TARGET PRELIMS 2024
BOOKLET-51; S&T-16
S&T CA UPDATES-4

PRELIMS MASTERS PROGRAM
SCIENCE AND TECH – 18
CA UPDATES-4

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Ph: 08045248491, 07041021151 | Email: students@levelupias.com

2. HEALTH

1) GLYCEMIC INDEX (GI), GLYCEMIC LOAD (GL) AND DIABETES

- The **Glycemic Index (GI)** of a food refers to the property of the food to **increase blood glucose level** and is a measure of '**quality**' of carbohydrate.
  - **Glucose** or white bread is used as a comparator. The GI of glucose is taken as **100** and the GI of other foods are given as a percentage of this.
  - Food is classified as low , medium, or high glycemic food and ranked on a scale of 0-100.
  - The lower the GI of a specific food, the less it may effect your blood sugar levels.
  - **Here are** three GI ratings:
    - » **Low: 55 or less**: Fruits (applies, strawberries, dates, oranges, Banana, Blue Berries etc); Vegetables (Carrots (boiled)); Grains (Barley, Quinoa); Legumes (Soyabeans, Kidney beans, Chickpeas, Lentils etc.); Dairy Products and alternatives (Soymilk; skim milk; whole milk; Yoghurt); Sweeteners (Fructose, Coconut sugar);
    - » **Medium: 56-69**: Fruits (Pineapple); Vegetables (Sweet potatoes (boiled)) Grains (Popcorn; Brown Rice); Sweeteners (Honey, Table Sugar);
    - » **High: 70 or above:** White bread, Whole Wheat Bread, White Rice, Cereals, Starchy Vegetables (potatoes, French fries), Baked goods (cake, doughnuts), Snacks (Chocolate, crackers, microwave popcorn, Chips,); Sugar Sweetened Beverages (Soda, fruit juice, sports drinks) etc.
  - **Food high in refined carbs and sugar** are digested more quickly and often have **high GI**, while foods **high in protein, fat, or fibe**r typically have a low GI.
  - **Food that contains no carbs** are **not assigned a GI** and include meat, fish, poultry, nuts, seeds, herbs, spices, and oils.
    - » **Only food containing carbohydrates** are assigned GI.
  - **Is food with High Glycemic Index bad?**
    - » As per the Prospective Urban Rural Epidemiology (PURE) study, **diets with high GI are associated with major cardiovascular events including deaths** across all ethnicities.
  - **Advantages of Low Glycemic Diet**:
    - » Improved **blood sugar regulation**.
    - » Increased **weight loss**: Some research have shown that following a low GI diet may increase short-term weight loss.
    - » Could **benefit people with fatty liver**: Low glycemic food could reduce liver fat and liver enzyme levels in people with on-alcoholic fatty liver disease.

- **The Glycemic Load (GL)**: It takes into account the amount of food eaten. So, **GL factors in the number of carbs in a serving of a food** to determine how it affect blood sugar levels.

2) ALL THE WAYS A HOTTER PLANET MAKES YOU SICKER

- **2023** was the hottest planet on record. It is going to get worse in future. Climate modelers are forecasting the year 2023 will be the coolest year in the life of people born in 2023.
- **Different ways** in which hot climate affect human health:
  - **Direct Effects** of heat exposure on the body.

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   - **Heat Wave** will get worse with higher wet bulb temperature. As per IMD, "**moist heat" stress** has increased by 30% between 1980 and 2020.
   - Heat acts through dehydration, inability of skin to cool the body through perspiration, dilation of blood vessels, and thickening of blood with increased risk of clot formation (thrombosis).
   - Often **air pollution** colludes with the excess heat to assault the lungs and blood vessels.
- **Increased Air pollution**: Wildfires triggered by excessive heat release PM2.5 and toxic chemicals can cause extensive inflammation, increasing the risk of cardiovascular diseases, respiratory diseases, diabetes, and pre-diabetes.
- **Extreme weather events**
- **Water Scarcity**
- **Vector borne diseases.**
- **Water Borne diseases.**
- **Non-Communicable diseases** (strokes; heart attacks; diabetes; respiratory diseases; cancers)
   - Heat increases the risk of brain strokes (paralytic attack) due to thrombosis in blood vessels of the brain.
   - It can also precipitate heart failures and sudden death by triggering clot formation in the coronary arteries.
   - Exercising vigorously in hot environment can be dangerous. Clots formed in the leg veins can travel to the lungs suddenly causing catastrophic "pulmonary embolism".
   - As our population ages and cardiovascular risk factors (like high BP, diabetes, and obesity) rise in our population, every 1-degree centigrade rise in ambient temperature will compound the risk of serious cardiovascular events.
- **Mental health disorders**
- **Food and nutritional insecurity** due to reduced food yield and nutrient quality of crops. Countries in South Asia and Sub-Saharan Africa grow rice and wheat at the highest levels of heat tolerance. A further increase of 1 degree centigrade will lower their yield by 10%. Protective foods like fruit, vegetables, and fish would also be depleted.

3. PHYSICS

1) ELEMENTARY PARTICLES: STANDARD MODEL OF PARTICLE PHYSICS

- **Background**
   - **Particle physics** is a branch of physics that studies the nature of particles that constitute matter and radiation. Currently, the dominant theory explaining these fundamental particles and fields, along with their dynamics, is called the Standard Model.
   - **The Standard Model** is a rigorous theory that predicts the behavior of the sub-atomic particles. It **describes three of the four known fundamental forces (the electromagnetic, weak and strong interactions, and not including the gravitational force) in the universe. It also classifies all known elementary particles.**

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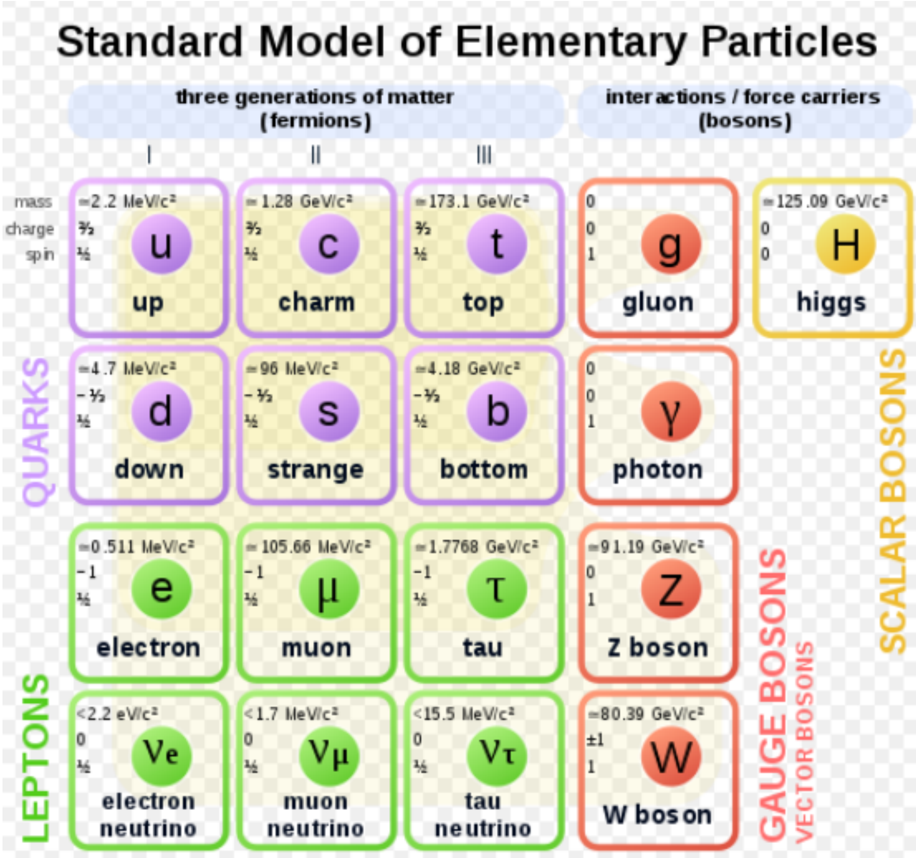

- **Various particles and their roles under Standard Model**
  - » Everything in the universe is made up of atoms. Atoms are made up of subatomic particles - Protons, Neutrons and Electrons. Earlier it was believed that subatomic particles are not divisible.
  - » But, experiments have confirmed that the subatomic particles can be further divided into **17 elementary or fundamental particles**.

<table>
<tr><th colspan="5">Elementary Particles</th></tr>
<tr><th colspan="3">Matter Particles</th><th colspan="2">Force Particles</th></tr>
<tr><th>Quarks</th><th colspan="2">Leptons</th><th colspan="2">Bosons</th></tr>
<tr><th>Unitary</th><th>Charged</th><th>Neutral</th><td>Vector Bosons</td><td>Scalar Bosons</td></tr>
<tr><td>1. Up
2. Down
3. Top
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5. Strange
6. Charm</td><td>7. Electrons
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9. Taus</td><td>10. Electron Neutrino
11.Muon Neutrino
12.Tau Neutrino</td><td>13. Photon
14. W Boson
15. Z Boson
16. Gluon</td><td>17. Higgs Boson</td></tr>
</table>

- The 17 elementary particles can be further divided into **3 Categories - Quarks, Leptons and Bosons**
  - » **Quarks and Leptons** constitute **matter** and are called the **matter particles** whereas the **bosons build up force** and hence are termed **force particles**
  - » **Quarks** are the fundamental constituent of matter. They are of six types: Up quark, down quark, top quark, bottom quark, strange quark, and charm quark.
    - They combine to form composite particles called **Hadrons**.
      - ▪ Hadrons can further be divided into two types: **Baryons and Mesons**.

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  - Baryons are made up of 3 quarks and the mesons are made up of one quark and one antiquark. Most common example of Baryons are protons and neutrons.
  - The up quarks and down quarks form protons and neutrons.

- An Up Quark (UQ) carries a charge of +2/3 and a Down Quark (DQ) carries a charge of -1/3.
  - Proton is made up of two up quark and one down quark
  - Neutron is made up of one up quark and 2 down quark.

» **Leptons** don't undergo any strong interaction with other particles but are observed during beta decay. They are of six types which can be grouped into two categories: **Charged** and **Neutral** (Anti)

- **Charged leptons** include Electrons, muons and Taus. Electrons are the most stable type of leptons. Muons and Taus are very high energy and are not stable. Hence, they transform to their lower energy states, the electrons.
- **Neutral Leptons** were theorized in 1930 when a difference in energy, momentum and angular momentum was observed between theorized and observed values of initial and final particles.
  - This was confirmed by Clyde Cowan and Frederich Reines in 1956.
  - Some people also theorize the existence of anti-neutrinos but nothing has been confirmed yet.

» **Quarks and Leptons** both complete together the picture of atom. But it doesn't clarify about the interaction between them. This interaction is determined by particles called bosons. The man behind bosons was Sir Satyendra Nath Bose.

» **Bosons** are called force particles as there is a boson causing every fundamental force. Bosons are of **two types**: Vector Bosons and Scalar Bosons

- There are four vector bosons.
  - **Photons** are responsible for electromagnetic interaction.
  - **W and Z Bosons** are responsible for weak nuclear interaction, or the force which binds the nucleus and the electrons.
  - **Gluons** are responsible for the Strong nuclear interaction or the force that binds protons and neutrons.
- **Scalar Boson** called **Higgs Boson** was discovered in July 2012. CERN - the European Organization of Nuclear Research - was responsible for this discovery.
  - These particles are **responsible for imparting mass to other particles**.

» **Graviton:** Scientists are still not clear about how to accommodate the gravitational force in standard model. They have conceptualized a particle called '**graviton**' which they say is responsible for gravity but they are not quite sure.

- These 17 elementary particles and graviton together complete the picture of the atom and its interactions as per the standard model of the particle physics.

- **Useful Videos:**
  - [What's the smallest thing in the universe? - Jonathan Butterworth]

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2) NEUTRINO AND ITS PARTNERS

- **Introduction**
  - » Neutrinos are one of the fundamental particles which make up the Universe. It is a fermion. They are similar to electrons but without any charge.
  - » Neutrinos are affected by weak subatomic force of much shorter range than electromagnetism and are therefore able to pass through great distances in matter without being affected by it.
    - ▫ Neutrinos **interact very weakly with most of the things** - trillions of them pass through every human body every second without anyone noticing.
  - » **A neutrino spin** always points in the opposite direction of its motion, and until a few years ago, neutrinos were believed to be massless. It is now generally believed that the phenomenon of neutrino oscillations requires neutrinos to have **tiny mass**.
  - » **Three types of neutrinos are known,** there are strong evidence that no additional neutrinos exist, unless their properties are unexpectedly very different from the known types.
  - » Each type or flavor of neutrino is related to a charged particle (which gives the corresponding neutrino its name). Hence, the "electron neutrino" is associated with the electron, and two other neutrinos are associated with heavier version of electrons called muon and the tau.
  - » The table below list the known types of neutrinos (and their electrically charged partners)

Neutrino	**n_e**	**n_m**	**n_t**
Charged Partners	**Electron (e)**	**Muon (m)**	**Tau (t)**

- **How are neutrinos formed?**
  - » Neutrinos are produced copiously in nuclear reactions in the Sun, stars, and elsewhere.
  - » Majority of neutrinos in the vicinity of earth are from the nuclear reactions in the Sun.
  - » They are formed on earth when unstable atoms decay, which happens in the planet's core and nuclear reactors.

- **Active Research Areas**
  - » **Large neutrino detectors**
    - ▫ Measure the neutrino masses and determine the precise values for the magnitude and rates of oscillations between neutrino flavors.

- **Motivation for research**
  - » Neutrinos **can be used to probe environments that other radiation (such as light or radio wave) cannot penetrate.**
    - ▫ Thus, Neutrinos can be used to probe the Universe, areas beyond our Solar system and phenomenon like Supernova.
  - » They can also enhance the understanding of basic physical laws as it provides a tool to study the structure of nucleons (protons and neutrons)

3) INDIAN NEUTRINO OBSERVATORY (INO) PROJECT IN THENI, TAMIL NADU

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- It is a Rs 1600 Crore Science Project conceived nearly 20 years ago and can put India on the world map in the field of Neutrino Physics. It will house a **massive iron detector which will be placed more than a Kilo meter below the surface of the earth**. With a weight of nearly 50,000 tonnes, it will be the **largest particle detector in the world**.
  - » The project is led by TIFR and has more than 25 top research institutions in the country as collaborators.
- Setting up of this opportunity would mean revival of a lost opportunity for India because in 1965 pioneering Indian Scientists at the Kolar Gold Field (KGF) observatory were among the first in the world to discover the traces of atmospheric neutrinos. With the closure of KGF mines in 1990s, experimental research on neutrinos came to an end in India.
- The project will be jointly supported by the **Department of Atomic Energy** and **The Department of Science and Technology**.
- **Issue Associated with INO**
  - » In 2015, the Union government had approved the project. But later NGT stayed the project citing environmental concerns. Later in 2018, the NGT upheld the environmental clearances given to the project but asked TIFR and DAE to take approval from National Board of Wildlife before moving ahead.
  - » TN Government filed a new affidavit before SC in May 2021 saying that the project fell within the Mathikettan-Periyar Tiger Corridors. TIFR team has sought wildlife clearance but the application is pending before the state board of wildlife.
  - » The matter has now reached Supreme Court which will assess the objections raised by the TN government and environmentalists vis-a-vis the central government support and regulatory approvals to decide whether an INO will become reality.

- **Useful Video:**
  - India based Neutrino Observatory A Mega Science Project

A) IN A FIRST SCIENTISTS SEE NEUTRINO EMITTED BY THE MILKY WAY GALAXY (JUNE 2023)

- For the first time, scientists have seen neutrinos originating from the central disk of the Milky Way. It was achieved with the help of IceCube Experiment. They detected high-energy neutrinos in pristine ice deep below Antarctica's surface, then traced their source back to locations in the Milky Way - **the first time these particles have been observed arising from our galaxy**.
- **About IceCube Experiment**:
  - » For the past 10 years, an array of small light sensors drilled into Antarctic ice has been detecting neutrinos as they zip through our planet. IceCube is an actual cube of these sensors, a km long on each side, that was sunk 1.5 and 2.5 km deep in the ice. In this translucent medium, the sensors pick up tiny flashes of so-called **Cherenkov radiation** that forms when a vanishingly rare neutrino hits the ice and creates a shower of secondary particles.
- **Significance:**
  - » The experiment established the galaxy as a neutrino source.
  - » Milky Way neutrinos may help scientists understand the origin of high-energy particles known as cosmic rays, which kick of the formation of neutrinos.

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4) HIGGS BOSON

- **Why in news?**
  - Peter Higgs, who proposed existence of Higgs Boson particle, had died at 94 (April 2024)

A) ABOUT HIGGS BOSON: "GOD PARTICLE"

- The existence of Higgs Boson, also called "**God Particle"** was first proposed by Peter Higgs in 1964. It is one of the 17 elementary particles that make up **standard model of particle physics**.
- **In 2012**, the presence of the particle was confirmed at CERN.
- It is the particle that is supposed to account for the mass of every other fundamental particles.
  - **Note**: Mass is not intrinsic to matter. Fundamental particles like electrons don't have a mass within themselves. Scientists realized this in 1950s and 1960s when the standard model was still being developed. Scientists realized that the equations didn't work if these particles had inherent mass.
  - **In 1964**, scientists developed the idea of **all-pervasive field** (later dubbed the "Higgs Field"), just like there is an electric field or a magnetic or gravitational field. It is through interaction with this field that elementary particles acquire the mass.
    - **Why Peter Higgs receives pre-eminence: Because of Prediction of a new elementary Particle** (which was later called Higgs Boson)
      - The day Peter Higgs submitted his original paper about the Higgs Field (at that time unnamed), on the same day, another paper by Belgian Physicists Francois Englert and Robert Brout was published describing **essentially the same theory**.
      - When this was brought to **Higgs attention**, he modified his own paper to add **another prediction** - that there should be a **new elementary particle associated with Higgs Field**. It belong to a class of particles called bosons and would itself have an extremely high mass. This was the particle that came to be known as **Higgs Boson**.
    - It is the interaction of particles with the Higgs Field - the way they change the field or get changed by them - that lends them the mass. **Greater is the interaction, larger is the mass**. Different particles interact with the field in different way, and that is what gives them different masses.
    - **A Photon**, which is a light particle, doesn't interact with the field at all, and is thus massless.
    - **Particles** like electrons and protons, do interact with the field and thus have masses.
    - **Higgs Boson** itself interacts with the field and thus have mass.

- **Higgs Boson** particle is known to **impart mass to every other particle**. Its discovery completed what is known as **Standard Model of Particle Physics**, which describes all the fundamental particles and fundamental forces.

B) ABOUT PETER HIGGS

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- He was a Nobel Prize winning Physicist. Higgs won the 2013 Nobel Prize in Physics for his work, alongside Francois Englert of Belgium, who independently came up with the same theory.

- He proposed the existence of the so-called "**God Particle**" that helped explain how matter formed after the **Big Bang** in **1964**.
  - He theorized that there must be sub-atomic particle of certain dimension that would explain how other particles and therefore all the stars and planets in the Universe - **acquired mass**. Without something like this particle, the set of equations physicists use to describe the world, known as the **standard model**, wouldn't hold together.
  - Higgs' work helps scientists understand **one of the most fundamental riddles of the universe**: How the Big bang created something out of nothing 13.8 billion years ago. Without mass from the Higgs, particles couldn't clump together into the matter we interact with every day.
- **Details of Life**:
  - Born on May 29, 1929, in Newcastle, Northeast England. He studied at King's College, University of London, and was awarded a PhD in 1954. He spent much of his career at Edinburgh, becoming the Personal Chair of Theoretical Physics at the Scottish University in 1980. He retired in 1996.
  - **An important Highlight** of Higgs' career came in the 2013 presentation at CERN in Geneva where scientists presented that the boson had been confirmed. He broke into tears, wiping down his glasses in the stands of a CERN lecture hall.
  - He was an extremely shy person, and preferred to work in isolation. He wasn't a prolific contributor and has produced just 12 papers in his entire career, only one with a co-author.

5) CERN (EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH) (CONSEIL EUROPÉEN POUR LA RECHERCHE NUCLÉAIRE)

- **Introduction**
  - CERN is a provisional body founded in 1952 with the mandate of establishing a world class **fundamental physics research organization in Europe**. At that time, pure physics research concentrated on understanding the inside of an atom, hence the word "nuclear".
  - European Organization for Nuclear Research officially came into being in 1954, following ratification by 12 states including France and Germany. The provisional CERN was dissolved but the acronym remained.
  - It operates the **world's largest particle physics** laboratory in the world.
    - **Members: 23** (Israel is the only non-European Country which has been grated full membership)

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- **Associate Members: 7** (India, Pakistan, Turkey, Ukraine, Lithuania, Croatia and Lativia)

- **Main Contributions**
  - CERN's main function is to provide the **particle accelerators** and other infrastructure needed for high energy physics research.
  - CERN is also the birthplace of World Wide Web.

6) THE LARGE HADRON COLLIDER

- **Introduction**
  - The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It first started up on 10 September 2008, and remains the latest addition to CERN's accelerator complex
  - The LHC consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way.
  - **What is done through LHC**
    - Inside the accelerator, two high-energy particle beams travel at close to the speed of light before they are made to collide. The beams travel in opposite directions in separate beam pipes – two tubes kept at ultra high vacuum.
- **Aim:** It aims to allow physicists to test the prediction of different theories of particle physics and high energy physics like the Standard Model, and particularly prove or disprove the existence of the theorized **Higgs boson** and the large family of new particles predicted by supersymmetric theories. The LHC is expected to address some of the unsolved questions of physics, advancing human understanding of physical laws.
- **Two Runs**
  - **2009-2013**
    - **Important Results So Far :** In 2013, the discovery of a particle matching Higgs Boson was confirmed by data from the LHC.
  - **Second Run 2015 onwards**
  - **Third Run**: The Large Hadron Collider was successfully reignited for the third time in July 2022. Since then it has discovered three exotic particles as per CERN. This will continue running for four years.
- In **10 years** since the discovery of Higgs Boson, scientists have been able to confirm that the particle is very, very close to being the Higgs Boson that is required in the so-called **Standard Model of Particle Physics**.
- **Future**:
  - Scientists hope to use the Higgs Boson as a tool to learn about the secrets of the universe, including Dark Matter.

7) EINSTEIN'S THEORY OF RELATIVITY

i. Theory of Special Relativity

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- **In 1905, Albert Einstein based his theory on two principles:**
    a. the **laws of physics are the same for all non-accelerating observers** (inertial reference frame), and
    b. that **the speed of light in a vacuum was independent of the motion of all observers** and is **unchanging** ($300 * 10^6$ m/s)
        - It is the time that changes (slows down for a fast moving object)
- As a result of these principles Einstein deduced that:
    a. There is **no fixed frame of reference** in the universe.
    b. Every-thing was moving **relative** to everything else, hence **Einstein's theory of relativity**.
- It is known as **special** relativity as it applies only to special cases; frames of reference in constant, unchanging motion.
- As a result he found that space and time are interwoven in a single continuum known as the **space-time**. Events that occur at the same time for one observer could occur at different times for another.
- **Consequence of special theory of relativity**
    a. **Time Dilation:** Time does not pass at the same rate for everyone.
        - A fast-moving observer measures time passing more slowly than a (relatively) stationary observer would. This phenomena is called **dilation**.
        - **Useful Video: Special Relativity: Crash Course Physics #42**
    b. **Length Contraction:** A **fast moving object appears shorter** along the direction of motion, relative to slow moving one. This effect is very subtle until the object travels close to the speed of light.
    c. **Simultaneity**: something that seems simultaneous to you might not seem simultaneous to another observer.
    d. **Mass and energy are different manifestation of the same thing**. Einstein's famous equation , $E = mc^2$.
        - As a result of this a fast moving object appears to have increased mass relative to slow moving one. This is due to the fact that increasing an object's velocity increases its kinetic energy and, therefore, its mass.

          The increase in mass is the reasons that Einstein says that matter cannot travel faster than light. The mass is increased with velocity until the mass becomes infinite when it reaches light speed. An infinite mass would require infinite energy to move, so this is impossible
    e. **Space and time** are part of one continuum, called space-time.
        - In Einstein's mathematics, space has three dimensions, and the fourth dimension is time. More recent theories presume extra dimensions that we do not perceive.

ii. General Theory of relativity

- After giving special theory of relativity, Einstein spent 10 years trying to include acceleration in the theory.
- In 1915, Einstein published the General theory of relativity, which applies to frames that are accelerating with regard to each other.
- Some consequence
    - Mass causes space time to curve which is how gravity is created
        - The rubber sheet model shows that gravity results from massive objects warping space-time. The warp is called gravity well.

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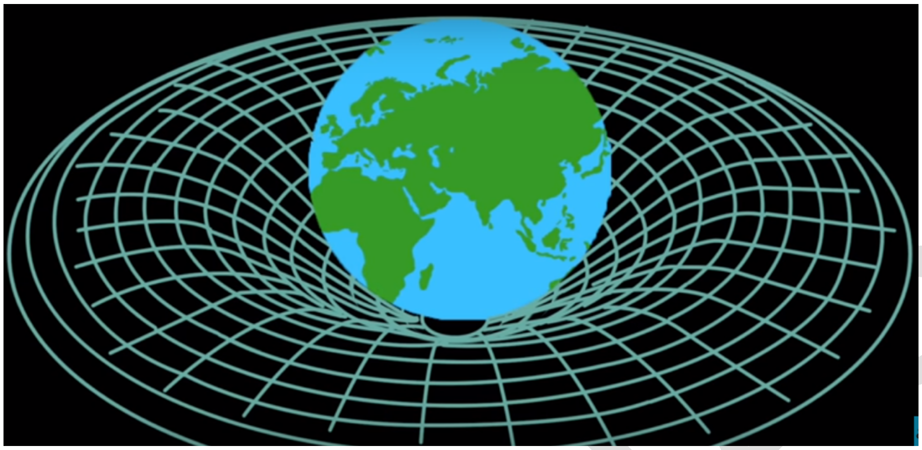
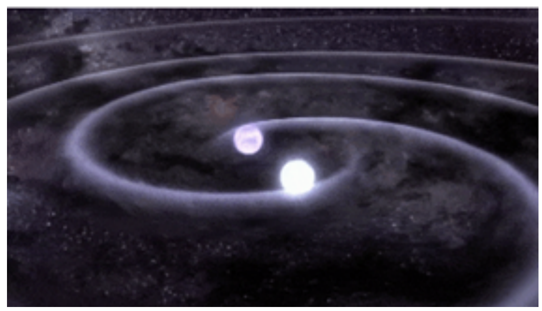
- Orbiting objects follow the path that is shortest and requires the least amount of energy. The planets move in ellipses, the most energy efficient path in gravity well of the sun.



- **Gravitational lensing**: Gravity bends light. This phenomenon is called Gravitational lensing. When we observe a distant galaxy, the gravity of matter between Earth and the galaxy causes light rays to be bent into different paths. When the light reaches the telescopes, multiple images of the same galaxy appear.
- **Universe is expanding.**

8) GRAVIATIONAL WAVE

- **Introduction**
  - » Gravitational waves are ripples in the curvature of spacetime which propagate as waves, travelling outward from the source. In other words gravitational waves are disturbance in space-time, the very fabric of universe , that travel at the speed of light.
    - ▫ The waves are emitted by any **mass that is changing the speed or direction**. The simplest example is the binary system, where a pair of stars or compact objects (like black holes) orbit their common center of mass.



  - » **Space-time around earth**: Einstein's theory of general relativity predicted that the space time around earth would be not only warped but also twisted by the planet's rotation.

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- It was **predicted in 1916** by Albert Einstein on the basis of general relativity, gravitational waves transport energy as gravitational radiation.
- The existence of gravitational waves is a possible consequence of the Lorentz invariance of general relativity since it brings the concept of limiting speed of propagation of the physical interactions with it. By contrast gravitational wave cannot exist in the Newtonian theory of gravitation, which postulates that physical interaction propagate at infinite speed.
- **Gravitational waves are very different from the more familiar electromagnetic waves**
  - EM waves -> created by magnetic charges, rather than moving masses
  - Gravitational waves with appreciable strength are so much more difficult to produce because gravitational force is much weaker than electromagnetic force.

- **Discovery of Gravitational wave (2016)**
  - In 2016, after decades of search for those ripples in space-time, which Albert Einstein predicted exactly 100 years ago, scientists working with the gigantic optical instruments in the U.S. called LIGO (Laser Interferometer Gravitational-wave Observatory) have detected signals of gravitational waves emanating from two merging black holes 1.3 billion light years away arriving at their instruments on the earth.
  - The advanced LIGO observatories in the US states of Washington and Louisiana have traced the warping of space from the merger of two black holes about 1.3 billion light years ago.
  - **How is gravitational wave detected in Lab**

    - The basic principle for detection is **interference** - when two waves combine, they produce a pattern based on relative positions of peaks and troughs in those waves.
  - **Normal circumstance - no light detector**
    - In LIGO, a high powered laser beam is split and sent down to L-shaped vacuum tunnels, each 4 KM long. They get reflected from two high precision mirrors and reach back at the base. They come back in such a way that they completely cancel out each other. No light is detected at the photo detector.
  - **When gravity wave passes by: Some pattern detected at the photo detector**
    - But when a gravity wave passes-by, it distorts space and changes the distance that the beams have to travel. No longer are the peaks and troughs of the two reflected waves perfectly aligned. As they do not cancel out each other now, some pattern is detected at the photo-detector.

- **How will the discovery of Gravitational wave change science and our world ?**
  - We will be able to
    - **Understand Universe Better**

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9) RAMAN EFFECT AND ITS APPLICATIONS

- **About CV Raman**
  - » Born in Tiruchirappalli on Nov 7, 1888, died on Nov 21, 1970.
  - » He discovered a **new phenomenon of scattering of light**, known as **Raman Effect / Raman Scattering**.
    - He received the 1930 Nobel Prize in Physics for this discovery and was the first Asian to receive a Nobel Prize.

- **Other Contributions:**
  - » He is known to give correct explanation for why the sea water appears blue.
  - » He attended the foundation ceremony of BHU and also held the position of permanent visiting professor.
  - » With a student, Nagendra Nath, he provided the correct explanation of the **acousto-optic effect** (light scattering by sound waves) in a series of articles resulting in the celebrated Raman-Nath theory.
  - » In 1933, he became the first Indian Director of the IISc.
  - » He also founded Indian Academy of Science the same year (1933)
  - » Later, in 1948 he established Raman Research Institute in 1948 where he worked to his last days.

- **Raman Effect: Definition**
  - » Raman effect, change in the wavelength of light that occurs when a light beam is deflected by molecules.
  - » When a beam of light traverses a dust-free, transparent samples of a chemical compound, a small fraction of the light emerges in direction other than that of the incident (incoming beam). Most of these scattered light is of unchanged wavelength. A small part, however, has wavelength different from that of the incident light. It's presence is a result of the Raman effect.
  - » Chandrashekhar Venkata Raman first published the observation in 1928. (Austrian physicist Adolf Smekal theoretically described the effect in 1923).

- **Applications**
  - » **Chemical industry**
    - a. To study catalysts
    - b. To monitor chemical purity in petro-chemical industry
    - c. Control of polymerization reaction
  - » **Nanotechnology and material science**
    - a. To study nano particles
    - b. To develop microelectronics devices and novel photovoltaic cells
  - » **Biomedical applications**
    - a. In vivo study of skins
    - b. Transdermal drug transfer
    - c. Cancer identification
    - d. Bone studies
  - » **Detection of Narcotics and Explosives**
    - a. Hand held Raman scanners to detect narcotics
    - b. Hand held Raman scanners to detect explosives such as TNT, RDX, HMX etc.

2nd Floor, 45 Pusa Road, Opp. Metro Pillar 128, Karol Bagh, New Delhi-110005
Ph: 08045248491, 07041021151 | Email: students@levelupias.com