National Science Bowl Study Guide

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Physics

The **velocity** or **speed** of an object is the distance that is travels in a certain amount of time: $\boxed{Velocity\ (or\ Speed) = \frac{Distance}{time}}$. In order to change an object's velocity (speeding it up *or* slowing it down, you need to apply a **force**.

A **force** is a measure of how hard you need to push or pull on something to change the speed at which it's moving (that speed could be zero if it's sitting still). It doesn't take any force to keep an object moving at the same speed—that is Newton's 1st law). The technical term for changing something's speed is **acceleration**. Another of Newton's Laws of Motion (the 2nd one) tells us that the force required to accelerate an object with a certain mass obeys the following relationship: $\boxed{Force = mass \times acceleration}$. So, if you know two of these three terms, you can find the other one by multiplying or dividing.

A special force that exists between all objects that have mass is **gravity**. Near the surface of our planet (Earth) gravity accelerates objects at a rate that is called the **"acceleration due to gravity"**. Scientists and engineers don't have enough time to say "acceleration due to gravity" all the time so we call it **"g"** for short. The value for g is approximately $9.8\ m/s^2$ (meters per second per second). Yes, that's two "per second's". An object falling under gravity (with no air resistance) will accelerate at such a pace that its speed increases 9.8 meters per second every second! (objects falling through air will eventually reach a terminal velocity due to air resistance, though, and don't keep accelerating indefinitely).

Gravity is always pulling us towards the center of the earth—that means the Earth is technically pushing up on us to keep us in place! That's okay, we push back on the earth, too, with the same force. Actually, it's always true that when a force pushes on an object, the object pushes back with the same force! (This is Newton's third law). Even cooler, since we can measure the mass of objects, and we know their acceleration due to gravity is **g** on the surface of the earth, we can use Newton's nifty 2nd law above to define a force that tells us how hard objects push down on the surface of the earth. We call that special force **weight**: $\boxed{Weight = mass \times g}$.

Newton was a smart guy. He also taught us that the force due to gravity decreases when you move two objects further apart (this is why we often talk of space shuttles "escaping" earth's gravity by travelling through the atmosphere into space). The force or acceleration due to gravity decreases or increases by a factor equal to the *square* of the distance that you move the objects apart or closer together. For example, if you double the distance between two objects, the gravity *decreases by four*.

Now that we've talked about forces, we can talk about **work**. **Work** is a measure of how much **energy** it takes to move an object with a certain force. $\boxed{Work = force \times distance}$. Work and energy have the same units, and are measured in things like Joules, Btu, kW-h (kilowatt-hours…like on your electric bill), and electron volts (physicists and chemists like electron volts).

Power is a term that tells us how much work is done per time. $\boxed{power = \frac{work}{time}}$. Power is measured in units like watts (a watt is a joule per second) and horsepower.

Electricity is the movement of electrons through a material. Electrons are pushed by a force caused by **voltage**. The number of electrons moving is related to the electricity's **current** (usually measured in "amperes" or "amps" for short). There is a special law for electricity: $\boxed{power = voltage \times current}$. If you multiple the volts by the amps in an electrical circuit, this gives you the **power** of the circuit in watts.

Chemistry

The **density** of an object is a measure of how much **mass** the object has within a certain **volume**. We say an object is "dense" when it feels heavy (due to a large mass) for its size. The formula for density is $\boxed{density = \frac{mass}{volume}}$. This can be remembered because when mass (m) is placed over volume (v) the m and the v make a heart shape.

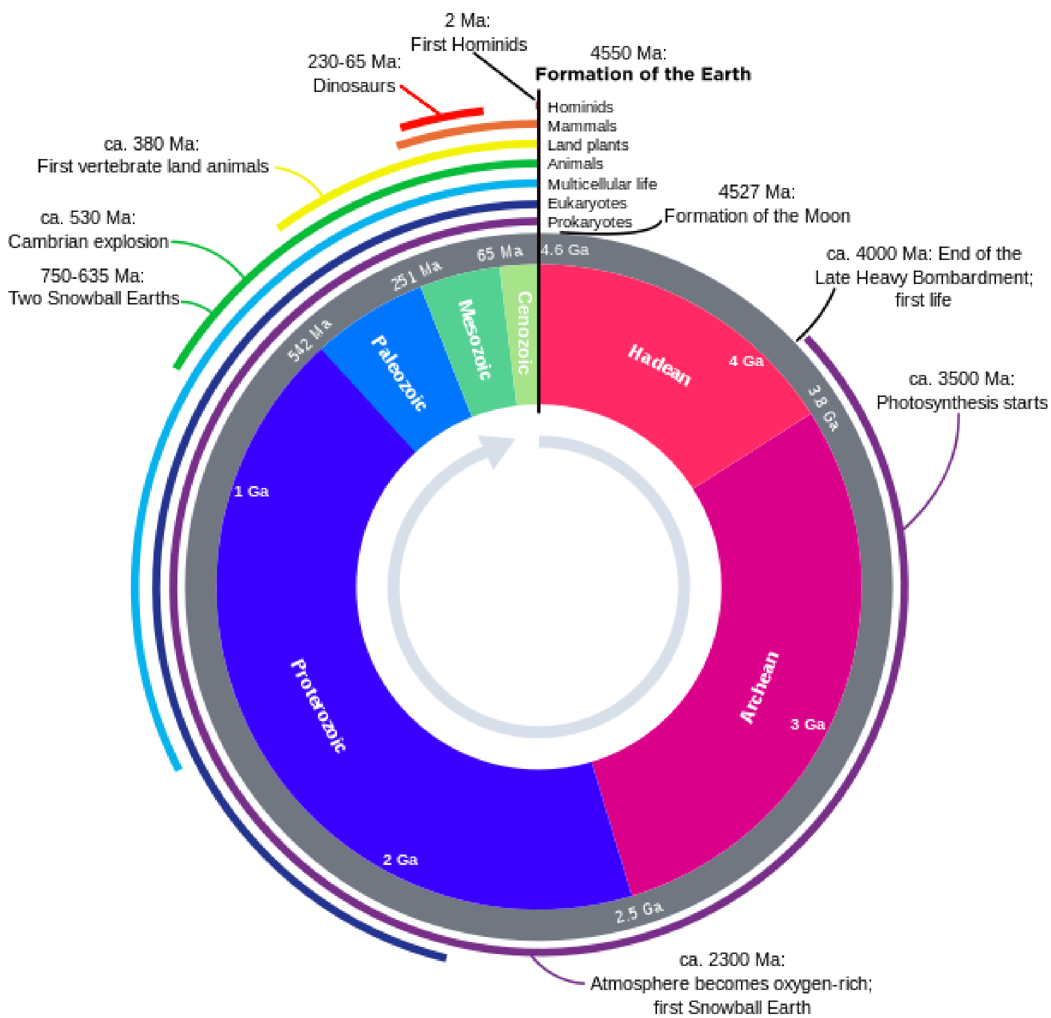
All matter is made up of molecules, which are made up of elements. There are over 100 elements, although many are very rare. The number of an element on the Periodic Table tells us how many **protons**, which have a positive charge, are in the center (called the **nucleus**)of one of its **atoms**. Elements usually have **neutrons**, which do not have a charge (they're "neutral") in their nucleus as well, and the number of neutrons may differ. An element is always named by the *number of protons it has*. Elements with the same number of protons but different neutrons are called **isotopes**. Carbon-12 and Carbon-14 are an example of **isotopes.** Carbon-12 has 6 protons and 6 neutrons. Carbon-14 has 6 protons and 8 neutrons. Carbon-14 slowly decays to Carbon-12 (by spitting out neutrons), and this is how *carbon dating* can be used to measure the age of things that used to be alive (including things like paper or papyrus, which come from trees and plants!) **Electrons**, which have a negative charge, orbit the nucleus of atoms. In neutral atoms, there are an equal number of electrons and protons. When there are more or less electrons than protons, an atom will have either a net negative (more electrons) or net positive (less electrons) charge. We call such atoms **ions**.

It would be good to review the periodic table of the elements (you can find it on the web). Can you memorize the first 10 elements? There are some important ones in there, like hydrogen, oxygen, carbon, and nitrogen!

If someone says "**hydrocarbons**" they are talking about molecules made up mostly of hydrogen and carbon. **Saturated hydrocarbons** have names ending in "-ane" like "propane". **Unsaturated hydrocarbons** have names ending in "-ene" or "yne" like "ethene" or "acetylene"

Other Science Topics

Questions on the planets and stars seem to be popular, as are planets about geology and geologic time scales. If you want to read about stars (specifically, their spectral classification, you make go here: http://en.wikipedia.org/wiki/Stellar_classification#Spectral_types). Here is an image from Wikipedia that outlines the major geologic time scales:



Source: http://en.wikipedia.org/wiki/Geologic_time_scale

Biology is another topic that is very broad. Something specific to focus on if your child is interested is the topic of **cells**. A summary can be found here: http://en.wikipedia.org/wiki/Cell_(biology). In specific, it may be useful to review the parts of a cell (the **organelles**) and what they do: http://en.wikipedia.org/wiki/Cell_(biology)#Organelles.