Gravity of Earth

The gravity of Earth, indicated by g, is the net acceleration given to objects due to the combined action of gravitation (from the distribution of mass within the Earth) and centrifugal force (from the rotation of the Earth). It is a vector quantity whose direction corresponds to a plumb bob and whose strength or magnitude is determined by the norm g. Concepts based on the Gravity of Earth are an essential part of the GATE ME syllabus.

On Earth, gravity gives physical objects their weight and regulates the tidal movements of the oceans. The mass and density of the planet, 5.97237 × 1024 kg (1.31668 × 1025 lbs) and 5.514 g/cm^3, respectively, determine the force of Earth's gravity. As a result, close to the surface, Earth has a gravitational strength of 9.8 m/s^2 (commonly known as 1 g), which naturally decreases as one moves further from the surface.

What is the Value of Acceleration due to the Gravity of Earth?

Standard gravity, the nominal "average" value at Earth's surface, is by definition equal to 9.80665 m/s^2 (32.1740 ft/s^2). The acceleration value due to the Gravity of Earth is widely used in the questions asked in the GATE exam.

Gravity of Earth Formula

The formula **f = mg** describes the force of gravity acting on a body. Where f represents the force acting on the body, g represents the acceleration due to gravity, and m represents the body's mass.

According to the universal law of Gravitation,

$$f = GmM/(r+h)^2$$

Where,

- f = the force exerted by two bodies,
- G = universal gravitational constant (6.67×10-11 Nm^2/kg^2)
- m = the object's mass,
- M = earth's mass
- r = earth's radius
- h = the distance between the body and the earth's surface.

SI Unit of Gravity of Earth

This acceleration is given in SI units as meters per second squared (m/s^2 or ms^{-2}).

Variation in Gravity of Earth and Apparent Gravity

A perfect sphere of uniform density, whose density varies entirely with distance from the center (spherical symmetry), would produce a uniform magnitude gravitational field at all places on its surface, always pointing directly towards the sphere's center. The Earth is not a perfect sphere but rather an oblate spheroid that is flatter at the poles and bulges at the Equator. As a result, there are modest variations in gravity's magnitude and direction over its surface. "Effective gravity" or "apparent gravity" refers to the net force (or equivalent net acceleration) measured with a scale and plumb bob. Other elements that influence net force are included in effective gravity.

Development of Gravitational Theory

Newton proposed that the motions of heavenly bodies and the free fall of objects on Earth are caused by the same force. On the other hand, the classical Greek philosophers did not believe that gravity influenced celestial bodies because they were observed to follow continually repeating condescending trajectories in the sky. As a result, Aristotle believed that each heavenly body moved in its own "natural" way, unaffected by other causes or agents. Aristotle also believed that big earthly objects have a natural propensity to gravitate toward the center of the Earth.

These Aristotelian notions, along with two others, persisted for centuries: that a body traveling at constant speed requires a continuous force exerted on it. That force must be applied through touch rather than interaction at a distance. These beliefs persisted into the 16th and early 17th centuries, hindering the understanding of fundamental laws of motion and precluding the emergence of notions about universal gravity. This deadlock began to break down with various scientific contributions to the problem of earthly and heavenly motion, which laid the groundwork for Newton's subsequent gravitational theory.

The 17th-century German astronomer Johannes Kepler accepted Nicolaus Copernicus' (and Aristarchus of Samos') argument that the planets orbit the Sun rather than the Earth. Kepler explained planetary orbits using basic geometric and arithmetic ratios based on improved observations of planetary movements provided by the Danish astronomer Tycho Brahe during the 16th century. The three quantitative laws of planetary motion established by Kepler are as follows:

- The planets have elliptic orbits, with the Sun occupying one focus (A focus is one of two places inside an ellipse; any ray from one of them bounces off a side of the ellipse and passes through the other focus).
- A line connecting two planets sweeps out equal areas at equal times.
- A planet's period of revolution is related to the cube of its average distance from the Sun.

During the same time period, Galileo Galilei, an Italian astronomer, and natural philosopher, made strides in comprehending "natural" motion and simple accelerated motion for earthly things. He understood that bodies unaffected by forces continue to move endlessly and that force is required to change motion rather than sustain constant motion. Galileo determined that the motion of objects falling toward Earth is one of constant acceleration while investigating how they fall. He established that the distance traveled by a falling body from rest in this manner varies as the square of time. As previously stated, the acceleration due to gravity at the Earth's surface is approximately 9.8 meters per second squared.

Newton’s Law of Gravity

Newton discovered the link between the motion of the Moon and the motion of a body falling freely on Earth. He clarified Kepler's laws and founded the present quantitative science of gravitation through his dynamical and gravitational theories. Newton hypothesized that an attractive force exists between all huge bodies that do not require bodily contact and acts at a distance. Newton concluded that a force applied by Earth on the Moon is required to keep it in a circular motion about Earth rather than going in a straight line by invoking his law of inertia (bodies not acted upon by force move at constant speed in a straight line). Questions based on Newton’s Law of Gravity can be checked in the GATE previous year's question papers.

In the long run, he understood that this force could be the same as the force that pushes items on Earth's surface downward. He defined gravity as the pull between two bodies that are proportional to their masses and inversely proportional to the square of their distance apart.

$$\textbf{Force} \propto (\textbf{mass}_1 \times \textbf{mass}_2)/\textbf{d}^2$$