Journal of Physics Special Topics
An undergraduate physics journal

# A5_2 The recoil of a 'flashlight'

M.J. Pitts, R. Howe, R. Javaid, F.R.J. Scanlan

*Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH*

December 10, 2017

**Abstract**

We investigate the effectiveness of the lasgun from Games Workshop's *Warhammer 40,000* as a firearm by analysing the recoil on the weapon compared to a modern equivalent. Using the radiative attenuation equation we calculate that the lasgun would have a recoil velocity of $3.20\text{x}10^{-7}$ $\text{ms}^{-1}$, making it more accurate than the M16 assault rifle's 1.55 $\text{ms}^{-1}$, but less effective against armor due to the laser's low energy.

## Introduction

In *Wahammer 40,000* the Lasgun, affectionately known as the flashlight by tabletop players for it's complete inability to damage anything, is the standard issue weapon in the Imperium of Man's military. In the games very detailed lore, the Lasgun is painted as a fairly effective weapon against lightly armored targets, but as almost useless against the mechanical and organic monstrosities that inhabit the *Warhammer 40,000* universe. The weapon itself is fairly simple, firing a concentrated laser pulse at the target: we look at its effectiveness compared to modern day equivalents such as an M16 assault rifle.

## Theory

In order to estimate the energy of the Lasgun's laser we shall use an example from the Warhammer books. A Lasgun is stated as being able to blow an unarmored human's arm off at close range [5]. We shall make the assumption that close range means attenuation due to the atmosphere is negligible and we shall assume that the energy needed to blow off a human's arm is the amount require to vaporize all the water in the part of the arm hit by the laser. The energy was calculated using the equations for heat capacity and the latent heat of vaporization [1].

$$\Delta E = C\pi r^2 \Delta x \rho \Delta T + \pi r^2 \Delta x \rho L_v \qquad (1)$$

Where $\Delta E$ is the energy lost from the laser, $r$ is the laser radius, $\Delta x$ is the estimated depth of a human upper arm, $C$ is the heat capacity of water, $L_v$ is the latent heat of vaporization of water and $\rho$ is the density of water. The proportion of the laser's energy absorbed was calculated using the radiative attenuation equation, which can be written with energies instead as energy is proportional to intensity [2][1].

$$I = I_0 e^{-\mu \Delta x} \rightarrow E = E_0 e^{-\mu \Delta x} \qquad (2)$$

Where $E_0$ and $I_0$ are initial energy and intensity respectively, $E$ and $I$ are energy and intensity at distance $\Delta x$ respectively and $\mu$ is the absorption coefficient. Rearranging equation (2) and using the fact that $E_0 - E = \Delta E$ gives an equation for the initial laser energy.

$$E_0 = \frac{\Delta E}{1 - e^{\mu \Delta x}} \qquad (3)$$

Using the equations for the momentum and energy of photons and the non-relativistic momentum equation, an equation for the recoil velocity of a Lasgun was found [1].

$$v_r = \frac{E_0}{cm} \tag{4}$$

Where $v_r$ is the recoil velocity, $c$ is the speed of light and $m$ is the mass of a Lasgun.

**Analysis**

In order to calculate the Lasgun's recoil several assumptions were made. To find the energy the beam had to lose to the arm in order to vaporize all water in it we assumed that the arm was made up of 70% water and we negated all other substances in the arm. We assumed that the depth of a human upper arm was $\Delta x = 0.14$ m (estimated for a muscular male). the other values used for the equation were: $C = 4184$ $\text{Jkg}^{-1}$, $\rho = 1$ $\text{kgm}^{-3}$ and $L = 2.26\text{x}10^6$ $\text{Jkg}^{-1}$. This gave an energy of $\Delta E = 77.7$ J required to blow a human arm off [1]. Equation (3) was then used to calculate the initial laser energy required to deposit this amount of energy into the arm. In order to calculate this the absorption coefficient at the Lasgun's emitted wavelength had to be found. various sources state different laser colours for the Lasgun, the one we shall use is a red laser at 750 nm based on the appearance of the Lasgun's beam in the game *Dawn of War 2* [3]. Water att this wavelength has an absorption coeficient $\mu = 3$ $\text{m}^{-1}$ [4], which gives an initial laser energy of $E_0 = 226$ J. Finally we used equation (4) to determine the velocity of recoil of a Lasgun. To do this we used the typical mass of a standard issue Lasgun of $m = 2.3$ kg [5]. This gives a recoil velocity of $v_r = 3.20\text{x}10^{-7}$ $\text{ms}^{-1}$.

**Discussion**

Compared to a modern weapon assault rifle, the Lasgun would be an incredibly stable weapon. The M16 has a recoil velocity of 1.55 $\text{ms}^{-1}$ [6] making it only accurate for short bursts. The Lasgun, however, has an almost non-existent recoil velocity meaning it could maintain almost perfect accuracy while firing continuously. However it's effectiveness in the 41st millennium would be limited. Against an unarmoured organism it would be incredibly effective; however when facing down a horde of Orks, who have a nasty habbit of nailing a couple of inches of solid cast iron plating to themselves, it would be almost useless. Metal, and other armor, will simply absorb the laser pulse and, while possibly melting a small hole in it, the laser is unlikely to pass through due to the high melting point and latent heat of melting of cast iron with enough energy to cause sufficient damage. Using equation (1) the energy required for a Lasgun to melt through a $\Delta x = 5$ cm thick piece of cast iron with $C = 460$ $\text{Jgk}^{-1}$,$\rho = 7800$ $\text{kgm}^{-3}$, $\Delta T = 1200^o$C and $L_m = 126,000$ $\text{Jkg}^{-1}$ would be $\Delta E = 83070$ J [7].

**Conclusion**

From this we can conclude that while the Lasgun would be a much more effective weapon against unarmored targets than the M16 it would be much less effective against any protected organisms or machines. While an M16's bullet may pierce a metal plate, a Lasgun's laser will not penetrate even a thin sheet of metal.

**References**


[1] P.A.Tipler, G.Mosca, TextitPhysics for Scientists and Engineers

[2] `goo.gl/XFgkj9` [accessed 21-11-2017]

[3] Relic Entertainment, Feral Interactive, THQ, SAGA, *Dawn of War 2*

[4] Pope.R.M.,Fry.E.S. (1997), *Absorption spectrum (380700 nm) of pure water.*, Applied Optics, 36 (33): 87108723

[5] Games Workshop, *Warhammer 40,000 6th edition Rulebook*

[6] `http://kwk.us/recoil.html` [accessed 21-11-2017]

[7] `https://goo.gl/Cz8ePs` [accessed 21-11-2017]