275. Change of Kinetic Energy due to Mutual Action of Two Particles, and Loss of Kinetic Energy by Collision

Author(s): A. L. Bowley

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MATHEMATICAL NOTES.

275. [R. 6.] *Change of Kinetic Energy due to Mutual Action of two Particles, and loss of Kinetic Energy by Collision.*

If an action and reaction of any kind take place between two particles, the changes of momentum may be written :

$$I = m(u_1 - u_2) = m'(v_2 - v_1),$$

where m, m' are the masses, u_1, v_1 velocities before and u_2, v_2 velocities after the action.

Let V_1, V_2 be the relative velocities before and after, so that $V_1 = u_1 - v_1$, $V_2 = u_2 - v_2$.

$$\text{Then } I(m + m') = mm'(v_2 - v_1 + u_1 - u_2) = mm'(V_1 - V_2).$$

$$\text{Loss of Kinetic Energy} = \frac{1}{2}m(u_1^2 - u_2^2) + \frac{1}{2}m'(v_1^2 - v_2^2)$$

$$= \frac{1}{2}I\{(u_1 + u_2) - (v_1 + v_2)\}$$

$$= \frac{1}{2}I(V_1 + V_2)$$

$$= \frac{1}{2} \frac{mm'}{m + m'} (V_1^2 - V_2^2).$$

Hence, in general, there is loss of K.E. in all cases where the relative velocity is diminished, and a gain in cases (*e.g.* attraction) where the relative velocity is increased.

In cases of impact, where Newton's coefficient of restitution applies,

$$V_2 = -e V_1,$$

$$\text{and loss of K.E. is } \frac{1}{2} \cdot \frac{mm'}{m + m'} \cdot V_1^2(1 - e^2),$$

which is positive since $0 < e < 1$.

Univ. Coll., Reading.

A. L. BOWLEY.

[This method was certainly familiar at Cambridge in 1889, and was given by Mr. R. R. Webb to his pupils. It was, I believe, due to Professor Greenhill, who has drawn attention to it by examination questions at the University of London and elsewhere.

The physical meaning of I is the blow or impulse Pt between the colliding bodies, t being the time the collision lasts, and P the average pressure.]

C S. J.

276. [A. 1. b.] *On certain Algebraical Factors.*

Let there be given a quadratic equation $ax^2 + bx + c = 0$ ($P = 0$), in which a, b, c are known coefficients. Then we can write

$$(\alpha) \dots \dots \dots ax^2 = -(bx + c) \dots \dots \dots (\alpha'),$$

$$(\beta) \dots \dots \dots bx = -(ax^2 + c) \dots \dots \dots (\beta'),$$

$$(\gamma) \dots \dots \dots c = -x(ax + b) \dots \dots \dots (\gamma'),$$

and any arbitrarily manipulated equation such as $\phi(\alpha, \beta', \gamma) = \phi(\alpha', \beta, \gamma')$ is satisfied by the values of x given by $P = 0$. Consequently

$$\phi(\alpha, \beta', \gamma) - \phi(\alpha', \beta, \gamma')$$

contains P as an algebraic factor.