Can a person be blown away by a bullet?

Let's say a bullet of mass 0.06 kg is moving at a velocity of 300 m/s. And let's also say that it embeds itself inside a person. Could this person be thrust back at high speed (i.e. blown away)?

To solve this assume the mass of the person is, say, 70 kg.

Apply conservation of linear momentum to the bullet and person, between the point just before the bullet strikes the person, and after it embeds inside the person (so that bullet + person both have the same final velocity).

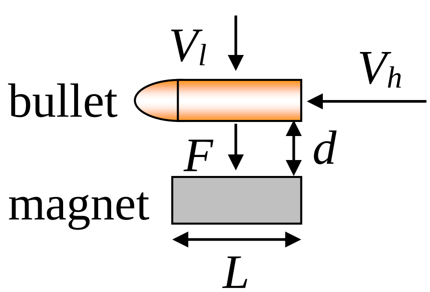
We have,

$0.06(300) + 70(0) = (70+0.06)V$

where V is the velocity of the bullet + person after the bullet embeds in the person. Solve for V = 0.26 m/s. This speed is far too low to cause the person to be "blown away".

Can a watch-sized electromagnet deflect a bullet? (from James Bond movie)

To analyze this let's say a bullet flies past a watch as shown in the figure below, with dimensions as shown.



For example, let's say the bullet moves at V_h = 300 m/s and we wish to deflect it a significant amount so that it misses its mark completely. If the intended target of the bullet is the one wearing the magnetic watch then the bullet would have to deflect a great deal to avoid hitting the target. So let's reasonably say the bullet would have to be deflected by an angle of 45°. This means that the lateral speed of the bullet (V_l) would be equal to the horizontal bullet speed (V_h). So V_l = 300 m/s. Before the bullet passes by the watch, its lateral speed is zero. As it passes by the watch the lateral bullet speed would have to be increased to 300 m/s. This means that the magnetic force of attraction F between bullet and watch would have to be very large in order to cause such a rapid lateral speed increase in the short time period it takes the bullet to pass by the watch. To maximize the magnetic force the bullet would have to pass as close as possible to the watch, so d would have to be as small as possible.

If we suppose the watch is L = 2.5 cm in diameter, then it takes the bullet 0.025/300 = 8.33×10^{-5} seconds to pass by the watch. Let's also suppose the mass of the bullet is 0.06 kg.

To solve for the force F we can use the impulse and momentum equation: $F\Delta t = mv_2 - mv_1$, where F is the average lateral force pulling on the bullet during the bullet pass, Δt is the time duration of the pass, m is the mass of the bullet, v_1 is the lateral bullet speed before the pass, and v_2 is the lateral bullet speed after the pass. Using the variables given previously, we have $F(8.33 \times 10^{-5}) = 0.06(300) - 0.06(0)$. Solving for F we get F = 216,000 N. This is equal to 22 tons! Clearly a watch sized magnet cannot even come close to sufficiently deflecting a bullet.

Note that a magnetic force varies with the inverse cube of the distance from the magnet. This means that the magnetic force F can only be high when the bullet is in very close proximity to the watch. This proximity requirement is approximately modeled by assuming that the magnetic force F is only acting on the bullet while it passes over the watch. In reality the magnetic force would also be acting on the bullet while it is some distance away from the watch, but in the calculations we assume that the force is only acting on the bullet as it passes over the watch, which is a reasonably good approximation.

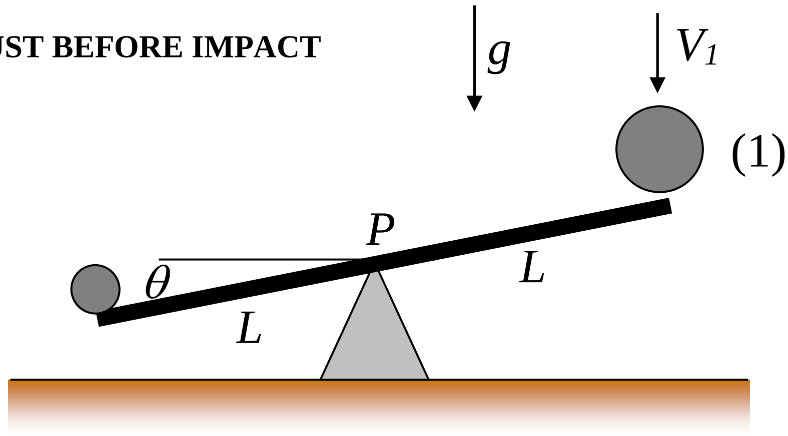
Could a skydiver whose parachute failed to open hit a playground seesaw and send a small girl flying seven stories high, and she could still survive?

We shall assume a conservative case where the skydiver does not rebound off the seesaw and instead "sticks" to it right after impact.

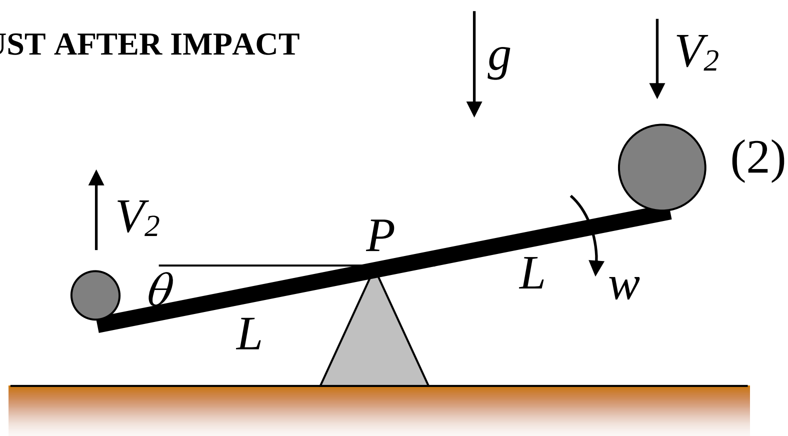
We can apply conservation of angular momentum to analyze this problem between stages (1) and (2) as shown in the figures below, with variables shown. The larger ball on the right represents the skydiver. The smaller ball on the left represents the girl.

The angle θ is small, which is a good approximation for the typical seesaw.

JUST BEFORE IMPACT



JUST AFTER IMPACT



Apply the conservation of angular momentum equation about point *P*, between stages (1) and (2)

$$m_s V_1 L = m_s V_2 L + m_g V_2 L + I_P w$$

Where:

m_s is the mass of the skydiver

m_g is the mass of the girl

V_1 is the velocity of the skydiver just before he impacts the seesaw

V_2 is the velocity of the skydiver (and girl) just after the skydiver impacts the seesaw

L is the distance from the pivot point P to the ends of the seesaw where the skydiver and girl are located

I_P is the rotational inertia of the seesaw about point P, which coincides with the center of mass of the seesaw (by assumption)

w is the angular velocity of the seesaw just after impact

Now, $w = V_2/L$ from the geometry. The above equation then becomes

$$m_s V_1 L = m_s V_2 L + m_g V_2 L + I_P (V_2 / L)$$

Solve for V_2.

$$V_2 = \frac{m_s V_1 L}{m_s L + m_g L + I_P / L}$$

As a reasonable approximation treat the seesaw as a slender rod, where

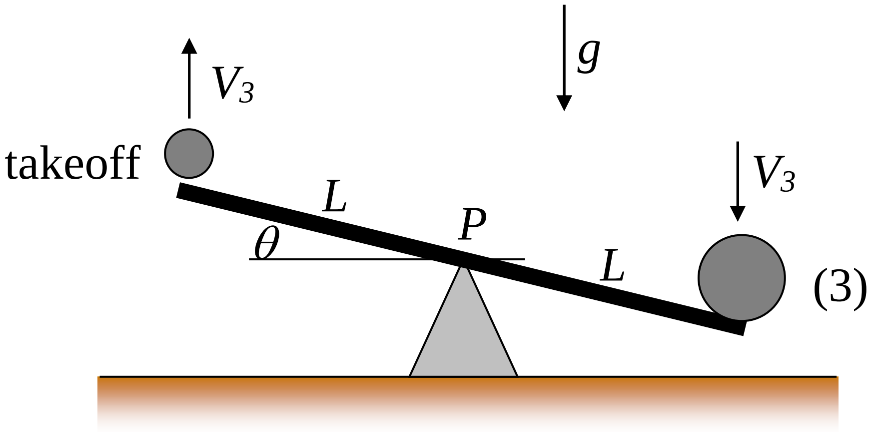
$$I_P = \frac{1}{12} m_r (2L)^2 = \frac{1}{3} m_r L^2$$

where m_r is the mass of the seesaw. It follows that

$$V_2 = \frac{m_s V_1}{m_s + m_g + \frac{1}{3} m_r}$$

Suppose we have V_1 = 120 mph (approximate terminal speed of skydiver), m_s = 80 kg, m_g = 30 kg, and m_r = 100 kg. Then from the above equation we have V_2 = 67 mph.

The figure below shows the takeoff point of the girl. This is stage (3).



At takeoff, the girl leaves the seesaw at $V_3 = V_2$ (approximately). There is very little time for the velocity of the girl on the seesaw to change beyond V_2 given the high V_2 velocity after impact (which quickly rotates the seesaw). This results in a negligible velocity change for the girl, between the time the impact occurs and when the girl takes off. Since we are considering a conservative case (sticking upon impact) then V_3 is the minimal takeoff velocity of the girl.

Now, 67 mph = 30 m/s, which results in a peak height reached of 46 meters, assuming negligible air resistance and the girl flying straight up (a good approximation given a small angle θ). This height is much greater than seven stories so the myth is indeed possible. However, unless she lands somewhere soft she is unlikely to survive the fall. This is in addition to the sudden upward acceleration, at takeoff, which can fatally injure her as well