Variations on the Equations of Energy-Work Relation

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Abstract: In classical mechanics, the energy of an object in motion is the form of energy that quantifies the work performed by the object due to its motion and mass. The energy is also transformed into sound energy, thermal energy including heat and light, and material deformation. This paper presents the variations of equations pertaining to the energy-work relationship.

Keywords: motion, deformation, heat, light, sound

Energy-Work Equations

In Newtonian mechanics, kinetic energy, force, and work [1-14] are measured by the mass, displacement, velocity, and, acceleration of a moving object over time.

Displacement is quantified by the linear distance between the initial and final positions of an object in motion. Velocity (v) is the rate of change in the displacement (s) of an object in motion over time (t).

$$v = \frac{\text{displacement}}{\text{time}} = \frac{s}{t} \Rightarrow s = vt. \tag{1}$$

$$a = \frac{v-u}{t} = \frac{v}{t}, \text{where the initial velocity } (u) = 0. \tag{2}$$

$$v^2 = u^2 + 2as \Rightarrow v^2 = 2as, \text{where the initial velocity } (u) = 0. \tag{3}$$

Now, let us prove the variations on the equations of relation between the energy (E) and the work (W) of a moving object given below:

$$(i)\ E = W = \frac{1}{2}mv^2 \text{ and } (ii)\ E = \frac{1}{2}W = \frac{1}{2}mv^2.$$

First, let us prove the equation (i).
The energy of motion, also called kinetic energy, is denoted by the following equation.

$$E = \frac{1}{2}mv^2 \tag{4}$$

By substituting the equation (3) in the equation (4), we get

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m \times 2as = ma \times s = F \times s = W, \text{where } F = ma. \tag{5}$$

From the equation (5), we conclude that

$$E = W = \frac{1}{2}mv^2.$$

Hence, the equation (i) is proved.

Next, let us prove the equation (ii).
Substituting the equations (1) and (2) in the equation (4) as follows:

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m(v \times v) = \frac{1}{2}m\left(\frac{s}{t} \times v\right) = \frac{1}{2}m\left(s \times \frac{v}{t}\right) = \frac{1}{2}ma \times s = \frac{1}{2}F \times s. \qquad (6)$$

From the equation (6), we conclude that

$$E = \frac{1}{2}W = \frac{1}{2}mv^2.$$

Hence, the equation (ii) is proved.
Both equations $E = W = \frac{1}{2}mv^2$ and $E = \frac{1}{2}W = \frac{1}{2}mv^2$ denote the variations.

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