Answer Question #69003 Physics – Mechanics – Relativity

An 8.0 gram bullet is shot into a 4.0 kg block, which is initially at rest, on a frictionless horizontal surface. The bullet remains lodged in the block. The block moves into a spring and compresses it by 5.1 cm. The spring constant of the spring is 1900 N/m. What is the initial velocity of the bullet?

Solution. Let the initial velocity of the bullet $\vec{v}$. After the impact of the bullet and block system speed will be $\vec{u}$. Using the law of conservation of momentum get (for a positive direction choose the direction of flight of a bullet strike consider inelastic)

$$m\vec{v} = (m+M)\vec{u} \to u = \frac{mv}{m+M} \text{ ($\vec{v}$ and $\vec{u}$ have same direction)}$$

where $m = 0.008$kg – bullet mass, $M = 4.0$kg – block mass.

Using the law of conservation of energy. The kinetic energy of the system bullet-block is converted into potential energy of the spring

$$\frac{(m+M)u^2}{2} = \frac{kx^2}{2}$$

where $k = 1900\frac{N}{m}$ – constant of the spring, $x = 0.051$m – the amount of compression of the spring. As result get

$$\frac{(m+M)}{2}\frac{m^2v^2}{(m+M)^2} = \frac{kx^2}{2} \to \frac{m^2v^2}{m+M} = kx^2 \to v = \frac{x}{m}\sqrt{k(m+M)}$$

$$v = \frac{x}{m}\sqrt{k(m+M)} = \frac{0.051}{0.008}\sqrt{1900(0.008+4)} \approx 556.3\frac{m}{s}$$

Answer: $v = 556.3\frac{m}{s}$.