

Military Technical College
Kobry El-Kobbah,
Cairo, Egypt



14th International Conference on
Applied Mechanics and
Mechanical Engineering.

A Three Dimensional-System of Units

By

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Abstract:

In recent years; scientific literatures as textbooks and journals have considered the SI system of units as undesirable in fundamental researches because the SI units of many physical quantities do not correspond to current scientific theories. This paper offers a new system that eliminates redundancies found in the SI system by involving physical concepts that found, by following an entropy approach, common features of the thermal, electrical and magnetic fluxes. The electric potential and the magnetic potentials were expressed as qualities of the electric charge and the magnetic flux in analogy to the temperature that represents, as stated by the second law of thermodynamics, the quality of heat. According to published experimental results; the electric or the magnetic potentials generates an E.M.F. through an Al-Fe thermocouple similar to the E.M.F. generated by a temperature difference in such thermocouple. So; the introduced system considers the generated E.M.F. as a unique dimensionless scale for measuring the qualities or the potentials of the considered energy fluxes. Accordingly, the introduced system of units is based only on three dimensions; E, L, and T, and four fundamental units; Joule, meter, second and the Volt. The postulated system of units introduces also a modified fundamental thermodynamic-equation that offers plausible explanations of the prevailing energy-system interactions in the fields of thermodynamics, electromagnetism and thermo-chemistry

Keywords:

dimensions, units, potentials, thermodynamics, electromagnetism, thermo-chemistry

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1. Introduction:

In a recently published paper [1], it was stated a new fundamental thermodynamic equation that embraces the transfer of electric charge, magnetic flux and heat, Fig.1. Such equation introduced the electric charge and the magnetic flux as forms of energy in transfer which have electric or magnetic potentials. Such equation defined the electric charge **Q** in terms of an electric potential " ϕ_e " times a change of entropy and defines the magnetic flux **B** in terms of a magnetic potential " ϕ_m " times a change in entropy in analogy to expressing the heat in terms temperature "**T**", as a thermal potential, times the change of the entropy. The experimental work of Kumar and others [2] compared the performance of some common thermocouples. They found high performance of an Aluminum-iron thermocouple in comparison to other combinations where aluminum fulfills the requirement of high electrical conductivity and iron has comparatively low thermal conductivity. Such Al-Fe thermocouple recorded the maximum E.M.F. for fixed temperature difference and recorded also a generation of excess E.M.F. by influence of the magnetic and electric fields. Accordingly; such generated E.M.F. was postulated as a dimensionless scale for the measurement of the electric, magnetic and thermal potentials. By analogy; the other potentials were postulated as dimensionless qualities of their corresponding energy fluxes.

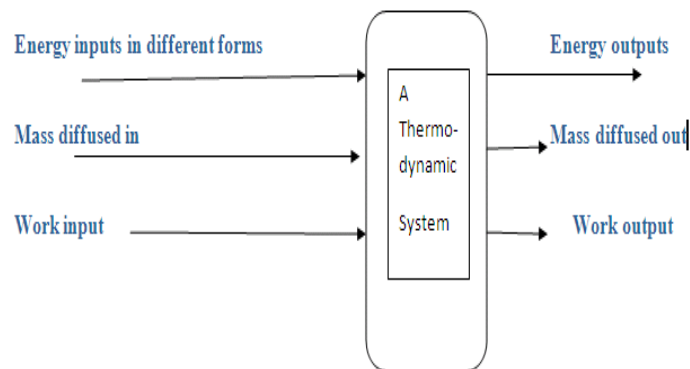


Figure (1): A General System Energy-Interactions

Many scientists found the available system of units, SI system historical, independent and redundant [3]. However; many papers failed in finding a plausible system that may diminish such redundancies [4,5]. The main source of such redundancies is found due trying to mix different mechanisms of energy transfer without considering the unique nature of such mechanism [6]. The introduced approach defines the different modes of energy transfer in terms of a dimensionless potential, measured in volts, times an entropy change expressed in Joule/volt. Such postulate leads to a system of units which is based on four units (meter, second, Joule and volt) and three dimensions (Length, Time and Energy). As the energy is the core of most physical and engineering fields; the Joule was considered as a basic unit and the kg is considered as a derived unit. Such concept deletes the found redundancies in determining the values of many physical constants [4] or in defining many physical quantities. However; in the introduced approach the candela was not considered as a fundamental

quantity as it is defined in terms of the energy intensity of a specified spectrum of energy-radiation. Similarly; the mole was not considered as a fundamental unit as it can be replaced by an appropriate number (6.02×10^{23}) of molecules.

The introduced three dimensional system of units led to a simple representation of the physical quantities in a three dimensional space. It leads also to a fundamental equation of thermodynamics that involves chemical energy in addition to the other forms of energy fluxes. The derived fundamental equation offers plausible explanations for recently discovered phenomena in energy-interactions fields of thermo-chemistry and electro-magnetism and finds plausible definitions, dimensions and units of many physical quantities.

2. A Universal Thermocouple:

During their experimental work to compare the performance of some common thermocouples; Kumar and others [2] found a better performance of an Aluminum-Iron thermocouple as compared to other combination. Aluminum fulfills the requirement of high electrical conductivity while iron has comparatively low thermal conductivity.

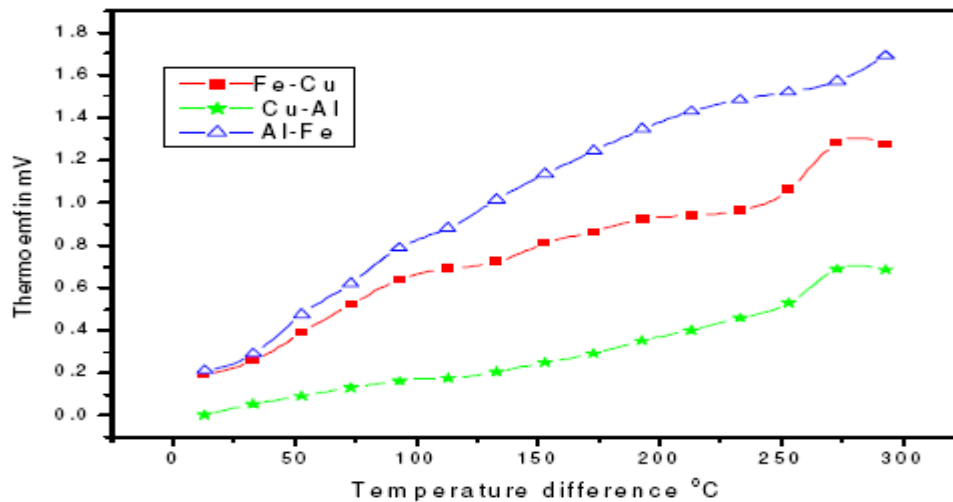


Figure2. Performance of Different Thermocouples [2]

Figure 2 shows the variation of the generated EMF due to variable temperature differences by various thermocouples where an EMF of “1.6892” mV was measured at temperature difference of 293⁰C when using an Al-Fe thermocouple.

Figure 3 shows the influence of the magnetic flux on the performance of Al-Fe thermocouple. When a magnetic field of magnetic flux density 120 G was applied on such thermocouple at parallel orientation of the thermocouple, the generated EMF increased to 1.898 mV at the same temperature difference of 293

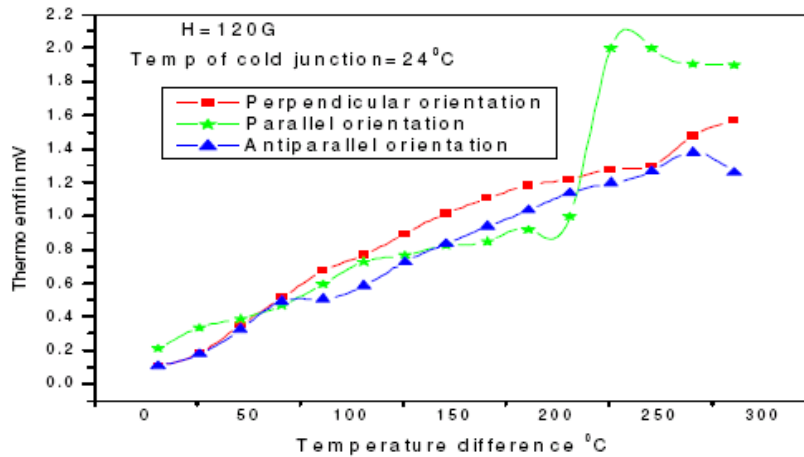


Figure 3. Influence of Magnetic Field on Performance of Al-Fe Thermocouple [2]

By application of an electric field of potential 4 V on such thermocouple at parallel and perpendicular orientation, a significant influence on the generated EMF is found according to the results shown in figure 4.

Such results of the measured EMF due to application of different fields by the use of an Al-Fe thermocouple sustain the similarity of the electric flux, magnetic flux and heat flux as forms of energy of different potentials that can be measured by the same unit. The found results lead also a way to a unique potential scale that can be used to measure all potentials in volts. Proportionality factors that may express ratio of the scales of such potentials may depend on the thermal, electric and magnetic properties of the materials of the thermocouple wires.

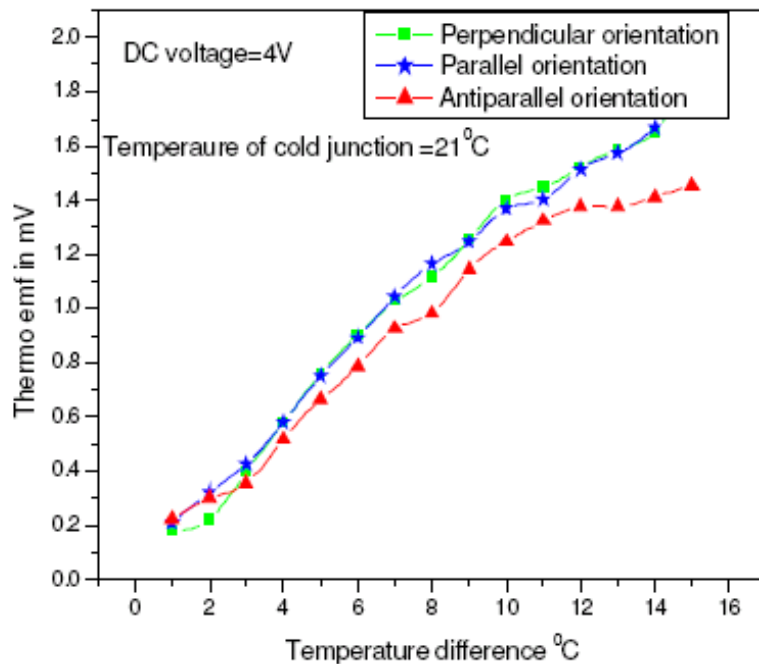


Figure 4. Influence of Electric Field on Performance of Al-Fe Thermocouple [2]

However; such scales may be directly found from the measurement results where 1.6983 mV mainly corresponded to 566 K and 0.423 mV corresponded to 300 K. The measured E.M.F. which is generated due to applying a magnetic flux of 120 G was found as (1.898 – 1.698 =) 0.2 mV. Similarly; the E.M.F. found due to applying an electric potential of 4 V was found to be (1.2 – 0.4 =) 1.2 mV. However; such scale is directly tied to the entropy of the material as it indicates the scale of empowering the system to give or receive energy by different grades or how the disturbance of the energy states is influenced by the imparted thermal, electrical and magnetic energies. It is not a directly measurable property but it is an indicator of the system's entropy or the concentration of the photons, electric charges or magnetic flux in a system. So, we may consider the volt-scale as a dimensionless unit that measures the effectiveness of the system's entropy to transfer energy or the concentration of photons, charges or magnetic flux. Such results indicate the existence of another effects or influences on thermocouples which is similar to the Seebeck effect. These are the effects of differences of the electrical and magnetic potentials or the magnetic and electric fields on thermocouple wires. The plausible explanation of such effects is sustaining the postulated definitions of magnetic flux and electric charges as forms of energies that possess specific potentials [4]. However; the objective of reviewing the results of these experiments is to show the potential of the concerned thermal, electrical and magnetic fields can be measured by one fundamental unit or scale, the Volt.

3. Analogy of Thermal, Electric and Magnetic Fields:

The Fourier Law of thermal conduction is stated as follows [5]:

$$\mathbf{q} = -k \nabla T \quad (1)$$

Where \mathbf{q} is the heat flux density in W / m^2 , T is the temperature in, as postulated, Volts and k is the thermal conductivity of materials in $W/ m^2 V$.

Similarly; Ohms Law of Electric conduction is stated as follows [6]:

$$\mathbf{J} = -\sigma \nabla \varphi_e \quad (2)$$

Where J is the electric flux density in W/m^2 , φ_e is the electrical potential in Volts and σ is electrical resistance in $W/m^2 V$ or Ohm.

The commonly used form for the relationship between the magnetic field parameters B and H is

$$\mathbf{B} = -\mu_m \mathbf{H} \quad (3)$$

B is sometimes called the magnetic flux density or the magnetic induction. The unit of a flux density is measured generally in W/m^2 . Hence, the unit of B should be, by analogy to the thermal and electrical flux, in W/m^2 too. μ_m is the magnetic permeability of a material. By analogy to equations (1) and (2) that define the heat flux and the electric current flux and their corresponding potentials, the magnetic field intensity H will be attributed the same unit, volt, and described by a similar equation, as the electric field intensity, of the form [6]:

$$\mathbf{H} = -\nabla \varphi_m \quad (4)$$

Substituting equation (4) in (3), we get an equation for the magnetic flux similar to the heat and charge flux:

$$\mathbf{B} = -\mu_m \nabla \varphi_m \quad (5)$$

According to equations (1), (2) and (4); the heat, electrical and magnetic fluxes, are denoted as \mathbf{q} , \mathbf{J} and \mathbf{B} and are measured, as postulated, in W / m^2 . Similarly; the thermal, electrical and magnetic potentials denoted as T , φ_e and φ_m are measured, as postulated, in Volts.

Finally, the unit of conductivities \mathbf{k} , σ and μ would be in $W / m^2 V$.

4. An Entropy Approach to a Modified System of Units:

In a recently published paper [1], it was introduced a new thermodynamic fundamental equation of the following (rather modified) form:

$$dU + p dV = T dS_t + \varphi_e dS_e + \varphi_m dS_m + \sum \mu_i dn_i \quad (6)$$

Such equation represents the electric charge, Q in terms of the electric potential, φ_e , times a change of entropy dS_e and the magnetic flux as magnetic potential, φ_m , times a change in entropy dS_m , in analogy to expressing the heat in terms of temperature (as the thermal potential or quality), T , times a change in entropy dS_t . In equation (6); the product of the two terms “ μ_i and dn_i ” is expressing the chemical energy where μ_i is the chemical energy added to the system per unit increase in the concentration of certain chemical specie dn_i . However, the entropy change dS_e may be defined as the flow of the entropic charge. Similarly, the entropy change dS_m can be defined as the flow of entropic magnetic flux and dS_t as the flow of the entropic heat.

Introducing the definition of the free Gibbs energy:

$$G = U + pV - TS \quad (7)$$

In this equation; we may consider the potential T as the sum of the driving potentials of the thermal, electrical and magnetic energies.

Taking total differential of G , we have:

$$dG = dU + p dV + V dp - T dS - S dT \quad (8)$$

Replacing dU in equation (8) from the fundamental equation (6); we get:

$$dG = T dS - p dV + \sum_i \mu_i dN_i + p dV + V dp - T dS - S dT$$

$$dG = V dp - S dT + \sum_i \mu_i dN_i \quad (9)$$

Dealing with systems that involves transfer of energies in thermal, electric and magnetic forms; equation (9) can be rewritten as follows:

$$dG = V dp - S (dT + d\varphi_e + d\varphi_m) + \sum_i \mu_i dN_i \quad (10)$$

Where the potentials; T , φ_e and φ_m will be substituted in multiples of volts and S in Joule/volt. By comparing the terms of equation (14); the term μ_i may be considered as the entropy added to the system due to the increase of the concentration of the chemical specie “ i ” by dn_i . So, the entropy may be considered in general as a form of specific energy indicating the energy required to increase the potential of a system by a unit of the thermal, electrical or magnetic potential. However; as we can discover; the definition of μ_i as a chemical potential is misleading since it represents the added chemical energy per unit increase in concentration and its driving potential is the concentration of each of the chemical species.

5. A Three-Dimensional System of Units:

In recent years; scientific literatures as textbooks and journals have considered the SI system of units as a historical, independent and redundant system [11, 12, 13 and 14]. Such references found it is undesirable to use such system in the thermo-chemical and electromagnetic fields as it fails to integrate properly the involved fields. The SI system does not find a physical significance of many constants or identical units of the quantities E, D, B, H and μ . Such system of units depends on 7 basic dimensions and units.

A recently defined system of units depends only on Space and Time (ST), as basic dimensions and units [11]. However; such ST system of units does not solve the found redundancy and adds many conflicts between the units. As an example; it defines the energy and temperature by the same dimensions $T S^{-1}$ which is physically incorrect. Similarly; such ST system assigns to the electric charge and the space the same dimension S which contradicts their definitions and physical meanings.

The introduced system depends on simplifying the SI system by introducing the physical concepts that consider the analogy between the thermal, electrical, magnetic and chemical energies. According to equation (5); the heat, electrical and magnetic fluxes are considered as forms of energy or electromagnetic waves that are measured by the energy dimensions and units. Similarly; the stated potentials of the three involved fields have the same dimensionless scale in Volts. Hence; we may propose a new system of units that may remove redundancies of the SI system and consider the uniqueness of the fields through the postulated definitions of each flux in terms of a potential and an entropy change of the same dimensions and units. According to the relativity; the mass can be considered as a form of energy. Hence; the proposed system consider the energy as a fundamental dimension or unit and the mass is a derived unit as the energy is the prevailing parameter in physical systems. According to the concept of dimensional homogeneity; it states the equality of dimensions of the quantities on both sides of any physical equation [12]. Postulating any potential as a unique dimensionless unit removes redundancies in the physical equations that discuss many energy interactions.

So, the introduced system is based only on three basic dimensions (and units): the length in meters, the energy in Joule and the time in seconds. The volt will be considered as a dimensionless scale that measures, as previously explained, the concentration of specific quanta of energy, as photons, electric charges or magnetic flux, in a system. It is the property that expresses the scale of motivation of the entropy of a system to be transferred as a form of energy. The candela is defined as the luminous energy intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $1/683$ watt per steradian [15]. The candela is therefore no longer strictly necessary to be considered as a fundamental unit, because it is defined in terms of radiant energy [16]. So; the other physical quantities can be derived from the postulated system of dimensions or units according to their definitions as follows:

As the Rate of flow of energy or the Power = Energy / Time

So; the dimensions and unit of the rate of flow of heat, electric charge and magnetic flux are: $E T^{-1}$ and W.

As the energy flux = Rate of Energy Flow/ Area

Hence; the dimensions and unit of the energy flow per unit time and per unit area as q, J and b are: $E T^{-1} L^{-2}$ and W/m^2 .

As the Energy = Force * distance

So; the dimensions and unit of the force will be $E L^{-1}$ and N.

As the Force = mass * acceleration

Hence; the dimensions and unit of the mass will be $E L^{-2} T^{-2}$ and kg.

As the Pressure = Force / Area

Hence; the dimensions and unit of pressure will be $E L^{-3}$ and Pa.

As the thermal, electric and magnetic conductivity = Energy flux per unit area/ Potential Gradient

Hence; conductivity dimensions and units are $E T^{-1} L^{-1}$ and W/m. Volt.

As the Resistance = Energy Flow per unit time per unit area / Potential difference.

So; resistance dimensions and units are: $E^{-1} T$ and Volts/Watt or Ohm.

As the Capacitance = Charge / Potential difference and it represents the stored energy (or charge) at potential 1 Volt.

Hence the Capacitance dimensions and units are E and Farad or Joules/Volt. In other words; the Farad is actually a unit of electric charge that has the dimensions of energy.

As the inductance = Potential difference / rate of change of current

Hence the inductance dimensions and unit are $E^{-1} T^2$ and Henry or Ohm. S.

As the permeability = the ratio of the rate of flow of magnetic flux density B (W/m^2) to the potential gradient in Volt/m.

Hence the permeability unit is W / m V or Henry/ m; and its dimensions are $E L^{-1} T^{-1}$

As the permittivity is the ratio D/E in free space where D is the displacement field in C/m^2 (or J/m^2) and E is the electric field gradient measured in volts/m

Hence the permittivity unit is Joule/V m or Farad/ m and its dimensions are: $E L^{-1}$

As the fine structure constant = quantum unit of electromagnetic force/quantum unit of inertia force = α = charge of electron²/4 π * permittivity of vacuum * Planck constant * speed of light in vacuum

So, substituting the dimensions of different terms in the definition of α ; α will be found as a dimensionless parameter that fits to its definition.

6. Comments on the Postulated Dimensional System:

This paper redefines the SI system of units for practical applications in the field of energy interactions. As can be seen; the dimensions of the physical quantities are simple and explicitly defined. Such system of units solves the conflicts found in the SI system where the units of physical quantities do not correspond to many scientific theories [16, 17]. The introduced dimensional system defines a space of three coordinates in which all physical quantities can be represented as points. Comparing this system to the other proposed or redefined systems [18, 19]; it is found that the introduced system has more applicability since it depends on physical concepts that depend on the analogy and similarity of the thermal, electrical and magnetic fields. Other systems which were proposed to redefine the SI system have added more conflicts as they do not rely on physical concepts.

However; reviewing the definition of the eV as a confusing unit of energy may show how the introduced system of units may remove the disability of the SI system of units to handle the eV as unit of energy. In physics, the electron-volt (symbol eV; also written electron-volt) is a unit of energy equal to approximately 1.602×10^{-19} J. By classical definition, it is equal to the amount of kinetic energy gained by a single unbound electron when it accelerates through an electric potential difference of one volt. However; the charge of an electron has also the same figure; i.e. 1.602×10^{-19} C. So, it is not known if it is kinetic energy of 1.602×10^{-19} J or as described a charge of the same quantity of 1.602×10^{-19} C multiplied by a confusing potential of 1 Volt. Such redundancy is deleted if we consider, as postulated here, the electric charge has the same unit as energy, Joule, and to consider the e. V as the specific charge of the electron; i.e. the amount of energy that increase the potential of the electron by 1 volt in analogy to the defined specific heat of a body as the amount of heat that increases the temperature of such body by one degree.

Such results assure the plausibility of the introduced system to explain the physical phenomena and to support the physical equations and concepts.

7. Conclusion

According to the conclusion of a previous paper, the electric charge was defined as a form of energy that has an electric potential and the magnetic flux as a form of energy that has also a magnetic potential. Such definitions were postulated by experimental and theoretical analogy between the thermal, electrical and magnetic fields. According to the experimental results of an Al-Fe thermocouple; E.M.F. was generated by the influence of electric and magnetic potentials similar to the generated EMF by the influence of temperature differences. Such generated E.M.F. was postulated as a unique scale for measurement of all potentials. Accordingly; it is introduced a new system of units that considers the Joule as a fundamental unit for heat, electric charge and magnetic flux and the Volt as a fundamental unit or the potential scale of the thermal, electric and magnetic potentials. So, the introduced system of units is based on three dimensions only; L for length, E for energy and T for time. The EMF is considered as a dimensionless physical quantity as it is directly related to the concentrations of photons, charges or flux. According to such postulated system of units; it was possible to represent all the physical quantities in the engineering fields in simple forms

that eliminate the redundancies found in the SI system of units. Such three dimensional system of units led to a fundamental equation that offers plausible explanations of energy-system interactions in the fields of thermo-chemistry and electro-magnetism. On a three dimensional space; we may find a point for every physical quantity.

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