

Motion (physics)

In **physics**, **motion** is a change in position of an object over time. Motion is described in terms of displacement, distance, velocity, acceleration, time, and speed. Motion of a body is observed by attaching a frame of reference to an observer and measuring the change in position of the body relative to that frame.

If the position of a body is not changing with respect to a given frame of reference, the body is said to be *at rest*, *motionless*, *immobile*, *stationary*, or to have constant (time-invariant) position. An object's motion cannot change unless it is acted upon by a force, as described. Momentum is a quantity which is used for measuring the motion of an object. An object's momentum is directly related to the object's mass and velocity, and the total momentum of all objects in an isolated system (one not affected by external forces) does not change with time, as described by the law of conservation of momentum

As there is no absolute frame of reference, *absolute motion* cannot be determined.^[1] Thus, everything in the universe can be considered to be moving.^{[2]:20–21}

Motion applies to objects, bodies, and matter particles, to radiation, radiation fields and radiation particles, and to space, its curvature and space-time. One can also speak of motion of shapes and boundaries. So, the term motion, in general, signifies a continuous change in the configuration of a physical system. For example, one can talk about motion of a wave or about motion of a quantum particle, where the configuration consists of probabilities of occupying specific positions.

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Motion involves a change in position, such as in this perspective of rapidly leaving Yongsan Station.

Laws of motion

In physics, motion is described through two sets of apparently contradictory laws of mechanics. Motions of all large-scale and familiar objects in the universe (such as projectiles, planets, cells, and humans) are described by classical mechanics. Whereas the motion of very small atomic and sub-atomic objects is described by quantum mechanics

First law:	In an <u>inertial reference frame</u> an object either remains at rest or continues to move at a constant <u>velocity</u> , unless acted upon by an <u>external force</u> .
Second law:	In an inertial reference frame, the <u>vector sum</u> of the <u>forces</u> F on an object is equal to the <u>mass</u> m of that object multiplied by the <u>acceleration</u> a of the object: F = ma .
Third law:	When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body

Classical mechanics

Classical mechanics is used for describing the motion of macroscopic objects, from projectiles to parts of machinery, as well as astronomical objects, such as spacecraft, planets, stars, and galaxies. It produces very accurate results within these domains, and is one of the oldest and largest in science, engineering, and technology.

Classical mechanics is fundamentally based on Newton's laws of motion. These laws describe the relationship between the forces acting on a body and the motion of that body. They were first compiled by Sir Isaac Newton in his work Philosophiæ Naturalis Principia Mathematica first published on July 5, 1687. Newton's three laws are:

1. A body either is at rest or moves with constant velocity until and unless an outer force is applied to it.
2. An object will travel in one direction only until an outer force changes its direction.
3. Whenever one body exerts a force **F** onto a second body (in some cases, which is standing still) the second body exerts the force **-F** on the first body. **F** and **-F** are equal in magnitude and opposite in sense. So, the body which exerts **F** will go backwards!^[3]

Newton's three laws of motion were the first to accurately provide a mathematical model for understanding orbiting bodies in outer space. This explanation unified the motion of celestial bodies and motion of objects on earth.

Classical mechanics was later further enhanced by Albert Einstein's special relativity and general relativity. Special relativity is concerned with the motion of objects with a high velocity, approaching the speed of light; general relativity is employed to handle gravitational motion at a deeper level.

Uniform Motion:

When an object moves with a constant speed at a particular direction at regular intervals of time it's known as uniform motion. For example: a bike moving in a straight line with a constant speed.

EQUATIONS OF UNIFORM MOTION:

If **v** = final velocity, **u** = initial velocity, **a** = acceleration, **t** = time, **s** = displacement, then :

$$v = u + at, v = at$$

$$s = ut + \frac{1}{2}at^2, s = \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as, v^2 = 2as$$

Quantum mechanics

Quantum mechanics is a set of principles describing physical reality at the atomic level of matter (molecules and atoms) and the subatomic particles (electrons, protons, neutrons, and even smaller elementary particles such as quarks). These descriptions include the simultaneous wave-like and particle-like behavior of both matter and radiation energy as described in the wave-particle duality.

In classical mechanics, accurate measurements and predictions of the state of objects can be calculated, such as location and velocity. In the quantum mechanics, due to the Heisenberg uncertainty principle, the complete state of a subatomic particle, such as its location and velocity, cannot be simultaneously determined.

In addition to describing the motion of atomic level phenomena, quantum mechanics is useful in understanding some large-scale phenomenon such as superfluidity, superconductivity, and biological systems, including the function of smell receptors and the structures of proteins

List of "imperceptible" human motions

Humans, like all known things in the universe, are in constant motion,^{[2]:8–9} however, aside from obvious movements of the various external body parts and locomotion, humans are in motion in a variety of ways which are more difficult to perceive. Many of these "imperceptible motions" are only perceivable with the help of special tools and careful observation. The larger scales of imperceptible motions are difficult for humans to perceive for two reasons: Newton's laws of motion (particularly the third) which prevents the feeling of motion on a mass to which the observer is connected, and the lack of an obvious frame of reference which would allow individuals to easily see that they are moving.^[4] The smaller scales of these motions are too small to be detected conventionally with humansenses.

Universe

Spacetime (the fabric of the universe) is expanding meaning everything in the universe is stretching like a rubber band. This motion is the most obscure as it is not physical motion as such, but rather a change in the very nature of the universe. The primary source of verification of this expansion was provided by Edwin Hubble who demonstrated that all galaxies and distant astronomical objects were moving away from Earth, known as Hubble's law, predicted by a universal expansion.^[5]

Galaxy

The Milky Way Galaxy is moving through space and many astronomers believe the velocity of this motion to be approximately 600 kilometres per second (1,340,000 mph) relative to the observed locations of other nearby galaxies. Another reference frame is provided by the Cosmic microwave background. This frame of reference indicates that the Milky Way is moving at around 582 kilometres per second (1,300,000 mph).^[6]

Sun and solar system

The Milky Way is rotating around its dense galactic center, thus the sun is moving in a circle within the galaxy's gravity. Away from the central bulge, or outer rim, the typical stellar velocity is between 210 and 240 kilometres per second (470,000 and 540,000 mph).^[7] All planets and their moons move with the sun. Thus, the solar system is moving.

Earth

The Earth is rotating or spinning around its axis. This is evidenced by day and night, at the equator the earth has an eastward velocity of 0.4651 kilometres per second (1,040 mph).^[8] The Earth is also orbiting around the Sun in an orbital revolution. A complete orbit around the sun takes oneyear, or about 365 days; it averages a speed of about 30 kilometres per second (67,000 mph).^[9]

Continents

The Theory of Plate tectonics tells us that the continents are drifting on convection currents within the mantle causing them to move across the surface of the planet at the slow speed of approximately 2.54 centimetres (1 in) per year.^{[10][11]} However, the velocities of plates range widely. The fastest-moving plates are the oceanic plates, with the Cocos Plate advancing at a rate of 75 millimetres (3.0 in) per year^[12] and the Pacific Plate moving 52–69 millimetres (2.0–2.7 in) per year. At the other extreme, the slowest-moving plate is the Eurasian Plate, progressing at a typical rate of about 21 millimetres (0.83 in) per year

Internal body

The human heart is constantly contracting to move blood throughout the body. Through larger veins and arteries in the body, blood has been found to travel at approximately 0.33 m/s. Though considerable variation exists, and peak flows in the venae cavae have been found between 0.1 and 0.45 metres per second (0.33 and 1.48 ft/s).^[13] additionally, the smooth muscles of hollow internal organs are moving. The most familiar would be the occurrence of peristalsis which is where digested food is forced throughout the digestive tract. Though different foods travel through the body at different rates, an average speed through the human small intestine is 3.48 kilometres per hour (2.16 mph).^[14] The human lymphatic system is also constantly causing movements of excess fluids, lipids, and immune system related products around the body. The lymph fluid has been found to move through a lymph capillary of the skin at approximately 0.0000097 m/s.^[15]

Cells

The cells of the human body have many structures which move throughout them. Cytoplasmic streaming is a way which cells move molecular substances throughout the cytoplasm.^[16] various motor proteins work as molecular motors within a cell and move along the surface of various cellular substrates such as microtubules, and motor proteins are typically powered by the hydrolysis of adenosine triphosphate (ATP), and convert chemical energy into mechanical work.^[17] Vesicles propelled by motor proteins have been found to have a velocity of approximately 0.00000152 m/s.^[18]

Particles

According to the laws of thermodynamics, all particles of matter are in constant random motion as long as the temperature is above absolute zero. Thus the molecules and atoms which make up the human body are vibrating, colliding, and moving. This motion can be detected as temperature; higher temperatures, which represent greater kinetic energy in the particles, feel warm to humans who sense the thermal energy transferring from the object being touched to their nerves. Similarly, when lower temperature objects are touched, the senses perceive the transfer of heat away from the body as feeling cold.^[19]

Subatomic particles

Within each atom, electrons exist in an area around the nucleus. This area is called the electron cloud. According to Bohr's model of the atom, electrons have a high velocity, and the larger the nucleus they are orbiting the faster they would need to move. If electrons 'move' about the electron cloud in strict paths the same way planets orbit the sun, then electrons would be required to do so at speeds which far exceed the speed of light. However, there is no reason that one must confine one's self to this strict conceptualization, that electrons move in paths the same way macroscopic objects do. Rather one can conceptualize electrons to be 'particles' that capriciously exist within the bounds of the electron cloud.^[20] Inside the atomic nucleus, the protons and neutrons are also probably moving around due to the electrical repulsion of the protons and the presence of angular momentum of both particles.^[21]

Light

Light propagates at 299,792,458 m/s, often approximated as 299,792 kilometres per second (186,282 mi/s) in a vacuum. The speed of light (or *c*) is also the speed of all massless particles and associated fields in a vacuum, and it is the upper limit on the speed at which energy, matter, information or causation can travel; the speed of light is the limit of speed for all physical systems.

In addition, the speed of light is an invariant quantity: it has the same value, irrespective of the position or speed of the observer. This property makes the speed of light a natural measurement unit for speed.

Types of motion

- Simple harmonic motion– (e.g., that of a pendulum).
- Linear motion– motion which follows a straight linear path, and whose displacement is exactly the same as its trajectory.
- Reciprocal motion (e.g. vibration)
- Random motion (e.g. vibration)

- Brownian motion (i.e. the random movement of particles)
- Circular motion (e.g. the orbits of planets)
- Rotary motion – a motion about a fixed point. (e.g. Ferris wheel).
- Curvilinear motion – It is defined as the motion along a curved path that may be planar or in three dimensions.
- Rotational motion
- Rolling motion - (as of the wheel of a bicycle)
- Oscillation - (swinging from side to side)
- vibratory motion
- Combination (or simultaneous) motions - Combination of two or more above listed motions
- Projectile motion - uniform horizontal motion + vertical accelerated motion
- Half projectile motion
- circular motion (this is a motion that move in a round of body e.g. the moon and the earth)
- Linear motion

Fundamental motions

- Linear motion
- Circular motion
- Oscillation
- Wave
- Momentum
- Relative motion

See also

- Simple machines
- Kinematic chain
- Power
- Machine
- Motion (geometry)
- Displacement
- Translatory motion

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