Zero work, escape velocity and the condition of minimum energy change.

Sonal Jagdish Gupta

Sarladevi Science Center,

C-5/2, M.I.D.C, Khamgoan, District - Buldhana. State - Maharashtra. India.

Abstract

All material bodies compromises of atoms/molecules in there pure form. The kinetic energy of any body is the sum of energies of its atoms and molecules this also applies to potential energy. The smallest change in energy is governed by the quantum of action and should be equal to 6.623×10^{-34} J. The number of atoms in a body determines its requirement for minimum energy when the applied force is unable to deliver this least quantum of energy to all the constituent particles compromising the body then there will be no observational motion and the work done is zero work. Mass act as a reluctance which opposes the change in state. When a body moves with reference to massive gravitating body then after a particular distance the potential energy of the system becomes lesser than the minimum energy then the massive body is unable to do any work on the moving body and the motion of the moving body becomes inertial thereafter. Velocity is quantized in one dimensional linear motion.

PACS – 04-80Cc.

1) This paper intends to prove that velocity is the measure of energy in one dimension linear motion.
2) The concept of zero work does not give pre-hand quantitative value of force, as to when the applied force will not be able to produce any displacement on a pre hand quantitative basis and this is an incompleteness that could not be explained by the conventional theory. But can be explained only if the condition of minimum energy change for linear motion is taken into account
3) Escape velocity determines the point in space from where the gravitational force becomes ineffective and this is analogues to zero work.
4) Force is ineffective if it is unable to make the required energy changes as per the condition of minimum energy.

Work is given as the product of force into displacement.The assumption or the argument of zero work states that when the applied force is unable to produce any kind of displacement it is called as zero work or when the work done is perpendicular to the direction of motion the work done is zero work.

This relation is given as

$$W = F \times S \times \text{cosine } \theta \qquad (1)$$

Where W = Work, F stands for force, S stands for displacement and θ is the angle between the direction of applied force and motion.

If S is zero the equality will get reduced to zero on the right hand side and the work will be zero work. Similarly, the work done in the direction perpendicular to the direction of motion is called as zero work for example, the motion of the planets around the sun or of other celestial body around there respective centers are example of zero work. However honorable Einstein has given a very different explanation of space time dissortation by the massive body which causes these revolutions in his general theory of relativity and the current paper does in no way intend to say anything in contrast to general theory of relativity.

The work energy principle states that work done is equal to energy transferred and the work- force relation is given as

$$W = F \times S \times \text{cosine } \theta$$

When $\theta = 0$, then the equation reduces to $W = F \times S$, as above

We know from Newton’s second law that $F = ma$, where m = mass and a = acceleration

Therefore, $W = maS$

Similarly, $v^2 = u^2 + 2aS$, (2)

Where v = final velocity and u = initial velocity

We can write, $\frac{v^2 - u^2}{2} = aS$

Substituting, $\frac{v^2 - u^2}{2}$ in the work equation we get,

$$W = m \left(\frac{v^2 - u^2}{2} \right) \quad (3)$$

Thus W = change in kinetic energy = ΔK.E

The above work equation can also be extended for change in potential energy, in that event

W = change in potential energy = ΔP.E

Thus W = change in energy = ΔE (4)

It is needless to mention that for calculation purposes the force will be considered as constant and acceleration will be considered as gravitational acceleration wherever required.

The concept of zero work is a straight forward observational fact which is bit flawed as it did not explain the limiting value as to when a particular force will be unable to do work. It does not give us a pre hand quantitative value of force as to when a force will not be able to produce any displacement. However it is known that there is no limiting value to force for which there is a general consensus among the scientific community

The great genius Max Planck had obtained the value of minimum energy interaction from his studies on black body radiation and had found that the smallest quanta of action or any amount of energy interchanged among matter and radiation is an integral multiple of a minimum value of energy equal to 6.623×10^{-34} J. with its multiples allowed. Classical mechanics does not put any lowermost limit on energy interactions as both these hypothesis had developed over a gap of 200 years [1]. But, it is interesting to note that there is no experimental evidence in classical mechanics which can prove that energy interchanges are not quantized in one dimensional linear motion and we have no reason to believe that why the energy interchanges in the realm of classical mechanics will not be quantized given the great generality of physics to hold. Therefore, from equations (1) and (4) we can write,

$$W = \Delta E = F \times S$$

$$E_{min} = F \times S \quad (5)$$

For the limiting case, the product of F × S should be equal to the smallest quanta of action and this is equal to 6.623×10^{-34} J. this is the limiting value of any kind of energy interaction.

If the product of force and displacement produces a energy change which is less than 6.623×10^{-34} J for an independent individual particle, then there will be no transfer of energy and hence no work can be derived or performed in such an interaction.

The equation of kinetic energy relates mass, velocity and energy and the equality is given as

$$\text{K. E} = \frac{1}{2}\,\text{m}v^2 \qquad (6)$$

As there is the limiting value to energy, let's call this as E minimum and denote it as E_{min} hereafter, we can write

$$E_{min} = \frac{1}{2}\,\text{m}v_{min}^2 \qquad (7)$$

As per equation (6) E_{min} determines the condition of minimum change in velocity and therefore in motion.

Any pure substance compromise of atoms and molecules which are identical in all respect and as the body moves with a constant velocity the atoms or molecules compromising the body also move with the same velocity as that of the body. Now as velocity is a manifestation of energy, all atoms moving with the same velocity and being identical in masses will have equal amount of energy? So if a body compromises of N atoms/molecules then each one of them has equal amount of energy then the total energy must be additive of the individual energies but this simple and straight logical conclusion leads us to an assertion that velocity must be quantized. Anybody compromising of N particles cannot lose arbitrary amount of energy in free motion as velocity is a measure of energy and if all has same velocity being identical all should have same energy if say one atom/molecule among the N ones loses the energy and the others don't then how we will be defining velocity as a measure of energy ? The change in velocity must cause a common energy change in all the constituents and vice-versa.

This equation (6) is the equation defining the condition of minimum energy for any interchange in question and for a body moving away from the massive gravitating body as this is the condition of minimum energy and no change lesser than this value will be a valid.

Now suppose that I give a kick to a ball of mass M compromising of N atoms for such a body in motion energy must be supplied to each and every atom so that equi-partation of kinetic energy with reference from the point of origin of the event can be justified each of these N atoms must receive at least one quantum of action i.e. 6.623×10^{-34} J of energy or its multiples and hence the accretion or dissipation of incremental amount of energy becomes equal to $\text{N} \times 6.623 \times 10^{-34}$ J which is equal to E_{min} thus the condition minimum energy becomes a necessary condition with the cost that the changes in velocity in one dimensional linear motion will also be quantized.Any force acting in opposition to the motion of the body is bonded to act in a manner that the equi-partation of energy among the constituents holds all the times.

Escape velocity is defined as the minimum velocity with which a body must be projected so that it can escape the gravitational attraction of a planet or any other massive gravitating body in question

The equation of escape comes from the concept of conservation of energy and it states that if the potential energy is equal to the kinetic energy of the body then the body will be freed from the influence of massive body and can be derived by equating potential and kinetic energy

$$\text{mgh} = \frac{1}{2}\ \text{m}v^2$$

For a gravitating body of mass M and radius R the acceleration due to gravity g is given as $\frac{GM}{R^2}$,and as the body to be projected is on the surface of the planet and therefore, h = R ,

So the above equality can be written as,

$$\frac{GM}{R^2}\,\text{m}\times\mathbf{R} = \frac{1}{2}\ \text{m}v^2$$

On cancellation we get,

$$\text{v} = \sqrt{\frac{2GM}{R}}, \qquad (8)$$

v is written as v_e as a common convention for escape velocity. It is admitted that there is no ambiguity with the equation for escape velocity and it holds good for the entire observational domain. It is accepted that gravitational fields extends to infinite distances and if this assumption is held true and we have no reason to believe as to why something will not return back to the planet from where it was projected and the conventional theory gives an incomplete explanation in this case.

Now, I ask a logical question as to where will be the point in this infinite journey of the body having the velocity equal to or greater than the escape velocity from where the body will be in a state of inertial motion as I really fail to understand as to how any material body can move against a varying force field if the minimum amount of energy dissipation has not been taken into consideration the existing laws of motion takes the equations in a sense that the continuous dissipation of energy is allowed. I have strict reservation against this assumption of continuous dissipation of energy. However no hypothesis should be accepted to be true if it is not supported by experimental facts it is a mandatory and good practice and I acknowledge this practice respectfully.

Therefore, I will propose a thought experiment which will prove the difference between the two theories. The main line of argument is that, is the dissipation of energy a continuous or discreet process?

If the sphere has energy equal to escape energy then we know that the sphere never returns back as there will be no complete dissipation of energy and the body will move away from the force field keeping one increment of minimum energy with itself forever. Potential energy on the surface of a body of mass M and radius R is given as

$$\text{P.E} = \frac{GMm}{R} \tag{9}$$

Where G = 6.67× $10^{-11}\ \frac{Kgm^2}{s^2}$, and m is the mass of the smaller body the smallest change in potential energy as per our hypothesis is E_{min}, which is the number of atoms in the smaller body multiplied by 6. 623 × 10^{-34} J therefore the above equality (9) for minimum potential energy change can be written as

$$E_{min} = \frac{GMm}{R} \tag{10}$$

Now consider an asteroid of mass of 10^4kg and a test sphere of mass 1 kg let the number of atoms in this spherical test mass equal to 1.083405×10^{25} for a body in uniform linear motion all atoms should have same velocity. The smallest change in energy as per our hypothesis is E_{min},which is the number of atoms in the smaller body × 6. 623 × 10^{-34} J Therefore the minimum change in energy in case of this test sphere comes out to 0.7175391315 × 10^{-8} J any energy change of order less than 0.7175391315 × 10^{-8} J will amount to zero work as this is the minimum required energy change in this case. Let the radius of the asteroid equal to 5.8097876714 m and let us assume the test mass as a point mass on its surface.

By using the above relation [2] $\qquad v_e = \sqrt{\frac{2GM}{R}}$,

Plugging in the above values, we get

$$v_e = 4.79179008388 \times 10^{-4}\text{m/s}$$

This will be the escape velocity from the asteroid, let us assume that a kick given to this test ball on this asteroid will just impart this escape velocity and let the energy associated with this escape velocity as the escape energy and this will be 11.480626104× 10^{-8} J. Before the motion of the test sphere becomes inertial there will be 14 step changes in velocity of the nature such that the distances between those incremental changes of velocity will keep on increasing as shown in the table below the last change will occur at a distance of 92.9566027438 m after which the motion will be truly inertial as the last increment of minimum energy is non-dissipative.

Escape energy	Escape velocity	Distance between the center of masses of the two spheres	Inertial distance for which the velocity will remain constant
$11.480626104 \times 10^{-8}$ J	$4.79179008388 \times 10^{-4}$m/s	5.8097876714 m	Onset of motion
$10.7630869725 \times 10^{-8}$ J	$4.63963079835 \times 10^{-4}$m/s	6.1971068495m	0.3873191781m
$10.045547841 \times 10^{-8}$J	$4.4823091908 \times 10^{-4}$m/s	6.6397573388m	0.4426504893m
$9.3280087095 \times 10^{-8}$ J	$4.31926121217 \times 10^{-4}$m/s	7.1505079033 m	0.5107505645 m
$8.610469578 \times 10^{-8}$ J	$4.14981194224 \times 10^{-4}$m/s	7.7463835619m	0.5958756586m
$7.8929304465 \times 10^{-8}$ J	$3.97314244559 \times 10^{-4}$m/s	8.4506002494 m	0.7042166875 m
$7.175391315 \times 10^{-8}$J	$3.78824268361 \times 10^{-4}$m/s	9.29566027438m	0.84506002498m
$6.4578521835 \times 10^{-8}$ J	$3.59384256291 \times 10^{-4}$m/s	10.328511459m	1.0328511847m
$5.740313052 \times 10^{-8}$ J	$3.38830726233 \times 10^{-4}$m/s	11.6195753429m	1.2910638839m
$5.0227739205 \times 10^{-8}$ J	$3.16947122419 \times 10^{-4}$m/s	13.2795146779m	1.6599393350m
$4.305234789 \times 10^{-8}$ J	$2.93436016501 \times 10^{-4}$m/s	15.4927671239m	2.2132524460m
$3.5876956575 \times 10^{-8}$ J	$2.67869209036 \times 10^{-4}$m/s	18.5913205487m	3.09855342480m
$2.870156526 \times 10^{-8}$ J	$2.39589504194 \times 10^{-4}$m/s	23.2277500111m	4.63642946240m
$2.1526173945 \times 10^{-8}$ J	$2.07490597112 \times 10^{-4}$m/s	30.9855342479m	7.7577842368m
$1.435078263 \times 10^{-8}$ J	$1.69415363116 \times 10^{-4}$m/s	46.4783013719m	15.492767124m
$0.7175391315 \times 10^{-8}$ J	$1.19794752097 \times 10^{-4}$m/s	92.9566027438m	46.4783013719m
$0.7175391315 \times 10^{-8}$ J	$1.19794752097 \times 10^{-4}$m/s	immaterial	No upper limit

.

Different masses requires different amount of energies to acquire same amount of velocity the condition of minimum energy change is for the rate of dissipation and it could apply no binding on the velocity of a body as we know that a body at rest has zero velocity and above all when we threw a ball vertically upward it stops momentarily prior to its gain in velocity in the direction of force. But, there is a condition as to what amount of energy it gains, it should gain at least E_{min} and this will depend on the potential energy of the two bodies forming a conservative system if the potential energy is less than E_{min} then there will be no energy change and no work and hence no motion. The amount of energy dissipated will be $0.7175391315\times 10^{-8}$ J in each transition and it will be the same amount gained in the first transaction after the momentarily stop in the other direction for the case discussed in the table above.

According to this hypothesis is it possible that I give a kick to a body and it will move without dissipating energy? The obvious answer is yes, provided that the escaping body is at a point above the center of mass of the system that the potential energy of the system is lesser than E_{min} in this event no energy will be dissipated and the motion will be all inertial. In the case discussed above as the 1kg mass is on the asteroid whose mass is 10^4kg and radius is 92.9566027438 m and this distance R will be the distances between the respective center of masses of the two bodies, and if the ball is supplied with energy of the order of E_{min} or its higher multiple then the ball will move away from the asteroid without dissipating any of its energy.

The kinetic energy of a body is the measure of its velocity, velocity of a body is a function of time and its distance from some fixed refernce hence velocity and motion are one and same if the direction remains unchanged. For the conservation of energy to hold in a conservative force fied the gain in potential energy should be equal to loss in kinetic energy and vice-versa. If the potential of the system ceases the optimum limit that is if the potential energy is less than the minimum energy as required by our condition of minimum energy change no kinetic energy can be supplied to the body and no work can be done on the body in question and in this way zero work and escape velocity gets co-related we will be discussing this issues with proposed experiments to prove our point below

Consider an iron block on a glass plate fixed to a rigid support and let us place an electromagnet just beneath it. Initially the block will remain at rest. Now, we increase the current supply to the electromagnet the block will remain at rest. If, we keep on increasing the supply to the electromagnet a point will come when the glass will broke and the slab will fall towards the electromagnet this will happen because the energy of the system compromising the slab and the electromagnet had reached to the required optimum value. The moral of the story is that no motion can ensure until and unless the requirement of minimum energy is fulfilled

Gravitational potential energy is the energy possessed by a body by virtue of its position in the gravitational field and is time independent. A box on the table in a gravitational field will remain there indefinitely against the action of gravitational force and it will not fall as it is constrained by the table which prevents the box fall. We had made our calculations considering the least feasible change in potential energy and had concluded that a body in free motion against the force field and having initial velocity equal to the escape velocity will not lose its last increment of minimum energy as if it is supported by a table against the force field and hence insulated from the dissipative power of the force field in opposition. A learned reader may argue that a body moving away from the gravitational force field can hardly be imagined to be resting on a table support. He is free to ask "where is the table?" and the answer is the mass of the body is the table which opposes the change of state as mass of a body is the measure of inertia, its reluctance to change, or you can call it "Constrain". Mass of the body will acts as a table that will resist against the change in energy once the potential energy of the system compromising the two bodies falls below the required minimum value.

It is understood that a physical theory cannot be proven completely it can only be disproven any experimentally verified negation to this hypothesis will be highly welcomed.

The Cavendish torsion balance experiment will prove beyond doubt that condition of minimum energy is a mandatory requirement for the onset of any energy change and this being a terrestrial experiment will leave no doubt to prove that the force will be unable to cause a state change and this effect is time independent. And this is the same phenomenon that co-relates escape velocity and zero work. It will also prove that zero work occurs as there is a quantitative deficiency of energy.

Let us consider an example of a bowling ball whose mass is taken to be 7.25 kg and a test ball of 0.05kg made up of lead, there will be two bowling balls and two test ball for any Cavendish torsion balance experimental set-up. As the test ball is 0.05 kg and is made up of lead the number of atoms in this test ball will be 1.453185328$\times 10^{23}$ and the condition of minimum energy requires that E_{min} = 9.62444642734$\times 10^{-11}$ J. if we plug in this value in the relation

$$E_{min} = \frac{GMm}{R}$$

We can determine the maximum distance for which the potential between the system will remain effective and in this example the value of R = 0.2512222410m it is interesting to note that if I increase the mass of the test ball to 0.1 kg the value of R will remain unchanged i.e. equal to 0.2512222410m.It is interesting to note that the force will get doubled in the latter case but it will remain ineffective as it is the energy requirement that determines the observational change and it is not the force that can ensure the observational change. The conventional theory at no point claims this difference between the superiority of energy over force for the onset of motion.

It is needless to mention that the torsion balance will not register any energy change if the center of mass distance between the two balls is greater than the value calculated above and this observation will be time independent. As per Newtonian mechanics a object will remain at rest unless and until a force act on it but our theory demands that there needs some finite minimum value of force in relation to its requirement of minimum energy for the onset of motion.

A learned reader will argue that the torsion balance experiment will only prove that the condition of minimum energy exist but it does in no way proves quantization of velocity in one dimensional linear motion and this is true as there will be no motion in the torsion balance in this experiment and therefore the question of verifying the quantization of velocity does not arise in this experiment.

To prove the quantization of velocity I will propose another simple experiment, consider a block of mass 1kg with Teflon coating placed on a Teflon surface in a vacuum tight enclosure. This arrangement is provided with an automated pendulum bob which could be adjusted for any angular change and the desired amount of energy can be delivered by lifting and tagging the block the gain in energy of the bob will be linearly proportional to the height it has been raised.

Let the minimum amount of energy required moving the block is $0.7175391315 \times 10^{-8}$ J as discussed earlier as the block moves against the Teflon surface whose co-efficient of static and kinetic friction of Teflon on Teflon μ = 0.04 and the value of g = 9.81m/s.[3].

Now we raise the bob to a height that it hit the block and impart the block with energy equal to $1.435078263 \times 10^{-8}$ J for this type of experimental setting the force of friction comes out to 0.3924N which will try to retard its motion and the block will move a distance of $3.65718211773 \times 10^{-8}$ m. There will be only one step change in the velocity instead of a continuous change before the block comes to a stop. If we increase the energy supplied to the block the number of incremental step changes will increase but the dissipation rate will remain constant provided that the co-efficient of friction remains constant. Therefore, if we can measure velocity changes at a precession, as required by our assumption of step change in velocity we will prove that velocity is quantized. If the same apparatus is operated under micro-gravity then the block will move a distance of 0.358769575m before it stops this distance change will be easy for observation purposes and the time period for which the block will keep sliding is about 43 seconds.

The soul of the experiment is that take a block of any pure material determine the number of atoms and observe for a change in velocity keeping the product of number of atoms in the block and the smallest quanta of energy i.e. 6.623×10^{-34} J in mind and observe for a step change in velocity as this requirement of dissipation of energy is a general requirement and it should hold under all observational conditions provided external influences are taken due care of.

Consider two points A and B separated by a distance of $1.82859105886 \times 10^{-8} m$ and as the velocity remains constant during this distance and as the changes are step changes then there will be an element of time difference that can be determined with the help of precise time calculation in this case a high speed camera can be used and the frame number can serve as a measurement of time provided the body is massive enough that it does not interact with the lighting arrangement. Different elements with similar mass will have different distance values of a velocity step change as the number of atoms per unit mass will vary.

ANALYSIS

The complete analysis of this argument on experimental basis will be very extensive as we observe objects moving and coming to stop on daily basis and to take all these effects into consideration will be too cumbersome so I will give a brief explanation as to why such an effect has never been observed in general and how this theory is consistent with all the observations in a much detailed manner.

Actually the changes in energy depends on per mass basis and if a body moves against a frictional surface the smallest change in velocity due to frictional force the will occur at a distance of 10^{-8}m on the earth surface which are too small to be observed under ordinary circumstances. So far as the Cavendish type torsion balance experiment are concerned they had not been tested to the level of distances and masses that are required by this argument in question. Moreover the conventional theory does not explain changes in energy of the order of scale as required by our argument as the order of scale involved has never been taken into consideration by the conventional theory our theory is in no way conflict with the observational findings observed generally since they are of much higher order in comparison to our theory and our theory will yield similar result for finding of higher order changes which are routinely observed.

There is no conflict with the fact that if the body is given energy equal to the escape energy it will move away from the massive gravitating body and will never return back but the conventional theory does not explain this phenomenon as to why this will happen and this is a kind of shortcoming of the conventional theory which our hypothesis explain more satisfactorily. Above all the system compromising the two bodies should have finite linear dimension as the energy supplied was finite and this is not explained by the conventional theory above all infinity is not a well defined parameter for calculation purposes.

When a smaller rigid body moves away from a central massive body the changes in the energy of the smaller body are in reference to the center of mass of the larger body in question and as the smaller body moves as a whole relative to the center of mass of the massive body the changes in potential energy should be the sum of changes in energy of all the particles constituting the smaller body the conventional theory does not take this into account by not justifying the lowermost division of energy. However both theories will give same result in the end.

The current theory is valid with all the observational facts and gives a much wider domain in understanding energy interactions of bulk matter with gravitational fields and addresses issues of infinity in a much proper sense which the conventional theory does not.

REFERENCES

1) Physics and reality – Albert Einstein, Page no 13-14
2) Khatri, Poudel, Gautam, M.K., P.R.,A,K,(2010),Principles of Physics, Kathmandu: Ayam Publication,pp,170,17
3) Hanoor,D,;Gan Y,;Einav,I. (2016) " Static friction on fractural interface"(PDF), Tribology International.93: 229-238.