic eruption or land slide that disrupt the ocean floor.

(ii) Vertical displacement:

The triggering event causes a sudden vertical displacement of the ocean floor, displacing large volume of water vertically.



(iii) Creation of waves:

The displaced water form waves that radiate outward from the initial disturbance.

(iv) Propagation:

The waves generated travel at high speed across the ocean, sometimes reaching speed upto 800 km/hr.

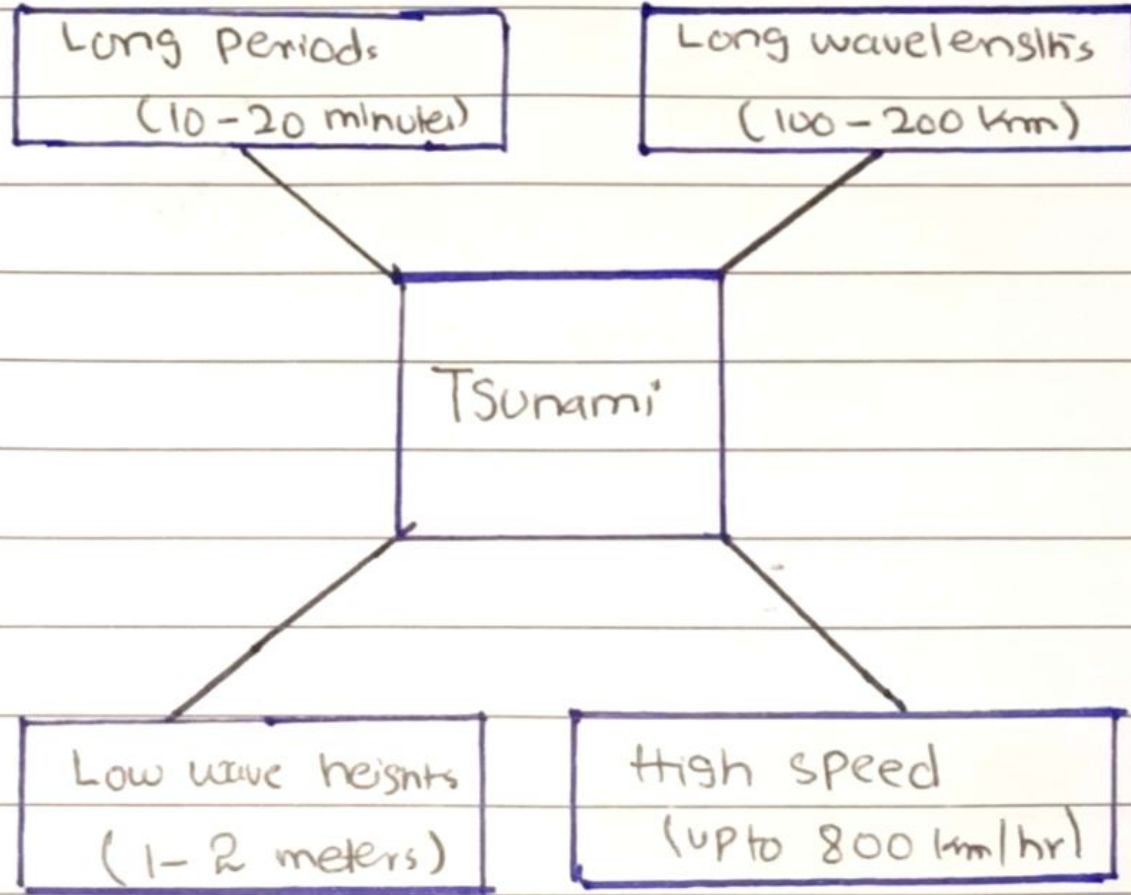
(v) Shoaling:

As the waves approach shallow coastal water, their speed decreases, but the height increases significantly due to the compression of wave energy.

(vi) Runup:

Finally, the waves reach the coastline, where they surge inland, causing widespread flooding and destruction.

Characteristics Of Tsunami



CSS-2016

What is an earthquake? Discuss Richter Scale - What was the magnitude of earthquake in Pakistan dated 26 Oct 2015 and what was its focus?

Earthquake

An Earthquake refers to the shaking of the earth's surface caused by a sudden release of energy within the earth's crust. This release of energy generates seismic waves which cause earthquakes.

Cause of an Earthquake

Earthquake happens when earth's tectonic plates suddenly slip. These plates move because of convection current underground. When these plates move and push against each other, friction builds up, but the pressure eventually becomes too much causing the plates to slip. This slip releases a lot of energy and creates an earthquake.

The point underground where an earthquake originates is called

Richter Scale

Charles F. Richter, a seismologist, created an earthquake magnitude measuring scale using the logarithm of

The largest seismic wave's amplitude to base 10, which is termed as Richter scale. This scale was invented in 1935 to record magnitude upto 7.0, now it is extended up to 10.0.

Formula of Richter scale

$$M_L = \log_{10} A - \log_{10} A_0(\delta) = \log_{10} [A/A_0(\delta)]$$

Where;

M_L = Magnitude of Earthquake

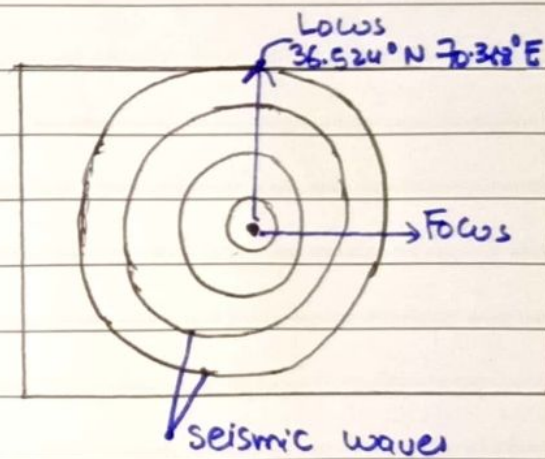
A = maximum excursion of the wood-Anderson seismograph

A_0 = epicentral distance

δ = station

Earthquake in Pakistan

The magnitude of earthquake in Pakistan dated 26 October 2015 was 7.5. The locus (location on Earth's surface directly above the origin point) of earthquake was $36.524^\circ N$ $70.368^\circ E$.



CSS - 2017

Differentiate between the occurrence of solar and lunar eclipse-

Eclipse

Eclipse is an astronomical event that occurs when an astronomical object is temporarily obscured, by passing into the shadow of another body or by having another body pass between it and the viewer.

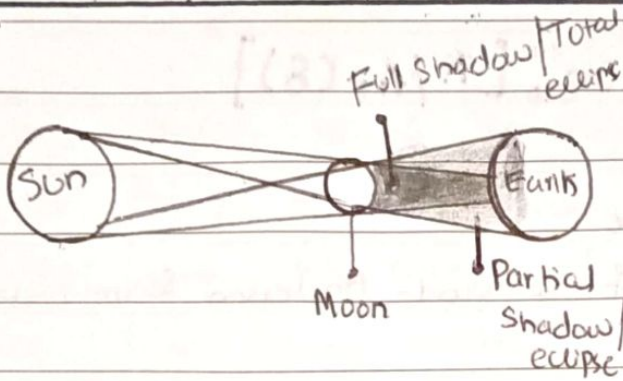
Solar Eclipse

A solar eclipse happens when the Moon passes between the Sun and Earth, casting a shadow on the Earth that either fully or partially block the Sun's light in some areas. This is called solar eclipse-

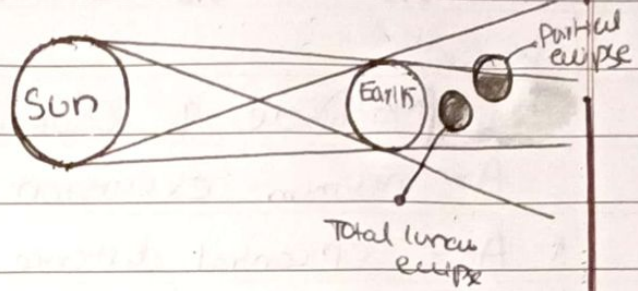
Lunar Eclipse

A lunar eclipse happens when the Earth passes between the Sun and Moon, casting a shadow on the Moon that either fully or partially block the Sun's light. This is called lunar eclipse-

Solar Eclipse



Lunar Eclipse



As per NASA: The maximum number of solar eclipses (Partial, Annular or total) is 5 per year, Total ^{solar} eclipse happen about once or twice a year.

As per NASA: At least two partial lunar eclipses happen every year, but total lunar eclipses are rare.

It is not safe to look at a solar eclipse with the naked eye.

It is safe to look at a lunar eclipse with naked eye.

It lasts for about 5 to 7 minutes.

It lasts for about hours.

It can be seen in a few places.

It can be observed in many places.

It occurs during a new moon phase.

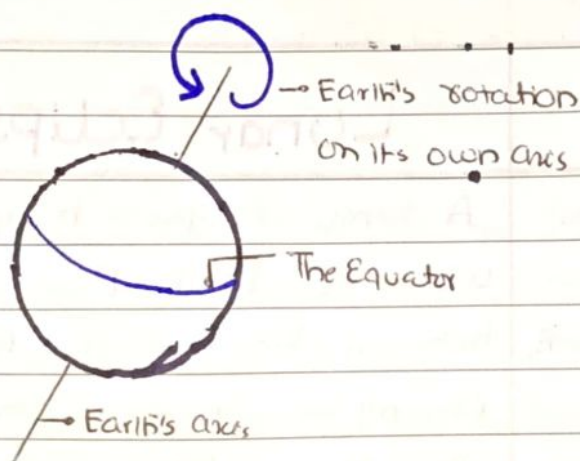
It occurs during a full moon phase.

CSS-2017

Briefly Explain, what effects are produced due to the rotation and revolution of earth.

Rotation of Earth

The spinning movement of a body around a central point (axis) is called rotation. Earth rotates from west to east (counter clockwise) on its axis.



Earth complete its rotation in 23 hrs 56 minutes and 4 secs \approx 24 hrs

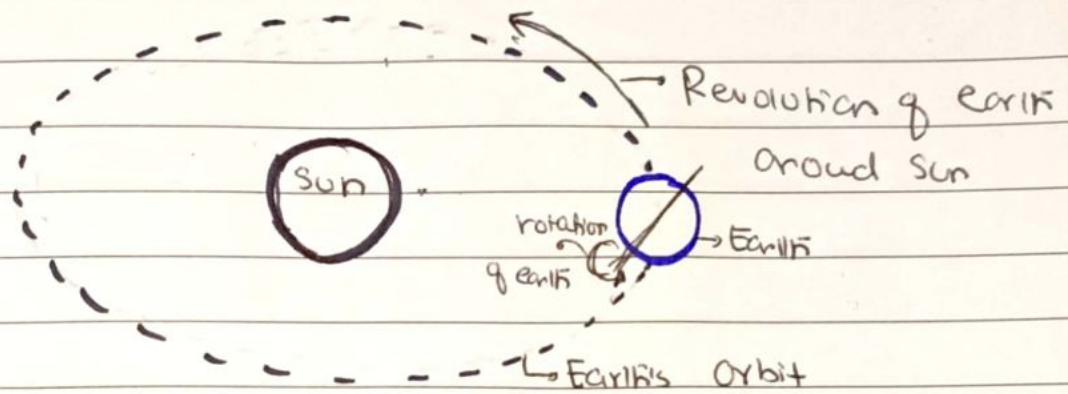
Effects Produced due to Earth's Rotation

- ① Rotation of Earth creates a cycle of daylight and darkness, determining our 24 hrs day.
- ② It creates CORIOLIS Effect; In this effect winds and currents are deflected to the right in northern hemisphere and left in southern hemisphere.
- ③ It leads to formation of equatorial bulge due to centrifugal force.

- ④ It also effects Climate and weather patterns.

Revolution of Earth

Revolution refers to the orbital motion of an object around another object. In the context of earth, the movement of the earth around the sun in a fixed path is called revolution of earth.



Earth revolves from west to east and takes 365.25 days to complete one revolution.

Effects Produced due to Earth's Revolution

- ① Earth's revolution causes seasons
- ② It causes perihelion (earth's shortest distance from sun) and aphelion (farthest distance of earth from sun)
- ③ It has direct effect on the varied length of day and night.

2018

Describe different methods to estimate the age of the universe.

Methods to Estimate Age of the Universe

Scientists have long been curious about the age of the Universe and how much time has elapsed since the Big Bang. Today, scientists estimated that the age of the Universe is approximately 13.8 yrs. But how did scientists estimate how old the Universe is and are they sure of that number? There are primarily two methods to estimate the age of the Universe.

Age of Universe

Age of the oldest star

Expansion rate of Universe

(i) Age of the oldest Star (Ancestral Star)

The first method to estimate the age of the Universe is to look to the oldest stars. The universe can't be younger than its oldest star. Therefore, to narrow down the age of the Universe, scientists measure the ages of the very first stars that formed in the Cosmos (universe). The life cycle of a star depends on its mass, with high mass stars burning fuel at a faster rate and therefore dying out faster. While low mass stars can live up to 20 billion years. Globular clusters are a dense stellar collection of around a million stars which all formed roughly around the same time. These clusters can then serve as time keepers for the Universe. By determining the masses of their stars, scientists can estimate when the globular cluster formed. The oldest

Globular Cluster contains stars that are 0.7 times less massive than the Sun, which suggests that they are b/w 11 to 18 yrs old.

(ii) Expansion Rate of the Universe

The Universe expansion rate is known as the Hubble Constant which is estimated at 46,200 mph per million light years. The Hubble Constant was first calculated in the 1920s by American astronomer Edwin Hubble after discovering that several galaxies were moving away from Earth. Based on Hubble's observation, the astronomers came up with Hubble's law, which shows a correlation b/w how far an object is and the speed at which it is receding. Using Hubble law, Scientists were able to estimate the expansion rate of the Universe. Scientists use the Hubble Constant to estimate the age of the Universe by working backward, all the way back to the Big Bang. This extrapolation depends on the current density & composition of the Universe. In 2012 NASA's Wilkinson Microwave Anisotropy Probe used that data and it was found that Universe is 13.772 billion years old. A year later, the European Space Agency's Planck Spacecraft estimated that the Universe's age to be 13.82 billion years.

2018

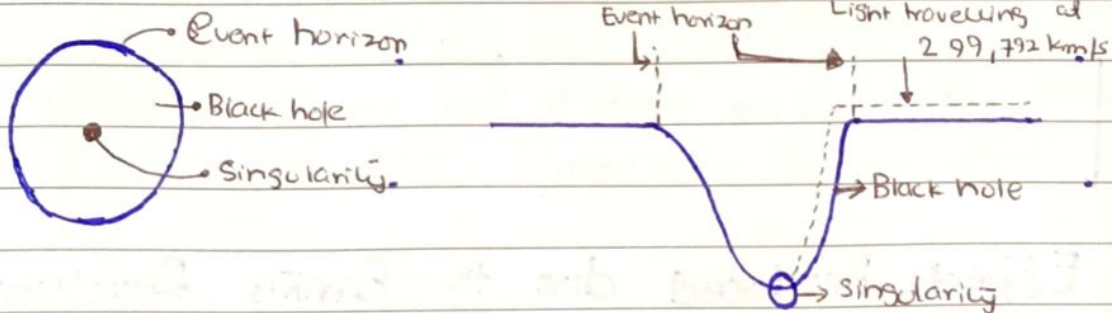
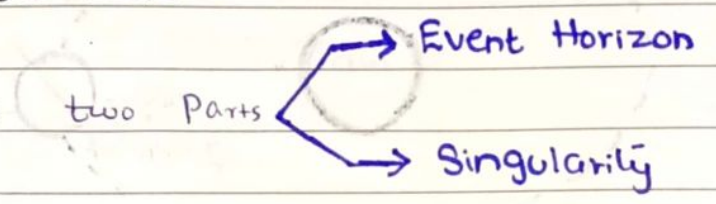
Define Black hole - What is expected inside it.

Black Hole

Black holes are among the most fascinating and mysterious objects in our universe. A black hole is a region in a space, where the force of gravity is so strong, not even light, the fastest known entity in our universe, can escape -

Inside Black Hole

Black holes have two parts



① Event Horizon

Event horizon is a boundary of a black hole. It is the region around a black hole where the gravitational pull is so strong that nothing, not even light can escape its grasp.

Once an object crosses the event horizon, it is forever trapped inside the black hole. It is like a "cosmic point of no return", where the laws of physics cannot apply.

② Singularity

Some black holes trap more and more material as their mass increases. The point where all the mass is trapped is called singularity. It is infinitely small but its influence is enormous.

2018

Explain the term Dark matter and Dark energy.

Dark matter

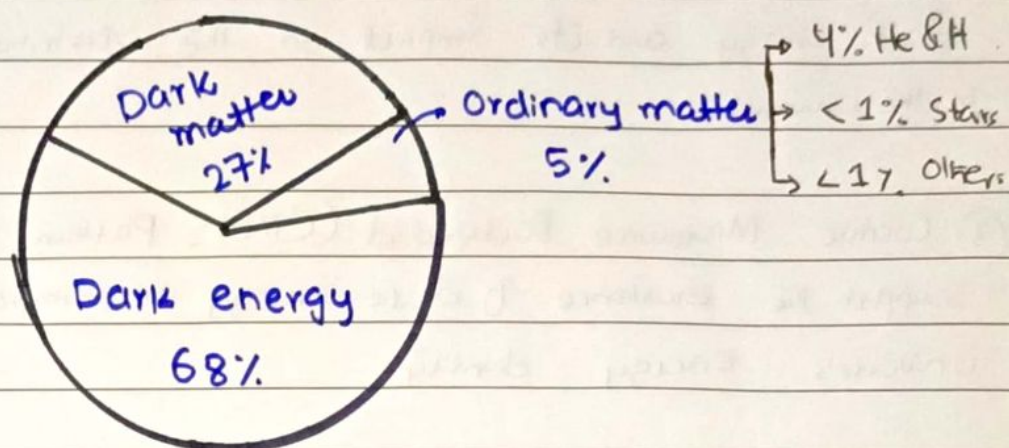
Dark matter is a mysterious substance that makes up about 27% of the universe. It does not emit, absorb, or reflect light, that is why it is "dark" and hard to detect directly. Instead, its presence is inferred through its gravitational effects on visible matter, galaxies and cosmic microwave background radiation. The concept of dark matter arose from the observation that the visible matter in galaxies couldn't account for the observed gravitational forces holding them together.

Evidences Supporting Dark matter existence

- ① Galactic Rotation Curves: Stars and gas in galaxies move at speeds inconsistent with visible mass alone, suggesting the presence of unseen matter (dark matter).
- ② Gravitational Lensing: Light bending around massive objects indicates the presence of additional unseen mass (dark matter).
- ③ Cosmic Microwave Background (CMB): Patterns in the CMB suggest the existence of dark matter, inferred from its gravitational effects on the early universe's evolution.

Various other theories propose different evidences of presence of dark matter. Despite decades of research, its true nature

Remains one of the biggest mysteries in astrophysics.



Composition of the Universe - NASA

Dark Energy

Dark energy is also a mysterious force that makes up about 68% of the universe, which exerts gravitational attraction, dark energy behaves like a repulsive force, causing the universe's expansion to accelerate. The existence of dark energy was inferred from observations of distant supernovae in the late 1990s. These observations revealed that the rate of expansion of the universe is increasing over time, contrary to what was expected based on gravitational pull of visible matter and dark matter alone.

Evidences supporting Dark energy existence

- ① Supernovae Observations: Distant supernovae, particularly Type 'Ia' supernovae, revealed the accelerated expansion of the universe.

② Gravitational Lensing: Observations of gravitational lensing effects provide additional evidence for the presence of dark energy and its impact on the distribution of matter in the universe.

③ Cosmic Microwave Background (CMB): Patterns in the CMB support the existence of dark energy as a component of the universe's energy density.

In addition to above theories, a large number of other theories were suggested by space scientists for presence of dark energy. However, the exact nature of dark energy too is still not fully understood, and it represents one of the most significant puzzles in the cosmology.

CSS-2018

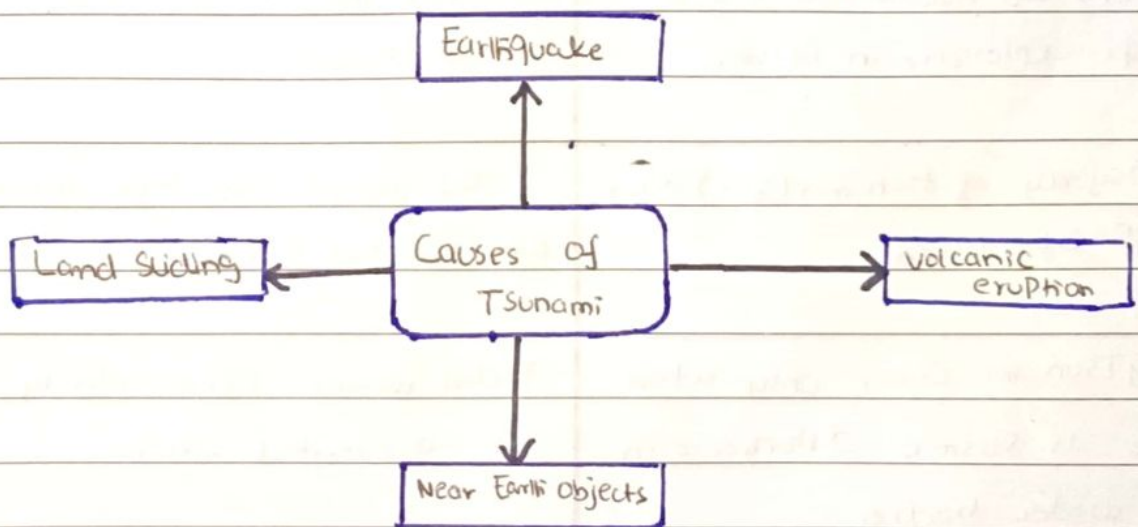
Describe different causes of Tsunami. Is there any difference b/w a Tsunami and tidal wave? Name the worst Tsunami ever recorded.

Tsunami

Tsunami is a Japanese word which means 'Harbour wave' - According to NOAA (National Oceanic and Atmospheric Administration):

"A tsunami is a series of extremely long waves caused by a large and sudden displacement of the ocean, usually the result of an earthquake below or near the ocean floor."

Causes of Tsunami



Most tsunamis are caused by an earthquakes on convergent tectonic plate boundaries - According to Global Historical Tsunami Database, since 1900, over 80% of tsunamis are generated by earthquakes. However tsunamis are also caused by other activities too, such as undersea volcanic eruption, undersea land sliding and near earth objects (asteroids, comets) colliding with or exploding above the ocean.

Tsunami Vs. Tidal Wave

Tsunami and tidal wave both are sea waves, but there are two different phenomena.

Tsunami	Tidal Wave
Tsunamis are generated by earthquakes, Land sliding, volcanic eruptions and due to near earth objects explosion in oceans.	Tidal waves are generated by the gravitational force of the Sun and the moon exerted on the oceans.
A majority of tsunamis (80%) occur in the Pacific ocean.	Tidal waves are seen most at coastal areas.
Tsunami occur only when there is seismic disturbance in large water bodies.	Tidal waves occur daily at a coastal area.

Worst Tsunami ever Recorded

According to NOAA:

The 26, December, 2004 tsunami was the deadliest tsunami on record. It was caused by a 9.1 magnitude earthquake that occurred 18 miles below the ocean floor on the coast of the Indonesian island of Sumatra in the Indian Ocean. The tsunami reached as high as 167 feet (51 meters) and caused flooding up to three miles.

That day the impacts were observed in 17 countries in South-eastern and Southern Asia to Eastern and Southern Africa. It caused 230,000 deaths, the displacement of 1.7 million people, and roughly \$13 billion 2017 dollars economic loss.

2019-CSS

How can the Sun have strong gravitational field if it is made of gases?

Gravitational Field

A gravitational field is a region where a mass experiences a force due to gravitational attraction.

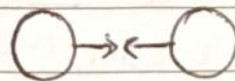
Factors affecting gravitational field.

Following factors affect gravitational field.

i) Mass :

If mass increases, the force of gravity increases.

If mass increases, gravitational field increases.

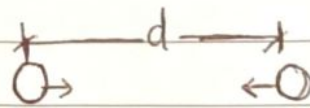


$$F \propto m$$

ii) Distance :

If distance increases, the force of gravity decreases.

If distance increases, gravitational field is decreased.



$$F \propto \frac{1}{d}$$

How the Sun have Strong Gravitational field

The Sun is a massive ball of mostly hydrogen and helium gases held together by its own gravity. Gravity is a fundamental force of nature that depends on the mass of an object; the more massive an

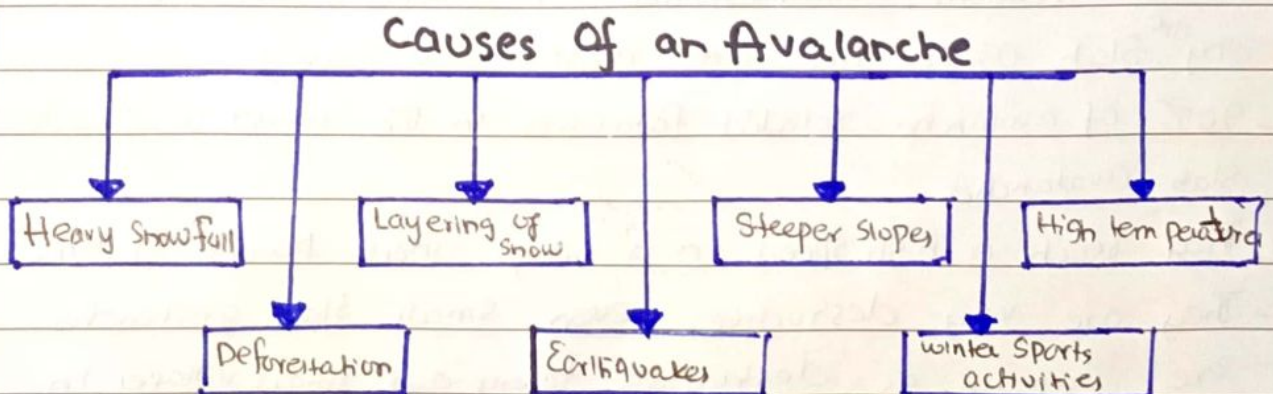
object is, the stronger. Its gravitational pull- The Sun is massive than all planets in the solar system, this is why despite of gaseous ball it has strong gravitational field through which the Sun attracts all planets and keeps the planets in orbit around it.

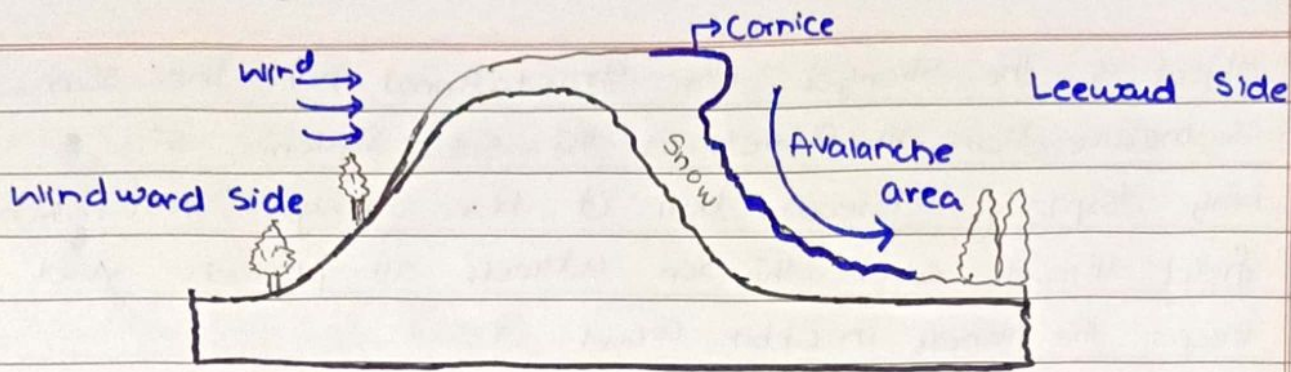
CSS-2020

On 7th April 2022, an Avalanche hit a Pakistan military base in Gayani sector trapping 140 soldiers and civilians under deep snow - What is Avalanche, describe its four types with focusing most dangerous type.

Avalanche

Avalanche is a French word which means "descent". It is a natural disaster where a large mass of snow, ice and debris slides down a mountain slope, often causing destruction and posing danger to people and infrastructure in its path.





Types of an Avalanche

(i) Loose Snow Avalanches

Loose snow avalanches happen when poorly bounded surface snow slides downhill under its own weight. Sometimes called a Sluffs. There are generally small and often triggered by small disturbances such as skiers or snowboarders.

(ii) Slab Avalanches - The most dangerous type

Slab avalanche occurs when a cohesive layer of snow (slab) slide over a weaker layer beneath. It is caused by weather conditions, human activities or natural disasters i.e. Earthquake.

Why ^{are} Slab avalanches are most dangerous -

- 90% of avalanche-related fatalities in the world is due to Slab avalanche.
- They reach a high speed in a very short period of time.
- They are very destructive, even small slab avalanches are capable of destroying forests and small villages in

the area.

(iii) Wet Snow Avalanches

Wet snow avalanches occur when the snowpack loses its strength due to warming temperatures or rain.

(iv) Powder Snow Avalanches

It is a combination of loose snow and slab avalanche. The bottom half consists of a slab, ice, and air, while the upper half has a cloud of powdered snow. It is common in mountainous regions.

- It can cross 190 miles/hr speed.

2020 - CSS

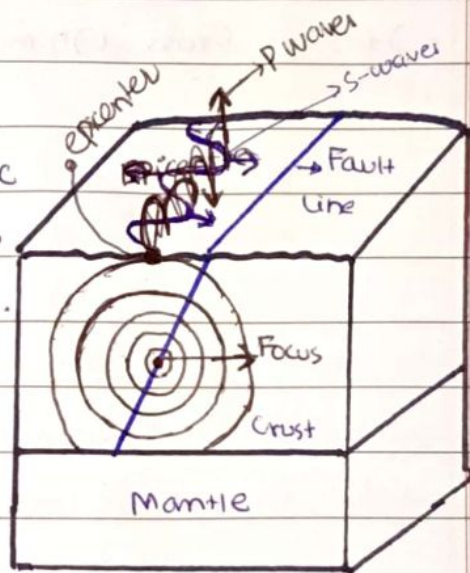
World's largest earthquake was assigned a magnitude of 9.5 by the U.S. Geological Survey on 22 May 1960 in Southern Chile Valdivia - What do you know about earthquake - Also explain shallow focus and deep focus earthquakes.

Earthquake

An earthquake refers to the shaking of earth's surface caused by a sudden release of energy within the earth's crust - This release of energy generate seismic waves, which trigger the earthquake.

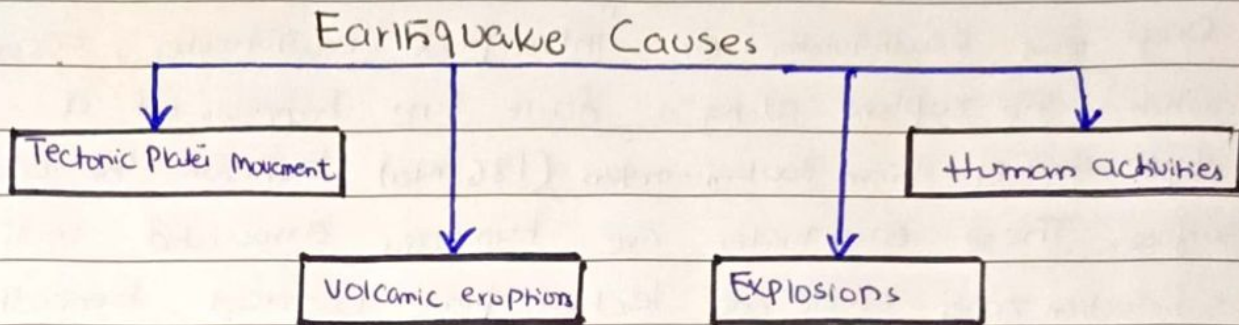
Mechanism of an Earthquake

Earthquakes happen when the Earth's tectonic plates suddenly slip. These plates move because of convection currents underground. When these plates meet and push against each other, friction is developed. But the pressure eventually becomes too much, causing the plates to slip. This slip releases a lot of energy which creates an earthquake.



The place underground where an earthquake originates is called focus or hypocenter, while the location above on the earth's surface directly above the focus is called epicenter.

Causes Types of Earthquake



Measurement of Earthquake

The magnitude of an earthquake is measured by ~~seismograph~~ Richter Scale, while for tracing the seismic waves, seismograph is used.

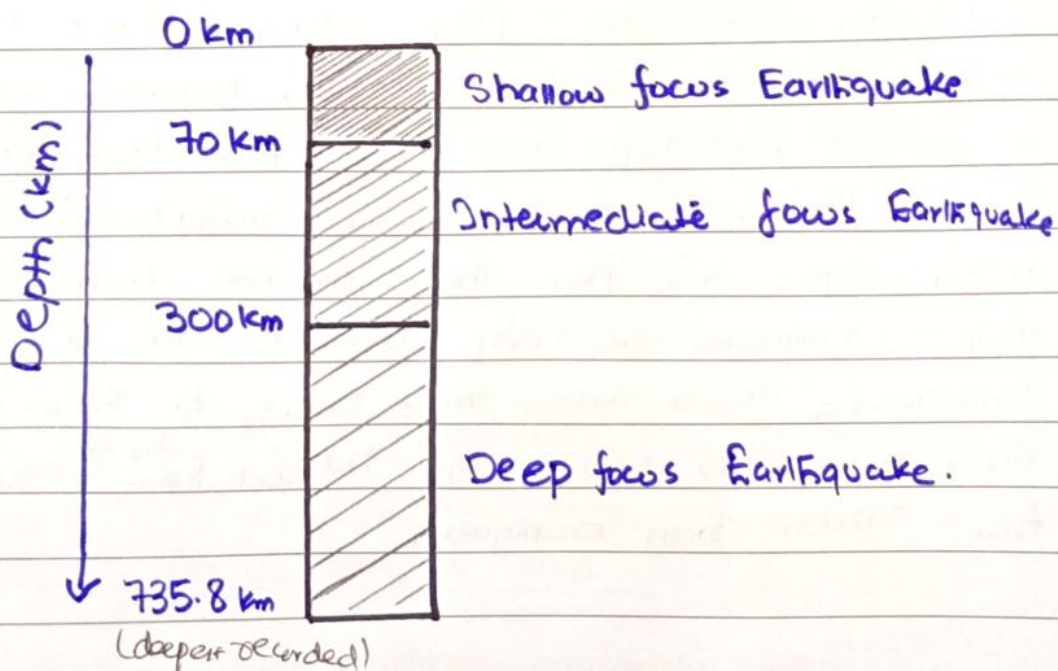
Shallow Focus Earthquake

Shallow focus earthquakes are commonly occurring "Coastal" earthquakes, caused by rupture along a fault line happens relatively close to the Earth's surface, typically within 70 kilometers (43 miles) deep. These occur quite frequently and at random. However, being of smaller magnitude^(1 to 5) and at lesser depths, very often they are not even felt. But these earthquakes are very destructive due to its shallowness which allows more energy to reach the surface. About 75% of the total energy released ^{due to} from earthquakes is from shallow-focus earthquakes.

Deep focus Earthquake

Deep focus earthquakes or "intra plate" earthquakes, occurs when the rupture along a fault line happens at a depth greater than 300 kilometers (186 miles) beneath the Earth's surface. These earthquakes are typically associated with subduction zones where one tectonic plate is forced beneath another. Their magnitude ^{usually} lies between 6 to 10. Deep-focus earthquakes are less common than shallow focus ones but can still produce significant seismic activity. Due to their depth they often cause less surface shaking and are less likely to cause damage compared to shallower earthquakes, although they can be still be felt over large distances.

The deepest earthquake ever recorded was of magnitude 4.2 in Vanuatu at a depth of 735.8 km (457.2 miles) in 2004.



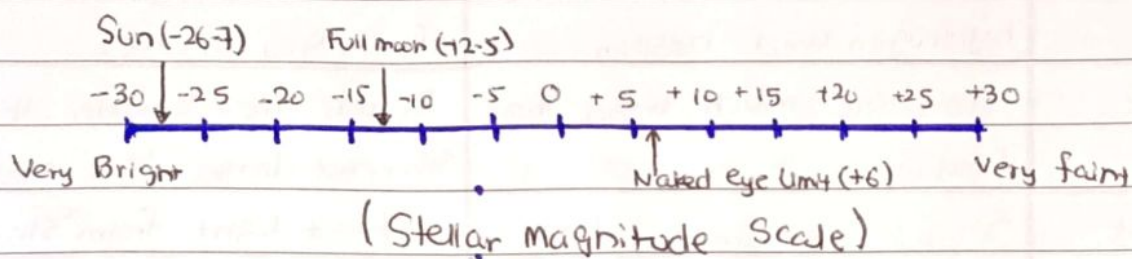
CSS-2021

Differentiate between a star and a planet - what is the magnitude of a star and how the colour of stars is correlated with their temperature.

Aspect	Star	Planet
Definition	A star is a celestial body that possesses ^{own} light.	A planet is a celestial body that does not have own light.
Composition	Stars are mostly composed of hydrogen and helium.	Planets are made up of rock, gas, or ice.
Size	Stars are much bigger than planets.	Planets are smaller than stars, but larger than moons.
Light	Stars emit light and heat.	Reflect light from star.
Orbit	Stars do not orbit other objects.	Planets orbit a star or another celestial body.
Temperature	Stars have high temperature.	Planets have low temperature.
Life cycle	Stars have life cycle.	Planets do not have life cycle.
Gravity	Stars have high gravitational force that allow planets to orbit it.	Planets have less gravitational force than stars.
Energy	Stars emit energy ^{from} through nuclear fusion reactions.	Planets do not emit energy from nuclear fusion.
Examples	Sun, Sirius, Betelgeuse, Alpha centauri etc.	Earth, Mercury, Mars, Jupiter etc.

The magnitude of a Star

The measure of the brightness of a star is called the magnitude of a star. It is measured with a stellar magnitude scale that ranges from -30 to +30. On this scale the brightest object has the smallest number, and the faintest object has the largest number. For example, the object of magnitude -20 is brighter than the object of magnitude +20.



Nexus between Stars Color and Temperature

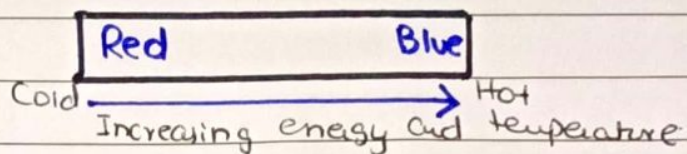
The color of a star is dependent on the surface temperature of star. In turn, the temperature indicates how much energy a given area of the star's surface radiates into space every second.

According to Planck's Equation: $E \propto \frac{1}{\lambda}$

where: E = energy and λ = wavelength of emitted light

Hence, the stars with a low wavelength have high energy

as well as high temperature, and thus are hot - Blue light stars are the hottest stars - While the stars with a high wavelength have low energy and low temperature, thus are cold - Red stars are the coldest coolest stars -



Example of Hot star: Sirius

Example of Cold star: Betelgeuse.

CSS-2021

Briefly describe the most popular and accepted theory about the origin of the universe.

Universe

Universe can be defined as, "The space and time in which galaxies, stars, planets and other celestial bodies are, as well as the laws and physical constants that govern them"

Origin of the Universe

There are various theories to explain the origin of the universe. However, the most popular and accepted theory is "The Expanding Universe Theory" or "Big Bang Theory".

Big Bang Theory

Georges Lemaitre, Belgian cosmologist proposed the Big Bang theory. The theory states the following points:

1- Origin

The current and past matter in the universe came into existence at the same time, roughly 13.8 billion years ago. At that time, all matter was compacted into a very small ball with infinite density and intense heat called a singularity.

2. Expansion

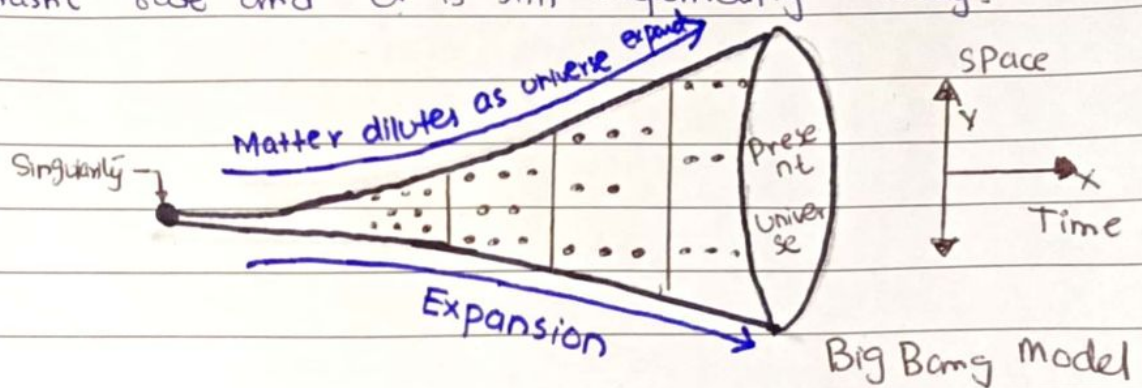
Suddenly, the singularity began expanding, and the universe that we know was born.

3. Formation of Elements

After the initial expansion, the universe cooled down, allowing atoms to form, leading to the creation of galaxies, stars and planets.

4. Continual Expansion

The universe kept on growing at a fantastic rate and it is still expanding today.



Evidences of Big Bang Theory

- ① The light from distant galaxies is red shifted, which means galaxies are moving away from us.
- ② Cosmic background ^{microwave} radiation also supports Big bang - Arno Penzias and Wilson detected a cosmic microwave background radiation while studying radio signals - These radiations are received from all parts of the universe and is thought to be heat left over from the big bang.

CSS-2021

What do you know about volcanoes - Discuss causes & effects of volcanic eruption.

Volcanoes

Volcanoes are opening on the surface of a planet or Moon that allows material warmer than its surroundings to escape from its interior. When this material escapes, it causes an eruption (eruption includes lavas, rocks and gases). An eruption can be explosive, sending material high into the sky or it can be calmer, with gentle flows of material.

Causes of Volcanic Eruptions

Volcanic eruptions occur when material significantly warmer than its surrounding erupts onto the surface. On the Earth, erupted material can be lava, ash, rocks, cinders or gases. There are three prime reasons for raising magma and cause eruption onto the Earth's surface.

1- Rifting

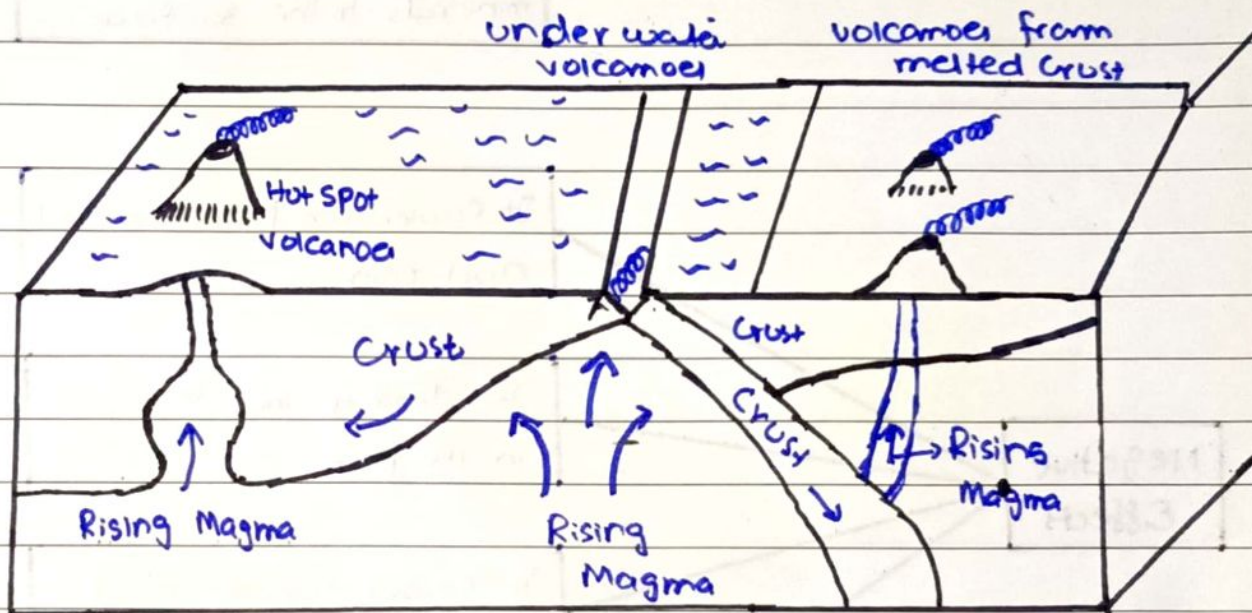
In this phenomena, the pieces of Earth's crust called tectonic plates slowly move away from each other. The magma rises up to fill in the space. This rising of magma causes eruptions. When this happens under water volcanoes are formed.

2- Subduction

In this process, the tectonic plates move towards each other. When this happens part of Earth's crust can be forced deep into its interior (mantle) - The high heat and pressure cause the crust to melt and rise as magma causing volcanic eruption.

3- Hotspots

These are hot areas inside the Earth. These hotspots heat up magma as a result of magma become less dense. Thus it rises due to lesser dense causing eruption.



Effects of Volcanic Eruption

Positive Effects

Where sites close to magma is close to surface can be used to produce geothermal energy.

Ash ejected by the volcano acts as a good fertilizer.

Volcanoes attract tourists thus improve economy.

Rising magma brings valuable minerals to the surface.

Negative Effects

It causes air pollution and acid rain.

It destroys the things in its path.

It causes vision and respiratory problems.

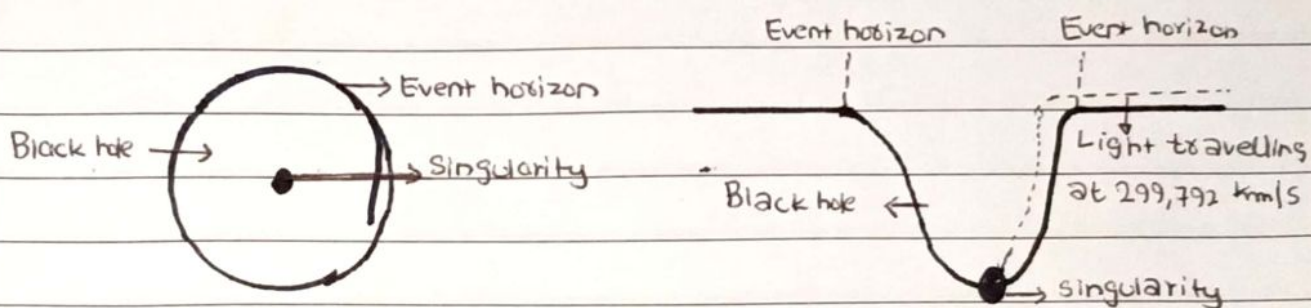
It can trigger tsunamis and earthquakes.

CSS-2023

What is black hole? How it is formed and discovered.

Black Hole

Black holes are among the most fascinating and mysterious objects in our universe. A black hole is a region in space, where the force of gravity is so strong, not even light, the fastest known entity in our universe can escape. The boundary of black hole is called event horizon, a point of no return, beyond which we truly cannot see. When something crosses the event horizon, it collapses into black hole singularity. Singularity is infinitely small, infinitely dense point where laws of physics do not apply.



Discovery of Black Hole

Albert Einstein predicted black holes in 1916 with his theory of relativity, but the term "black hole" was coined by John Wheeler in 1967.

The first black hole spotted was Cygnus X-1, in 1964.

1964 by astronomer using X-ray detection on a sounding rocket. In 1971, it was confirmed that the X-rays ^{were} originated from a bright blue star orbiting a strange dark object, believed to be a black hole consuming material from the star.

Formation of Black Hole

Black holes are formed when massive stars run out of fuel and collapse under their own gravity. When a star's core collapses, it produces a supernova explosion, leaving behind a dense core. If the core is massive enough, it collapses into a singularity, creating a black hole.

