

ENERGY & MOMENTUM

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The starting points from which all theoretical physics is derived are the empirical measurements of patterns in changes of velocity. Fundamental theory consists of mechanical interpretations of causes for these changes of velocity. In general, this mechanical interpretation is called *force*. There are some theoretical interpretations that avoid the use of the word *force*. However, in this essay, anything that causes change of velocity is understood to be generic in its empirical support. In all cases of an object changing its velocity, some unknown cause is involved. As long as the natures of causes remain unknown, and their effects continue to be changes of velocity, it remains empirically proper to group them under the general category of *force*.

When an identical force is applied to a variety of objects, it is observed that the objects change their velocities by a variety of magnitudes. In other words, each object has its own magnitude of resistance to force. This resistance to force is called *mass*. All higher-level theory consists of imagined mechanical interpretations of force, resistance to force, and their relationships to distance and time.

Newton's formula expressing the general relationship between force, resistance to force and acceleration is:

$$f = ma$$

This equation says the magnitude of force equals the magnitude of mass multiplied by the magnitude of acceleration. Written in a slightly different form:

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

It is seen that acceleration, or change of velocity measured with respect to time, is equal to force divided by resistance to force. The importance of this form of Newton's equation is that: The left side represents empirical evidence. The right side represents properties that are recognized to exist, but have unknown physical natures. Newton's formula should be read: Something, of unknown nature, causes an object to accelerate an amount inversely proportional to a resistance of unknown nature. It is not proper to say: A force causes a mass to accelerate. The object is not the mass. The object is not in the equation. Only its properties enter into mathematical analysis.

The equation addresses an observable effect having an unknown cause. It is important to recognize, from the start, that: The only physically observed quality represented in the equation is acceleration. Since force and mass are unobservable, they cannot be used as the origin of the derivation of a known physical nature for anything. This lack of knowledge is actually the

basis for the need to develop theory. Theory begins with mechanical interpretations of the causes for acceleration and resistance to acceleration. Theory is used to disguise a lack of knowledge. This problem, of lack of knowledge, enters at the beginning of theory and remains pervasive throughout physics theory.

The mathematical formulations that combine force and resistance to force with expressions of distance and time are the basis for the derivation of the rest of physics theory. This practice begins with assigning unique units to both force and mass. These units are theoretical because there is no empirical knowledge to tell us how to proceed. We do not begin by knowing, so we begin by assuming. It is assumed that force and mass require unique units of measurement. This practice is acceptable and useful so long as it is recognized as being temporarily necessary and to be improved upon as soon as possible.

Higher-level theoretical mechanical properties consist of equations formed from different combinations of force, mass, distance and time. Beginning with force multiplied by time, this calculation is called momentum represented by P :

$$P = ft = mv$$

Newton's equation $f = ma$ results from the use of momentum in his earlier equation:

$$f = \frac{d(mv)}{dt}$$

This says that force is equal to the differential, meaning an extremely small change, of momentum divided by the differential of time. It is read as: Force is equal to the rate of change of momentum with respect to time. Multiplying both sides by the differential dt measure of time:

$$f dt = d(mv)$$

The differential of time means an extremely small period of time. Differentials, in general, represent almost instantaneous changes of a varying function. They are the basis of the derivation of the mathematics of change called calculus. Force multiplied by dt is equal, by definition, to the differential of momentum. Integrating the differential of momentum, i.e. adding up a series of very small changes, with initial conditions of zero, i.e. $v = 0$ when $t = 0$, yields:

$$ft = mv$$

Force multiplied by its time of application is conserved during interactions of objects. This important fact is used in the solutions of many problems. It is convenient to give it a name, and it is called momentum. The assignment of this name adds no new physics knowledge. The quality remains defined as force times time ft and, for non-relativistic events, is found to be equal to the constant rest mass of an object times its final velocity:

$$\int f dt = \int d(mv) = \int m dv = m \int dv = mv$$

The integral of force multiplied by the differential of time is the calculus definition of a change in momentum. It does not matter how the force may have been varying with time. The end result is equal to mass times the final velocity. Since this is true for all variations of force times time, then

any calculation of momentum can be equivalently represented by a constant force multiplied by the time period that yields the same result. This is written as:

$$ft = mv$$

It says: A constant force applied over a period of time causes an object with mass m to achieve a velocity of v .

Momentum is just one method of measuring the effect of a change of velocity. There is a second method. It is to measure the force as being applied across a distance. This calculation is the force multiplied by the distance. It is assigned the name energy. When the force varies, the mathematical representation begins with:

$$f dx$$

This calculation of force times the differential of distance is the differential of kinetic energy. Energy is also conserved and is very useful in solving many problems. It is often used in conjunction with momentum to help solve problems of motion. There are no other kinds of energy or momentum. Energy and momentum are simply calculations describing an effect of force on an object. The effect is always a change of velocity. The names energy and momentum represent calculations that involve action. There is no state of inaction that fits with their definitions.

Potential energy is not energy. It is a recognition that a force exists. If that force is freed to act upon an object across a distance, then there exists an action upon which the calculation we call energy can be performed. In other words, there is the potential for an object to change its velocity and for a new product of force multiplied by distance to be calculated. There simultaneously exists the potential for momentum to be calculated.

Energy is not superior, by virtue of a unique material existence, to momentum. They are two perspectives of an identical event. They are two different kinds of calculations because: One involves distance and the other involves time. The magnitudes of the calculations of energy and momentum, for the same event, will differ. However, since they are measuring the same event they, therefore, should be expected to share characteristics such as conservation.

Energy and momentum are related to each other by the equation:

$$E = \frac{1}{2} v P$$

Or, saying the same thing:

$$fx = \frac{1}{2} v ft$$

It can be seen that the distance x can be calculated using:

$$x = \frac{1}{2} v t$$

And:

$$\frac{x}{t} = \frac{1}{2} v$$

Therefore, momentum is converted to energy by multiplying the momentum by the distance traveled divided by the period of time. The distance divided by the time and then multiplied again by the time simply yields the distance back:

$$fx = f\left(\frac{1}{2} v t\right)$$

So, both energy and momentum are calculations involving the same force whose effect is measured with regard to either distance or time. In other words the nature of either energy or momentum is dependent upon the nature of force. It is force that is the property that must yet become understood.

However, in modern physics theory both momentum and energy are interpreted as if they are unique fundamental physical properties that have their own material existence. Energy is given a position of prominence by interpreting it as the physical substance from which all things are formed. The universe neither gains nor loses energy. Its supply of energy is said to be transferred around and converted into different forms. This idea cannot be supported by empirical data. Empirical data always involves only distance and time. The theory of energy is introduced as a given in higher-level theory.

Empirical data is the basis of the fundamentals. If a material nature for energy were shown to exist by empirical evidence, then it would enter physics theory at the beginning, fundamental level. As far as the empirical universe is concerned, the name of energy could be replaced with the phrase *force times distance* and nothing of empirical significance would be lost.

When it is said that mass and energy are equivalent, it is empirically more informative to restate this as: Mass and the product of force and distance are equivalent. However, this statement is still not expressed in full empirical form. To state the same claim in empirical language it is necessary to say: Resistance to force and force times distance are equivalent. However, whether or not this statement is true depends upon understanding the significance of velocity in the equation. If velocity simply represents a value of conversion, then the statement may represent the truth.

If velocity plays its own important physical role in the operation of the universe, then its own significance must be recognized and the statement of simple equality needs to be reconsidered and examined for deeper, more complete, meaning. The importance of this point becomes clear when including the speed of light. The speed of light is a very important property of the operation of the universe. Using it as a mere value of conversion may be undercutting its true significance when considering a relationship between mass and energy.

The modern theoretical representation of energy existing as a fundamental physical substance comes from a common interpretation of Einstein's equation:

$$E_T = mC^2$$

This equation describes total energy. It was derived, by Einstein, as a part of his equation for kinetic energy. His complete equation is written as:

$$E_K = mC^2 - m_0C^2 = E_T - E_0$$

This says kinetic energy is equal to total energy minus rest energy. It is the equation used to support the statement that: Mass and energy are equivalent. It is used to predict the conversion of energy into matter. However, mass and matter are not the same. Mass is a property of matter. Matter is the theoretical concept that a material substrate exists from which the properties of force and resistance to force emanate. The existence of matter cannot be empirically demonstrated. However, we know, from patterns in changes of velocity that objects, whatever their true nature, do have properties. The properties are empirical. Whether or not a material substrate exists does not affect the derivation of physics theory.

If energy and mass are really equivalent, then wherever there is energy there is also mass. Light would have mass. Yet it is often stated that light does not have mass. The theoretical basis of this claim is represented mathematically by converting Einstein's energy equation into an equation of energy and momentum. This conversion produces an equation that can appear to not directly include mass. The equation is written as:

$$E_K^2 = (PC)^2 + E_0^2$$

This equation permits the theorist to speak in terms of energy and momentum instead of mass and velocity. With regard to light there is no rest energy so the equation becomes:

$$E_K = PC$$

It is known that light has both energy and momentum. Why does this eliminate a dependence upon mass? It only does so for those theorists who believe in the independent existences of energy and momentum. By this practice, the derivation of theory is turned upside down. Instead of working from empirical evidence and developing theory based firmly upon fundamentals, the theorist assumes the unique material existence of energy and momentum are established facts. Now the theorist can begin with the givens of energy and momentum and work backward to derive such things as mass and force.

This practice releases higher-level theory from being dependent upon the fundamentals. Instead, the fundamentals become dependent upon higher-level theory. An example of the consequences of this change in direction of derivation of theory is:

“Every single principle that we teach in intro-college physics is based on only two principles: Conservation of momentum and conservation of energy/mass. ... Conservation of momentum is based on the isotropic symmetry of empty space, conservation of energy on the symmetry of time....”

In other words: The fundamentals of physics are to be based upon theoretical properties that are empirically impossible to verify. These properties are *the isotropic symmetry of empty space* and *the symmetry of time*. Energy becomes something greater than force time distance. It is assumed to be a universal fundamental material that is moved around and transformed. Its greatest theoretical achievement is it can produce force and mass. So force and resistance to force are no longer the beginning point for physics theory. They become the result of a reverse derivation beginning with a *fundamental given called energy*. Unfortunately for theoretical physicists, no one can produce even one thimble full of energy for examination.

In spite of this empirical deficiency, energy is adopted as the fundamental universal material of modern physics theory. Looking again at the basis of this belief:

$$E_K = mC^2 - m_0C^2$$

The equation says: Kinetic energy is equal to total energy minus rest energy. Since energy and momentum are considered to be important fundamental properties by which to understand the nature of the universe, it has been the practice to express energy in terms of momentum. In the fundamentals of relativity theory, this can be accomplished in the following manner. Mass, according to Einstein, is expressed as:

$$m = \frac{m_0}{\left(1 - \frac{v^2}{C^2}\right)^{\frac{1}{2}}}$$

Squaring this equation:

$$m^2 = \frac{m_0^2}{1 - \frac{v^2}{C^2}}$$

Multiplying both sides by:

$$C^4 \left(1 - \frac{v^2}{C^2}\right)$$

Yields:

$$m^2 C^4 \left(1 - \frac{v^2}{C^2}\right) = m_0^2 C^4$$

Multiplying the left side:

$$m^2 C^4 - m^2 v^2 C^2 = m_0^2 C^4$$

Rearranging gives:

$$m^2 C^4 = m^2 v^2 C^2 + m_0^2 C^4$$

This equation, using symbols for total energy, rest energy, and momentum, becomes:

$$E_T^2 = (PC)^2 + E_0^2$$

It says: Total energy squared equals the square of the product of momentum and the speed of light plus the square of rest energy.

This equation is derivable from the fundamentals as long as it is applied to the motion of particles moving at less than the speed of light. These are what we actually observe and from which we gather our empirical evidence. The P in the formula is derived only as the product mv .

It includes mass. Photon momentum and energy is where a break with the fundamentals is made. When the above equation is applied to photons, it is done in such a way that its fundamental derivation no longer applies. First, since photons are never at rest, they are said to have no rest energy. In this case the equation reduces to:

$$E_T = PC$$

Our ignorance about the nature of mass is what leads to this confusion over how to apply Einstein's energy equation to photons. Einstein's equation for mass does not help us. When the particle speed is C , there is no solution for the quantity of mass. The equation becomes indeterminate. What then is the most fundamental, empirically based form we can use to express what this equation is telling us? It is to replace the terms for both energy and momentum with their fundamental definitions using force, distance, and time:

$$E_T^2 = (PC)^2 + E_0^2 = (ft)^2 C^2 + (f_0 x)^2$$

The equation contains force times time in place of momentum and force times distance in place of energy. The term f_0 represents the intrinsic force of an object at rest that we know is available as in nuclear reactions. Using this equation, we need no longer to be bogged down in the debates over what is mass and what has mass. Instead we can talk in terms of time, distance, and force.

For a photon, the available rest force is zero. The energy equation for a photon reduces to:

$$E = (ft) C$$

This equation does represent empirical evidence. We observe that photons do exert force over a period of time. At least the particles of matter react as if this is what occurs. The particles of matter undergo changes of velocity.

What then is the significance of the speed of light in this equation?

$$E = PC$$

It appears to represent the constant of proportionality between energy and momentum. In other words, it represents the conversion of force times distance to force times time. This conversion is accomplished by multiplying force times distance by the velocity of the photon. The velocity C is necessary instead of the conventionally expected $(1/2)C$ because the velocity of the photon is always C . Therefore, the distance across which the photon acts is always equal to the velocity C multiplied by the period of time required for the photon to cause its effect upon a particle of matter. Reflecting this fact in the equation above:

$$E = PC = ft C$$

This equation is representative of a property of photons. It applies to an object moving at the speed of light. It is a definition of potential energy. It is not energy because it is not representative of force acting across a distance. It is representative of the potential for force to act across a distance. There is also potential momentum. The product of force times time is representative of the potential for the force to be applied during a period of time. Later when the

photon is applying its force causing an object to change its velocity, there is the opportunity for both measurements to be made.

Thus far, I have used the speed of light in the manner usually employed. It is usually said to be the conversion multiplier between mass and energy. For example, it greatly magnifies the amount of energy said to be intrinsic to rest mass:

$$E_0 = m_0 C^2$$

However, there is something about this interpretation that suggests severe inadequacy. The speed of light is an incredibly important fundamental property of the universe. The inclusion of the square of the speed of light in Einstein's energy equation suggests very strongly that: The properties of light play a fundamental role in establishing this connection between *force times distance* and *resistance to force times distance*.

It is telling us that matter and the properties of light are interdependent. Something about matter behaves in a manner similar to that of photons. It can be anticipated that we are to discover that matter is representative of the potential for energy to be transmitted at the speed of light. Matter produces light and does this at the speed of light. There must be even more to it.

The light leaves matter moving away at a controlled speed. It must then be the case that matter is directly related to the cause for the existence and speed of light. Matter cannot be wholly unique from the nature of light. It is representative of potential light. Its own nature shares unity with the nature of light. Matter makes light active, and light makes matter active. They share properties and abide by shared principles. This interdependence of properties demonstrates fundamental order. Fundamental order is evidence of fundamental unity.

The true relevance of the properties called energy and momentum are dependent upon gaining an understanding of the property of force. So long as we do not understand the nature of force, we cannot hope to understand mass, momentum or energy. Learning the natures of force and resistance to force is essential. In my theory, I pursue new interpretations for the natures of force and resistance to force.