Task. A bullet of mass $m = 12$ grams enters a piece of wood travelling at a speed of $v_0 = 500$ m/s. It exits from the piece of wood at a speed of $v_1 = 190$ m/s. Calculate the average force exerted by the wood on the bullet if the thickness of the wood is $d = 5$ cm.

Solution. Assume that the bullet moved with constant acceleration a. Then the average force will be equal to $F = ma$.

Let t be the time taken for the bullet to come through the wood. Then

$$a = \frac{v_1 - v_0}{t},$$

whence

$$v_1 - v_0 = at.$$

On the other hand, since the bullet is moved with constant acceleration, the distance d is equal to

$$d = v_0 t + \frac{at^2}{2} = v_0 t + \frac{t}{2} \cdot at = v_0 t + \frac{t}{2} \cdot (v_1 - v_0) = v_0 t + \frac{v_1 t}{2} - \frac{v_0 t}{2} = \frac{(v_0 + v_1)t}{2}.$$

Hence

$$t = \frac{2d}{v_0 + v_1}.$$

Therefore

$$a = \frac{v_1 - v_0}{t} = \frac{(v_1 - v_0)(v_0 + v_1)}{2d} = \frac{v_1^2 - v_0^2}{2d},$$

and the average force is equal to

$$F = ma = m\frac{v_1^2 - v_0^2}{2d}.$$

Substituting values we obtain the average force:

$$F = 0.012 * \frac{190^2 - 500^2}{2 * 0.05} = \frac{0.012 * (-213900)}{0.1} = -25668N.$$

The sign "$-$" means that the direction of force is opposite to the velocity.