CATECHISM: Motion and Newton's Laws of Motion

Gentleman, what are you?
I am a king, for I rule myself.

Ladies, what are you?
I am a queen, for I rule myself

What does it mean to rule yourself?
I am free to do good. I am not the slave of my desires.

Who has made you kings and queens?
For as many as are led by the Spirit of God, they are the sons of God. For ye have not received the spirit of bondage again to fear; but ye have received the Spirit of adoption, whereby we cry, Abba, Father. The Spirit itself beareth witness with our spirit, that we are the children of God: And if children, then heirs; heirs of God, and joint-heirs with Christ; if so be that we suffer with Him, that we may be also glorified together. (From Romans 8:14-17)

What separates us from God?
The vices are pride, avarice, lust, envy, gluttony, wrath, sloth, and despair.

What does it mean to be human?
The virtues are faith, hope, love, wisdom, justice, courage, temperance.

Why should we seek virtue?
Verily, verily, I say unto you, I give unto you to be the salt of the earth; but if the salt shall lose its savor wherewith shall the earth be salted? The salt shall be thenceforth good for nothing, but to be cast out and to be trodden under foot of men. Verily, verily, I say unto you, I give unto you to be the light of this people. A city that is set on a hill cannot be hid. Behold, do men light a candle and put it under a bushel? Nay, but on a candlestick, and it giveth light to all that are in the

house; Therefore let your light so shine before this people, that they may see your good works and glorify your Father who is in heaven. Think not that I am come to destroy the law or the prophets. I am not come to destroy but to fulfil; For verily I say unto you, one jot nor one tittle hath not passed away from the law, but in me it hath all been fulfilled. And behold, I have given you the law and the commandments of my Father, that ye shall believe in me, and that ye shall repent of your sins, and come unto me with a broken heart and a contrite spirit. Behold, ye have the commandments before you, and the law is fulfilled. Therefore come unto me and be ye saved; for verily I say unto you, that except ye shall keep my commandments, which I have commanded you at this time, ye shall in no case enter into the kingdom of heaven. (From 3 Nephi 12:13-20)

What is the grandest thing in science?

Theories are the grandest thing in science. Strong, successful theories are the glory and goal of scientific research. We don't speak of theories as being proven or disproven. Instead we speak of them in terms such as how successful they have been at making predictions and how accurate predictions have been.

What is truth?

Truth is the way things really are.

What is the SI?

Typically known in the US as the metric system. There are seven base units, we are only using the first five: meter (length), kilogram (mass), second (time), ampere (electric current), and Kelvin (temperature).

What is the MKS system?

The MKS system is a subsystem of the SI system. The three base units used in the MKS system are meter, kilogram, second.

What is the difference between accuracy and precision?

The lower the error is in a measurement, the better the accuracy. If you want greater precision, you must use a more precise instrument. The precision in any measurement is indicated by the number of significant digits it contains.

What implies a fraction?

The term "per," sometimes written as "p," such as "mph" for miles per hour, or "gps" for gallons per second.

What temptation must you resist?

We are to show all of our work, and to resist the temptation to skip steps or take shortcuts. We develop correct habits for problem solving and stick to them. Write down information, perform needed unit conversions, write equation to be used in standard form, perform algebra necessary to isolate the unknown, insert the values using MKS units and compute, convert to non-MKS units if required in problem, write the result with correct significant digits and units of measure, check your work and look for errors, make sure your result is reasonable, then revel in satisfaction!

What are the two types of motion we address?

Motion at a constant velocity, when an object is not accelerating, and motion with uniform acceleration. In this course velocity is speed and speed is velocity; velocity is a quantity that describes how fast an object is moving and in which direction. At a constant velocity, the velocity of an object is defined as the distance the object travels in a certain period of time. Velocity is the rate at which an object's distance is changing.

How can velocity be expressed mathematically?

$$v = \frac{d}{t}$$

Velocity (v) is calculated by dividing the distance (d) the object travels by the amount of time (t) it takes to travel that distance. The units for a velocity are meters per second (m/s).

What is the acceleration?

The quantity we use to measure if a velocity is changing, and if so, how fast it is changing, is the acceleration.

What equation do we use to calculate uniform acceleration?

$$a = \frac{v_f - v_i}{t}$$

a is the acceleration (m/s^2), t is the time spent accelerating (s), and v_i and v_f are the initial and final velocities, respectively (m/s). A negative value for acceleration means an object is slowing down. We must be careful to distinguish between velocity (m/s) and acceleration (m/s^2). If velocity is constant then the acceleration is zero; if the object is slowing down or speeding up, then the acceleration is not zero.

What do the heavens tell us?

The heavens declare the glory of God, and the sky above proclaims His handiwork. (From Psalm 19)

What is Kepler's First Law of Planetary Motion?

Each of the planetary orbits is an ellipse, with the sun at one focus.

What is Kepler's Second Law of Planetary Motion?

A line drawn from the sun to any planet sweeps out a region in space that has equal area for any equivalent length of time.

This law implies that the planets travel faster when they are closer to the sun and slower when they are farther away.

What is Kepler's Third Law of Planetary Motion?

The orbits of any two planets are related as follows:

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^3$$

where T_1 and T_2 are the planets' orbital periods, and R_1 and R_2 are their mean distances from the sun.

Kepler's third law relates the period of any planet's orbit to that planet's mean distance from the sun.

What is the first quantitative law of gravity called?

The law of gravitation is Newton's theory that all objects with mass attract all others, with a force that is directly proportional to the product of two masses and inversely proportional to the square of the distance between them. Everything in the universe pulls on everything else.

What are examples of matter?

Matter is the term we use for anything made of atoms or parts of atoms. Examples of matter are things like bananas, protons, carbon atoms, and planets. Examples of things that are not matter include radio waves, Beethoven's ninth symphony, and justice. These are all real things, but they are not material objects and have no mass.

What is a property that all matter possesses?

Inertia is a property of all matter that causes matter to prefer its present state of motion, quantified by the variable mass. In order to change the motion of an object a force is required. Without a net force on an object, the object's inertia makes it continue doing whatever it is presently doing.

What is the variable we use to specify a quantity of matter?

Mass is a quantitative variable that specifies an amount of matter, a quantity of matter. We think of inertia as a quality of matter and mass as the quantity of a specific portion of matter.

What is the difference between force and net force?

Force is simply a push or a pull. Net force is a force or combination of forces on an object that is not balanced by any other force, thus causing acceleration.

What is Newton's First Law of Motion?

An object at rest remains at rest, and an object in motion continues moving in a straight line at a constant speed, unless it is compelled to change that state by forces acting on it.

The first law applies when there is no net force acting on an object. The first law is sometimes called the law of inertia.

What is Newton's Second Law of Motion?

The acceleration of an object is proportional to the force acting on it, or

$a = \frac{F}{m}$

where a is the acceleration of the object (m/s^2), F is the net force on the object in newtons (N), and m is the object's mass (kg).

The second law applies when there is a net force present and says what the object does as a result; the acceleration is directly proportional to the force. The MKS unit of measure for force is the newton (N), a derived unit. All derived units are formed by various combinations of the seven base units. Force is mass times acceleration (that is, F=ma), the unit for force is the product of the units for mass and acceleration, or

$1\ N = 1\ kg \cdot \frac{m}{s^2}$

What is Newton's Third Law of Motion?

For every action force, there is an equal and opposite reaction force.

A better way to state the law is: for every force, there is an equal and opposite push-back force.

The third law describes the way objects always act on one another when forces are present.

What will you do every time you write down a value of any kind, in any problem?

We will write the units that go with it, every time!

How do you calculate the weight of an object on earth?

Weight is the force on an object due to gravity.

$F_w = mg$

where F_w is the weight of the object (N) and g is the acceleration due to gravity, which for earth is approximately equal to 9.80 m/s^2 (at sea level). We use this equation any time we have an object's mass and need its weight, or vice versa. On the surface of earth, any object that falls freely accelerates with an acceleration of 9.80 m/s^2. This is a special case of Newton's second law using g as the acceleration. An object's weight depends on the gravitational field it is in.

How do you apply Newton's Laws of Motion?

If there is no net force and no acceleration, the first law is the one to apply. If any scenario that depicts objects at rest and remaining at rest, or moving at a constant velocity and continuing so, the first law applies.

If the velocity is not constant, the second law applies. If any object is depicted as accelerating, apply the second law, which says that the acceleration of the object is directly proportional to the net force applied to it.

If the scenario refers to two objects pushing or pulling on each other, regardless of whether they are moving, apply the third law. The action-reaction pair is always a pair of forces, not anything else like actions, processes, or events. Newton was referring to forces, that is, pushes or pulls.

What is momentum?

The product of an object's mass and velocity.

What is evidence of a great mind?

To overcome difficulty is evidence of a great mind. Growth follows difficulty, without a challenge there is little to no growth.

First a thing is impossible, then it is difficult, then it is done!