Work and kinetic energy

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We point to a problem with the current generally accepted idea that work $W = \int F \cdot dx$ transfers kinetic energy $KE = (1/2)mv^2$, showing that with exactly the same amount of work, done through a pulley or a lever, different amounts of kinetic energy can be imparted to objects of different masses. We do this without violating the laws of classical mechanics, or the work-kinetic energy theorem $W = \Delta KE$.

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We demonstrate that with the same constant force $\boldsymbol{F} = d\boldsymbol{p}/dt$, applied through the same distance x during time t, through two-disk pulleys, it is possible, to impart different amounts of kinetic energy $KE = (1/2)mv^2$ to objects of different masses. This, without violating Newton's laws of motion, or the work-kinetic energy theorem $W = \Delta KE$.

Three pulleys, with two disks of radii r and $2r$, are mounted on axles anchored on top of a frictionless air table. A block of mass m, $2m$, or $m/2$, is attached to a cord wrapped around a disk of each pulley; another cord, where a constant force $\boldsymbol{F}$ is applied, is wrapped around the other disk, or the same disk, in the case of the block of mass m. This is illustrated in the following figure.

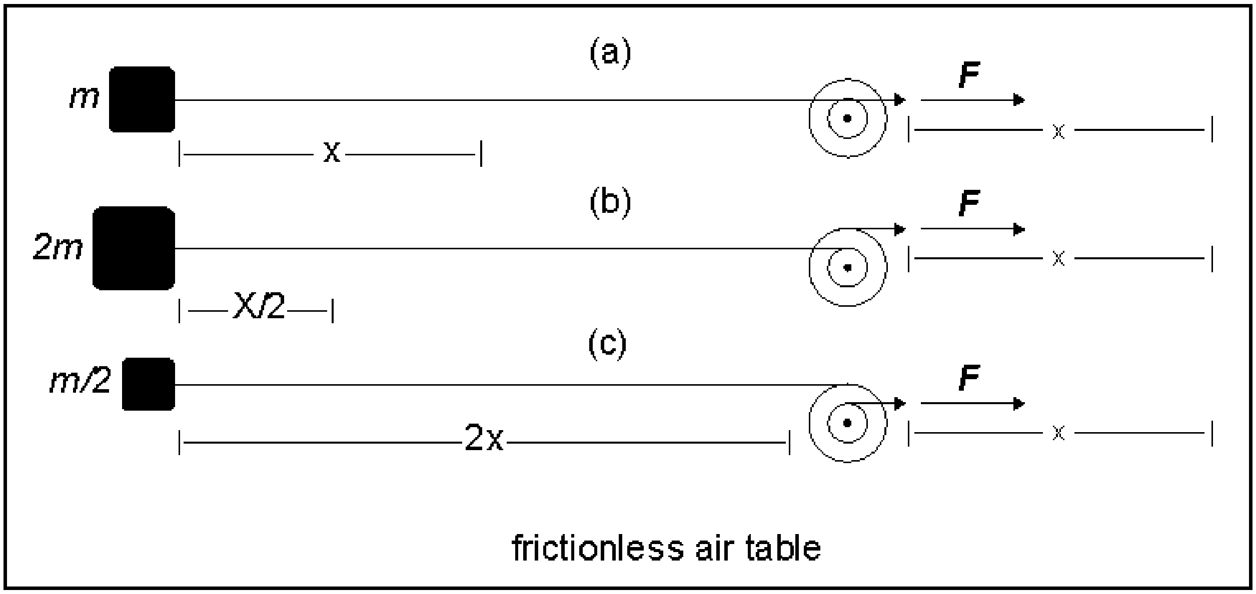

FIG. A person exerts a constant force through distance x in time t. on the loose end of the cord of each pulley, in the direction shown in the figure. Simultaneously, by their respective geometric constraints, the block of mass m is displaced a distance x; the block of mass $2m$ is displaced a distance $x/2$; and, the block of mass $m/2$ is displaced a distance $2x$, as shown in the figure.

To calculate the kinetic energy of the blocks, as customary, for simplicity, we assume the pulleys and cords have negligible mass, the cords are unstretchable, and there is no friction. Since we know the displacements of the blocks, and the time during which the displacements occur, we can find their accelerations, because, acceleration $\boldsymbol{a} = 2x/t^2$; thus, the acceleration of the blocks are, respectively, $\boldsymbol{a}_{(a)} = 2x/t^2$, $\boldsymbol{a}_{(b)} = 2(x/2)/t^2$, and $\boldsymbol{a}_{(c)} = 4x/t^2$. Since we also know the masses of the blocks, we can find the force that acts on them, i.e., $\boldsymbol{F}_{(a)} = m2x/t^2$, $\boldsymbol{F}_{(b)} = 2mx/t^2$, and $\boldsymbol{F}_{(c)} = (m/2)4x/t^2$, which we see are equal. Therefore, by the work-kinetic energy theorem, the kinetic energies of the blocks are, respectively,

$$K_{(a)} = m2x^2/t^2 = max, \tag{1}$$

$$K_{(b)} = 2m2(x/2)^2/t^2 = (1/2)max, \qquad (2)$$

and

$$K_{(c)} = (m/2)2(2x)^2/t^2 = 2max, \qquad (3)$$

which are different, and shows that work does not transfer kinetic energy, because, if that were true, every time a person or other agent exerts the same constant force $\boldsymbol{F}$ though the same distance x, equal amounts of kinetic energy would be transferred. The problem we have described originated in about 1829, when Gaspard-Gustave de Coriolis, a French mathematician and engineer, defined *work* in the same terms as kinetic energy, believing that *work* transferred kinetic energy. If *work* had been defined, perhaps more logically, as force times time, it would have become evident that *work* does not transfer kinetic energy, and this problem would not exist.

The results we have obtained do not violate the law of conservation of energy: this law is only valid in closed, isolated systems, and these results suggest that we are not in such a system.

The foregoing is part of a theory, currently in preparation, based on the premise that to do *work* or any activity, energy in some form is always required.

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