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Review Article

Conversion of the Units of the mks and British Systems

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Abstract: There are two frequently used systems of units for physical properties. The mks System employs the meter (m) and kilogram (kg) as the units of distance and inertial mass, whereas the British System employs foot (ft) and pound (lb) in their place. In many cases, a conversion between the numerical values of a given object can be obtained by simply making use of the respective ratios of these quantities. It is helpful to realize that any physical property can be expressed as a product of the variables of distance, inertial mass and time. One can expand the applicability of the two Systems to the description of electromagnetic properties by adding the Coulomb (Coul) to this list. The situation is made more complicated by the fact that the British System employs a unit of force (lbf) which depends on the location of the object lying within a gravitational field with a particular value of g. As a consequence, 1 lbf = 4.44822 N = 32.173722 ft lb / s^2 within the British System itself. Relationships between the units of energy and power are also disused.

Keywords: *mks System of Units, British System, Vector Notation for Units, Conversion of Units between Systems*.

I. INTRODUCTION

In recent work, [1-3], a four-dimensional system of units has been introduced which is capable of describing all dynamic and electromagnetic properties. In essence the three fundamental quantities of distance, inertial mass and time have been augmented by the Coulomb as the fourth fundamental property. The resulting scheme is referred to as the mksC System. The units themselves can be represented by four-dimensional vectors whole positions are occupied by the respective integral values of the meter (m), kilogram (kg), second (s) and Coulomb (Coul). The question to be considered below is how the mksC system can be adapted in a relatively straightforward manner to the British System of units. Clearly, the unit of distance must be changed from meter (m) to foot (ft), while that for inertial mass must be changed from kilogram (kg) to pound (lb). The desired adaptation can be accomplished, however, without replacing either the second (s) or the Coulomb (Coul) as the remaining fundamental quantities employed to describe the various properties in the British System.

II. Conversion Factors between the Two Sets of Units

It is generally recognized that the mks System is more easily applied than the British System. This is because it is based on factors of ten, whereas the British System relies on factors such as 2, 4, 8 and 12. For example, 1 kilometer (km) is equal to 1000 m and the kilogram (kg) is equal to 1000 gram (g). On the other hand, 1 foot (ft) is equal to 12 inches and 1 ounce (oz) equals 1/16 pound (lb) in the British System. It is nonetheless a simple manner to relate the two systems on the basis of the relationships between m and ft for distance and kg and lb for inertial mass. In this way a British System can be developed from the mksC System which can be referred to as the ftlbsCoul System. Ony two key conversion factors are required for this purpose, namely a=3.28084 ft/m and b= 2.2046 lb/kg.

Use of the above two factors can be conveniently based of the four-dimensional vectors (i,j,k,l) defined in recent work [1-3], to describe all properties, both dynamic and electromagnetic.

As a simple example, the vector for distance is (1,0,0,0). A value of X m is converted over to Y ft in the British System by multiplying X with $a^i= a^1$. The corresponding transformation of a value of X kg, which is (0,1,0,0) in the mksC System, to the British System is accomplished by multiplying X with $b^j=b^1$. No conversion is required for either s or Coul. Other properties such as speed are easily handled by using this procedure. It has a unit of m/s in the mksC System or

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(1,0,-1,0) in vector notation. Therefore a speed of X m/s becomes Y=aX ft/s in the British System.

III. Conversion of the Units of Force, Energy and Power

The mks unit of force F is m kg/s^2 = N consistent with F=ma relation of Newtonian Physics. The corresponding mksC vector notation is thus (1,1,-2,0). Based on the above procedure, the value of force Y in the British System is obtained by multiplying the mks value of X by ab = 7.232940; the unit of Y is therefore ft lb/s^2. The latter is not the standard unit of f force in the British System, however, but rather the pound force lbf. It is defined as the force on an object which results when a mass 1.0 lb is subjected to an acceleration of g_E = 32.17372 ft/s^2, which is a typical value of the acceleration due to gravity g at the Earth's surface. In mks units this amounts to the product of 0.453597 kg and 9.80654 m/s^2 = c N =4.44822 N. Hence, the lbf is equal to 7.23294 c ft lb/s^2 = 32.17372 ft lb/s^2, which is the same *numerical* value as used above for g_E. In other words, the ratio of the lbf to the standard unit of ft lb/s^2 is directly determined by the value chosen for g_E in the above argument.

Accordingly, the corresponding unit is expressed as kg m s^{-2} in the mks System. It is especially noteworthy that only *integral factors* of the three fundamental quantities appear in each property unit; they can be both positive or negative or zero. As discussed in the following, this characteristic allows one to express the units in terms of three-dimensional vectors in which the elements are the powers of m. kg and s, respectively.

The unit for energy in the mks system is the Joule (J) which is equal to 1 Nm or 1 m^2 kg s^{-2}. The corresponding vector notation is therefore (2,1, -2). The corresponding unit in the British System is 1 ft lbf s^{-2}. The ratio of the energy of 1 ft lbf s^{-2} to 1 J =1 Nm is therefore c/a = 1.35581. This means that, within the British System itself, the standard unit of energy, namely 1 ft lbf s^{-2}, is equal to (c/a) a^{2}b = abc = 32.17372 ft^2 lb s^{-2}, the same numerical value as found in two other ratios already mentioned above.

The physical quantity of power is defined as the ratio of energy to elapsed time. Its mksC unit is watt (W), which is defined to be m^{2}kgs^{-3}, which is (2,1,-3,0) in the corresponding vector notation. In accord with previous definitions given above, the amount of power Y in standard British units, i.e. ft^{2}lbs^{-3} is equal to a^{2}b X (J/s). The most common British unit of power is the horsepower (hp), however, whereby 1 hp/W = d= 745.7. As a result, Y(hp) = da^{2}b X(J/s).

Another key British unit is the BTU or British Thermal Unit of energy. It is equal to 0.293watt hour = 1.0548 J. Finally, in chemistry there is a key relationship between kinetic energy and heat, namely 4.184 J of mechanical energy= 1.0 cal of heat, whereby 1 cal is the energy needed to raise the temperature of 1 gram of water by 1 °C at T =25 °C.

IV. CONCLUSION

In many cases, the conversion of the value of a physical property between the mks System of units and the corresponding British System is accomplished entirely with the aid of two factors, namely a = 3.28084 m/ft and b = 2.2046 lb/kg. In the mks System, each property can be represented as a product of the units of distance (m), inertial mass (kg), time (s) and electric charge (Coul). A four-dimensional vector (i,j,k,l) can be formed in each case, with each of the four integers corresponding to powers of the m, kg, s and Coul, respectively, in the composition of a given property. The corresponding conversion factor is accordingly a^{i}b^j. For example, a speed of X m/s converts to Y = a ft/s in the British System.

The situation with the unit of force is more complex, however, because of the way in which the main unit of force in the British System, the lbf, is defined. It is equal to the force exerted on 1.0 lb of mass by a gravitational field with g_E = 32.17372 ft/s^2. In the mks System, g_E = 9.80654 m/s^2, so the corresponding force is equal to the product of (1/b) and g_E, which corresponds to a force of 4.44822 N. Within the British System itself, therefore, 1 lbf = 32.17372 ft lb/s^2.

The unit of energy in the British System is 1 ft^2 lb /s^2 = 1.35581 J in the mks System, i.e. (4.44822/a) J. A related energy unit in the British System is the British Thermal Unit or BTU. It is equal to 1.0548 J. Finally, the most common unit of power in the British System is the horsepower (hp). It is defined to be equal to 745.7 W.

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