

# MAGNETS, MOTION and MEASUREMENT

## PART 1

### THE PURPOSE OF THIS BOOK

**This book is written for people interested in doing home experiments related to alternative energy. In particular, it is written for those who have an interest in magnets and their interactions.**

**None of the concepts presented herein, are given in any way near the detail and completeness that a physics course would entail. But then neither are they intended to constrain the experimenter's thinking within any context or premise of physics's laws of conservation.**

**Those conservation laws while useful, should I think, be defined as principles existing within a known and limited range of phenomena only. Not as absolute limitations.**

**This book is intended to aid in practical application.**

**The information is first a presentation of basic physics principles and secondly, a how to guide in respect to the measuring of interactions between magnets in terms of energy, work and power.**

**It is also my intention that the present work will be of value to experimenters as an aid in determining the significance and meaning of the measurements they have made.**

**The materials presented include some of the basic principles of physics while utilizing the least amount of mathematics I could manage. The descriptions given are in terms of Newtonian or classical mechanics, and Galilean relativity with the exception of some brief and occasional reflections upon Einstein's theories of relativity.**

**Often there are many different definitions for a specific / same word. Even within science one finds that the definition of a word has within one branch of science, a specific meaning of which those working within another branch of science are generally unaware.**

**The definitions and terminologies within the present work are primarily from that branch of science which is called mechanics.**

**There is a great deal of redundancy in the presentation. By repetition of the concepts presented here in, and while also stating those concepts in varied ways, it is my hope that the subjects may become easy. This repetition of concepts also gives each topic more completeness or ability to stand on its own.**

### TOPICS COVERED IN PART 1

**energy, inertial frame of reference, speed, velocity, gravity, force, acceleration, the forces of acceleration, constant acceleration, acceleration by gravity, inertia, momentum, mass, weight, mass v weight, the newton, work, the joule, aspect ratio, time, power**

Good hunting  
The author

## SOME DEFINITIONS Excerpts From Wikipedia

Below are some excerpts from Wikipedia articles, relevant to the definition of the word energy. I have placed specific words in **bold type** to indicate that they will be the subject of another Wikipedia topic excerpt.

"Energy is a **property** of **objects**, **transferable** among them via **fundamental interactions**, which can be **converted** in form but not **created** or **destroyed**. The joule is the **SI** unit of energy, based on the amount transferred to an object by the mechanical work of moving it 1 meter against a force of 1 newton.[1]"

**The "SI" is le Système International d'Unités or the International System of Units.**

PHYSICAL PROPERTY: "A physical property is any property that is measurable, whose value describes a **state** of a **physical system**."

STATE "In classical mechanics, state is a complete description of a system in terms of parameters such as positions and momentums at a particular moment in time

PHYSICAL SYSTEM : "a physical system is the portion of the physical universe chosen for analysis. Everything outside the system is known as the environment, which in analysis is ignored except for its effects on the system. The cut between system and the world is a free choice, generally made to simplify the analysis as much as possible."

OBJECT: "In physics, a physical body or physical object (sometimes simply called a body or object) is a collection of **matter** with some common attributes, most important, the spatial location. Examples of models of physical bodies include, but are not limited to a particle, several interacting smaller bodies (particles or other), and continuous media."

TRANSFERABLE: "In the physical sciences, an energy transfer or 'energy exchange' from one system to another is said to occur when an amount of energy crosses the **boundary** between them, thus increasing the energy content of one system while decreasing the energy content of the other system by the same amount."

BOUNDARY: (from the Wikipedia topic titled system and the sub heading system concepts) "System theory views the world as a complex system of interconnected parts. We scope a system by defining its boundary this means choosing which entities are inside the system and which are outside – part of the environment. We then make simplified representations (models) of the system in order to understand it and to predict or impact its future behavior. These models may define the structure and/or the behavior of the system."

MATTER: "Matter is a poorly defined term in science (see definitions below). The term has often been used in reference to a substance (often a particle) that has rest mass. Matter is also used loosely as a general term for the substance that makes up all observable physical objects. [1][2]"

## **SOME DEFINITIONS**

### **Excerpts From Wikipedia**

(The following paragraph is also an excerpt from the Wikipedia article titled "Matter").

"Albert Einstein showed that ultimately all matter is capable of being converted to energy (known as mass-energy equivalence) by the famous formula  $E = mc^2$ ,"

FUNDAMENTAL INTERACTIONS : "Also called fundamental forces or interactive forces, are modeled in fundamental physics as patterns of relations in physical systems, evolving over time, that are not (beneficially) reducible to relations among more basic entities (at prevalent energy scales). Four fundamental interactions are conventionally recognized on empirical evidence: gravitational, electromagnetic, strong nuclear, and weak nuclear."

CONVERTED : "Energy transformation or energy conversion is the process of changing one form of energy to another."

## **SOME DEFINITIONS**

### **Omissions from Wikipedia**

The words destroyed and created are not topics for articles in Wikipedia. However these words are frequently used in many of Wikipedia's science articles. Some small and exemplary accounting of their usage is given below

The word destroyed is used 3 times in the article "Matter", 6 times in the article "Mass Energy equivalence", 7 times in the article "Energy", 1 time in the article "Energy transformation" and 3 times in the article titled "Mass".

The word created is used 6 times in the article "Matter", 2 times in the article "Mass Energy equivalence", 6 times in the article "Energy", 2 times in the article "Energy transformation" and 1 time in the article titled "Mass".

The online Oxford dictionary was lacking these definitions (in the context of physics) as well.

**Energy, what a concept ! What it is essentially, I have never found an explanation of, and I doubt that anyone is actually capable of making such an explanation. It may be that we possess neither the words nor the understanding for such an explanation.**

**The concept of energy, for the most part is derived from observation of the physical changes that occur when energy is transferred between two bodies or systems. It might be said that energy has only ever been defined through describing the effects it has.**

**The effects energy will have when it is expressed or transferred between two objects has been studied, measured and recorded, with extreme accuracy and precision, countless times and in innumerable ways. A great deal is known about energy in this respect.**

**Following are examinations of the definitions of energy and work from two of my old dictionaries.**

#### **Webster's New World Dictionary 1956**

energy: the capacity for doing work and overcoming resistance

work: the transference of force from one body, or system to another, measured by the product of the force and the amount of displacement in the line of force.

#### **The American College Dictionary 1947 / 1948**

energy: the property of a system which diminishes, when the system does work on any other system, by an amount equal to the work so done.

work: the transference of energy from one body or system to another.

**It is interesting to note that the Webster's definitions of energy and work are defined by each other. Except that the word force is used in place of the word energy in the definition of work. Note that a force is an expression of energy that is causing any object to undergo a change, in its movement, direction, or geometrical construction.**

**The American College definition of energy says that energy is a property of a system. This is an interesting beginning for the definition, in light of the fact that any physical system is composed entirely of energy, 100% so. Matter is composed entirely of energy and I think that probably energy is also. Although perhaps energy is composed of some sort of information that organizes it ? Even if this is so, the dictionary definitions stand unaffected.**

**So to continue.....**

energy: "the property of a system"

**Therefore energy is the property of energy or, energy is the property of it's self.**

"which diminishes"

**Energy is a property that diminishes. We can safely assume that this diminishing is not caused by the destruction of energy (else all hell should break loose). It must therefore be that this diminishing is either transformation or transfer. I'm guessing that transference is the cause of the diminishing and will interpret it as such.**

**which transfers**

"when this system"  
**when this energy**

"does work"  
**transfers energy**

"on any other system"  
**to any other energy**

"by an amount equal to the work so done"  
**by an amount equal to the energy so transferred**

**And now the complete interpretation.**

**Energy is the property of energy that transfers, when this energy transfers energy to any other energy by an amount equal to the energy so transferred.**

**The only questions I'm left with at this point are:**

- 1 Does it require an expenditure of energy in order for energy to transfer it's self ?**
- 2 Is transference the expenditure of energy or is it rather that, energy IS transference ?**

**Definitions of energy by the use of terminology such as "fundamental interactions", make the rabbit hole deeper, but the same questions remain unanswered. An interaction is an energy exchange, even if it is "fundamental", and even if it does violate conservation.**

FOR SO LONG AS ONE IS WILLING TO CHANGE THE DEFINITION OF ENERGY  
ONE CAN ALSO "PROVE" THAT ENERGY IS CONSERVED

**The following brief paragraph is a quotation from the Wikipedia article the "Conservation of energy". It is excerpted from a section of that article which is titled Noether's theorem.**

"Since any time-varying system can be embedded within a larger time-invariant system (with the exception of the universe), conservation can always be recovered by a suitable re-definition of what energy is and extending the scope of your system."

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts From Wikipedia**  
**ENERGY WORK AND FORCE**

**From a Wikipedia article on energy** “The distinctions between different kinds of energy is not always clear-cut. As Richard Feynman points out: ”

**The following 2 tables of forms of energy are excerpts from Wikipedia.**

**Forms of energy, table 1**

<b>Type of energy</b>	<b>Description</b>
Kinetic	( $>0$ ), a form of mechanical energy propagated by a material's oscillations
Chemical	that contained in molecules
Electric	that from electric fields
Magnetic	that from magnetic fields
Radiant	( $>0$ ), that of electromagnetic radiation including light
Nuclear	that of binding nucleons to form the atomic nucleus
Ionization	that of binding an electron to its atom or molecule
Elastic	that of deformation of a material (or its container) exhibiting a restorative force
Gravitational	that from gravitational fields
Intrinsic the rest	( $>0$ ), that equivalent to an object's rest mass
Thermal	A microscopic disordered equivalent of mechanical energy
Heat	an amount of thermal energy being transferred (in a given process) in the direction of decreasing temperature
Mechanical work	an amount of energy being transferred in a given process due to displacement in the direction of applied force

**Forms of energy, a second excerpt from Wikipedia, table 2**

<b>Type of energy</b>	<b>Description</b>
Kinetic	( $\geq 0$ ), that of the motion of a body
Potential	A category comprising many forms in this list
Mechanical	The sum of (usually macroscopic) kinetic and potential energies
Mechanical wave	( $\geq 0$ ), a form of mechanical energy propagated by a material's oscillations
Chemical	that contained in molecules
Electric	that from electric fields
Magnetic	that from magnetic fields
Radiant	( $\geq 0$ ), that of electromagnetic radiation including light
Nuclear	that of binding nucleons to form the atomic nucleus
Ionization	that of binding an electron to its atom or molecule
Elastic	that of deformation of a material (or its container) exhibiting a restorative force
Gravitational	that from gravitational fields
Intrinsic or the rest energy	( $\geq 0$ ), that equivalent to an object's rest mass
Thermal	A microscopic, disordered equivalent of mechanical energy
Heat	an amount of thermal energy being transferred in (a given process) in the direction of decreasing temperature
Mechanical work	an amount of energy being transferred in a given process due to displacement in the direction of an applied force

The descriptions made within the present work are in terms of Newtonian or classical mechanics, and Galilean relativity with the exception of some brief and occasional reflections upon Einstein's theories of relativity.

According to Einstein's theory of general relativity, an increase in the speed of an objects motion is also an increase in the energy of that object. All forms of energy have mass, therefore an increase in the energy of an object is also an increase in the mass of that object. There are numerous relativistic effects / consequences which are not accounted for within Newtonian mechanics but then, neither are they topics within the present work.

At very small scales (atomic and sub atomic), and /or at very high speeds, the ratio of the rest mass of an object to its relativistic mass is very significant. In this context, Newton's laws of motion must be viewed as only approximations.

Please note that an object does not have to be moving at or very near the speed of light for its relativistic mass to significantly vary from its rest mass. Relativistic mass has been estimated to be about 0.5 % greater than rest mass at a speed of, about 1/10 the speed light.

One tenth of the speed of light is about 107,925,280 kilometers per hour or about 670,615,200 miles per hour. While 10% of the speed of light (67 plus million miles per hour) is extraordinarily fast, it is still considerably less than the speed of light.

The speed of light in a vacuum is found experimentally to be 299,792,458 meters per second.

The speed of light is 17,987,547,480 meters per minute.

The speed of light is 1,079,252,848,800 meters per hour.

The speed of light is 1,079,252,848.8 kilometers per hour.

1 % of the speed of light is 10,792,528 kilometers per hour

10% of the speed of light is 107,925,280 kilometers per hour

The speed of light is approximately 186,282 miles per second

The speed of light is about 11,176,920 miles per minute

The speed of light is about 670,615,200 miles per hour

1 % of the speed of light is approximately 6,706,152 miles per hour

10 % of the speed of light is approximately 67,061,520 miles per hour

### SPEED and VELOCITY

In physics, the words speed and velocity do not have the same meaning. Speed is the ratio of the distance an object moves to the amount of time it takes it to move that distance. It is not necessary to know, or specify the direction of an objects motion in order to specify it's speed.

.....

Speed is a scalar quality (has only magnitude).

Velocity is a vector quality (has both magnitude and direction).

Please note that, **MAGNITUDE** is the value of a measurement of some property in terms of it being either greater or lesser, when compared to a standard of measurement of that same kind of property.

Commonly (in scientific usage), both speed and velocity are stated in units of meters and seconds, although not always.

Speed is a ratio of distance to time and written as distance divided by time.

As examples: meters per second (m/s) or miles per hour (mi/hr) or kilometers per hour and so on.

.....

Velocity being a vector quality, its specification requires both speed and direction.

That an automobile is moving at 60 miles per hour is, a specification of speed.

That an automobile is moving east, is a specification of direction.

That an automobile is moving at 60 miles per hour eastward, is a specification of velocity.

That an object is moving a distance of 1.25 meters per second (speed), from point A toward point B (direction), is a specification of velocity.

Because velocity is a specification of both the speed and direction of an objects motion, any change in the **SPEED** of an objects motion is therefore also a change in it's velocity.

Because velocity is a specification of both the speed and direction of an objects motion, any change in the **DIRECTION** of an objects motion is therefore also a change in it's velocity.

**EARTH and GRAVITY**

The weight of a given object on Earth can vary depending upon the location at which the weighing of that object is done. This is because the effect that Earth's gravity has upon an object can vary.

Not only can the **EFFECT** that Earth's gravity has upon the weight of an object vary, but also **THE ACTUAL PULL OF EARTH'S GRAVITY** can vary depending upon the locations at which measurements are made.

.....

In physics, **FREE FALL** is the motion of an object caused by gravity when the weight of an object is the only force acting upon the falling object. For example when an object falls while within a vacuum, and there is no resistance to its acceleration due to friction with the air.

.....

All objects (small objects) free fall with the same rate of acceleration when under the influence of a given gravitational attraction. This characteristic of free falling objects is referred to as the **UNIVERSALITY OF FREE FALL**. We will examine the reasons for this characteristic of free falling objects at a later point.

.....

An acceleration rate for a free falling object of 9.80665 meters per second per each second of its fall, is a nominal value for the variations at which objects free fall in near Earth gravity. This acceleration rate of 9.80665 m/s/s is called **STANDARD GRAVITY**.

The near Earth rate of acceleration of a free falling object in standard gravity is constant at 9.80665 meters per second during each second that the object falls.

In other words a free falling object in standard gravity would increase its velocity by 9.80665 meters per second during each second that it falls. There fore an object starting from a state of rest will reach a velocity of 9.80665 meters per second at the end of one second, a velocity of 19.6133 meters per second at the end of two seconds, a velocity of 29.41995 meters per second at the end of three seconds and so on.

Meters per second per second is some times written as m/s/s or as  $m/s^2$ .

This rate of acceleration which is 9.80665 m/s/s is called Earth's gravitational constant of acceleration.

This phrase is commonly shortened to the phrase "Earth's gravitational constant".

The letter g is used to stand for any LOCAL gravitational constant of acceleration but usually refers to EARTH'S nominal gravitational constant of acceleration which is 9.80665 m/s/s (standard gravity). The letter g can also stand for a specific local gravity on Earth (due to local variations) or for any local gravity (for example that of the moon or that of any other body).

#### VARIATION IN EARTH'S GRAVITY AND VARIATION IN ITS EFFECT

The near Earth rate of acceleration due to gravity is constant to only about 0.5 % and to about 0.25% of standard gravity. A major cause of variation in the EFFECT that Earth's gravity has upon objects is the centrifugal force caused by Earth's rotation. This centrifugal force partially counter acts the pull of Earth's gravity. This centrifugal force varies with latitude.

The table below shows the variation in free fall acceleration due to gravity but also the variation in weight as measured upon a spring type of weight scale at different latitudes on the Earth's surface.

More precise values may be found through searches on the internet.

approximate latitude	approximate acceleration as meters per second per second
90 degrees	9.8322 (polar)
60 degrees	9.8168
30 degrees	9.7968
0 degrees	9.7803 (equatorial)

VARIATION IN EARTH'S GRAVITY AND VARIATION IN ITS EFFECT

The effect of Earth's gravity can vary by about 0.05 m/s/s due to change in latitude.

9.8322 maximum (polar) - 9.7803 minimum (equatorial) = 0.0519 variation

0.0519 variation = x% of the 9.7803 (maximum value) ?

100 ÷ 9.7803 = 10.22463

10.22463 x 0.0519 = 0.53065 %

This is about 0.5 % or 0.005 variation

.....  
The effect of Earth's gravity can vary from the mean value (standard gravity) by about 0.025 m/s/s due to change in latitude.

9.8322 maximum (polar) - 9.80665 (standard gravity) = 0.02555 variation

0.025 variation = x% of the 9.8322 (maximum value) ?

100 ÷ 9.8322 = 10.1706

10.1706 x 0.025 = 0.25426 %

This is about 0.25 % or 0.0025 variation

.....  
The variations in the free fall rate of acceleration of objects as described above, are due to centrifugal force. That centrifugal force does not change the magnitude of Earth's gravitational pull. That centrifugal force partially counter acts gravity's pull.

OTHER GRAVITY AND WEIGHT CONSIDERATIONS

A variation in the MEASURED weight of an object as compared to the pull that Earth's gravity actually exerts upon that object, and which is caused by some force other than the acting gravity is sometimes referred to as the APPARENT WEIGHT of an object.

.....  
The Earth's gravitational force upon an object decreases with the distance of that object above the Earth's surface. These variations are not likely to affect at-home experiments given that measurements will likely be made while at or near the Earth's surface. These variations are not exemplary of the concept of apparent weight but represent actual variations in gravity's pull and therefore also, actual variations in the weight of objects.

.....  
Buoyancy of an object within Earth's atmosphere causes variation in that objects weight as measured. This effect is apparent when one observes a helium balloon. Please note that objects are less buoyant in the atmosphere at higher altitudes. For most purposes atmospheric buoyancy is too small to merit its being taken into account by the home experimenter. However the buoyancy of an object within a liquid (for example due to immersion in water) has a large effect upon the measured weight of an object. These variations are exemplary of apparent weight.

OTHER GRAVITY AND WEIGHT CONSIDERATIONS

Variation in the Earth's density at different locations modifies Earth's gravitational pull. These variations are small enough that they can probably be disregarded by the home experimenter. These variations are exemplary of actual changes in the weight of an object.

Variations in the distance from Earth's center to its surface (the Earth is not a perfect sphere) cause variations in Earth's local gravity. Again, these variations are small enough that they can probably be disregarded by the home experimenter. These variations are exemplary of actual changes in the weight of an object.

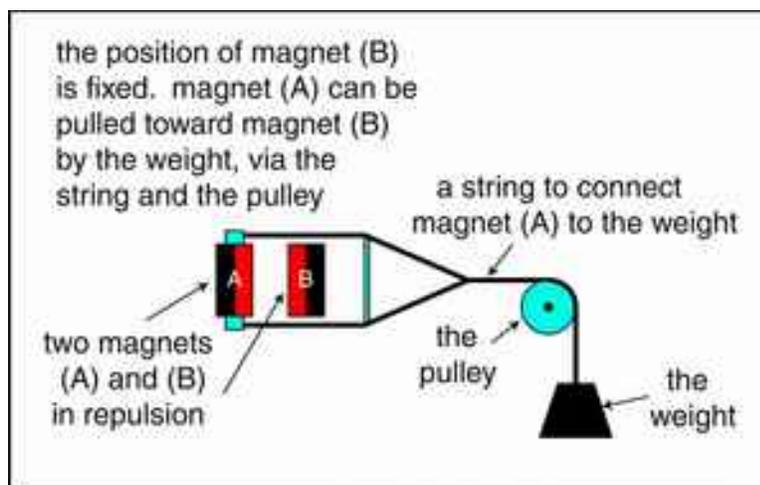
An object will weigh less upon the moon than it weighs upon the Earth. This is because Earth exerts a greater gravitational pull than does the moon. This variation is exemplary of an actual change in the weight of an object.

If the weighing of an object is done through the use of a balance type of scale, then the AMOUNT OF SUBSTANCE THE WEIGHED OBJECT IS COMPOSED OF (this is not its weight) can be said to be accurate to the degree of the accuracy of the balance scale used. This is because a local variation in gravity and / or a local variation in the effect that gravity will have, is the same for each side of a balance scale.

For example, 1 cubic centimeter of lead when placed on a balance scale will balance when another 1 cubic centimeter of lead is placed upon the other side of the scale, whether the lead and balance scale are upon the moon or upon the Earth.

If however one were to instead use a spring type of scale upon the moon, one would need to place about 6 cubic centimeters of lead upon the scale before it would indicate the same value as when 1 cubic centimeter of lead is placed upon that spring scale on Earth.

When using weight as a means to measure the interactions between magnets (magnetic force), these variations in gravity and / or in gravity's effects have certain or specific implications.



**In the illustration above a variation in either gravity or gravity's effect would change the amount of pull by the weight, but would not change the amount of force required to close the gap between magnet (A) and magnet (B). If the force present as the weight is not actually known due to a variation in gravity or in its effect, then also the force needed to close the gap between the magnets is not known. Most variations ( $\leq 0.25\%$ ) are probably too small to merit being taken into account by the home experimenter.**

**Use of a spring type of scale (a force scale) in place of a weight object, would make the variations in gravity or variations in gravity's effect irrelevant.**

.....  
**Consider also that under the conditions of free fall, a spring type scale will indicate the weight of an object as zero. But at least in principle, a balance scale if it were indicating the weight of that object before beginning a free fall would continue to indicate the same weight during acceleration, deceleration and also while at a constant speed of descent. This is because the forces of acceleration will be the same on both sides of the balance scale.**

### **THE PRINCIPLE OF INERTIA**

**The principle of INERTIA states that an object tends to remain in the same state of motion. This tendency may be seen as having several aspects to it.**

- 1. the tendency to resist a change in direction of motion.**
- 2. the tendency to resist beginning to move from a state of rest.**
- 3. the tendency to resist an increase in speed of motion**
- 4. the tendency to resist a decrease in speed of motion**

**An object in motion tends to remain in motion, in the same direction and at the same speed, until acted upon by some influence.**

### **THE PRINCIPLE OF INERTIA AT REST or IN MOTION**

**That an object is either at rest or in motion can only truly be said from within an INERTIAL FRAME OF REFERENCE (a certain point of view). Consider for instance, that we are in motion now, as the Earth is rotating upon its axis. Consider also that any object which is upon the Earth and which we observe to be either at rest or in motion, is only so relative to that moving frame of reference from which we are observing (Earth).**

**That an object is "at rest" can only be said from within an INERTIAL FRAME OF REFERENCE (point of view) which is:**

- 1. moving at the same speed as that object  
and  
displacing in the exact same direction and line as that objects displacement. That is to say directly in line with its motion (before or after, in front of or behind).**

or

2. moving at the same speed as that object

and

displacing in the same direction as the objects displacement except that in a line which is parallel to the line of the objects displacement. (a line which is beside)

or

3. moving at the same speed as that object

and

displacing in the same direction as the objects displacement while within that object, as for example, when one is within a moving train car.

4. There are yet other considerations not represented here.

Other wise, all known objects are actually in motion. It follows also that the velocity (the speed and direction) of the motion of an object (like its "at restness") can only be measured or stated within an inertial frame of reference. This principle of an inertial frame of reference is sometimes called a Galilean reference frame.

#### DISTANCE vs DISPLACEMENT

In physics, the **DISPLACEMENT** of an object from a point (A) to a point (B) is the length of a straight line between points (A) and (B), (the shortest distance between them). Obviously the **DISTANCE** that an object moves in order to arrive at a point (B) from a point (A) could be greater than the shortest distance between those points (A) and (B). The displacement of an object is equal to the distance actually traveled by an object, **ONLY** when that object has moved from a point (A) to a point (B) along a straight line. If that object travels from a point (A) to a point (B) by any rout other than a straight line, the **DISTANCE** it moved would be greater than it's displacement.

#### ACCELERATION

In physics a change in the velocity of an object is called acceleration.

An object is accelerating if there is a change in the direction of it's motion.

An object is accelerating if it begins to move from at rest.

An object is accelerating if it's speed increases.

An object is accelerating if it's speed decreases (called deceleration).

.....  
An acceleration is written as an amount of velocity change that occurs over a specific period of time. For example, meters per second (as an amount of velocity change), written over the seconds (that are the period of time it takes for this change to occur). Commonly written as meters per second, per second or m/s/s.

This is a fraction over a fraction.  $\frac{m/s}{s}$

.....

Like velocity, acceleration is a vector quality (has both magnitude and direction). It is specified in terms of both the speed and direction of an objects motion.

The 5 examples below are complete statements of acceleration in that they include a direction.

An acceleration of 2 miles per hour, per second, east.

An acceleration of 5 kilometers per hour, per second, north.

An acceleration of 9 meters per second, per second, up.

An acceleration of 3 miles per hour, per minute, 3 degrees west.

An acceleration of 3 miles per minute, per hour from point A toward point B.

.....  
Acceleration is commonly written as  $m/s^2$ . While this may simplify the resolving of equations for those versed in engineering mathematics, it may not make it easier to grasp the basic concept.

Acceleration is commonly written as  $m/s^2$  and read as meters per second squared.

why?

Because of the relationships between multiplication and division.

please consider the following

If acceleration = meters, divided by seconds, divided by seconds.... THEN acceleration = meters divided by seconds TIMES seconds

because

When  $X = (A \div B) \div C$  then  $X$  also =  $A \div$  by  $(B \cdot C)$ .

When it so happens that B is = C, as in 1 second is = 1 second (as in per second per second) the product of their multiplication is then also the square of B (or the square of C).

an example 1a

An acceleration of 24 meters per 4 seconds, per every 5 seconds that passes, would be  $24m \div 4s \div 5s$  and is equal to 1.2 m/s /s,

This has the same value as,  $24m \div (4s \cdot 5s)$  which is also equal to 1.2 m/s/s.

an example 1b

$5 m / 3s / 2s = 0.833 m/s/s$ , This has the same value as,  $5m \div (3s \cdot 2s) = 0.833 m/s/s$ .

Next please consider an example 2a

$9m/s^2$  can be written as  $9m /1s /1s$  and has the same value as  $9m \div (1s \text{ times } 1s)$  .

and

1 times 1 is equal to 1 squared (as in 9 meters per second squared).

.....  
There will be much more discourse upon acceleration under various contexts at later points.

.....  
.....

**FORCES OF ACCELERATION  
ACTION and REACTION - OPPOSITE and EQUAL**

**For the present you might think of a force as simply a push or pull upon an object. Please note however that in physics the word FORCE has a detailed and specific meaning which we will look at later.**

.....  
**When an object is accelerating, it is because a force is acting upon it.**

**This force is sometimes referred to as an ACTING FORCE.**

.....  
**Acceleration is / occurs only during the time that this force is acting.**

.....  
**Any object has a resistance to acceleration due to that object's inertia.**

.....  
**This resistance to acceleration may be described as a force acting against the acceleration.**

.....  
**This resistance to acceleration is opposing or opposite the accelerating force.**

.....  
**The TENDANCY to oppose acceleration (inertia) is always present in an object.**

.....  
**The ACTUAL FORCE of inertia which opposes acceleration is present only during an acceleration.**

.....  
**This force which is opposite to acceleration is sometimes referred to as a REACTIVE FORCE.**

.....  
**The "reactive force" is equal to the acting force.**

.....  
**There are often forces in opposition to an acceleration other than those due to inertia.**

**EQUAL AND OPPOSITE TO**

**Newton's third law of motion states that to every action there is always an equal and opposite reaction, and that the actions of two bodies upon each other are always mutual, equal, and directed to contrary parts.**

.....  
**Most of us are familiar with the acceleration forces present when a firearm (a pistol or rifle) is discharged. If not through first hand experience, then perhaps because of television or other media. When a pistol is fired it "kicks". While the bullet is being propelled down the barrel by the explosive charge, the pistol is also being thrust backward. The force of this "kick" is EQUAL TO AND OPPOSITE TO the force expelling the bullet from the gun's barrel. If not for the fact that the pistol has more inertia than the bullet, the pistol would accelerate as rapidly as the bullet, but in a direction opposite to that of the bullet.**

**In this pistol - explosive charge - bullet example, the explosive charge is between the pistol and the bullet. It is therefore easy to see why the force of its explosion would push in opposite directions and with equal force.**

.....

**FORCES OF ACCELERATION  
ACTION and REACTION - OPPOSITE and EQUAL**

As a second example of equal and opposite forces consider that an object (O) near Earth is pulled upon in a downward direction by Earth's gravity. This pull is also called the weight of that object (O). There is a reactive force in this interaction, which is the pull by that object (O) upon the Earth.

If object (O) is suspended from a string, the supporting string would exert a force upon the suspended object (a tension force), and prevent the object from falling. This tension force must be equal to and opposite to the force of gravity, or else the suspended object would either fall, rise or move in some other direction.

.....

As a third example of equal and opposite forces consider two billiard balls in deep space. Said balls are of the the same mass, composition and shape. Ball (R) is at rest, ball (M) is in motion.

If ball (M) collides directly into ball (R), ball (R) will accelerate by the same amount as ball (M) is decelerated (except for losses due to energy transformations).

.....

In the following examples it may be less easy to see that the opposing forces are equal. Also please note that in the following, as a simplification, we will again omit consideration of losses due to friction and energy transformations.

.....

**INERTIA GIVING RISE TO A REACTION FORCE**

Most of us are familiar with acceleration forces as we have experienced them while pushing a car when its engine will not start. Given that the car is on smooth level pavement, you may have noticed that it takes a greater effort to either INITIATE the car's motion or to SPEED UP the car than is required to MAINTAIN the cars motion once it has gotten up to some speed. This is because the opposition to acceleration (due to inertia) is present only during acceleration (the speeding up). While maintaining the pushing speed, we need only to overcome the friction involved in pushing the car.

A person pushing the car would have accelerated to a greater speed (for the same amount of effort or energy expenditure) if the car had not been before him or her. In the absence of the car, that person would need to over come only the inertia of their own body in order to accelerate. Which is of course, less than the inertia of both the car and a human body combined. This force opposing the acceleration of the car (due the inertia of the car) is a REACTION force.

Please note that the inertia of an object gives rise to a reactive force ONLY while another force is ACCELERATING that object.

**FORCES OF ACCELERATION**  
**ACTION and REACTION - OPPOSITE and EQUAL**  
**A REACTION FORCE WITHOUT CONSIDERATION OF INERTIA**

Consider now a push-measuring-device which is in some ways like unto a spring type of weight scale. The characteristics of this device are such that, when we push with our hands upon the opposite ends of the device, a spring within the device is compressed. Greater push upon the device causes greater compression of the spring. The distance this spring is compressed is indicated by a needle and a marked scale upon the face of a dial. Displacement of that needle upon the dial is in direct proportion to the amount of push exerted upon the device.

.....

If we place one end of the push-measuring-device against a practically immovable wall and then push upon its opposite end we get a reading from the device.

A greater push upon the device yields a higher reading upon the scale.

.....

If we flip the device around so that its end which was at first against the wall becomes now the end we push upon, we see (the obvious) that flipping the push measuring device does not change the fact that a greater push upon the device is indicated by a higher reading upon the scale.

In either orientation of the measuring device, the needle displacement upon the scale is a result of both the push acting upon the device and the resistance of the wall to motion (the REACTIVE push from the wall). Flipping the measuring device makes no difference (the obvious) .

.....

If we again place the push-measuring-device against the immovable wall but do not push upon its opposite end with our hand, we get no reading upon the device's scale, No force can be measured without an acting push (the obvious) .

.....

Please note that in the following paragraph I have intentionally disregarded the reactive force which would be present due to the inertia of the push-measuring-device etc..

If next we place one end of the push-measuring-device against a MOVABLE WALL, one which offers practically no resistance to a push upon it (a paper wall ). When we push upon the opposite end of our device we get no reading upon the device. The device simply displaces (along with the wall) as a result of the push. No force can be measured without a reactive push. (the obvious).

.....

With a push from our hand, but in the absence of an opposing reactive push from the wall no push is indicated upon the dial.

and

In the absence of an acting push from our hand, no push from the immovable wall is indicated upon the dial.

.....

**FORCES OF ACCELERATION  
ACTION and REACTION - OPPOSITE and EQUAL  
CHANGE IN DIRECTION AS ACCELERATION**

**Although the one push may be called reactive, both the acting push and reactive push occur only simultaneously. That is to say, that one push does not precede the other and neither does one push exist before the other. The push exists only as both, the acting and reactive push. Both are part of a single interaction. The push exists only because there is both an acting push and a resisting (or reactive) push. In physics, a push against nothing is not a push.**

**The acting and reactive components, comprises the push measured by our push-measuring-device even though each part may be said not to exist (as push) without the other.**

.....  
**Please note that in a consideration as to which push is "the acting" and which is the "reactive", it is arbitrary. Either of the two may be considered to be the acting, while the other is considered as the reactive. Use of these terms is just one way of labeling these aspects distinctly.**  
.....

**The point I wish to make clear in this next section, is why (in physics) a change in the direction of motion of an object is considered to be a change in velocity.**

**Most of us are familiar with acceleration forces as we have experienced them while being a passenger in a moving car.**

**As examples**

**1.**

**When a car speeds up, a passenger experiences a sensation as if being pushed or pulled backwards into the seat. This is an acceleration force. Note that this sensation of being pushed backwards into the seat occurs only during acceleration.**

**The acting push of the car is against that aspect of inertia which is the resistance of the passengers body to acceleration, (an opposing reactive push).**

**2.**

**When a car suddenly slows down, a passenger feels as if being pushed or pulled forward away from the seat. This is also an acceleration force. Note that this sensation of being pulled away from the seat is occurring only during the slowing down (deceleration).**

**The acting push of the passengers body is due to that aspect of inertia which is the tendency of the persons body to remain in motion at the same speed. It is against the opposing reactive pull from the car which is being made to slow down by the braking action.**

**3.**

**When the car goes around a curve in the road a passenger feels pushed or pulled toward the outside of the curve. This is also an acceleration force. Note that this sensation of being pushed or pulled side ways is occurring only during the car's turning.**

**FORCES OF ACCELERATION**  
**ACTION and REACTION OPPOSITE and EQUAL**  
**CHANGE IN DIRECTION AS ACCELERATION**

The push upon the passenger is in the direction opposite to the direction of turning while the push (from the car) upon the passenger is in same direction as the direction of turning. The push experienced by the passenger while rounding a curve is caused by that aspect of inertia which is the tendency of the passengers body to remain in motion in a straight line.

.....  
In all three examples the inertia of an object is playing a role as one of the two sides of push (either acting or reactive).

We may consider the inertia to be the acting or reactive part of push.

.....  
Inertia may participate as reactive push, as a RESISTANCE to a change in speed, or as a RESISTANCE to a change in direction.

Inertia may instead be considered as participating by acting as a push in the form of a PERSISTENCE in speed or as a PERSISTENCE in the direction of motion.

.....  
The point I wish to make clear here, is why (in physics) a change in the direction of motion of an object is considered to be a change in velocity.

.....  
A push can change the speed of an objects motion.

A change in the speed of an objects motion is resisted by the objects inertia.

.....  
A push can change the direction of an objects motion.

A change in the direction of an objects motion is resisted by the objects inertia.

.....  
A push acting upon an object can cause a change in either the speed or the direction of the motion of that object or both the speed and direction.

.....  
A change in either the speed or direction of an object's motion is the result of a push.

The reactive side of push arises due to the resistance to either a change in speed or a change in direction or both speed and direction.

.....  
An acting push is against the reactive push given rise to by the inertia of an object, whether the push causes a change in speed or a change in direction (or both speed and direction).

.....  
The causes and the effects of changes in the speed of an objects motion are very like the causes and effects of changes in the direction of an objects motion. This is why in physics, a change in the direction of an object's motion is considered to be a change in velocity, as is also a change in its speed so considered.

.....  
This is why velocity and acceleration are specified in terms of both speed and direction (as vector qualities).

.....  
As a point of clarification, please consider that the above descriptions of interactions could have been made within a context either of pushing upon or pulling upon objects.

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts from Wikipedia**  
**MASS**

**My own comments and additions are written in bold type, to distinguish them. Excerpts from Wikipedia are in regular type and enclosed within quotation marks.**

**From a Wikipedia article on mass.**

"mass describes the amount of matter in an object. However, at very high speeds or for subatomic particles, general relativity shows that energy is an additional source of mass. Thus, any body having mass has an equivalent amount of energy, and all forms of energy resist acceleration by a force and have gravitational attraction"

**It is difficult to discuss mass, its quantification and its measurement without also some discourse upon force. The present topic will therefore include a little discourse about force.**

"mass describes the amount of matter in an object "

.....  
**The SI standard for mass is a physical reference object. There are multiple copies of this object which were manufactured for the purpose of providing a stable and consistent reference for the unit of measurement of mass which is the kilogram.**

.....  
**The mass of a given object may also be determined through various processes other than the comparison of an object to a standard mass object. A brief discourse on one of these processes follows this next brief review of the principle of inertia**

.....  
**All objects that have mass exhibit the characteristics of the principle of inertia.**

.....  
**The principle of INERTIA states that any object that has mass, tends to remain in the same state of motion. This tendency may be viewed as having several aspects to it.**

- 1. the tendency to resist a change in direction of motion.**
- 2. the tendency to resist beginning to move from a state of rest.**
- 3. the tendency to resist an increase in speed of motion**
- 4. the tendency to resist a decrease in speed of motion**

**An object in motion tends to remain in motion in the same direction and at the same speed, until acted upon by some influence. An object at rest tends to stay at rest.**

**An object tends to remain in the same state of motion.**

.....  
**The inertial characteristics of an object are in direct proportion to the mass (the amount of substance) of that object. The greater the mass of an object the greater is also that object's tendency to remain in the same state of motion. This might be stated as "the inertia of an object is in direct proportion to its mass". The greater the mass of an object the greater also is that object's inertia. The less the mass of an object the less also is that object's inertia.**

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts from Wikipedia**  
**MASS**

.....  
**The resistance of an object to acceleration (due to inertia) is in direct proportion to the mass of that object.**

**Therefore the MASS of an object may be determined by applying a KNOWN magnitude of FORCE to that object and measuring the resulting RATE OF ACCELERATION (when the resistance to the acceleration of that object is caused solely by the inertia of that object).**

**Please note that in terms of the mass and acceleration of an object and when speaking of a resistance to a change in the state of an object's motion, it may generally be assumed that what is being spoken of, is that resistance which is due solely to the inertia of the object.**

.....  
**The kilogram is the unit of measurement of mass in the SI.**

.....  
**The newton is the unit of measurement of force in the SI.**

.....  
**Please note that the "SI" is le Système International d'Unités or the International System of Units.**

.....  
**force = mass • acceleration**

**A FORCE of 1 newton will cause an ACCELERATION at the rate of 1 meter per second during each second it is applied to overcome the resistance to acceleration caused by the inertia of a 1 kilogram MASS.**

**mass = force ÷ acceleration**

**A MASS of 1 kilogram will ACCELERATE at the rate of 1 meter per second during each second that a FORCE of 1 newton is applied to that mass.**

.....  
**Mass (in kilograms) = the applied force (in newtons) times the rate of acceleration (in meters per second per second) caused by that force .**

$$1 \text{ kg} = 1\text{N} \div 1 \text{ m/s/s}$$

$$1 \text{ N} = 1\text{kg} \cdot 1\text{m/s/s}$$

.....  
**Through the above formulas we see that force and mass may each in turn be used to quantify the other.**

.....  
**The WEIGHT in NEWTONS of an object on Earth, divided by the acceleration rate of 9.80665 meters per second per second gives the approximate value of that object's MASS in kilograms. 9.80665 m/s/s is a median value of the rate of acceleration in meters per second per second of an object in free fall under the influence of near Earth gravity.**

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts from Wikipedia**  
**MASS**

.....  
**Please recall, that free fall is the motion of an object caused by gravity when the weight of that object is the only force acting upon the falling object. For example when an object falls while within a vacuum, and there is no resistance to its motion due to friction with the air.**  
.....

.....  
**The SI standard of mass is based upon a physical reference object. There are multiple copies of this object which were manufactured for the purpose of providing a stable and consistent reference for that unit which is the kilogram of mass.**

**The mass of these mass reference objects is far more consistent than the variations one can encounter in Earth's gravity. However even the mass of these reference objects is found to have small variations over time.**

.....  
**All objects that have mass also exert a gravitational pull upon nearby objects.**

.....  
**The more massive an object, the more gravitational pull it can exert upon a given, other object.**

.....  
**The more massive an object the greater its inertia.**

.....  
**The more massive an object the greater its weight under a given gravitational pull.**

.....  
**The kilogram is a unit of measurement of mass in the SI (not of weight).**

.....  
**The mass of an object (in grams) may be measured by "weighing that object" upon a gram scale.**

.....  
**According to the theory of relativity all forms of energy have mass Therefore the mass of an object increases with the speed of that object's motion. The kinetic energy gained by the object during its acceleration being the source of that mass increase. These changes in mass are negligible except during extremely large changes in speed or when an object has an extremely small amount of mass to begin with (as in the case of subatomic particles). This information can generally be disregarded within the context and purposes of the present work.**

**Please note that an object does not have to be moving at or very near the speed of light for its relativistic mass to significantly vary from its rest mass. Relativistic mass has been calculated to be about 0.5 % greater than rest mass at a speed of 9.96 % or about 1/10the speed light. 10 % of the speed of light is approximately 670,061,520 miles per hour or 107,925,280 kilometers per hour.**

.....  
**There will be much more said of both mass and force in later topics.**

**VELOCITY and ACCELERATION  
THE PRINCIPLE OF INERTIA**

**An automobile rolling along a level road has resistance to its motion. This resistance is caused by the friction of the air against the surface of the automobile, friction within the wheel bearings, friction between the tires and the road, and the over coming of forces within the rubber tires as they compress and stretch in response to the weight of the vehicle as they rotate and so on. These forms of resistance and forces are acting against the vehicles tendency to remain in the same state of motion due to momentum. Therefore an automobile driven upon a road, requires a constant input of energy to maintain its speed, and still more input of energy to accelerate.**

**Consider now a SPECIFIC OBJECT which unlike an automobile is free from the effects of gravity or any other external force and any external resistance to its motion. This is because it is within a supposed environment like unto deep space. But said supposed environment is more perfectly free from the effects of friction and gravity than even the vacuum of deep space.**

.....  
**There is no resistance to, or opposition to its motion, and yet there is a resistance to any change in its state of motion. This resistance is due to the object's inertia.**

.....  
**If this object is at rest it will tend to remain at rest unless it is acted upon by some force.  
If this object is in motion it will tend to remain in motion unless it is acted upon by some force.**

.....  
**If this object is at rest, but it is then acted upon by A SUFFICIENT MAGNITUDE OF force for a period of 1 second of time that object would displace 1 meter during that second of time.**

.....  
**The speed of the object at the beginning of this second of time is 0m/s (zero meters per second).  
The speed of the object at the end of this one second of time is 1m/s (1 meter per second).**

.....  
**The object did not at first move at the rate of 1m/s. It required some amount of time for this speed to be reached. The object had to accelerate.**

.....  
**The rate of acceleration of the object was at the rate of 1m/s during that second (1m/s/s).**

.....  
**The object will remain in motion at this speed (1m/s) indefinitely unless another force acts upon the object.**

.....  
**When the said sufficient magnitude of force acted upon the object there was a reactive force. That force opposed or resisted the acting force. This resisting force was due to the aspect of inertia which is for an object to remain at rest. Both the acting push and the resisting push exist (as a push) only simultaneously. There is a resisting push only when / while there is an acting push (or force). There is an acceleration only when there is a push or pull (a force) acting to cause an acceleration. There is a resistance to acceleration only when there is an acceleration.**

.....  
**The object will not continue to accelerate when the force is no longer being applied to it.**

.....  
**The object will remain in motion due to its inertia / momentum.**

.....  
.....

**VELOCITY and ACCELERATION  
THE PRINCIPLE OF INERTIA**

If after this first second of time, the same (a sufficient magnitude of) force is again applied to the object (in the same direction) the object will again accelerate.

.....  
If after this first second of time the same (a sufficient magnitude of) force is applied for 1 second of time (in the same direction), the speed of the object at the end of this second, (second number two) will be 2m/s. This is because the object had already a speed of 1m/s and the velocities are additive.

.....  
The object was not at the beginning of second number 2, moving at the rate of 2m/s. It required 1 second of time for this speed to be reached. The object had to accelerate from a speed of 1m/s to a speed of 2m/s.

.....  
The rate of acceleration of the object was at a rate of 1m/s/s during this next second (second number two) that the force was applied.

.....  
The object will remain in motion at this speed indefinitely (2m/s) unless another force acts upon the object.

.....  
Again, and as occurred during the first second that the object was acted upon by the said sufficient magnitude of force, there was a reactive force. That force opposed or resisted the acting force. This resisting force was due to the aspect of inertia which is for an object to remain at the same speed. Both the acting push and the resisting push exist (as a push) only simultaneously. There is a resisting push only when / while there is an acting push (or force). There is an acceleration only when there is a push or pull (a force) acting to cause an acceleration. There is a resistance to acceleration only when there is an acceleration.

.....  
As before, the object will not continue to accelerate unless we continue to apply force to it. It will have zero acceleration when no force is being applied.

.....  
If we continually apply this same (a sufficient magnitude) of force to the object (in the same direction) the object will continue to accelerate at the rate of 1m/s, during each second that this force is applied (1m/s/s).

.....  
This acceleration is against the reactive force which is due to the aspect of inertia which is for an object in motion to remain in motion at the same speed.

.....  
If both, the force applied and the mass of the object remain constant, the rate of acceleration will also remain constant.

.....  
For so long as this (a sufficient magnitude) of force is being applied, there will be an acceleration at the rate of 1meter per second for each second that lapses (1m/s/s).

.....  
Or in other words an acceleration at the rate of 1 meter per second, per each second that lapses.

Or written another way, an acceleration of 1 m / 1 second / each 1 second that lapses

**VELOCITY and ACCELERATION  
THE PRINCIPLE OF INERTIA**

Or written as an acceleration of 1 m / s / each s that lapses

Or written as an acceleration of (1m/s)/s

Or written as an acceleration of 1m/s/s.

Or written as an acceleration of 1m/s<sup>2</sup>

.....  
When the speed of an object changes, it is due to a transfer of energy as a force.

.....  
When energy is transferred to an object as a force causing an acceleration, this transfer occurs over some period of time.

.....  
This speed change (acceleration) also occurs over some period of time.

.....  
When a change in speed occurs, it happens only during the energy transfer, which is the cause of that acceleration (at the same time).

.....  
Reconsider now that same SPECIFIC OBJECT, which is free from the effects of gravity or any other external force and any resistance to its motion.

.....  
There is NO resistance OR opposition to its remaining in motion, and yet there is a resistance to any CHANGE in its state of motion.

.....  
If this specific object is at rest it will remain at rest unless it is acted upon by some force.

If this specific object is in motion it will remain in motion unless it is acted upon by some force.

**VELOCITY and ACCELERATION  
THE NEWTON OF FORCE, AND THE PRINCIPLE OF INERTIA**

If this specific object is at rest, has a mass of 1 kilogram (1kg), is acted upon by a force of 1 newton (1N), for 1 second of time, that specific object would accelerate to a speed of 1 meter per second (1m/s).

.....  
The speed of the object at the beginning of this second of time was zero meters per second. The speed of the object at the end of this one second of time will be 1m/s (1 meter per second).

.....  
The object did not at first move at the speed of 1m/s. It required some amount of time for this speed to be reached. The object had to accelerate.

.....  
When 1 newton (1N) of force acted upon the object there was a reactive force. That force opposed or resisted the acting force. This resisting force was due to the aspect of inertia which is for an object to remain at rest.

.....

**VELOCITY and ACCELERATION  
THE NEWTON OF FORCE, AND THE PRINCIPLE OF INERTIA**

**It is because the object has 1kg of mass and the applied force is equal to 1N that the object accelerates to the speed of 1m/s during that second.**

.....

**The greater the mass of an object the greater also is its inertia.**

**The greater the inertia of an object the greater also is the force required to cause it to accelerate at a given rate.**

**If the object had a mass of 2 kg instead of 1kg while the applied force remains as 1N, the object would have accelerated to a speed of 1/2 m/s during that second (accelerated at 1/2m/s/s).**

**Conversely, if the mass of the object had remained as 1 kg, but the applied force was increased to 2N the object would have accelerated to a speed of 2m/s during that second (accelerated at 2m/s/s).**

.....

**Considering again this specific object as having a 1 kilogram mass, a speed of 1m/s, and the applied force as 1 newton.**

.....

**The object will NOT continue to accelerate when we have stopped applying force to it.**

**The object will remain in motion at this speed (1 meter per second) indefinitely unless another force acts upon the object.**

**The object will remain in motion due to that aspect of inertia which is for an object in motion to remain in motion at the same speed.**

.....

.....

**If after this first second of time, 1N of force is again applied to the object (in the same direction) the object will again accelerate.**

.....

**If after this first second of time, 1N of force is applied for 1 second of time (in the same direction), the speed of the object at the end of this second, (second number two) will be 2 m/s.**

**This is because the object had already a speed of 1 m/s and the speeds are additive.**

.....

**The object was not at the beginning of second number 2, moving at the speed of 2m/s. It required 1 second of time for this speed to be reached. The object had to accelerate from a speed of 1 m/s to a speed of 2 m/s.**

.....

**When 1 newton of force acted upon the object there was a reactive force. That force opposed or resisted the acting force. This resisting force was due to the aspect of inertia which is for an object to remain moving at the same speed.**

.....

**The greater the mass of an object the greater also is its inertia.**

**VELOCITY and ACCELERATION  
THE NEWTON OF FORCE, AND THE PRINCIPLE OF INERTIA**

P 24

**The greater the inertia of an object the greater also is the force required to cause it to accelerate at a given rate.**

.....  
**It is because the object has 1 kg of mass and the applied force is equal to 1N that the object accelerates from a speed of 1 m/s, to a speed of 2m/s in 1 second of time (accelerates at 1m/s/s).**

.....  
**The rate of acceleration of the object is 1m/s/s during this (second number two) that the force was applied.**

.....  
**The object will remain in motion at this speed (2 m/s) indefinitely unless another force acts upon the object.**

.....  
**As before, the object will not continue to accelerate unless we continue to apply force to it. It will have zero acceleration when no force is being applied.**

.....  
**If we continually apply 1 newton of force to the object (in the same direction) the 1 kilogram mass will continue to accelerate at the rate of one meter per second, for each second that this force is applied.**

.....  
**If both, the force applied (1N) and the mass of the object (1kg) remain constant, the acceleration will remain constant at 1m/s/s.**

**VELOCITY and ACCELERATION  
With Excerpts From Wikipedia  
MOMENTUM AND THE PRINCIPLE OF INERTIA**

**From a Wikipedia article on momentum.**

"In classical mechanics, linear momentum or translational momentum ( $p$ , momenta; SI unit kg m/s or equivalently, N s) is the product of the mass and velocity of an object. For example, a heavy truck moving rapidly has a large momentum—it takes a large or prolonged force to get the truck up to this speed, and it takes a large or prolonged force to bring it to a stop afterwards. If the truck were lighter, or moving more slowly, then it would have less momentum."

"The units of momentum are the product of the units of mass and velocity. In SI units, if the mass is in kilograms and the velocity in meters per second then the momentum is in kilogram meters/second (kg m/s). An equivalent derived unit is the newton second (1 N s = 1 kg m/s). In cgs units, if the mass is in grams and the velocity in centimeters per second then the momentum is in gram centimeters/second (g cm/s) or dyne seconds (1 dyne s = 1 g m/s). "

"For example, a 1 kg model airplane, traveling due north at 1 m/s in straight and level flight, has a momentum of 1 kg m/s due north measured from the ground. "

**The momentum of an object is its mass times the velocity it is moving at ( $m \cdot v$ ). In SI units this is kg • m/s ... a 1 kilogram mass moving with a velocity of 1 meter per second has the momentum of 1kg m/s.**

**or equivalently this can be stated as**

**Momentum = force • time. In SI units this is newtons • seconds (N s).**

**VELOCITY and ACCELERATION  
MOMENTUM AND THE PRINCIPLE OF INERTIA**

**A force of 1 newton acting for 1 second of time would cause a 1 kg mass to accelerate to a velocity of 1 m/s. This would then be a 1 kg mass moving at a velocity of 1 m/s (a momentum of 1kg m/s).**

.....  
**A 4 kg mass moving at a velocity of 1/4 m/s has the same momentum as does a 1kg mass moving at a velocity of 4m/s.**

.....  
**A 1 kg mass moving at a velocity of 1/4 m/s has 1/4 of the momentum of a 4 kg mass moving at 1/4 m/s.**

.....  
**Like velocity, linear momentum is a vector quantity, it is described in terms of both direction and magnitude.**

**SOME DEFINITIONS AND EXPLANATIONS  
With Excerpts From Wikipedia  
ENERGY FORCE AND WORK**

**My own comments and additions are written in bold type, to distinguish them. Excerpts from Wikipedia are in regular type and enclosed in quotation marks.**

**From a Wikipedia article on force.**

"In physics, a force is any influence that causes an object to undergo a certain change, either concerning its movement, direction, or geometrical construction. In other words, a force can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), e.g., to accelerate, or a flexible object to deform, or both. Force can also be described by intuitive concepts such as a push or a pull. A force has both magnitude and direction, making it a vector quantity. It is measured in the SI unit of newtons and represented by the symbol F."

**INTUITIVE CONCEPTS**

"Force can also be described by intuitive concepts such as a push or a pull."

**Before I continue with and about energy, work and force, I will make a brief objection to the use of the phrase "intuitive concepts" in the Wikipedia excerpt above. As I see it, concept and intuition are very distinct things from one another. Conceptualization is not intuition, but rather it is deliberate construction. Intuiting is the arriving at some insight, understanding, or the receiving of some information, as a result of processes or sources unknown. Intuition may imply or involve psychic and or spiritual processes. Although my own experiences inform me that intuition is a real thing, intuition as a concept is not accepted within science proper. Use of either of the phrases, "familiar concept" or "instinctive concept" might have been a better choice.**

.....  
**The words energy and force are not synonymous in physics. In the above Wikipedia article the word "force" could have been replaced with the phrase "energy acting as a force".**

**The word force is a more specific or restricted term for energy than the word energy itself.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK**

.....  
**When energy is acting as a force it causes an object to undergo a "certain change in its movement, direction, or geometrical construction".**

.....  
**When energy is acting as a force it is described as a vector.**

.....  
**Energy acting upon an object and causing "certain changes " is a called a force.**

.....  
**When a force acts upon an object and work is done on that object, that force continually acts upon the object as the object displaces. A force acts upon an object over time and distance.**

**For example, When a person runs while holding a baseball they are exerting a force upon the ball over some amount of distance. The point of application of force is moving with the ball.**

**When a person hits a baseball with a bat there is only a brief contact between the bat and the ball. That brief contact (energy transference) can cause the ball to move a great distance. Work is done upon the baseball, but because the energy transference to the ball is instantaneous, this interaction is an energy transfer which is not easily described in terms of force.**

.....  
**If we push a book across the surface of a table work is done upon the book by the force we apply as the continuous pushing.**

.....  
**If we push the book beyond the edge of the table and it falls, work is done upon the book by the force of gravity. The force of gravity continually acts upon the book as it falls.**

**As in the previous example of a baseball being carried by a running person, the point of application of force upon the book moves with the object.**

.....  
**When a book is at rest upon a table, gravity is exerting a force upon that book but no work is being done on the book by that gravity. The atomic and molecular forces present within the table (as the rigidity of the table), act as a force and prevent the book from falling even as the force of gravity continually pulls upon the book. Forces are acting upon the book but no work is being done upon it, as the book is not in motion.**

**More than 1 force is acting upon the book. The pull by gravity and the rigidity of the table are in equilibrium. These two forces are opposite in direction but equal in magnitude. The NET FORCE of these two forces is equal to zero. This is why there is no motion of, acceleration of, or work being done upon the book by gravity.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK**

.....  
In physics, when some form of energy causes a "certain change", either concerning the movement, direction, or geometrical construction of an object, that energy is called a force.

- That certain change can be to cause an object to begin to move from a state of rest.
- That certain change can be to speed up an object's motion,
- That certain change can be to maintain an object's motion at a constant speed.
- That certain change can be to slow down an object
- That certain change can be to end an object's motion.
- That certain change can be to change the direction of an objects motion.
- That certain change can be to change the geometrical shape of an object.
- That certain change can be to keep an object from beginning to move, when under the specific condition that two or more forces influencing an object are in equilibrium.

.....  
The term force is commonly used in regard to things as intangible as the energy present surrounding a magnet. But that energy isn't a force unless it "influences a certain change" in an object.

.....  
The distinction between energy and force is generally pretty simple to understand. However, when the effect of a force is as slight as the deflection of a single electron, one might feel inclined to ask if that electron is a physical object or not and, if that energy, is then acting as force or not.

.....  
Force is NOT defined as a FORM of energy. But the source or origin of any force is an energy source.

.....  
The energy present in an object as the motion of that object is the result of a FORCE.

The motion of that object IS considered to be one of the FORMS of energy and is termed as KINETIC ENERGY. One calls this, the kinetic energy of the object due to its motion.

- .....  
The unit of measurement of force in SI terms is the newton
- The unit of measurement of energy in general, and in SI terms is the joule.

.....  
The unit of measurement of kinetic energy in SI terms is the joule.

.....  
But the energy that an object possesses due to its motion may also be stated equivalently as newtons of force times the amount of time that force would need to act, in order for an object to accelerate from a state of rest to some specific velocity, or to decelerate from a specific velocity to a state of rest (newtons times seconds).

For example:  
Force = mass • acceleration rate. It requires 1 newton of force to accelerate a 1 kilogram mass at the rate of 1 meter per second per second. Therefore it would require 15 newtons of force to accelerate a 5 kilogram mass at the rate of 3 meters per second per second.

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts From Wikipedia**  
**ENERGY FORCE AND WORK**

**If this said 15 newtons of force acts to accelerate a 5 kilogram mass for a period of 4 seconds, that mass would accelerate to a velocity of 12 meters per second.**

**and conversely**

**The 5 kilogram mass moving at a velocity of 12 meters per second could act against a force of 15 newtons for a period of 4 seconds before that moving mass would come to rest.**

**and since**

**Kinetic energy is equal to  $1/2 \cdot \text{mass} \cdot \text{velocity squared}$ , a 5 kilogram mass moving at a velocity of 12 meters per second possesses 360 joules of kinetic energy. ( $1/2 \cdot 5\text{kg mass} \cdot 12\text{m/s}^2 = 1/2 \cdot 5 \cdot 144 = 1/2 \cdot 720\text{m} = 360 \text{ joules of kinetic energy}$ ).**

**therefore**

**This 360 joules of kinetic energy can be stated equivalently as 15 newtons of force acting for a period of time of 4 seconds. This can be mathematically reduced to an equivalent 60 newtons of force acting for a time period of 1 second (60 newtons times 1 second or 60 N s).**

**because**

**60 newtons acting upon a 5 kilogram mass would cause an acceleration at the rate of 12 meters per second in 1 second. The 5 kilogram mass would displace 6 meters, during that 1 second acceleration (to 12 meters per second). And... 60 newtons of force times 6 meters of displacement = 360 joules of kinetic energy is equivalent to 60 N s).**

**Please recall that the "SI" is le Système International d'Unités or the International System of Units.**

.....  
.....

**If we look at force and work from the other side so to speak, in terms of energy as the motion of an object (kinetic energy) we may get just a bit more understanding.**

**From a Wikipedia article on kinetic energy.**

"In physics, the kinetic energy of an object is the energy that it possesses due to its motion. [1] It is defined as the work needed to accelerate a body of a given mass from rest to its stated velocity. Having gained this energy during its acceleration, the body maintains this kinetic energy unless its speed changes. The same amount of work is done by the body in decelerating from its current speed to a state of rest. "It is measured in the SI unit of newtons and represented by the symbol F."

**From a Wikipedia article on kinetic energy.**

"Newtonian kinetic energy" and also at the subtitle "Kinetic energy of rigid bodies"

"In classical mechanics, the kinetic energy of a non-rotating object of mass  $m$  traveling at a speed  $v$  is  $1/2 mv^2$ . In relativistic mechanics, this is only a good approximation when  $v$  is much less than the speed of light."

"In classical mechanics, the kinetic energy of a point object (an object so small that its mass can be assumed to exist at one point), or a non-rotating rigid body depends on the mass of the body as well as its speed. The kinetic energy is equal to the mass multiplied by the square of the speed, multiplied by the constant  $1/2$ . In formula form:

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts From Wikipedia**  
**ENERGY FORCE AND WORK**

$$E_k = 1/2mv^2$$

"For example, one would calculate the kinetic energy of an 80 kg mass (about 180 lbs) traveling at 18 meters per second (about 40 mph, or 65 km/h) as

$$E_k = 1/2 \cdot 80 \cdot (18\text{m/s})^2 = 12960 \text{ J} = 12.96 \text{ kJ} "$$

.....

**We will look at the formula  $E_k = 1/2 \cdot m \cdot v^2$  in some detail at a later point.**

.....

.....

**Please recall that in terms of the mass and acceleration of an object and when speaking of the resistance to a change in the state of an object's motion, it may generally be assumed that what is being spoken of is the resistance which is due solely to the inertia of the object.**

**The newton is the unit of measurement of force in the SI.**

**1 newton is the force needed to accelerate a 1 kilogram mass object (against that object's resistance to acceleration due to inertia solely) at a rate of 1 meter per second, per second.**

$$1\text{N} = 1 \text{ kg} \cdot 1\text{m/s/s} \quad \text{or} \quad 1 \text{ N} = 1 \text{ kg} \cdot 1\text{m/s}^2$$

**or written another way**

**1 newton of force = 1 kilogram times 1 meter per second per second**

**or written another way**

**1 newton = the force needed to accelerate a 1 kilogram MASS (not weight) at a rate of 1 meter per second, during each second that the force is being applied to that mass.**

**or written another way**

**The newton is the SI unit of force. It is defined as the amount of force required to cause and / or to maintain the acceleration of a one kilogram mass object, at the rate of 1 meter per second during each second the object is accelerated.**

**or written another way**

**1 newton is a unit of measurement of the continuously acting force, required to cause and or maintain the continuous acceleration of a 1 kg mass object at the rate of 1 m/s/s, against the continuous reactive force due to that aspect of the inertia of the object which is to resist an increase in velocity.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK**

or written another way ....

**One newton is a unit of measurement of the force which is being maintained at a constant value, by the constantly increasing magnitude of energy per second, that is required to maintain a constantly increasing amount of displacement per second that occurs when an object is being constantly accelerated. This under the specific conditions that the object has 1 kilogram of mass, and that the velocity increase is by 1 meter per second during each second in which that increasing energy per second (in maintaining a constant force) is transferring to the accelerating object.**

**1 N = 1 kg • 1m/s/s**

.....

**A force acts continually upon an object. As that object is displaced work is done.**

**When the time required for the (joules of) energy (as force) to do work is being accounted for, an event is (by definition) being described in terms of power.**

**The rate at which work is done (work per second) is equivalent to the joules per second of energy transferred.**

**Power is defined in physics as the amount of energy consumed (transferred) per unit of time. Power is defined by the ratio of work to time.**

**However, it would not properly be considered that the newton is a unit of measurement of power. The newton is the SI unit of measurement of the force that is maintained by the joules per second of energy transferred when a force acts.**

**A force acts continually upon an object as it displaces that object. As that force acts, it is maintained as a particular magnitude of force only because there is a continuous input of energy.**

.....

**Given that the mass of an accelerated object remains constant and that it's acceleration is opposed only by the inertia of that mass.**

**During a constant and uniform acceleration, THAT FORCE which is giving rise to the acceleration MUST ITSELF BE CONSTANT AND UNIFORM.**

**while**

**THE ENERGY required to maintain that force as constant, is INCREASING THROUGHOUT EACH SECOND of the acceleration.**

.....

**Force is described at a vector.**

.....

**Please recall that a vector has both magnitude and direction.**

.....

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts From Wikipedia**  
**ENERGY FORCE AND WORK**  
**THE JOULE**

**Please also recall that, magnitude is the value of a measurement of some property in terms of it being either greater or lesser, when compared to a standard of measurement of that same kind of property.**

.....  
**From a Wikipedia article on the joule.**

“The joule is the SI unit of energy, based on the amount transferred to an object by the mechanical work of moving it 1 meter against a force of 1 newton.[1]”

**The joule is the SI unit of energy, it is BASED on the amount of ENERGY transferred to an object by the mechanical work of moving that object, 1 meter against a force of 1 newton.**

**Please note that the transfer of a joule of energy does not have to result in mechanical work in order for it to be equal to 1 joule.**

.....  
**If a joule of energy (or some percentage there of) is causing a "certain change" in the motion of an object it may be called a force.**

.....  
**If that energy is in the FORM of the motion of an object it is called kinetic energy. However that energy could be in any of various FORMS (not only kinetic), and it's expression or transference, does not need to result in a force, or the doing of mechanical work. It would still remain that this energy is some specific amount of joules.**

.....  
**The joule is in the SI, defined and BASED on the amount of energy transferred to an object by the mechanical work of moving that object 1 meter against a force of 1 newton. But of course, energy and the joule are not limited to that particular outcome of their expression. The joule is the SI unit of measurement of BOTH WORK AND ENERGY.**

**The JOULE is the SI unit of ENERGY of any form. It is BASED on the amount of ENERGY that must be transferred to an object in order to cause the mechanical work of moving it 1 meter against a force of 1 newton.**

.....  
**Please note also that there is no specification of an amount of time during which that mechanical work is or must be done.**

**Energy transference causing the displacement of an object is work. The above Wikipedia article has defined work in terms of the newton. The ratio of work (as the acceleration of an object) to time is what defines the newton. The newton should then perhaps, not be a part of a discourse on work, but rather the other way around.**

**One newton is a measure of the force needed to accelerate an object with a 1 kilogram mass against that objects resistance to a change in acceleration (when said resistance is caused solely by the inertia of that mass), at a rate of 1 meter per second during each second that the force is being applied.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE**

**$F=ma$  ... Force = mass times acceleration**

**(in SI units) Force (in newtons) = mass (in kilograms) times acceleration (in meters per second, per second) ....  $1\text{ N} = 1\text{ kg} \cdot 1\text{m/s/s}$**

**1 newton = the force required to accelerate a 1 kilogram mass at the rate of 1 meter per second, per second (against the resistance to acceleration due solely to the inertia of that mass).**

.....  
.....

**Work is the displacement of an object against something that is opposing that displacement. Its measure is given by the amount of that opposition multiplied by the amount of that displacement. In SI units these values are stated in joules of work, newtons of force and meters of displacement.**

**By definition, energy transferred (as work) is equal to 1 Joule, when in opposition to a force of 1 newton, an object is displaced 1 meter.  $1\text{ joule} = 1\text{ newton} \cdot 1\text{ meter}$**

.....  
.....

**Work is the displacement of an object against an opposition to that displacement.**

**The acceleration of any object is against that object's inertia. Acceleration is therefore the displacement of an object against an opposition to the object's displacement.**

.....  
.....

**For a constantly and uniformly accelerating object, the amount that the velocity increases during each second as it accelerates, is the same amount during each second that it accelerates (the acceleration is uniform).**

**For a constantly and uniformly accelerating object, its velocity during any given second differs from its velocity during any other second of the acceleration. The velocity is not constant, but instead the velocity is constantly changing.**

.....  
.....

**For a constantly and uniformly accelerating object, the velocity at the end of each second is greater than it was at the end of the previous second. The velocities are adding up. The final velocity from any previous second is in addition to the velocity increase of the current second.**

**Therefore when an object is constantly accelerating, that object's DISPLACEMENT is greater in each successive second than it was in the previous second.**

.....  
.....

**The amount of the displacement of an accelerating object IS NOT the product of its final velocity and the amount of the time of the acceleration.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE**

**When an object is constantly and uniformly accelerating, the amount of its displacement is equal to the product of (the objects average velocity during the acceleration) multiplied by (the amount of time of the acceleration).**

.....  
**For a constantly and uniformly accelerating object, the average velocity during that acceleration is equal to the object's initial velocity ( $V_i$ ) plus its final velocity ( $V_f$ ) divided by 2.**

$$V_{\text{average}} = V_i + V_f \div 2$$

.....  
**When an object constantly and uniformly accelerates at 1m/s/s for 1 second of time, and that object begins to accelerate from a velocity of 0m/s, the object's average velocity during that second may be calculated as ...**

$$0 \text{ m/s} + 1\text{m/s} \div 2 = 1/2\text{m/s}$$

**The average velocity during the above one second interval, is 1/2 meter per second (1/2 m/s).**

$$V_{\text{average}} = 1/2\text{m/s}$$

.....  
**The average velocity for an object that accelerates at a rate of 1m/s/s for a period of 2 seconds of time is 1m/s, although the objects final velocity is 2m/s.**

.....  
**When an object is constantly and uniformly accelerating, the amount of its displacement is equal to the product of (the objects average velocity during the acceleration) multiplied by (the amount of time that the object accelerates).**

**Given that an object begins to move from a state of rest and that it accelerates for 1 second of time, it requires a constant acceleration at the rate of 2m/s/s to displace the object 1meter during that 1 second.**

**and / or**

**Given that an object begins to move from a state of rest and accelerates for 2 seconds of time, it requires a constant acceleration at the rate of 1m/s/s to displace the object 1 meter during those 2 seconds. Even though the object's final velocity is 2m/s.**

.....  
.....  
**Energy transferred is equal to 1 Joule, when in opposition to a force of 1 newton, an object is displaced 1 meter. 1 joule = 1 newton • 1 meter (by definition).**

**Energy transferred is equal to 1/2 Joule, when a 1 kg object accelerates at 1m/s/s for a period of 1 second....**

**because the object has a final velocity of 1m/s.... it therefore has an average velocity of 1/2m/s.**

**and**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE**

The object is displacing for 1 second of time...

therefore

The object's is displaced 1/2 meter during that 1 second of time ( $1/2\text{m/s} \cdot 1 \text{ second}$ ).

and

The object was acted upon by one newton of force.

and

We know this because 1 newton (by definition) is the amount of force required to accelerate a 1 kg mass at the rate of 1 m/s/s.

and

A 1/2 meter displacement against 1 newton of force, is an energy transfer of 1/2 joule, because by definition  $1 \text{ joule} = 1 \text{ newton} \cdot 1 \text{ meter}$

kinetic energy ( $E_k$ ) = force • displacement

$E_k$  = mass x acceleration • ( $1/2$  Velocity final • the duration of the acceleration)

joules = kg x m/s/s (newtons) • meters of displacement

**Kinetic energy = the amount of the opposition to a displacement times that displacement.**

**Joules = newtons x meters**

.....

**FOR UNIFORM / CONSTANT ACCELERATIONS  
BOTH THE DISPLACEMENT AND THE ENERGY TRANSFERRED ARE IN  
PROPORTION TO THE SQUARE OF THE TIME THAT LAPSES DURING THE  
DISPLACEMENT**

Energy transferred is equal to 2 Joules, when a 1 kg object constantly accelerates at 1m/s/s for a period of 2 seconds.....

because

The object has a final velocity of 2m/s and

therefore

The object has an average velocity of 1m/s.

and since

The object is accelerating for 2 seconds of time.

it therefore

Is displaced 2 meters during those 2 seconds of time (an average velocity of  $1\text{m/s} \cdot 2 \text{ seconds}$ ).

This is 4 times greater than the 1/2 meter displacement that occurs during a 1 second acceleration.

and

The object was acted upon by one newton of force because a 1 kg mass is accelerated at 1m/s/s.

and

A 2 meter displacement by 1 newton of force, is an energy transfer of 2 joules.

kinetic energy ( $E_k$ ) = force • displacement

Joules = newtons • meters

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE**

**FOR UNIFORM / CONSTANT ACCELERATIONS  
BOTH THE DISPLACEMENT AND THE ENERGY TRANSFERRED ARE IN  
PROPORTION TO THE SQUARE OF THE TIME THAT LAPSES DURING THE  
DISPLACEMENT**

$$E_k = \text{mass} \times \text{acceleration rate} \cdot \left(\frac{1}{2} \text{Velocity}_{\text{final}} \cdot \text{the duration of the acceleration}\right)$$
$$\text{joules} = \text{kg} \times \text{m/s/s (newtons)} \cdot \text{meters of displacement}$$

**Kinetic energy = the amount of the opposition to a displacement • that displacement.**

**4 times more displacement occurred during a 2 second acceleration than occurs during a 1 second acceleration. This is twice the time duration but 4 times the displacement.**

.....  
**It requires 1/2 joule to accelerate a 1kg object to a velocity of 1m/s.  
It required 2 joules to accelerate a 1kg object to a velocity of 2m/s.  
It required 4 times as much energy to accelerate a 1Kg object to twice the velocity.  
Twice the velocity requires 4 times more energy (the velocity increase squared) .**

.....  
**Example 1:**

**Three times the velocity requires 9 times more energy (which is the velocity increase squared).**

**Force = 1 N**

**Mass = 1 kg**

**Time = 3 seconds**

**final velocity = 3m/s**

**average velocity = 1.5 m/s**

**displacement = 1.5m/s • 3s ... 1.5 • 3 = 4.5 meters**

**This is 9 times the displacement that occurs during a 1 second acceleration.**

**1 newton • 4.5 meters = 4.5 joules**

**3m/s is 3 • 1m/s .... 3 squared = 9 .... 9 • 1/2 joule = 4.5 joules ..... 3 times the velocity and 9 times the energy.**

**4.5 joules is 9 times greater than 1/2 joule transferred during a 1 second acceleration.**

.....  
**Example 2:**

**Four times the velocity requires 16 times more energy (which is the velocity increase squared)**

**Force = 1 N**

**Mass = 1 kg**

**Time = 4 seconds**

**final velocity = 4m/s**

**average velocity = 2 m/s**

**displacement = 2m/s • 4s ... 2 • 4 = 8 meters**

**This is 16 times the displacement that occurs during a 1 second acceleration.**

**1 newton • 8 meters = 8 joules**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE**

**FOR UNIFORM / CONSTANT ACCELERATIONS  
BOTH THE DISPLACEMENT AND THE ENERGY TRANSFERRED ARE IN  
PROPORTION TO THE SQUARE OF THE TIME THAT LAPSES DURING THE  
DISPLACEMENT**

4m/s is  $4 \cdot 1\text{m/s}$  ....  $4^2 = 16$  ....  $16 \cdot \frac{1}{2} \text{joule} = 8 \text{joules}$  ..... 4 times the velocity and 16 times the energy.

8 joules is 16 times greater than  $\frac{1}{2}$  joule transferred during a 1 second acceleration.

.....  
.....

**THE JOULE, VELOCITY ACCELERATION AND DISPLACEMENT**

The final velocity of an object after 6 seconds of **CONSTANT ACCELERATION** at  $1\text{m/s/s}$  is  $6\text{m/s}$

if

The objects velocity had instead been, a **CONSTANT VELOCITY** of  $6 \text{ m/s}$  for 6 seconds, the displacement would have been 36 meters.

but

Since the object was at a **CONSTANT ACCELERATION RATE** of  $6\text{m/s/s}$  the displacement will be 18 meters.

Note that 18 is  $\frac{1}{2}$  of 36.

.....  
.....

The sum of the average velocities during each second of a constant acceleration is equal to  $\frac{1}{2}$  of the square of the final velocity.

.....

An acceleration at  $1\text{m/s/s}$  for 6 seconds results in a final velocity of  $6\text{m/s}$  ....  $6^2 = 36$  ....  $\frac{1}{2}$  of 36 = 18

.....

$1\text{m/s/s}$  acceleration rate x 6 seconds duration =  $6\text{m/s}$  final velocity

The average velocity for the entire 6 second acceleration is  $3\text{m/s}$

The total displacement during the 6 seconds is  $3\text{m/s} \times 6 \text{ seconds} = 18 \text{ meters}$

.....

The final velocities (m/s) at the end of each of the 6, one second intervals of acceleration is, 1, 2, 3, 4, 5, 6 (m/s).

.....

The displacements during each of the 6, one second intervals of acceleration is, 0.5, 1.5, 2.5, 3.5, 4.5, 5.5 (meters).



ENERGY FORCE AND WORK

THE KINETIC ENERGY THAT AN OBJECT POSSESSES DUE TO ITS MASS AND VELOCITY IS EQUAL TO THE ENERGY THAT WAS REQUIRED TO CAUSE THE ACCELERATION OF THE OBJECT TO THAT VELOCITY  $E_k = 1/2 \text{ MASS} \cdot \text{VELOCITY}^2$

then

$$J = 5 \cdot (12/4) \cdot 1/2 \cdot (12 \cdot 4) = 1/2 \cdot 5 \cdot 3 \cdot 48 = 360 \text{ joules of work}$$

and also

$$1/2 m \cdot v^2 = 1/2 \cdot 5 \cdot 12^2 = 360 \text{ joules of work}$$

The kinetic energy causing an acceleration ... Energy<sub>kinetic</sub> = force • displacement ... or Energy<sub>k</sub> = mass • acceleration rate (is force) • displacement.

"Energy<sub>k</sub> = force • displacement".

.....

In SI units this is 1 joule = 1 newton of force • 1 meter of displacement (1 meter of displacement against 1 newton of force).

or ...

1 joule = the energy required to accelerate a 1 kilogram mass to the velocity of 1.4142135623730950488016887242097 meters per second against a resistance to acceleration which is caused solely by the inertia of that 1 kilogram mass.

1.4142135623730950488016887242097 is the square root of 2

.....

There is no specific period of time during which this acceleration must occur in order that the 1 joule of energy is transferred to the 1 kilogram mass.

.....

1 joule = the kinetic energy of a 1 kilogram mass, displacing at a velocity of 1.4142135623730950488016887242097 meters per second.

$$1 \text{ joule } (E_k) = 1/2 \cdot 1 \text{ kg} \cdot 1.4142135623730950488016887242097 \text{ m/s}^2$$

1.4142135623730950488016887242097 is the square root of 2

or...

1 joule = the kinetic energy of a 2 kilogram mass, displacing at a velocity of 1 meter per second.

$$1 \text{ joule } (E_k) = 1/2 \cdot 2 \text{ kg} \cdot 1 \text{ m/s}^2$$

.....

.....

THERE IS NO TIME PERIOD DURING WHICH ENERGY MUST BE TRANSFERRED IN ORDER TO QUANTIFY THE JOULE OF ENERGY

Neither is there a rate of acceleration which must occur in order that joules of energy can act or be defined. Such a stipulation would only apply to the defining of the JOULE PER SECOND.

.....

**THERE IS NO TIME PERIOD DURING WHICH ENERGY MUST BE TRANSFERRED IN ORDER TO QUANTIFY THE JOULE OF ENERGY**

Time is intrinsic within and unalienable from the newton of force and its definition. This is because the newton is defined in terms of acceleration against the reactive force of inertia in a mass. That reactive force of inertia exists only during an acceleration. And of course acceleration is described and defined in terms of a displacement over an interval of time per another interval of time, as in  $m/s^2$  (meters per second per second).

.....  
But there is no time period which must be stipulated in order to quantify the joule of energy.

.....  
If we transfer 2 joules of energy, in a manner such that it will cause the acceleration of a 1 Kg mass, that energy acts as a force.

.....  
If we transfer 2 joules of energy to cause the acceleration of a 1 Kg mass (against the inertia of that mass solely),  
and  
that 1 Kg mass accelerates to a velocity of 2 meters per second in 1 second ( $2m/s/s$ ).

The object will have displaced only 1 meter during that second.

2 newtons of force must have acted upon the mass, because the 1kg mass accelerated at  $2m/s/s$ .  
because  
 $1kg \cdot 1m/s/s = 1 N$  (by definition) .... therefore  $1kg \cdot 2m/s/s = 2 N$

If the force applied is 2 newtons and the displacement is 1 meter the energy expended is 2 joules.

$1kg \cdot 1m/s/s = 1N$  ... and  $1N \cdot$  a displacement of  $1m = 1$  joule ....  
therefore ....  
 $1kg \cdot 2m/s/s = 2N$  ...  $2N \cdot$  displacement of  $1m = 2$  joules

But it is not necessary for that acceleration to occur in one second of time, in order that 2 joules of energy are expended.

When we transfer joules of energy to cause the acceleration of a 1 Kg mass (against the inertia of that mass solely), the time required for said 1 Kg mass to reach a velocity of  $2m/s$ , will be dependent upon the rate at which the joules of energy are transferred to the 1 Kg mass. The joules per second.

.....  
When we transfer 2 joules of energy to cause the acceleration of a 1 Kg mass (against the inertia of that mass solely), that 1 Kg mass WILL ACCELERATE at the rate of 2 meter per second per that second, ONLY WHEN the energy is transferred AT A RATE OF 2 joules per second.

This is the amount of energy PER SECOND (2 joules per second) (as force in newtons) required to accelerate a 1 kilogram mass, from rest, to a velocity of  $2 m/s$ , IN ONE SECOND of time. (against the inertia of that mass solely).

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK**

**THERE IS NO TIME PERIOD DURING WHICH ENERGY MUST BE TRANSFERRED IN  
ORDER TO QUANTIFY THE JOULE OF ENERGY**

**Redundantly stated, this is also the amount of energy required, to cause an object to displace 1 meter against a force of 2 newtons.**

.....  
**Also redundantly stated, it will not matter if the transfer of those joules of energy has occurred over some period of time other than 1 second. It still remains that it is just 2 joules of energy.**

.....  
**The energy transferred in accelerating a 1 kilogram mass (against the inertia of that mass solely) to some specified velocity, is the same amount whether the mass is accelerated to that specified velocity, rapidly or slowly.**

.....  
**A FIRST EXAMPLE**

**If it takes 1/2 second of time for a 1 kilogram mass to accelerate to a final velocity of 2 meters per second, the energy was transferred at a rate of 2 joules per 1/2 second.**

**2 m/s in 1/2 second is an acceleration at the rate of 4 m/s in 1 second or 4m/s/s.**

**The average velocity of a constant or uniform acceleration is 1/2 of the final velocity.**

**The average velocity of the 2m/s final velocity is 1m/s.**

**The duration of the acceleration is 1/2 second.**

**The displacement that occurred during the 1/2 second is the average velocity times the duration of the acceleration. This is 1m/s times 1/2 second or 1/2 meter of displacement.**

**We have a 1kg mass accelerating at a rate of 4m/s/s. This is equal to 4 newtons of force.**

**4 newtons of force times a displacement of 1/2 meter is 2 joules per that second.**

**and**

**That's 2 joules per second, but it's still remains that this is 2 joules.**

.....  
**A SECOND EXAMPLE**

**If it takes 20 seconds of time for a 1 kilogram mass to ACCELERATE to a 2 meters per second final velocity.**

**then**

**The 1 kilogram mass accelerated to a velocity of 2/20<sup>th</sup> of a meter per second in the first second.**

**The mass accelerated an additional 2/20<sup>th</sup> of a meter per second, during second number 2, for a total velocity of 4/20<sup>th</sup> of a meter per second by the end of second number two.**

**A total velocity of 6/20<sup>th</sup> of a meter per second was reached by the end of second number 3 and so on.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK**

**THERE IS NO TIME PERIOD DURING WHICH ENERGY MUST BE TRANSFERRED IN  
ORDER TO QUANTIFY THE JOULE OF ENERGY**

**and**

**At the end of 20 seconds the mass will have reached a total velocity of 40/20<sup>th</sup> of a meter per second or in other words a final velocity of 2 meters per second.**

**If it requires 20 seconds of time for the 1 kilogram mass to accelerate to a velocity of 2 meters per second, the energy was transferred at a rate of 2 joules per 20 seconds.**

.....  
**2 m/s in 20 seconds is an acceleration at the rate of 0.1 meter in 1 second or 0.1m/s/s.**

**The average velocity during this acceleration (to the final velocity of 2m/s) is 1m/s. The average velocity of a constant or uniform acceleration is 1/2 of the final velocity.**

**The duration of the acceleration is 20 seconds.**

**The displacement that occurred during the 20 seconds is the average velocity times the duration of the acceleration. This is 1m/s times 20 seconds or 20 meters of displacement.**

**We have a 1kg mass accelerating at a rate of 0.1m/s/s. This is equal to 0.1 newton of force. 0.1 newton of force times a displacement of 20 meter is 2 joules per that 20 seconds.**

**That's 2 joules per 20 seconds, but it's still remains that this is 2 joules of work or 2 joules of energy transferred to accelerate the 1 kg mass to a velocity of 2 m/s.**

.....  
**Whether the velocity of 2m/s was reached via an acceleration rate of 4m/s/s during 1/2 second or the velocity of 2m/s was reached via an acceleration rate of 0.1m/s/s during 20 seconds ....**

**It required the same amount of energy to accelerate the 1 kilogram mass to that velocity of 2m/s. It required the same amount of energy whether the acceleration was a rapid one or a slow one.**

.....  
**The force applied and / or the joules per second transferred are different in the two scenarios.**

**SOME DEFINITIONS AND EXPLANATIONS  
THE JOULE OF ENERGY IN A SIMPLIFIED PRESENTATION**

**Science defines the joule in terms of the newton of force because (at least in theory) this is a more fundamental and self-consistent approach to defining it, than other options. In terms of the actual measuring of energy this approach is frequently less direct and less practicable than other options.**

.....  
**One joule is the amount of energy transferred in lifting an object 1 meter, when that object has the same weight as does a mass of 0.101971 kilograms (in standard gravity).**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY FORCE AND WORK  
THE JOULE OF ENERGY IN A SIMPLIFIED PRESENTATION**

**0.101971 kilograms is equal to 101.971 grams and / or is approximately 102 grams.**

.....  
**The period of time in which that object is lifted 1 meter does not change the amount of energy expended.**

.....  
**One joule is also the amount of energy transferred when an object that has the same weight as does a 101.971 gram mass, falls 1 meter (in standard gravity).**

.....  
**The period of time during which that object falls 1 meter does not change the amount of energy transferred. For example, the energy transferred to the object (from gravity) when one lowers that object slowly by means of an attached string is the same as the energy transferred when the object falls freely.**

.....  
**Please recall that standard gravity is a nominal value for the rate of acceleration that Earth's gravity causes in free falling objects. This is an acceleration at the rate of 9.80665 meters per second per each second that the object free falls.**

.....  
**Please also recall, that the conditions under which the joule is defined and quantified are of course not the only conditions in which a joule of energy may be transferred / expended.**

**WORK**

**There are articles titled in Wikipedia as "work" (electrical, physics and thermodynamics). Mechanical work redirects to work (physics). The descriptions made within this presentation are in terms of "mechanical work"**

**From a Wikipedia article on work.**

"In physics, a force is said to do work when it acts on a body, and there is a displacement of the point of application in the direction of the force. For example, when you lift a suitcase from the floor, the work done on the suitcase is the force it takes to lift it (its weight) times the height that it is lifted."

**While it is true that a force is said to do work when applied as above, it is a more direct explanation of work, to simply say (Work = energy · displacement).**

**The Wikipedia article uses the term force in a place where (for our purposes) the phrase " energy acting as a force" might be more appropriately applied.**

.....  
**Work is the displacement of an object.**

.....  
**The amount of an object's displacement and the magnitude of that which is opposing an objects displacement are that which quantifies an amount of work.**

.....

As examples of possible causes of an opposition to an objects displacement consider the following. An object's inertia, an object's weight, a spring's resistance to compression, an object's resistance to submersion in a fluid (buoyancy), a magnetic attraction or repulsion between to objects and so on, may oppose an object's displacement.

.....  
Work is the result of a force.

.....  
Energy is called a force when it “causes a body to undergo a certain change, either concerning its movement, direction, or geometrical construction”.

.....  
However, a force is not absolutely restricted to the doing of work. For example, a force can act upon an object and in so doing prevent another force from displacing that object.

.....  
A force is described as a vector (in terms of both magnitude and direction). But work is not typically described as a vector, although one may do so. There is no direction which must be specified in a description of work done. Work is scalar (as it has only a magnitude).

.....  
Work is described in terms of an amount of or a magnitude of displacement of an object against that which is being overcome in order to displace that object. That which is being overcome in order to displace an object is also of some amount (of some magnitude).

For example when one lifts an object, the work done may be described in terms of the height of that lifting (the magnitude of the displacement) and the weight of that object (the magnitude of the opposition to displacement). The magnitude of that work is described as the product of the multiplication of the height of the lifting times the weight of the object lifted. One joule of work is done in lifting an object which has the same weight (in standard gravity) as does a mass of approximately 0.10197 kilograms .... a height of 1 meter.

A BREAK DOWN AND EXPLANATION OF

$$E_k = 1/2 mv^2$$

As another example, when an object undergoes a constant acceleration (against the resistance to acceleration due to inertia solely) the work done may be described in terms of these formulas.

where in

**F** stands for force in newtons.

**m** stands for mass in kilograms.

**t** stands for time in seconds.

**J** stands for joules of energy.

**a** stands for acceleration rate in meters per second per second.

**v** stands for velocity in meters per second.

**v<sub>f</sub>** stands for final velocity in meters per second.

**v<sub>av</sub>** stands for average velocity in meters per second.

**s** stands for displacement in meters.

**E** stands for energy

**k** stands for kinetic

**SOME DEFINITIONS AND EXPLANATIONS  
WORK**

P 44

**A BREAK DOWN AND EXPLANATION OF**

$$E_k = 1/2 mv^2$$

**F = m • a .... force = mass • acceleration. One newton of force will cause a 1 kilogram mass to accelerate at the rate of 1 meter per second, during each second that the force is applied.**

**v<sub>f</sub> = a • t .... final velocity = acceleration rate • the time duration of the acceleration**

**v<sub>av</sub> = 1/2 v<sub>f</sub> .... average velocity = 1/2 of the final velocity**

**s = v<sub>av</sub> • t .... displacement = average velocity • the duration of the acceleration**

**E<sub>k</sub> = F • s .... (kinetic energy = force • displacement)**

or

**E<sub>k</sub> = m • a • (1/2 v<sub>f</sub>) • t .... kinetic energy = mass • acceleration rate • 1/2 final velocity • duration of the acceleration.... and m • a = FORCE .... and 1/2 of the final velocity = the average velocity... and the average velocity • the duration of the acceleration = displacement (s) .... and E<sub>k</sub> = F • s .**

or

**E<sub>k</sub> = (m • a) • [1/2 • (a • t)] • t .... kinetic energy = mass • acceleration rate • 1/2 of the final velocity (v<sub>f</sub> = a • t) • the duration of the acceleration.**

and since

**E<sub>k</sub> = force times displacement or E<sub>k</sub> = (m • a) • [1/2 • (a • t)] • t**

or

**E<sub>k</sub> = (m • a) is the force .... a • t is the final velocity .... {1/2 • (a • t)} is the average velocity ... and [1/2 • (a • t)] • t is the displacement and E<sub>k</sub> = force • displacement or E<sub>k</sub> = F • s**

then also

$$E_k = (m \cdot a) \cdot 1/2 \cdot (a \cdot t) \cdot t$$

then also

$$E_k = 1/2 \cdot (m \cdot a) \cdot (a \cdot t) \cdot t$$

then also

$$E_k = 1/2 \cdot m \cdot (a \cdot a) \cdot (t \cdot t)$$

then also

$$E_k = 1/2 \cdot m \cdot a^2 \cdot t^2$$

and since

**a • t = v .... acceleration rate • length of time of the acceleration = velocity**

and

$$E_k = 1/2 \cdot m \cdot a^2 \cdot t^2$$

then

$$E_k = 1/2 \cdot m \cdot v^2 \dots E_k = 1/2 mv^2 \dots E_k = \frac{mv^2}{2}$$

because

**velocity = a • t .... and because any A<sup>2</sup> • B<sup>2</sup> = (A • B)<sup>2</sup> For example, 5<sup>2</sup> = 25 and 4<sup>2</sup> = 16 and 25 • 16 = 400 ..... but also 5 • 4 = 20 and 20<sup>2</sup> also = 400 ..... as in a<sup>2</sup> • t<sup>2</sup> = (a • t)<sup>2</sup> .... and as in, **velocity squared** is another way of saying either (a<sup>2</sup> • t<sup>2</sup>) or (a • t)<sup>2</sup> or v<sup>2</sup>.**

**SOME DEFINITIONS AND EXPLANATIONS  
WORK**

**A BREAK DOWN AND EXPLANATION OF**

$$E_k = 1/2 mv^2$$

For example when .....

$$F = 2 \text{ N}$$

$$m = 5 \text{ Kg}$$

$$v = 2.4\text{m/s}$$

$$a = 0.4\text{m/s/s}$$

$$t = 6 \text{ sec}$$

$$s = 1/2 \cdot 2.4 \cdot 6 = 1/2 \cdot 14.4 = 7.2\text{m}$$

then

$$E_k = 2\text{N} \cdot 7.2\text{m} = 14.4 \text{ J}$$

and

$$E_k = 1/2 mv^2 \text{ ..... } 1/2 \cdot 5\text{Kg} \cdot 2.4\text{m/s}^2 = 14.4 \text{ J}$$

or

$$E_k = 1/2 \cdot m \cdot (a \cdot a) \cdot (t \cdot t) \text{ ..... } 1/2 \cdot 5 \cdot (0.4 \cdot 0.4) \cdot (6 \cdot 6) = 1/2 \cdot 5 \cdot 0.16 \cdot 36 = 14.4 \text{ J}$$

.....  
The rate of an acceleration times the mass of the accelerated object .... represents an opposition to displacement due to inertia, (a force) .... this times the amount of that displacement .... is work.

.....  
It requires 1 newton of force to accelerate a 1 kilogram mass at a rate of 1 m/s/s (by definition). 1 newton of force applied over a displacement of 1 meter is equal to 1 joule of work done or 1 joule of energy transfer (by definition).

.....  
It is not necessary to describe the weight of an object as a force in order to measure the amount of work done in lifting it some specific distance.

However physics describes the weight of an object in terms the magnitude of the force that pulls upon an object. This pull is a result of both the mass of the attracted object and the magnitude of the gravity of the attracting body.

In SI terms the weight of an attracted object is stated as the newtons (of force) exerted upon an object by a gravitational attraction.

.....  
Work may of course be done either, by or in opposition to, a force imposed by some form of energy other than gravitational energy.

.....  
If this energy is of some form other than gravitational, (magnetic for instance) it is appropriately termed (for example magnetic energy).

When this magnetic energy “causes a body to undergo a certain change, either concerning its movement, direction, or geometrical construction”, it is acting as a force, and is then appropriately termed (for example as magnetic force).

.....

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts From Wikipedia**  
**WORK**

**Both work and energy are measured in units of joules (SI system). However Kinetic energy may also sometimes be stated in terms of newtons of force (SI system) and time duration, or as newtons of force and an amount of displacement.**

.....  
**That TIME IS NOT AN ELEMENT IN THE MEASUREMENT OF WORK, might not need mentioning, except that (as previously stated) time is an element in the computation of the SI unit of measurement of force the "newton". The joule in turn, is typically defined in terms of the newton and.... that SI unit of measurement of energy (the joule), is not only the unit of measurement of energy, but it is also the SI unit of measurement of work .**

**From a Wikipedia article on work.**

"The term work was introduced in 1826 by the French mathematician Gaspard-Gustave."  
"Coriolis[1][2] as "weight lifted through a height", which is based on the use of early steam engines to lift buckets of water out of loaded ore mines. The SI unit of work is the newton-meter or joule (J)."  
The newton times 1 meter (newton meter) or joule is an SI unit of work."

"work done by a constant force of magnitude  $F$  on a point that moves a displacement (not distance)  $s$  in the direction of the force is the product.  $W = Fs$ . For example, if a force of 10 newtons ( $F = 10 \text{ N}$ ) acts along a point that travels 2 meters ( $s = 2 \text{ m}$ ), then it does the work  $W = (10 \text{ N})(2 \text{ m}) = 20 \text{ N m} = 20 \text{ J}$ ."

**In quoting the above Wikipedia articles I may be confusing the subject at hand. I will however, for the present, follow through with the trend toward the newton, and the newton-meter regardless.**

**Work is not defined by the amount of time required for a displacement to occur, but the newton and of course work over time are defined in terms of time.**

.....  
**Energy transference causing the displacement of an object is work.**

.....  
**One joule is the amount of work done in lifting an object 1 meter, when that object has the same weight (in standard gravity) as does a mass of approximately 101.971 grams.**

.....  
**One newton is the amount of force that pulls down on a object when that object has the same weight (in standard gravity) as does a mass of approximately 101.971 grams.**

**One newton is the amount of force that pulls down on an object (in standard gravity) when that object has a mass of 101.971 grams or 0.101971 kilograms.**

.....  
**One joule is the amount of work done in LIFTING an object 1 meter when the force opposing that LIFTING is equal to 1 newton.**

.....  
**One joule is the amount of energy transferred in DISPLACING an object 1 meter when the force opposing that DIAPLACEMENT is equal to 1 newton.**

**SOME DEFINITIONS AND EXPLANATIONS  
WORK**

**One NEWTON is the amount of FORCE required to accelerate an object with a 1 kilogram mass at the rate of 1 meter per second per each second, that one newton is applied (against that objects resistance to acceleration when said resistance is caused solely by inertia).**

.....  
**ONE HALF JOULE is the amount of work done in accelerating an object with a 1 kilogram mass, FROM REST, at a rate of 1 meter per second per second, FOR ONE SECOND OF TIME, (against that objects resistance to acceleration when said resistance is caused solely by the inertia of that object). The object displaces 1/2 meter during that 1 second acceleration.**

.....  
**ONE HALF JOULE OF WORK PER SECOND is the RATE at which work is done as a force accelerates an object with a 1 kilogram mass, FROM REST, at a rate of 1 meter per second per second, DURING THAT ONE SECOND OF TIME (against that objects resistance to acceleration when said resistance is caused solely by the inertia of that object.)**

.....  
**ONE HALF METER is the amount an object displaces when 1/2 joule of work is done IN ONE SECOND OF TIME in accelerating from rest, an object with a 1 kilogram mass, to a velocity of 1 meter per second, (against that objects resistance to acceleration when said resistance is caused solely by inertia).**

.....  
**One joule is the amount of ENERGY transferred in displacing an object 1 meter when the force opposing that displacement is equal to 1 newton.**

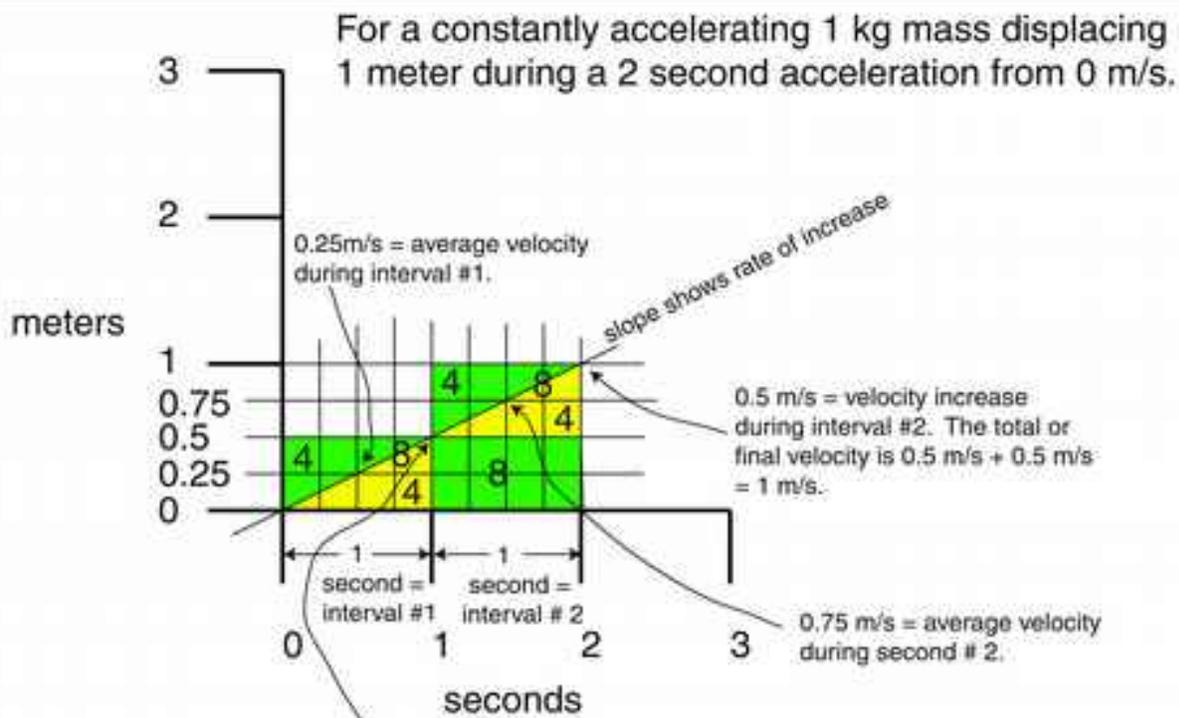
.....  
**One joule is the amount of WORK done in displacing an object 1 meter when the force opposing that displacement is equal to 1 newton.**

.....  
**Conversely the work of displacing a 1 kilogram mass object, 1 meter, in one second of time, (against the opposition to that displacement caused solely by the objects resistance to acceleration due to inertia), requires the application of 1 newton of force all during that second.**

.....  
**Please recall that (as previously stated) an object that uniformly / constantly accelerates from rest, at a rate of 1meter per second, for one second of time, will DISPLACE ONLY 1/2 METER DURING THAT SECOND OF TIME, even though the objects final velocity is 1m/s. This is because the object's average velocity during the constant acceleration is 1/2 of its final velocity.**

.....  
**TWO SECONDS IS THE AMOUNT OF TIME required for an object with a mass of 1 kilogram to displace FROM REST, 1 meter, when that work is done AT A RATE OF 0.125 JOULES PER SECOND during the first second but AT A RATE OF 0.375 JOULES PER SECOND during second number 2. The 1 kg accelerates at the rate of 0.5 m/s/s (against that objects resistance to acceleration when said resistance is caused solely by the inertia of that object).**

**SEE THE EXPLINATION NEXT**



0.5 m/s = velocity increase during 1st second. 0.5 m/s/s is then, the rate of acceleration.

- mass = 1kg
- final displacement = 1 meter
- duration of acceleration = 2 seconds
- acceleration rate = 0.5 m/s/s
- applied force = 0.5 newtons (1 kg is accelerated to 0.5 m/s in 1 second)
- final velocity = 1 m/s

The displacement during interval #1 is the average velocity during interval #1 times the duration of that interval (1 second). 0.25m/s is this average velocity. The displacement during interval #1 = 0.25 m.

displacement during interval #1 is average velocity in interval #1 (0.25m/s) times, the duration of interval #1 (1 second) and is = 0.25m

The displacement during interval #2 is the average velocity during interval #2 times the duration of that interval (1 second). 0.75 m/s is this average velocity. The displacement during interval #2 = 0.75 m.

**joules expended during interval # 1** is 0.5 newtons times 0.25 meters = 0.125 joules.

The total displacement during the 2 second acceleration is 0.25 + 0.75 = 1 m.

displacement during interval #2 is average velocity in interval #2 (0.75 m/s) times the duration of interval #2 (1 second) and is = 0.75m

1 newton • 1 meter = 1 joule

0.5 newtons • 1 meter = 0.5 joules

**joules expended during interval # 2** is 0.5 newtons times 0.75 meters = 0.375 joules.

$$E_k = 1/2 mv^2$$

$$0.5 \text{ joules} = 1/2 \cdot 1 \text{ kg} \cdot 1 \text{ m/s}^2$$

Total joules expended is 0.125 joules + 0.375 joules = 0.5 joules.

A displacement within a period of time (along with its direction) defines a velocity.

.....  
Mass, and velocity together, define a persistence in velocity (momentum) due to inertia.

.....  
Similarly an object at rest has a persistence in remaining at rest (due to inertia).

Mass and the resistance to acceleration force define this persistence.

.....  
An object at rest does not begin to move at some given velocity. That object must accelerate in order to reach some given velocity.

.....  
When an object is constantly accelerating there is (due to inertia), a resistance specifically to its acceleration. This is to say that this resistance to acceleration, exists only during the acceleration.

.....  
1 newton is defined by the amount of force required to overcome a specific amount of resistance to acceleration.  $1\text{N} = 1\text{kg} \cdot 1\text{m/s/s}$

.....  
When an object is at rest but then displaces 1/2 meter in one second of time, the object has accelerated to a velocity of 1 meters per second, during that 1 second (final velocity = 1 m/s).

.....  
An object at rest which has 1 kilogram of mass has a specific amount of resistance to its displacing 1/2 meter in one second (accelerating at a rate of 1 m/s/s ).  $1\text{N} = 1\text{kg} \cdot 1\text{m/s/s}$

.....  
If the mass of that object were 2 time greater its resistance to displacing 1/2 meter in 1 second would be 2 times greater, and it would require twice as much force to displace it 1/2 meter in 1 second of time (to accelerate it at a rate of 1 m/s/s ).

.....  
If the mass of that stationary object were 1/2 times less, its resistance to displacing 1/2 meter in 1 second would be 1/2 times less and it would require 1/2 as much force to displace it 1/2 meter in 1 second of time (to accelerate it at a rate of 1 m/s/s ).

.....  
When the mass of that object is 1 kilogram it requires 2 newtons of force to cause it to accelerate from rest, to a velocity of 2 m/s, in one second. The object displaces 1 meter during that 1 second.

.....  
When the mass of that object is 2 kilograms, it requires 4 newton of force to cause it to accelerate from rest, to a velocity of 2 m/s, in one second. The object displaces 1 meter during that 1 second.

.....  
When the mass of that object is 1/2 kilogram it requires 1 newton of force to cause it to accelerate from rest, to a velocity of 2 m/s, in one second. The object displaces 1 meter during that 1 second.

.....  
If the mass of that object is equal to 1 kilogram and 2 newtons of force act to cause its constant acceleration the object will accelerate at the rate of 2 m/s/s. The object will displace 1 meter during that 1 second acceleration.

.....  
If the mass of that object is equal to 1 kilogram and 1/2 newton of force acts to cause its acceleration the object will accelerate at 1/2 m/s/s. The object will displace 1/4 meter during that 1 second acceleration.

.....  
There is no opposition to acceleration due to inertia when an object is at rest or when an objects velocity remains constant. There is an opposition to acceleration only when an object accelerates.

Therefore the amount of force needed to cause the displacement of an object against inertia must be stated in terms of a rate of acceleration for that object.

.....  
The force required to cause a specific amount of acceleration of an object is dependent upon that object's resistance to acceleration due to inertia.

The inertia of an object is dependent upon the object's mass.

Therefore the amount of force needed to cause the displacement of an object against inertia must also be stated in terms of the mass of that object.

.....  
Therefore the amount of force needed to cause the displacement of an object against inertia must be stated in terms of both a rate of acceleration for that object and the mass of that object.

.....  
.....  
It should be recalled at this point, that as force does work, it continuously acts upon an object while that object displaces. As when a person continuously exerts a force upon a base ball by running with it. As when gravity acts upon a falling object continuously, as that objects falls. As when a magnet acts continuously upon a near by iron object, while that object is pulled toward the magnet. As when a force acts and some amount of acceleration occurs over some period of time.

Also please recall that:

Velocity is a vector quality (has both magnitude and direction).

Acceleration is a vector quality.

Force is a vector quality.

.....  
ONE HALF JOULE OF WORK PER SECOND is the RATE at which work is done as a force accelerates an object with a 1 kilogram mass, from rest to a velocity of 1m/s, DURING ONE SECOND OF TIME. (against the opposition to that displacement which is caused solely by the objects resistance to acceleration due to inertia).

1/2 joule is expended to accelerate a 1 kilogram mass from rest to a velocity of 1m/s, regardless of the amount of force applied and of the resulting RATE of acceleration. (against the opposition to that displacement which is caused solely by the objects resistance to acceleration due to inertia).

Once again, the newton should then perhaps, not be a part of the discourse on work but rather the other way around. However what counts is gaining an understanding of the concepts.

Science defines the joule in terms of the newton of force because this (at least in theory) is a more or less fundamental and self-consistent approach to defining it. In terms of the actual measuring of energy this approach is frequently less direct than other options.

The amount of an object's displacement and the magnitude of that which is opposing an objects displacement are that which quantifies an amount of work.

.....  
As examples of possible causes of an opposition to an objects displacement consider the following. An object's inertia, an object's weight, a springs resistance to compression, an objects resistance to submersion in a fluid (buoyancy), a magnetic attraction between two objects and so on, may oppose an object's displacement.

**THE JOULE OF WORK IN A SIMPLIFIED PRESENTATION**

One joule is the amount of work done in lifting an object 1 meter, when that object has the same weight (in standard gravity) as does a 0.101971 kilogram mass. Note that 0.101971 kilograms is approximately equal to 102 grams of mass. Note that actually 0.101971 kg should be precisely 0.10197162129779282425700927431896 kg.

.....  
One joule is the amount of work done in lifting an object 2 meters, when that object has the same weight (in standard gravity) as does a 0.05098 kilogram mass ( $0.05098 \cdot 2 = 0.10196$ ).

.....  
One joule is the amount of work done in lifting an object 1/2 meter, when that object has the same weight (in standard gravity) as does a 0.20394 kilogram mass ( $0.20392 = 0.10196 \cdot 2$ ).

.....  
One joule is the amount of work done in the displacing of an object (A) against whatever opposes the displacement of object (A), when the opposition to the displacement of object (A) is equivalent to the lifting of an object (B) 1 meter when object (B) has the same weight (in standard gravity) as does a 0.101971 kilogram mass.

.....  
One joule is also the amount of work done on an object by gravity, when that object has the same weight (in standard gravity) as does a 0.101971 kilogram mass, and that object falls 1 meter.

**SOME DEFINITIONS AND EXPLANATIONS  
WORK LESS INERTIA**

**Lifting force and accelerating force**

Generally, in a calculation of work done there is no accounting for the energy expended in acceleration against inertia. But also generally, in a calculation of work there is no accounting for the energy of momentum during deceleration. Because generally, these two cancel each other out, anyway.

**SOME DEFINITIONS AND EXPLANATIONS  
WORK LESS INERTIA**

**Lifting force and accelerating force**

**When work is done in lifting an object, the energy (as force) applied to lift it, is in opposition to the gravitational energy (as force), attracting the object. The lifted object is the intermediary of that lifting energy (as force) and the gravitational energy (as force) .... as both the lifting force and the gravitational force have grabbed a hold of the object, so to speak.**

.....  
**While an object is being lifted energy must be constantly transferred to that object during that lifting. This is because the attraction by gravity is present during the whole time the lifting occurs.**

.....  
**Additional energy transfer is required to cause the object to accelerate (in order to overcome the inertia of the object). This additional energy needs to be applied, only to cause the acceleration and during the acceleration only. It is against the inertia of the mass.**

**When an object is displaced from a point A to a point B, it does not simply and suddenly appear at point B. It will require time to reach point B. Neither does an object instantaneously move at some given speed, it must accelerate as it begins to move.**

**Inertia opposes ONLY THE CHANGES in the velocity of an object, NOT an object's constant velocity. Inertia supports a constant velocity (as momentum). Reactive opposition due to inertia is present only during acceleration and deceleration.**

.....  
**When an object is lifted, the lifting force adds kinetic energy to that object at a rate which is greater than the rate at which the object is receiving energy from the gravitational source.**

.....  
**When energy is being transferred to the object as the lifting force at a greater rate than it is being transferred by the gravitational source, this lifting energy causes an acceleration of the object (up).**

.....  
**Energy that is being transferred to the object to cause its acceleration becomes “kinetic energy” within the object during its acceleration.**

.....  
**If energy is no longer applied to the object as lifting force, its ACCELERATION will end immediately, although its MOTION will not.**

.....  
**Both the kinetic energy of the object and its speed will begin to decrease.**

.....  
**The object will continue to displace upwardly (coast), until this kinetic energy has completely transferred to the gravitational source which is opposing the objects upward motion.**

.....  
**When the kinetic energy of the object (as upward displacement) reaches a value of zero, the upward displacement of the object will end.**

.....

Lifting force and accelerating force

That portion of the energy that was transferred (force applied) to overcome the inertia of the object (to accelerate it) is equal to the energy transferred to the gravitational source during the objects deceleration (its coasting).

They balance and cancel out. The input accelerating energy minus the output coasting energy equals zero.

.....

During the lifting, the energy applied as "force to lift," is opposing the energy in gravity's force. These two forces are in equilibrium and opposite. This force can be measured as the "weight" of the lifted object.

When the lifting force is no longer being applied, the energy that was spent to cause acceleration (to over come inertia), remains present within the object as the kinetic energy in the coasting of the object (momentum). This kinetic energy is being transferred to the gravitational source as the objects coasting velocity decreases. Then the object's ascent ends.

.....

There is no element of time in the calculation of work.

Generally, in a calculation of work done there is no accounting for the energy expended in acceleration against inertia. But also generally, in a calculation of work there is no accounting for the energy of momentum during deceleration. Because generally, these two cancel each other out, anyway. One may of course include the work done in causing acceleration against inertia, since conditionally one may some times need to do so.

The measuring of the WORK done in LIFTING an object does not take into account the speed of an objects displacement or its acceleration and deceleration. This is because the energy transferred to cause acceleration is recovered as the energy of momentum (the coasting). It takes the SAME AMOUNT OF ENERGY to do the work of LIFTING an object against the force of gravity from a point A to a point B, whether it travels to point B rapidly, or slowly. It's just that the work has been done in a shorter period of time when the object arrives at point B sooner.

The measuring of ENERGY transferred in DISPLACING an object (energy as force times the displacement) does not take into account the the amount of TIME required to do that WORK. It takes the SAME AMOUNT OF ENERGY to do the WORK of DISPLACEING an object from a point A to a point B, whether it travels to point B rapidly or slowly, It's just that the energy has been transferred in a shorter period of time when the object arrives in a shorter period of time.

Conditionally / depending upon circumstances, one may some times need to include the work done to cause acceleration against inertia in addition to other work which is done upon an object.

.....

Keep in mind that this discourse is made under the premise of the ideal conditions of no friction losses and so on. In the real world these losses are a big deal. They are left out of the topics at this point as a simplification. We will look at some of the causes of loss at a later point.

**SOME DEFINITIONS AND EXPLANATIONS  
MASS COMPARED TO WEIGHT**

"Mass describes the amount of matter in an object. "

.....  
Mass describes, or is at least an attempt to describe or quantify the amount of substance an object is composed of.

.....  
The SI unit of measurement of mass is the kilogram.

.....  
The ratio of the mass of an object to the magnitude of a force needed to cause a given rate of ACCELERATION against that object's inertia (as resistance to acceleration) is a constant.

.....  
The ratio of the mass of an object to the magnitude of a force needed to cause a given rate of DECELERATION against that object's momentum (inertia as resistance to deceleration) is a constant.

.....  
There is no SI unit of measurement of inertia, as inertia describes a principle and not specific or single attribute.

.....  
However there are units of measurement for that aspect of inertia which is called momentum. momentum = mass times velocity. In SI units this is stated as kilogram meters/second and is abbreviated as (kg m/s). The mass of an object in kilograms multiplied by that object's velocity in meters per second is equal to the momentum of that object as kilogram meters per second.

.....  
The ratio of the mass of an object to the static weight of that object is a constant proportion, when that object is under the influence of a given and unchanging gravitational influence.

.....  
Mass itself is neither the weight nor the inertia of an object.

.....  
There is no SI unit of measurement which is specifically of weight and especially of static weight.

.....  
However there is an SI unit of measurement of force. That unit is the newton. The newton is not specifically a unit of weight, but of force in general.

.....  
In SI terms, a force has the value of 1 newton when it is sufficient to cause an object with a mass of 1 kilogram to accelerate at the rate of 1 meter per second, during each second that, that force acts upon the object, and when the only resistance to the acceleration of that object is caused by the objects inertia.

.....  
When the force acting upon an object is a gravitational attraction, that force is in certain ways mathematically equivalent to the weight of that object.

.....  
In the SI, both the process of the measuring of weight and the way in which weight is defined are in terms of interactions involving force giving rise to motion. In the SI weight is a quality which is measured and defined through dynamic conditions.

.....  
Static weight might be thought of as a potential force (like potential energy). However, static

**SOME DEFINITIONS AND EXPLANATIONS  
MASS COMPARED TO WEIGHT**

weight is not typically described by use of the phrase "potential force". In the language of contemporary physics, weight is static because the net forces acting upon an object are in balance, and therefore those net forces give rise to zero work.

.....  
It is peculiar that in SI terms, weight is described in terms of the force to cause acceleration while in our common experience weight is a static quality of objects. The amount of weight of an object is what has been arrived at, once the scales stop moving.

.....  
In the U.S. a one pound mass (international avoirdupois pound) has a weight on Earth of 1 pound (in standard gravity). Strictly speaking (in science and engineering) 1 pound of weight is called 1 pound-force, while 1 pound of mass is called 1 pound-mass.

.....  
The international avoirdupois pound (pound-mass) is defined as exactly equal to 0.45359237 kilograms (of mass).

.....  
Pound-force like unto the newton, is measured and defined by means of a dynamic operation. Pound-force is defined as equal to one international avoirdupois pound (1 pound-mass) times standard gravity ( $9.80665\text{m/s}^2$ ).

mass (pound-mass) times acceleration (feet per second) equals force (pound-force)  
One pound-force is equal to 4.44822 newtons

.....  
Commercially in the U.S., the labeling of packaged items does not include or use the word mass. For example, the labeling upon a 1 pound loaf of bread will typically read as follows "NET WT 16 OZ (1 lb ) 454 g". Where "NET WT" is the weight (pound-force) of the product with out the packaging and lb is an abbreviation for pound. Strictly speaking it should read as NET WT 1 pound-force. But I have never seen usage of the phrase "pound-force" upon a package in the U.S..

.....  
Because NET WT 1 pound is also the mass of a loaf of bread that weighs 1 pound (in standard gravity), the statement that the content of the package is "454 g" (has a mass of 454 grams) is also a correct one.

.....  
In common usage the kilogram IS A UNIT OF WEIGHT, but IS NOT a unit of weight in the SI. Rather strictly in the SI, the kilogram is of mass only.

.....  
The word mass IS NOT a typical or common or colloquially used word for weight in the U.S., although there is often misunderstanding in regard to the difference between mass and weight.

.....  
Note however that there is a unit of measurement of weight in common usage (in engineering) in the U.S. which is called "kilogram-force". 2.20462 pound-force is equal to one kilogram-force .

In the U.S., the phrase "Kilogram-force" is typically truncated to "kilogram" or to "kilo". Colloquially 1 kilo is equal to about 2.2 pounds of weight.

.....  
There is no unit specifically of weight in the SI, but only of that unit of force the "newton". The newton is a specification of the force required to cause a specific rate of acceleration to a given mass (when the resistance to that acceleration is caused solely by the inertia of that mass). A one kilogram mass accelerates at a rate of 1 meter per second, per each second that it is accelerating, when the force causing that acceleration is equal to 1 newton.

.....  
The "weight" of an object can be measured in terms of the newton, only because of that objects motion. The weight of an object is so measured, in terms of mass, displacement against inertia and time.

.....  
The newtons of force (exerted by a gravitational influence) which cause the acceleration of an object are mathematically the equivalent of the weight of that object. However when speaking in precise terms, these newtons of force are not identical to the weight of that object.

.....  
The static weight of an attracted object ( under a given gravitational influence) is in direct proportion to that objects mass.

while

That dynamic quality, which is the free fall rate of acceleration of an attracted object is in direct proportion to the magnitude of the gravity of the attracting body, but independent of the mass of the attracted object.

.....  
An object with a mass of approximately 0.101971 kilograms (approximately 102 grams of mass), is pulled down with a force of 1 newton while under the influence of Earths nominal, mid range value of gravitational pull (standard gravity). One newton is the weight of that object in the SI terms of the force of gravity needed to cause acceleration at the rate of 9.80665 m/s/s. Not the static weight of that object.

.....  
An object with a mass of 1 full kilogram, if under that same gravitational influence, would exert a force of 9.80665 newtons down (roughly 10 newtons of force as weight). This also is not, strictly speaking, the weight of the object, and especially not the static weight of that object.

.....  
Given that a balance scale and / or its counter weights are in units of grams, such a device is (in SI terms) more appropriately called a mass scale, rather than a weight scale.

This is of course, because the kilogram is a unit of measurement of mass, rather than weight in the SI.

.....  
If a balance scale is marked and calibrated in pounds it is appropriately called either a weight or a mass scale or both. However when stating the out come of a measurement one needs to specify either pound-force or pound-mass in order be truly explicit.

.....  
The weight of an object of a given mass may be defined by the effect that the force of gravity has upon that mass. The force of gravity may in turn be defined by the effect it has upon (the weight it gives to) an object of a known given mass.

**SOME DEFINITIONS AND EXPLANATIONS  
MASS COMPARED TO WEIGHT**

.....  
The weight of an object while under a steady / unvarying gravitational influence is in proportion to its mass. On Earth, the weight of an object of greater mass, is greater than the weight of an object on Earth of a lesser mass. The same is true if upon the moon. That is to say, upon the moon the weight of an object of greater mass is greater than the weight of an object of a lesser mass. But the weight of an object of a given mass would be less upon the moon than the weight of that same object when upon Earth. Because the moon's gravity is of a lesser magnitude than Earth's gravity.

The ratio of weight to mass of a weighed object changes is proportion to the magnitude of the gravity of the attracting body.

.....  
The weight of an object while under an unvarying gravitational influence is in an unvarying proportion to the mass of that weighed object.

.....  
The mass of the attracted object is equal to the weight (in newtons of force) of the attracted object divided by the gravitational constant of acceleration of the attracting body.

weight (newtons) = mass • acceleration rate caused by gravity, force = mass • acceleration  
also

mass = weight • acceleration rate caused by gravity, mass = force ÷ acceleration  
also

acceleration rate caused by gravity = weight • mass, acceleration = force ÷ mass

The mass of an object may be determined by measuring the rate of acceleration of that object while it is under the influence of a force of a known magnitude.

.....  
An object is determined to have 1 kilogram of MASS, when an applied force of 1 newton causes that object to accelerate at the rate of 1 meter per second per each second that the force is applied. (against a resistance to acceleration of that object caused solely by the inertia of that object),

$$F = m \cdot a$$
$$m = F \div a$$
$$a = F \div m$$

.....  
The mass of an object may be directly measured upon a balance scale if that scale is calibrated in mass units (grams, kilograms or pound-mass).

.....  
Generally, one might think of the force applied to cause a given rate of acceleration of an object as being independent of or from the mass of that accelerated object.

As examples

Generally speaking, one newton of force will cause a 1 kilogram mass to accelerate (from rest) to a velocity of 1 meter per second, when that force acts on that object for a 1 second of time.

**SOME DEFINITIONS AND EXPLANATIONS  
MASS COMPARED TO WEIGHT**

while

One newton of force will cause a 2 kilogram mass to accelerate (from rest) to a velocity of 1/2 meter per second when that force acts on that object for a 1 second of time.

.....  
However, a given gravitational magnitude exerts a greater force upon an object of greater mass than it exerts upon an object of a lesser mass. The force (weight) exerted by a given attracting magnitude of gravity, is in proportion to the mass of the attracted object. Yet, all objects will free fall (are accelerated by gravity) with the same rate of acceleration under the influence of that given magnitude of attracting gravity. The rate of free fall acceleration is in proportion to the gravitational magnitude of the attracting body but not in proportion to the mass of the free falling object.

This is referred to as the universality of free fall.

.....  
The **WEIGHT** of an object under a given gravitational magnitude **IS** in proportion to the mass of that attracted object.

Under the influence of a given gravitational magnitude, the weight of an attracted object is greater if the mass of the attracted object is greater, and the weight of an attracted object is less when the mass of the attracted object is less.

.....  
The free fall **RATE OF ACCELERATION** caused by a given gravitational magnitude **IS NOT** in proportion to the mass of the falling object, even though the **STATIC** weight of that object **IS** in proportion to the falling objects mass.

**ANY** object in free fall, accelerates (in standard gravity) at a rate of approximately 9.80665 meters per second during each second that it falls. We know this because it has been measured innumerable times. The peculiarity of acceleration caused by gravity is the next topic.

.....  
**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY**

Please recall that in physics, free fall is the motion of an object caused by gravity when the weight of that object is the only force acting upon the falling object. For example when an object falls while within a vacuum, and there is no resistance to its motion due to friction with the air.

The rate of acceleration of an object in free fall in standard gravity is due to:

1. the magnitude of Earth's gravity.
2. the amount of substance comprising that falling object (its mass).
3. the tendency of the falling object to resist acceleration (due to its inertia).

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY**

.....  
**In general, it may be considered that the magnitude of a force exerted upon an object IS INDEPENDANT OF the mass of the object upon which that force is exerted.**

**but contrary to this generality**

**The attraction (force) that a given GRAVITATIONAL magnitude exerts upon an object (an objects weight) IS in proportion to the mass of that attracted object.**

**If the mass of an object is greater, gravity's pull upon it will also be greater.**

.....  
**The magnitude of an objects resistance to a change in velocity (due to inertia) is also in proportion to the amount of substance (the mass) of that object.**

**If the mass of an object is greater, inertia's effects will also be greater.**

.....  
**The universality of the ratio between these two properties (weight, and the resistance to acceleration due to inertia), causes the rate of acceleration of objects in free fall to be the same for all objects which are free fall accelerating under the influence of a same gravitational magnitude. Even when the MASS of those objects is different and even when the WEIGHT of those objects is different.**

.....  
**The rate of acceleration of a falling object is dependent upon the gravitational magnitude of the attracting body (for example Earth), and independent of the either the mass or the weight of the free falling object.**

.....  
**Therefore a feather and a cannon ball free fall with the same rate of acceleration when both are under the influence of a same gravitational source. Therefore also, is the free fall rate of their accelerations changed, when the magnitude of the gravity which they are above is changed.**

.....  
**The reasons that (when in the presents of Earth's atmosphere) a falling cannon ball accelerates more rapidly than a feather are that:**

- 1. A cannon ball is more aerodynamically streamlined than a feather.**
  
- 2. A cannon ball at a given velocity, has more kinetic energy (as momentum) than has a feather if at the same velocity. This is due to the cannon ball having a greater mass than the feather. The moving cannon ball has more force than the moving feather with which to overcome wind resistance (at any given velocity at which both are moving).**

.....  
**Also, if one reshaped the materials composing a cannon ball into the form of a thin parachute and suspended weight, and if one also compressed the material that composes a feather into a dense spherical shape, the feather would accelerate more rapidly than the cannon ball when falling (in air).**

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY**

.....  
**As another example consider a hollow ping pong ball and a solid steel ball bearing, each having exactly the same shape and dimensions as the other and therefore the same wind resistance characteristics and aerodynamics. Falling while under the influence of Earth's gravity and within Earth's atmosphere the ball bearing will accelerate more rapidly than the ping pong ball. Under the influence of Earth's gravity but within a vacuum, the ball bearing and ping pong ball will accelerate at the same rate.**

.....  
**The rate of free fall acceleration of an object while under a given attracting gravitational magnitude is in proportion to that attracting gravitational magnitude.**

.....  
**The gravitational magnitude of an attracting body is in proportion to the mass of that attracting body.**

.....  
**The Earth has greater mass than does the moon and therefore the Earth can exert a greater gravitational pull upon a given object than does the moon.**

.....  
**All free falling objects undergo the same rate of acceleration when their accelerations are caused by near Earth gravity.**

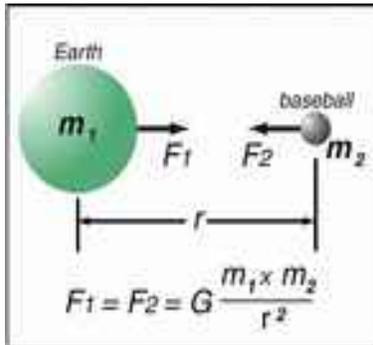
**All free falling object undergo the same rate of acceleration when their accelerations are caused by the near moon gravity.**

.....  
**The rate of free fall acceleration caused by the near Earth gravity is greater than the rate of free fall acceleration caused by the near moon gravity. This is because the Earth has greater mass than does the moon.**

.....  
**Any object that has mass, can also exert a gravitational force. Thus for example, not only is a baseball attracted to the Earth, but the Earth is attracted to that base ball as well. They have a mutual gravitational attraction.**

.....  
**The gravitational constant of Earth is in proportion to Earth's mass. The gravitational constant of any particular object is in proportion to the mass of that object.**

.....  
Gravitational force decreases as the distance between the attracted objects increases. While this may be an interesting topic in its self, it is not of much importance to home experimenters, given that we are likely to remain close to the Earth.



Where  $G$  is the mutual gravitational attraction between the two objects  
 $m_1$  is the mass of the earth  
 $m_2$  is the mass of a baseball  
 $r$  is the distance between their centers.

.....  
The inertia exhibited by the earth is so great as to make it impossible to actually measure the earth's movement toward a baseball. In terms of what is practicable, and observable, it can be said that during an acceleration due to their mutual gravitational attraction, the baseball is moving toward the earth, while the earth is stationary.

.....  
The **ATTRACTION** of the earth toward the baseball is present even though movement of the earth toward the baseball may be undetectable.

.....  
The mass of an object is proportional to the magnitude of it's mutual gravitational attraction to another object with mass.

.....  
When considering small objects and their attraction to a given large object, the magnitude of the gravitational attraction that is exerted upon a small object by the large object is proportional to the mass of the small object . For example, the weight on Earth (a large object), of a base ball (a small object), is in proportion to the mass of that baseball.

.....  
When considering a small object and its attraction to a given very large object, both the attraction of an object to a gravitational source and the inertia of that attracted object are in proportion to the mass of the attracted object. Therefore (for small attracted objects) a given gravitational attraction (earth's gravity for example) causes the **SAME RATE** of free fall **ACCELERATION**, for any two free falling object's. Even when one of those free falling objects has a greater mass and weight than the other.

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY**

.....  
If two very large objects (for example two planets the size of earth) were in close proximity to each another, one might prefer to consider their attraction as mutual and also their acceleration toward one another as mutual. One might also prefer to use a third object which one considered as not being in motion, as a frame of reference. Galileo used the constellations (the stars in the back ground).

**CONSTANT ACCELERATION**

We have already described acceleration briefly in earlier discourse. A "constant" acceleration is one in which the change in velocity is the same in each time period that lapses during that acceleration. The phrase uniform acceleration is perhaps more concise than the phrase constant acceleration although use of the latter is most common.

.....  
A free falling object near Earth undergoes a constant and uniform acceleration.

Its velocity increases by the same amount during each second it free falls.

.....  
The rate of this acceleration (in standard gravity) is an increase in speed of 9.80665 meters per second, during each second that the object free falls (9.80665 m/s/s).

.....  
If we take this acceleration rate of 9.80665 m/s/s and as a simplification round it up to 10/m/s/s, we may then easily see certain relationships which exist between distance and time during a uniform acceleration.

The tables below shows the relationships between the time (in 1 second intervals), the change in velocity (in meters per second) and the displacement (in meters) of an object the velocity of which is increasing at the rate of 10 meters per second during each second that passes (a constant acceleration of  $10\text{m/s}^2$  or 10 meters per second per second).

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

Interval	Change in velocity during interval	Average velocity During Interval	Displacement During Interval	Displacement From 0 Seconds To End of Interval
0 - 1 s	≈ 0 to 10 m/s	≈ 5 m/s	≈ 5 m	≈ 5 m
1 - 2 s	≈ 10 to 20 m/s	≈ 15 m/s	≈ 15 m	≈ 20 m
2 - 3 s	≈ 20 to 30 m/s	≈ 25 m/s	≈ 25 m	≈ 45 m X
3 - 4 s	≈ 30 to 40 m/s	≈ 35 m/s	≈ 35 m	≈ 80 m
4 - 5 s	≈ 40 to 50 m/s	≈ 45 m/s	≈ 45 m	≈ 125 m
5 - 6 s	≈ 50 to 60 m/s	≈ 55 m/s	≈ 55 m	≈ 180 m X
6 - 7 s	≈ 60 to 70 m/s	≈ 65 m/s	≈ 65 m	≈ 245 m
7 - 8 s	≈ 70 to 80 m/s	≈ 75 m/s	≈ 75 m	≈ 320 m
8 - 9 s	≈ 80 to 90 m/s	≈ 85 m/s	≈ 85 m	≈ 405 m
9 - 10 s	≈ 90 to 100 m/s	≈ 95 m/s	≈ 95 m	≈ 500 m
10 - 11 s	≈ 100 to 110 m/s	≈ 105 m/s	≈ 105 m/s	≈ 605 m
11 - 12 s	≈ 110 to 120 m/s	≈ 115 m/s	≈ 115 m/s	≈ 720 m X

OBSERVATIONS WE MIGHT MAKE BASED UPON THE TABLE

1. The rate of acceleration is constant as an increase in velocity of 10 meters per second, per each 1 second interval.

.....  
2. The object's velocity is continuously changing during each interval.

The velocity at the start of interval 0-1s is 0m/s. The velocity at the end of interval 0-1s is 10 m/s.

The object's velocity was not 10 m/s all through interval 0-1s.

The object's velocity reached 10 m/s only at the end of interval 0-1s.

Because the acceleration rate is uniform, the 1/2 way point in a time interval is also the point at which the 1/2 way point of a velocity increase (the average velocity) is reached.

The average velocity in each interval is equal to the the sum of that intervals initial velocity plus that intervals final velocity divided by the number of values to be averaged in an interval.

Because there are two values in each of the above time intervals (the initial and the final), the average velocity = (initial velocity + final velocity) ÷ 2

For example

interval 0-1s average v is equal to  $(0 \text{ m/s} + 10 \text{ m/s}) \div 2 = (10\text{m/s} \div 2) = 5\text{m/s}$  average velocity

interval 1-2s average v is equal to  $(10 \text{ m/s} + 20\text{m/s}) \div 2 = (30\text{m/s} \div 2) = 15\text{m/s}$  average velocity

interval 2-3s average v is equal to  $(20 \text{ m/s} + 30\text{m/s}) \div 2 = (50\text{m/s} \div 2) = 25\text{m/s}$  average velocity

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

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4 - 5 s	≈ 40 to 50 m/s	≈ 45 m/s	≈ 45 m	≈ 125 m
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11 - 12 s	≈ 110 to 120 m/s	≈ 115 m/s	≈ 115 m/s	≈ 720 m X

.....  
**3. The displacement of the falling object that occurs in each interval IS NOT directly the result of the final velocity during the interval. But rather, the displacement of the falling object that occurs in each interval is the result of the average velocity during the interval.**

The average velocity during a time interval multiplied by the duration of that time interval gives us the value of the object's displacement during that interval.

For example

because the duration of each time interval is 1 second

The displacement during interval 0-1s is equal to  $(5\text{m/s} \cdot 1 \text{ second}) = 5 \text{ meters}$

The displacement during interval 1-2s is equal to  $(15\text{m/s} \cdot 1 \text{ second}) = 15 \text{ meters}$

The displacement during interval 1-2s is equal to  $(25\text{m/s} \cdot 1 \text{ second}) = 25 \text{ meters}$

.....

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

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7 - 8 s	≈ 70 to 80 m/s	≈ 75 m/s	≈ 75 m	≈ 320 m
8 - 9 s	≈ 80 to 90 m/s	≈ 85 m/s	≈ 85 m	≈ 405 m
9 - 10 s	≈ 90 to 100 m/s	≈ 95 m/s	≈ 95 m	≈ 500 m
10 - 11 s	≈ 100 to 110 m/s	≈ 105 m/s	≈ 105 m/s	≈ 605 m
11 - 12 s	≈ 110 to 120 m/s	≈ 115 m/s	≈ 115 m/s	≈ 720 m X

**4. Although the rate of ACCELERATION is the SAME in each interval (at 10m/s/s) the VELOCITY is INCREASED by 10m/s in each successive interval. This is because the velocity is adding up or building in each interval and the velocity of a previous interval is added to the velocity of the succeeding interval.**

**For example**

**The rate of acceleration in interval 0-1s is constant at 10m/s/s**

**The velocity increased in interval 0-1s by 10m/s therefore the final velocity in that interval was increased from 0m/s to 10m/s or in other words increased as 0m/s + 10m/s.**

**The rate of acceleration in interval 1-2s is constant at 10m/s/s**

**The velocity increased in interval 1-2s by 10m/s therefore the final velocity in that interval was increased from 10m/s to 20m/s or in other words increased as 10m/s + 10m/s which is 20m/s.**

**The rate of acceleration in interval 2-3s is constant at 10m/s/s**

**The velocity increased in interval 2-3s by 10m/s therefore the final velocity in that interval increased from 20m/s to 30m/s or in other words increased as 20m/s + 10m/s which is 30m/s.**

.....

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

Interval	Change in velocity during interval	Average velocity During Interval	Displacement During Interval	Displacement From 0 Seconds To End of Interval
0 - 1 s	≈ 0 to 10 m/s	≈ 5 m/s	≈ 5 m	≈ 5 m
1 - 2 s	≈ 10 to 20 m/s	≈ 15 m/s	≈ 15 m	≈ 20 m
2 - 3 s	≈ 20 to 30 m/s	≈ 25 m/s	≈ 25 m	≈ 45 m X
3 - 4 s	≈ 30 to 40 m/s	≈ 35 m/s	≈ 35 m	≈ 80 m
4 - 5 s	≈ 40 to 50 m/s	≈ 45 m/s	≈ 45 m	≈ 125 m
5 - 6 s	≈ 50 to 60 m/s	≈ 55 m/s	≈ 55 m	≈ 180 m X
6 - 7 s	≈ 60 to 70 m/s	≈ 65 m/s	≈ 65 m	≈ 245 m
7 - 8 s	≈ 70 to 80 m/s	≈ 75 m/s	≈ 75 m	≈ 320 m
8 - 9 s	≈ 80 to 90 m/s	≈ 85 m/s	≈ 85 m	≈ 405 m
9 - 10 s	≈ 90 to 100 m/s	≈ 95 m/s	≈ 95 m	≈ 500 m
10 - 11 s	≈ 100 to 110 m/s	≈ 105 m/s	≈ 105 m/s	≈ 605 m
11 - 12 s	≈ 110 to 120 m/s	≈ 115 m/s	≈ 115 m/s	≈ 720 m X

5. Because the velocity of the falling object is building, the velocity is greater in each successive interval. Therefore the average velocity during each interval is also greater in each successive interval.

Therefore also, is the amount of the object's displacement greater in each successive interval.

Although the rate of ACCELERATION is the SAME in each interval, the amount of DISPLACEMENT in each interval CHANGES. The displacement is not uniform.

For example

interval 0-1s acceleration rate is 10m/s and the displacement is 5 meters during interval 0-1s.

interval 1-2s acceleration rate is 10m/s and the displacement is 15 meters during interval 1-2s.

interval 2-3s acceleration rate is 10m/s and the displacement is 25 meters during interval 2-3s.

.....

**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

Interval	Change in velocity during interval	Average velocity During Interval	Displacement During Interval	Displacement From 0 Seconds To End of Interval
0 - 1 s	≈ 0 to 10 m/s	≈ 5 m/s	≈ 5 m	≈ 5 m
1 - 2 s	≈ 10 to 20 m/s	≈ 15 m/s	≈ 15 m	≈ 20 m
2 - 3 s	≈ 20 to 30 m/s	≈ 25 m/s	≈ 25 m	≈ 45 m X
3 - 4 s	≈ 30 to 40 m/s	≈ 35 m/s	≈ 35 m	≈ 80 m
4 - 5 s	≈ 40 to 50 m/s	≈ 45 m/s	≈ 45 m	≈ 125 m
5 - 6 s	≈ 50 to 60 m/s	≈ 55 m/s	≈ 55 m	≈ 180 m X
6 - 7 s	≈ 60 to 70 m/s	≈ 65 m/s	≈ 65 m	≈ 245 m
7 - 8 s	≈ 70 to 80 m/s	≈ 75 m/s	≈ 75 m	≈ 320 m
8 - 9 s	≈ 80 to 90 m/s	≈ 85 m/s	≈ 85 m	≈ 405 m
9 - 10 s	≈ 90 to 100 m/s	≈ 95 m/s	≈ 95 m	≈ 500 m
10 - 11 s	≈ 100 to 110 m/s	≈ 105 m/s	≈ 105 m/s	≈ 605 m
11 - 12 s	≈ 110 to 120 m/s	≈ 115 m/s	≈ 115 m/s	≈ 720 m X

6. For objects undergoing a given constant acceleration there is a fixed relationship between the duration of the time period of the object's acceleration and the amount of displacement that occurs during that time period.

The total displacement from interval 0-1s and then through any given displacement is proportional to the square of the time that lapses during that displacement.

- 2 times the time interval 0s-1s results in  $2^2$  or 4 times the total displacement of interval 1.
- 3 times the time interval 0s-1s results in  $3^2$  or 9 times the total displacement of interval 1.
- 4 times the time interval 0s-1s results in  $4^2$  or 16 times the total displacement of interval 1.

.....

**example 1a**

By the end of interval 0s-1s the total time of displacement is 1 second.

By the end of interval 0s-1s the total displacement is 5 meters.

By the end of interval 1s-2s the total time period from 0s through interval 1-2s is 2 seconds.

By the end of interval 1s-2s the total displacement from 0s through interval 1-2s is 20 meters.

2 seconds is 2 times 1 second as in 2 times the time period of interval 0-1s.

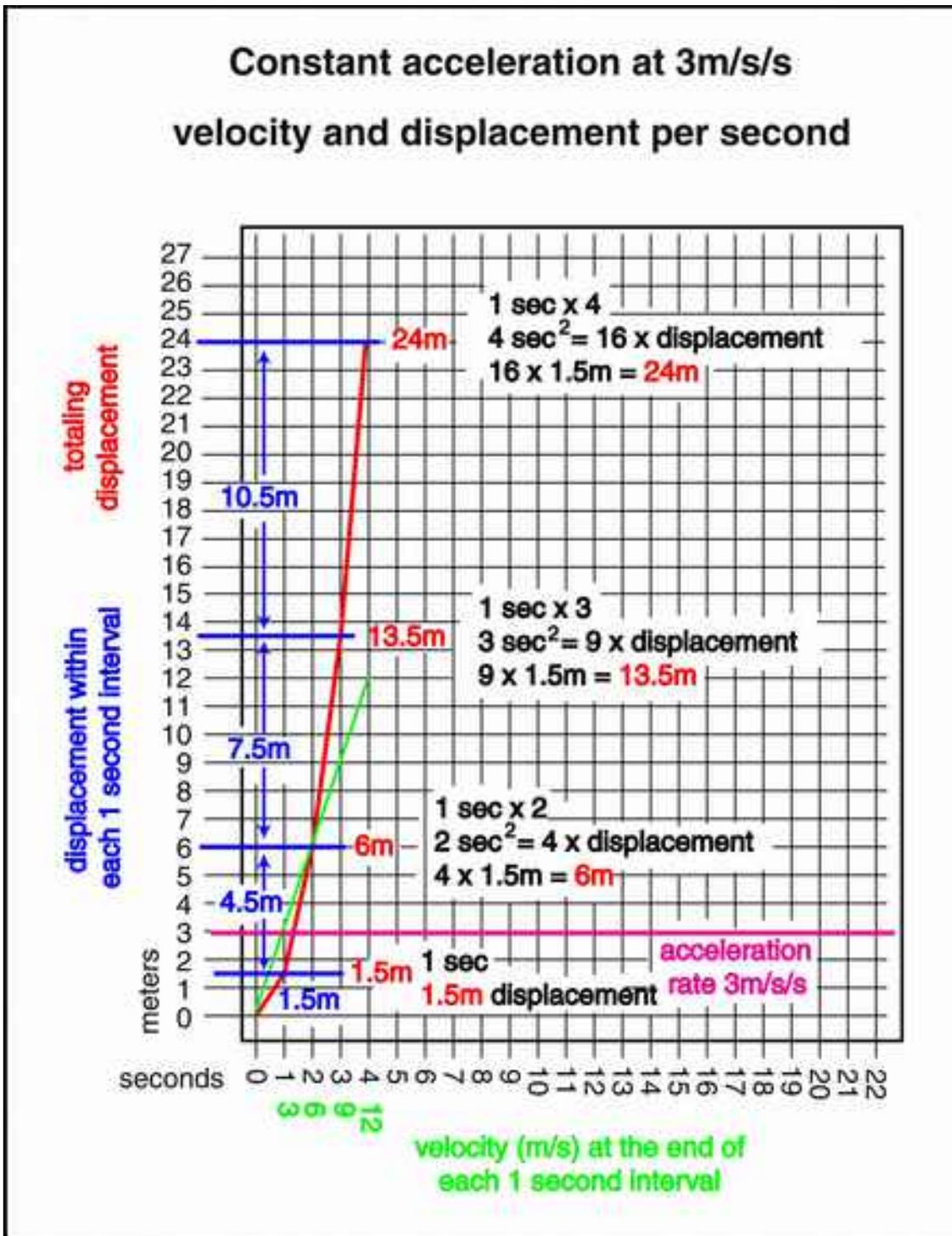
2 squared is 4.

20 meters divided by 4 is equal to 5m.

The 20m total displacement by the end of interval 1s-2s is 4 times the 5m displacement that occurs by the end of interval 0s-1s.

.....

SOME DEFINITIONS AND EXPLANATIONS  
 ACCELERATION CAUSED BY GRAVITY  
 CONSTANT ACCELERATION



**SOME DEFINITIONS AND EXPLANATIONS  
ACCELERATION CAUSED BY GRAVITY  
CONSTANT ACCELERATION**

**example 1b**

**By the end of interval 0s-1s the total time of displacement is 1 second.**

**By the end of interval 0s-1s the total displacement is 5 meters.**

**By the end of interval 3s-4s the total time from 0s through interval 3s-4s is 4 seconds.**

**By the end of interval 3s-4s the total displacement from 0s through interval 3s-4s is 80 meters.**

**4 seconds is 4 times 1 second as in 4 times the time period of interval 0-1s.**

**4 squared is 16.**

**80 meters divided by 16 is equal to 5m.**

**The 80m total displacement by the end of interval 3s-4s is 16 times the 5m displacement in interval 0s-1s.**

.....

**example 2a**

**By the end of interval 2s-3s the total time period from 0s through interval 2-3s is 3 seconds.**

**By the end of interval 2s-3s the total displacement from 0s through interval 2-3s is 45 meters.**

**By the end of interval 8s-9s the total time period from 0s through interval 8s-9s is 9 seconds.**

**By the end of interval 8s-9s the total displacement from 0s through interval 8s-9s is 405 meters.**

**9 seconds is 3 times 3 seconds as in 3 times the total time period from 0s through interval 2s-3s  
3 squared is 9.**

**405 meters divided by 9 is equal to 45m.**

**The 405m total displacement by the end of interval 8s-9s is 9 times the 45m displacement in interval 2s-3s.**

.....

**example 2b**

**By the end of interval 2s-3s the total time period from 0s through interval 2s-3s is 3 seconds.**

**By the end of interval 2s-3s the total displacement from 0s through interval 2s-3s is 45 meters.**

**By the end of interval 11s-12s the total time period from 0s through interval 11s-12s is 12 seconds.**

**By the end of interval 11s-12s the total displacement from 0s through interval 11s-12s is 720 meters.**

**12 seconds is 4 times 3 seconds as in 4 times the total time period from 0s through interval 2s-3s  
4 squared is 16.**

**720 meters divided by 16 is equal to 45m.**

**The 720m total displacement by the end of interval 11s-12s is 16 times the 45m displacement in interval 2s-3s.**

.....

**For uniform / constant accelerations, displacement is in proportion to the square of the time that lapses during the displacement.**

**With Excerpts from Wikipedia**

**MASS VS. WEIGHT**

**HOW DID ISSAC NEWTON DO IT**

**From the Wikipedia article titled Mass.**

"As mass is difficult to measure directly, usually balances or scales are used to measure the weight of an object, and the weight is used to calculate the object's mass."

**Physics texts abound which contain the statement that "the mass of an object may be determined by weighing that object and then dividing its weight by the rate of its free fall acceleration.**

**We know the rate of free fall acceleration near Earth will be 9.80665 m/s/s because this rate is a constant. But how can we know the weight from which to calculate the mass unless we have a weight scale ?**

**We could measure the mass upon a mass scale, calculate the weight and then calculate the mass. But where can one acquire a weight (newtons), rather than a mass scale or balances.**

**HOW DID ISSAC NEWTON DO IT**

**Newton didn't use a mass scale, he used a weight scale. Balance scales in his time were marked and calibrated to measure weight, not mass. He weighed various objects not in terms of dynamic force and rates of acceleration, but by the comparison of the weighed object to his (standard) weight objects. The out come of the operation of his weighing of objects was based upon a set of objects upon his weight scale (the standard and the weighed), being in equilibrium (in balance) and static (not in motion).**

**The value (weight) of each of the weighed objects was determined in comparison to a standard weight object. The weights were as parts of weight or as parts per the weight of his standard weight objects (a ratio). Newton defined two object as being equal in weight when they were in equilibrium (when they balanced) while upon the two sides of a balance scale. He defined weight in terms of a ratio of 1 to 1, or 1/2 to 1, or 3 to 1, or ten 1/10ths to 1 and so on, as compared to his standard weight object. In Newton's time, that property which he called the weight of an object was defined in terms of its equilibrium (a static state) with a standard weight object upon a balance scale.**

**The static weight of an object is in proportion to the amount of the substance it is composed of. Newton knew this to be true. This was in fact common knowledge. One thousand grains of barley will balance with another 1,000 grains of barley, 1 cup of wine will balance with another cup of wine of the same size, and a bar of gold of certain dimensions will balance with another bar of gold of those same dimensions.**

**However, in Newtons day it was generally believed that the rate of acceleration of a falling object was in proportion to its weight, but this was not and is not so.**

**SOME DEFINITIONS AND EXPLANATIONS  
MASS VS. WEIGHT  
HOW DID ISSAC NEWTON DO IT**

**P 71**

Newton measured / calculated the rate of acceleration (a ratio) of objects of various weights, during free fall \*. In so doing, he discovered that all of his objects fell with the same rate of acceleration even though they weighed differently

.....  
\*Note that the accelerations Newton actually measured were of spheres rolling down an inclined plane (a track). The timing devices available to Newton in his time were limited to fairly large increments of time. Slowing the accelerations was necessary in order to enabled a greater precision to his experiments. This is why he rolled his spherical weights down an inclined track rather than dropping them.

Newton knew that the rate of acceleration of his spheres upon the track, was in proportion to the angle of the inclination of the track (a ratio). This meant that the rate at which his spheres would have accelerated if during a straight down descent, could be calculated.

Newton's methods only approximated the absence of air resistance (free fall), in that the slower speeds of descent (upon an inclined track) reduced friction against the air.

.....  
All of which may bring us to the following questions.

1. What is the unit of measurement of static weight ?
2. What is the ratio of an objects static weight (on Earth) to its mass ?
3. What is the ratio of an objects static weight (on Earth) to the newtons of force Earth's gravity exerts upon it ?
4. Where can I acquire a scale that measures static weight ?

Facetious answers

1. The units I prefer are the conceptional "static weight of kilograms" which I abbreviate as swkg, and the conceptional "static weight of a gram" (abbreviated as swg)
2. The ratio is 1 swkg (in standard gravity) to 1 kg of mass and 1 swg (in standard gravity) to 1 gram of mass.
3. The ratio is 1 swkg to 9.80665 newtons of force, and 1 swg to 0.00980665 newtons of force.
4. I use a balance type of scale and counter weights which are in increments of grams of mass. I convert the mass of these objects to their equivalent swg (static weight of grams). As previously stated (above), the ratio for this conversion is 1 to 1.

Please note that there is in usage, a unit of measurement which is similar to the swkg, it is the "kilogram-force (abbreviated as kgf ). Like unto the swkg (static weight of a kilogram) the kilogram-force (kgf) is a non SI unit. However kilogram-force is in ways, more similar to the newton than it is to the static weight of a kilogram. This is because, both the newton and kilogram-force are defined in terms of the dynamics and acceleration of a mass object, while the swkg (static weight of a kilogram) is defined in terms of the stasis and equilibrium of or between two weight objects.

**SOME DEFINITIONS AND EXPLANATIONS  
MASS VS. WEIGHT  
HOW DID ISSAC NEWTON DO IT**

P 72

$m = F / a$ , mass (in kilograms) is equal to force (in newtons) divide by acceleration (in meters per second, per second)

Force (1 newton) divided by 9.80665 meters per second per second (acceleration) is equal to . 0.10197 (mass)

One newton is the force exerted upon approximately 0.10197 kilograms of mass, by near Earth's gravitational force.

The **WEIGHT** of an object on Earth (in newtons) is equal to that objects **MASS** times a magnitude of force which is sufficient to cause its acceleration at the rate of 9.80665 meters per second per second.

One such force which is of a magnitude sufficient to cause acceleration at the rate of 9.80665 meters per second, per second **IS THE NEAR EARTH GRAVITATIONAL FORCE**. This is called the "Earth's gravitational constant of acceleration". This phrase is sometimes shortened to "Earth's gravitational constant" and is also called "standard gravity" (abbreviated as g). Bear in mind that this rate of acceleration (9.80665 m/s/s) is actually a nominal value.

The letter "g" sometimes has the meaning "local gravity". That is to say, not only Earth's gravity. The letter "g" may instead refer to the gravitational constant of the moon if or when one is upon the moon rather than upon Earth.

$f = ma$     **WEIGHT** (on Earth) as force equals mass times Earth's gravitational constant.  
 $m = f / a$     **MASS** equals weight (on Earth) as force divided by Earth's gravitational constant.  
 $a = f / m$     **Acceleration** near Earth equals weight (on Earth) as force divided by mass.

An object with an earthly **WEIGHT** equivalent to 1 newton of force, divided by the near Earth gravitational constant of acceleration, has a **MASS** equal to 0.10197 kilograms. One newton of **WEIGHT** (on Earth) divided by 9.80665 is equal to approximately 0.10197 kilograms of **MASS**.

An object with a **MASS** of one kilogram has a weight of about 9.80665 newtons (SI) on the surface of the Earth.

**WEIGHT** (force in newtons) on Earth = mass times the Earth's gravitational constant of acceleration.

Therefore also, the **MASS** of an object multiplied by Earth's gravitational constant (a force which causes an acceleration of 9.80665 meter per second per second, in opposition to an object's own inertia) is equal to that object's weight on Earth. An object with a **MASS** of approximately 0.10197 kilograms has an earthly **WEIGHT** of 1 newton. 9.80665 multiplied by 0.101971621977982425700927431896 = 1 newton of force (weight).

$$\text{force} \div \text{acceleration} = \text{mass}$$
$$(1 \text{ newton} \div 9.80665 \text{ m/s/s} = 0.101971621977982425700927431896 \text{ kg})$$

**SOME DEFINITIONS AND EXPLANATIONS  
WEIGHT AS FORCE VS HEAVINESS AND LIGHTNESS  
THE OPERATIONAL DEFINITION OF WEIGHT**

An object with a mass of 1 kilogram would still be composed of the "same amount of substance" (have the same mass) whether it was upon the moon or upon the Earth. The gravitational magnitude of a body is in proportion to the mass of that body. Because the Earth has about 6 times more mass than the moon, it exerts about 6 times more gravitational influence than does the moon. An object with 1 kilogram of MASS will exert a force down (WEIGHT) on Earth of 9.80665 newtons but will exert a force down (WEIGHT) upon the moon of about 1.63444 newtons (about 1/6 of its earthly weight). Any small object in free fall (regardless of that object's mass) under the influence of near lunar gravity will accelerate at a rate of about 1.63444 meters per second per each second that lapses. this is about 1/6 the rate of acceleration caused by near earth's gravity.

Note that we are not considering that the moon's motion differs from the Earth's. Earth's 9.80665 m/s/s rate of acceleration is the mean acceleration when centrifugal force due to earth's rotation is accounted for. We are making no centrifugal adjustments for the moon.

Force as weight is defined (in the SI) by the changes in velocity over time (acceleration) of a mass. There is no unit specifically of weight in the SI but only of a force (in newtons). If a force is due to gravity it may be termed as weight in the SI.

While it is true that the weight of an object may be defined in terms of force and acceleration, the weight of an object is not always so defined.

It is peculiar that the SI equivalent of the weight of an object (force in newtons) is defined in terms of acceleration rate. This seems especially peculiar when one considers that the rate of acceleration for all free falling objects is the same (not in proportion to their mass) while the static weight of any object is in direct proportion to its mass.

**A non SI definition of weight.**

**Weight as a static attribute rather than as a force causing acceleration**

**Any object that has mass, has also inertia.**

.....  
**The inertia of an object is proportional to the mass of that object.**

.....  
**Any object that has mass, can also exert a gravitational force. Thus for example, not only is a baseball attracted to the Earth, but the Earth is attracted to that base ball as well. They have a mutual gravitational attraction.**

.....  
**The gravitational constant of Earth is in proportion to Earth's mass. The gravitational constant of any particular object is in proportion to the mass of that object.**

.....  
**The ATTRACTION BY GRAVITY (for example attraction by earths gravity) upon a given object, IT'S STATIC WEIGHT, (NOT its rate of acceleration) IS IN PROPORTION to the mass of that attracted object.**

With Excerpts from Wikipedia  
WEIGHT AS FORCE VS HEAVINESS AND LIGHTNESS  
THE OPERATIONAL DEFINITION OF WEIGHT

.....  
The gravitational attraction that an attracting body exerts (for example earth's gravity) upon an object as static weight, can be used to determine the mass of that attracted object.

.....  
If the attracted object is twice as heavy as some other object, this is because it has a 2 times greater mass than that other object. If the attracted object is 1/3 as heavy as some other object, this is because it has 1/3 the mass of that other object.

.....  
In a static state (and although the principles of inertia still apply to the weighed object), the inertia of the weighed object is not acting against acceleration. The weighed object's inertia is not acting against acceleration, because the object is not accelerating.

.....  
During an acceleration either toward or away from the center of mass of the attracting body, the weight indicated by a spring scale will be different, because the weight of the object IS different.

.....  
A given object IS HEAVIER near the earth's north pole than when near the equator because of the earth's rotation upon its axis.

.....  
From a Wikipedia article on weight.

"There is also a rival tradition within Newtonian physics and engineering which sees weight as that which is measured when one uses scales. There the weight is a measure of the magnitude of the reaction force exerted on a body. "

There is a rival tradition, but I think, that rival tradition is not clearly presented in the above Wikipedia excerpt. Clearly stated, the difference lies in how weight is represented and quantified. This may be either in terms of FORCE acting upon an object against that object's inertia, and the resultant ACCELERATION of that object or... in terms of weight as a characteristic of an object when that object is STATIONARY or static and in EQUILIBRIUM with another STATIONARY object (as when two objects are in balance with one another upon a balance / weight scale).

.....  
If a person is supporting a shoulder bag while standing line at the airport, said person is not expending energy to overcome the inertia of that bag. There is no necessity to define the weight of that bag in terms of the acceleration THAT WOULD OCCUR IF some force other than earth's gravity, but otherwise equal in force to earth's gravity were to accelerate it. That person's muscles and bones are supporting a static weight.

"Operationally" the weight of the shoulder bag is of some amount of heaviness in proportion to or in comparison with a standard of weight. That weight standard could be formal and explicitly declared or informal and relative to some context of use. Either way, simply removing some things from the shoulder bag will make it weigh less.

**SOME DEFINITIONS AND EXPLANATIONS  
WEIGHT AS FORCE VS HEAVINESS AND LIGHTNESS  
THE OPERATIONAL DEFINITION OF WEIGHT**

.....  
If one were to travel to various latitudes upon the earth and precisely measure the weight of that shoulder bag by use of a spring type of weight scale, one would find that the weight of the bag varies with latitude even while the earth's gravity remains the same. The operation of so weighing the bag would reveal that the bag is in fact either heavier or lighter at different locations. Note however that a balance type of weight scale would not indicate those variations.

.....  
It requires about 1/2 % more energy to support the hand bag while at the north pole than to support it at the equator. The weight difference is due to variations in centrifugal force. These variations are in turn due to the earth's rotation and the differences in distance from the axis of earth's rotation at or near the equator as compared to at or near its poles. The same hand bag is heavier at the north pole than it is at the equator.

.....  
A spring type of scale would also indicate that the weight of an object is lighter upon the moon than it is upon the earth, while a balance scale would not.

.....  
One might use the difference between an object's weight on earth and its weight on the moon as a basis for quantifying units of measurement of gravity by ratio. No considerations need be given to the rates of acceleration of falling objects or force as defined by  $F = ma$  (force = mass times acceleration) in order to so quantify gravity.

.....  
The weight of an object can change under certain other conditions as well.

The weight of an object changes if that object is allowed to accelerate toward the attracting body. For example when one is upon an elevator and accelerating toward Earth (downward). Note that the lightness of weight is only during the acceleration of the elevator. Once the elevator speed becomes constant (is no longer accelerating) the weight returns to normal, even though one is still descending. The same gravity is present during the descending acceleration as was present before the descent.

The weight of an object changes if it is within an environment that provides buoyancy to that object. For example, when one lifts a large jug of water from a swimming pool, one may observe how its weight increases. The jug becomes distinctly heavier as the jug emerges from the surface of the water. The earth's gravitational influence upon the jug is the same whether it is submerged in the pool or not. But its weight changes.

.....  
The point in my having represented these differing points of view (as to what weight is) is not to take a side, but rather to illuminate the sensibility and relevance of each.

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts from Wikipedia**  
**ENERGY, FORCE AND WORK**  
**GRAVITY, WORK AND THE JOULE**

**From a Wikipedia article on the joule.**

It is equal to the energy expended (or work done) in applying a force of one newton through a distance of one meter (1 newton metre or N·m),

**From a Wikipedia article on work.**

"Notice that the work is doubled either by lifting twice the weight the same distance or by lifting the same weight twice the distance."

**From the same Wikipedia article on work.**

"If an object is displaced upwards or downwards a vertical distance  $y_2 - y_1$ , the work  $W$  done on the object by its weight  $mg$  is:"

$$W = F (y_2 - y_1) = Fg\Delta y = mg\Delta y$$

"where  $F_g$  is weight (pounds in imperial units, and newtons in SI units), and  $\Delta y$  is the change in height  $y$ . Notice that the work done by gravity depends only on the vertical movement of the object. The presence of friction does not affect the work done on the object by its weight."

**Friction does not affect the work done on the OBJECT by its weight, but the total work done, not simply the work "done on the object" would include friction.**

.....  
**Work = Force of gravity (weight in newtons) • vertical distance (either up or down)**

**Work = force of gravity (weight in newtons) • the change at  $y$**

**Work = force (mass • Earth's gravitational constant of acceleration) •  $\Delta y$ .**

**Note that " $\Delta y$ " is spoken as delta  $y$ " and has the meaning of "the change in  $y$ , or the change at  $y$  or the change of  $y$  or the change as  $y$ ".**

.....  
**From a Wikipedia article on the joule.**

1 joule = the energy required to lift a small apple (with a mass of approximately 100g) vertically through one meter.

**Earths gravity exerts a force sufficient to cause acceleration at the rate of 9.80665 meters per second during each second that it pulls upon the small apple.**

**100 grams of mass = 1/10 kilogram of mass**

**0.1 kg • 9.80665 = 0.980665 and 0.980665 • 1 meter = 0.980665 joules or approximately 1 joule.**

**Note that more precisely 0.10197162129779282425700927431896 grams of mass • 980665 • 1 meter is equal to 1 joule.**

**SOME DEFINITIONS AND EXPLANATIONS  
ENERGY, FORCE AND WORK  
GRAVITY, WORK AND THE JOULE**

The apple that is being lifted has 100 grams (0.1 kilograms) of mass and this lifting is in opposition to a gravitational force sufficient to cause an acceleration at the rate of 9.80665 meters/s/s (Earth's standard gravity)

.....  
force = mass • acceleration

$$F = m \cdot a$$

Newtons of force = kilograms • meters per second per second

$$N = kg \cdot m/s/s$$

0.1kg of apple times a force of 9.80665 m/s/s, is equal to 0.980665 newtons or approximately 1 newton of force.

.....  
Kinetic energy = force • displacement

$$E_k = F \cdot s$$

Joules of kinetic energy = newtons • meters

$$J = N \cdot m$$

One newton lifted through a displacement of 1 meter or 1 newton times 1 meter is equal to 1 joule.

.....  
Because the total displacement is 1 meter, the energy expended is 0.980665 newtons times 1 meter. This is equal to 0.980665 joules or approximately 1 joule.

**ASPECT RATIO AND UNITS**

Please recall that "swkg" is static weight of kilograms in standard gravity. If by a first process we measure the meters lifted (m#1) of (swkg#1), and then multiply (m#1) by (swkg#1), we may arrive at a value for the work so done. .... Call this work #1 (w#1).

If then by a second process, we measure the meters lifted (m#2) of a (swkg#2), and then multiply (m#2) by (swkg#2), we may arrive at some other value for this second work done.  
..... Call this work 2 (w#2).

We may then compare (w#1) to (w#2), as a difference or as a percentage or ratio.

or

We may convert swkg ... into kilograms of mass and the ... kilograms of mass into their equivalent SI weight on Earth (as newtons of force) ... and then calculate the joules of energy transferred, as (joules#1) and (joules#2).

We can use the formulas below.

Approximately 0.10197 (mass) times 9.80665 (Earth's gravitational constant of acceleration) = 1 newton. Note that, precisely  $0.10197162129779282425700927431896 \cdot 9.80665 = 1$  newton.

**SOME DEFINITIONS AND EXPLANATIONS  
ASPECT RATIO AND UNITS**

**and**

**Energy = force times displacement. In Si units this may be written as joules = newtons times meters.**

**1 joule of energy = 1 newton of force times 1 meter of displacement.**

.....  
**Use of these formulas will tell us how many joules of work are present. For example (w#1) = (joules#1) and (w#2) = (joules#2).**

**The ratio of (w#1) to (w#2), will be the same as the ratio of (joules#1) to (joules#2).**

.....  
**Please consider the following.**

**(a times b) is to (c times d) as [(a times b) times n] is to [(c times d) times n]**

**for example**

**(2 • 5) = 10 and (5 • 6) = 30 their ratio is 10 to 30 or 1 to 3**

**and**

**(2 • 5) • 6 = 60 and (5 • 6) • 6 = 180 their ratio is 60 to 180 or 1 to 3**

**This is the same ratio as 10 is to 30.**

**Time is marked or measured (and in some ways defined) by the consistency of repetitions with which force acts upon objects.**

**As examples consider. The force of gravity pulling the sand grains in an hour glass through the orifice at it's middle, at a constant rate. The force of gravity acting upon the weight and against the inertia of a pendulum, resulting in the regular periods of it's oscillations. The similar forces causing the Earth's motions that result in the time of day, time of year, year and so on. The regularity of the periods of certain electric, molecular or atomic oscillations in modern chronometers, which are the results of forces.**

.....  
**A period of time is defined by a pattern.**

**A pattern is defined by the repetition of some change.**

**This regularity of repetition is determined by comparison to a standard.**

**A standard is a record of and from the past,**

**The past is time, as defined in the aspects of before and after.**

**Patterns of time as intervals are typically defined by the repetition of:**

- 1. Change as the displacement of a mass in relationship to two positions (a before and an after),**
- 2. Change in the direction of the displacement of a mass in relationship to two positions (a before and an after).**
- 3. Comparison of either of or both of the above changes to a standard.**

.....  
**The repetition of those patterns is in general, caused by a relationship that exists between the magnitude of a MASS and the magnitude of the energy as FORCE that gives rise to a magnitude of DISPLACEMENT of that mass and by which a magnitude of TIME is defined.**

**The magnitude of that MASS may defined by:**

- 1. the magnitude of the time of the displacement of that mass**
- 2. the magnitude of the energy as force**
- 3. the magnitude the displacement of that mass.**

**The magnitude of that energy as FORCE may be defined by:**

- 1. the magnitude of the time of the displacement of that mass**
- 2. the magnitude of the mass**
- 3. the magnitude of the displacement of that mass.**

**The magnitude of the DISPLACEMENT of that mass may be defined by:**

- 1. the magnitude of the energy as force**
- 2. the magnitude of the mass**
- 3. the magnitude of the time of the displacement of that mass**

**The magnitude of the TIME period of the displacement of that mass maybe defined by:**

- 1. the magnitude of the energy as force**
- 2. the magnitude of the mass**
- 3. the magnitude of the displacement of that mass**

**SOME DEFINITIONS AND EXPLANATIONS**  
**With Excerpts from Wikipedia**  
**POWER AND TIME**

**From a Wikipedia article on power.**

“In physics, "power (symbol: P) is defined as the amount of energy consumed per unit time. In the MKS system, the unit of power is the joule per second (J/s), known as the watt (in honor of James Watt, the eighteenth-century developer of the steam engine). For example, the rate at which a light bulb converts electrical energy into heat and light is measured in watts—the more wattage, the more power, or equivalently the more electrical energy is used per unit time.[1][2]"

**Note: MKS system. MKS stands for meters, kilograms and seconds.**

**In the above Wikipedia example of a light bulb, the conversion of electricity into heat, light, radio waves, magnetic energy and so on, has been termed "the amount of energy consumed", rather than as the amount of energy transferred. However the described energetic event (the running of a light bulb) entails both transference and conversion.**

**Does that energy transference occur as the energy, escapes / crosses the BOUNDARY from the light bulb to the exterior space, or as it escapes from the filament of the light bulb, or at an atomic or sub atomic level in the space within the filament ? Where precisely does this escape boundary lie? This consideration is outside the scope of the present topics**

.....  
**The rate at which energy is “converted” (transformed), from one form of energy to another might be considered as transference, but that discourse is also outside the scope of the present topics and its consideration could get us into a kind of conundrum.**

.....  
**All of which brings to my mind three questions.**

- 1. Why it is that in the Wikipedia article “Power”, energy TRANSFERRED per unit of time, is called energy CONSUMED per unit of time?**
- 2. What is efficiency ?**
- 3. Why are florescent and l.e.d. lights, said to be more energy efficient than incandescent lights ?**

**Surely florescent and LED lights are more energy efficient during hot weather and especially so when one is also using energy to cool an interior space. But during cold weather incandescent lights contribute to the heating of an interior space. Also consider that in terms of longevity, incandescent bulbs can, and have been manufactured with a longevity as great as that of most florescent lamps. Incandescent bulbs cost less money, and they generally contain less toxic substances. So once again I ask, what is efficiency ?**

.....  
.....  
**From a Wikipedia article on power.**

"Energy transfer can be used to do work, so power is also the rate at which this work is performed. The same amount of work is done when carrying a load up a flight of stairs whether the person carrying it walks or runs, but more power is expended during the running because the work is done in a shorter amount of time."

Strictly speaking, **POWER IS NOT EXPENDED**, rather it is energy that is "expended" or yet more concisely stated, it is energy that is transferred. The same amount of **ENERGY** would be transferred whether running or walking up the stairs, but that energy would be transferred during a shorter period of time when running.

additionally

In physics, power is neither an object nor a property of an object and it cannot be expended or transferred. It is a mathematical construct, an abstraction. Power is the **RATIO** of a **MAGNITUDE** of energy **TRANSFERRED**, to the period of **TIME** during which that transfer occurred. The type (form) of energy transferred may be kinetic or any other form of energy.

.....  
The joule is the SI unit of energy, (**ENERGY OF ANY FORM**). The joule is a non specific or more or less, universal unit of **ENERGY** measurement. It is not assigned exclusively to any one **FORM** of energy. In the MKS (meters, kilograms, seconds) system, the joule **PER SECOND** is the unit of measurement of **POWER** for all **FORMS** of **ENERGY**.

.....  
A specific magnitude of one **FORM** of **ENERGY** may be shown to be equivalent to a specific magnitude of some other **FORM** of **ENERGY**, in terms of (for example) the amount of mechanical work each can do. Note, however that the scientific standards for these equivalencies, has changed as more efficient devices and methods of doing work were discovered.

.....  
The joule **PER SECOND** is a non-specific or more or less **UNIVERSAL UNIT OF POWER** measurement. It is not assigned exclusively to any one "type" of power.

.....  
A given magnitude of one type of power may be shown to be equivalent to a given magnitude of another type of power.

.....  
A specific magnitude of one **FORM** of **ENERGY** transferred over a specific **TIME** period (power) may be considered as equivalent to a specific magnitude of some **OTHER FORM** of **ENERGY** transferred over that same specific **TIME** period (power).

.....  
This power equivalency is **BASED** in terms of the amount of mechanical work each form of energy could do within a same and specific period of time. However, power does not need to result in mechanical work in order for it to be power.

.....  
The ratio of the energy spent (transferred) to do **MECHANICAL WORK**, to the time required to do that work, is some times called the horse **POWER**. One horse power is equal to **745.7** joules **PER SECOND**.

.....  
Power is the ratio of the magnitude of energy transferred, to the time required for that transfer to occur. The ratio of energy transferred to time is not dependent upon the **FORM** of the energy transferred.

.....  
The rate that energy is transferred (power) is not dependent upon the out come of that energy transfer. For example, the transfer of energy does not have to result in mechanical work.  
.....

Energy exists, occurs or is manifested in many “forms”. The terminology used for power is some what dependent upon the form of energy being transferred.

as examples

1 joule per second = 1 watt for electrical power,  
1 watt = 1 joule per second

1 joule per second = 0.00134 horse power for mechanical power  
1 horse power = approximately 746 joules per second

.....  
The newtons of force which act upon an object due to Earth's gravity are mathematically the SI equivalent to what is commonly called the weight of an object on Earth. 1 newton of weight on Earth (in standard gravity) is equivalent to 1 newton of force.

An object with a MASS of approximately 102 grams, or of approximately 0.102 kilograms, or more precisely of (0.101971621977982425700927431896) kilograms, is pulled down by Earth's standard gravity with a force of 1 newton.

this can be explained by / as

Force = mass • acceleration

$$F = m \cdot a$$

$$F \div m = a$$

$$F \div a = m$$

.....  
All free falling objects accelerate at the rate of 9.80665 m/s<sup>2</sup> in standard gravity.  
and

1N of force ÷ an acceleration of 9.80665m/s/s = 0.101971621977982425700927431896 kg of mass.  
and since

Force = mass • acceleration

then also

mass • acceleration = force

or

0.10197 kg • 9.80665 m/s<sup>2</sup> = 0.99998 N or approximately 1 newton of force.

.....  
A 0.10197 kg mass exerts a force of 0.99998 N or approximately 1 newton. When that mass accelerates at the rate of 9.80665 m/s<sup>2</sup> for one second of time, it will displace 4.90332 meters. This is the product of the average velocity during the acceleration (4.90332 m/s) multiplied by the duration of the acceleration (1 second).

**SOME DEFINITIONS AND EXPLANATIONS  
POWER AND TIME**

.....  
**Kinetic energy = force • displacement ...  $E_k = F \cdot s$   
Joules of kinetic energy = Newtons • meters ....  $j = N \cdot m$   
therefore**

**0.99998 N or approximately 1 newton of force acting over a displacement of 4.90332 meters is equal to approximately 4.90332 joules of energy.  
and because**

**This 4.90332 joules of energy was transferred to the free falling object, from Earth's gravity, over a time period of 1 second. The power of said event, is equal to 4.90332 joules per that second. This may also be stated as the power is 4.90332 joules per second or as 4.90332 watts of power.**

**Alternatively one might solve for power through the formula  $E_k = 1/2 m \cdot v^2$ .**

**$E_k = 1/2 m \cdot v^2$  ....  $1/2 \cdot 0.10197 \text{ kg} \cdot 9.80665 \text{ m/s}^2 = 4.90332$  joules transferred during the 1 second acceleration. This is 4.90332 joules per second or 4.90332 watts of power.**

.....  
.....

**MORE DEFINITIONS**  
**MAGNET BASICS**  
**AVERAGING**  
**INVERSE SQUARE LAW**  
**INTEGRATION OF FORCE OVER A DISTANCE**  
**GAUSS**  
**PERMEABILITY**  
**SATURATION**  
**B AND H "FIELDS"**  
**RIGHT HAND RULE**  
**OTHER RULES**  
**MAGNETIC DOMAINS**  
**MEASUREMENT**  
**FRICION LOSSES**  
**OTHERS**