Dynamic Chiropractic

HEALTH & WELLNESS / LIFESTYLE

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## PHYSICS XVII: PINNING DOWN MASS

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The Kinetic Theory of Matter (anything that has mass and occupies space) has it that atoms and molecules are always in constant motion, or, since atoms and molecules both have mass and motion, they have kinetic energy. The theory is based on the idea that matter is composed of randomly moving atoms and molecules whose K.E. (Kinetic Energy) of a moving single molecule of gas is 1/2 mv2, where m is the mass and v is the velocity of motion. This motion increases with temperature, i.e., K.E. is directly proportional to temperature.

In a windless room small floating dust particles in the air will be "pushed around" by the random movement of the air molecules, or small particles floating in a fluid colloid or in a regular fluid will also be bumped about by the random movement of the fluid's molecules. This type of motion is called "Brownian movement" after Robert Brown (1827).

Mass is the quantity of matter in a body/object/thing. Technically, the mass of an object is a quantitative summary statement of the number of atoms or molecules that make up that object, or would be if we could know that exact number. Avogadro's Number (6.02 x 1023) is the gram-molecular weight (or mole) of any compound, which always contains the same number of molecules. (One mole of a compound is its molecular weight in grams.) The molecular weight of a substance is the sum of the atomic weights of the atoms comprising one molecule: the AMU (Atomic Mass Unit) is 1.67 x 10-2 gm. A gram approximates to the mass of a cubic centimeter (cc) of water. Avogadro's number gives the number of entities in one mole of a substance; thus, there are 6.0221 x 1023 entities in a mole of a substance. A mole, then, is the amount of a substance that contains as many elementary entities as there are atoms in exactly 0.012 kg of 12C.

Since atoms/molecules take up a certain amount of space, technically they "claim" or "reserve" by the intrinsic motions and forces of their internal relationships a specific volume of space which other atoms/molecules cannot occupy at the same time; they thus have weight. It is this "weight" and space occupancy of these minute components of matter which give mass. In physics, however, mass is the quantity of matter in a body without regard to volume (space occupancy) or pull of gravity (weight). Then, how is mass measured if its spatial area may vary (i.e., its density) and its weight may vary in different gravitational field strengths and even at different altitudes in a given g-field? The amount of mass remains the same no matter how densely compacted it may be or how strong a given gravitational field may be. (The stronger the g-field intensity is on a given amount of mass, the more it weighs. Thus, a 150 lb. person on Earth weighs less on the Moon though his mass remains the same.)

Thus, in physics, mass is a measure of the "resistance" of an object to any change in its state of rest or uniform motion; mass is a quantitative measure of its inertia (Newton's First Law of Motion). At normal speeds, i.e., non-relativistic speeds, the mass of an object is independent of its speed. However, at greater speeds near to that of the speed of light, or relativistic speeds, mass becomes relative to the observer of it. Within the same inertial frame of reference, objects with equal masses have the same weight. Thus, the same mass of lead or paper will have the same weight in the Earth's gravitational field, though the number of atoms and their densities will vary between the two substances.

I have devoted so much space to "mass" because it is a fundamental reality upon which other concepts, such as force and acceleration, are built and which are reciprocally dependent. Thus, the ratio of force (F) to acceleration (a) for a given body is constant for that body and thus defines its mass (m): m = F/a. "Force" itself is defined as the product of mass and acceleration: F = ma.

Mass, then, is the amount of inertia of a body or the amount of matter the body contains. Mass is a fixed quantity as long as the body retains its original condition. The weight of a body-mass is a measurement of the gravitational attraction, or pull, of the Earth on that body. At the Earth's surface, the weight of a body is proportional to its mass but not equal to it, and this proportionality (W m) of a given body depends upon the locality (i.e., distance from the gravitational center) at which the weight is determined. The same mass 2,000 miles from the Earth's center will weigh less at 4,000 miles distance from the Earth's g-center.

The mass of an extended body (i.e., which occupies a given volume of space) is assumed to be concentrated in a point called the center of mass. Forces which produce translational motion are thought of as acting at the center of mass of a body. A body with mass but consisting of only a single point can undergo only translational motion.

There are only two basic types of motion: translatory and rotational, or combinations of these two, which does not constitute a third pure kind of motion. Translational motion, then, is the motion as a whole of a body through space. A rotating body-mass spins about some point (or line, axis). If that point is all that exists, then there is nothing to spin, so only linear (straight-line) motion is possible. It is with regard to such theoretical point-masses that Newton's Laws of Motion apply most simply. However, in the real world, no point-masses exist. All actual masses are bodies with extension, but in some ways such real three-dimensional bodies can be shown to behave as if all of their mass were concentrated at a single point, or the center of mass.

Mass is also defined by this constant: F/a. For each separate existing body the ratio of the magnitude of the force to that of acceleration is always the same, but this ratio is different for different bodies. This constant ratio of force to acceleration is considered a property of the body called its mass. Thus: m = F/a or, transposed, F = ma (a vector equation; Newton's Second Law of Motion). The mass of a body thus represents the force per unit of acceleration. If, in Newton's Second Law, for "change of motion," we read it as "rate of change of velocity" (that's acceleration), this law then states that the acceleration is proportional to the resultant force, and is, of course, in the same direction of this force, i.e., a F.

Since the ratio of force to acceleration is always the same for a given body, the mass of that body is constant. Example: If the a of a given body is 5 ft/sec2 when the force is 20 lbs., the mass of the body is:

m = F/a

20 lbs. = 5 $ft/sec^2$

4 lbs. = 2 $ft/sec^2$

Finally, for now at least, when a large force is needed to (1) speed up a body (accelerate it), (2) slow it down (decelerate it), or (3) deviate it sidewise if it is moving (i.e., deflect it), the mass of the body must be likewise large; such a body has large inertia. If a small force can do the job, then the object has small mass and, accordingly, small inertia.

Thus, the mass of an object can be considered to represent in a quantitative way that property of matter which is described qualitatively by the concept of inertia.