Design Graphics Team Project
Fall 2020

Reverse Engineering a Toy Nerf Gun

Nerf Rebelle

Audrey Pick - *Team Leader*
17295
(audreygpick@gmail.com)

Owen Mann
17350
(owen.mann@utexas.edu)

Keri Christian
17350
(keri.em.christian@gmail.com)

Justin Campbell
17350
(campbelljustin989@gmail.com)

Brenna Hurley
17295
(hurleybren@gmail.com)

Lab Instructor: Mark Chiarello

Discussion of Mass Properties Analysis Report

The plastic casing of the gun was selected as the part for the generation of a mass properties analysis report because, by enclosing all of the sub-assemblies in the device, it is what the child makes physical contact with more so than any other part during its use. The plastic casing will be manufactured out of an ABS plastic material because it facilitates high strain resistance and yield strength that will make the gun durable, and well-suited for exposure to mechanical wear and tear from child play. Additionally, the material is a good thermal insulator, and therefore, the performance of the gun will behave under a variety of outdoor environments.

The first of three mass properties that will be discussed in this report is the mass of the plastic casing. According to Newton's Second Law, mass is an intrinsic property that measures the ability of an object to resist changes in motion under applied loads. In this context, then, it can be realized that it is important to optimize the mass of the plastic casing to ensure that the user will be able to comfortably maneuver the gun during its occupation. The second mass property that will be discussed is the volume. It is important to take this property into account in the design to ensure that the exterior boundary surfaces of the gun are streamlined in size for the user. Lastly, the second moment of inertia of the plastic casing about the x-axis (identified in the figure below) will be examined to gain a solid understanding of the object's tendencies to resist rotation about the axis of the barrel, thus influencing the trajectory of the bullet.

Analysis of Mass Properties Here

Mass is important both from the standpoint of Newton's Second Law and manufacturing. The mass should be sufficient enough to resist acceleration from the bullet firing and to maintain a good change of momentum for the bullet's initial velocity. The mass of the case is 0.5 lbs, which is a good size as it can easily be held by a child (**Figure 5.2**).

In addition, the volume, or the space that a shape occupies, is an important consideration in the manufacturing of the toy gun. In our case, the volume of the toy is 1.34 cubic inches which is ideal for the standard user (**Figure 5.2**). The volume of the gun greatly affects the holding and maneuvering of the toy, and this user experience is of utmost importance. The volume is especially important for the vacuum seal created in the handle portion of the gun, as it affects the displacement of the springs which determine the kinetic energy given to the bullet when it fires. Moreover, the volume is an important consideration when determining the various subsystems that are to be enclosed in the case, and an appropriate volume perfectly encloses each part without compromising their performance!

Lastly, from the derivation from Newton's second law, torque = mass moment of inertia multiplied by the angular acceleration. Therefore, the mass moment of inertia is important to understand any possible rotation and how the case will resist it, as we want the gun to fire straight. The mass moment of inertia taken about the x axis from the mass properties is 0.22 lb-in^2 (**Figure 5.2**) This is ideal as a larger mass moment of inertia entails less rotation, so the design of the case overall will minimally rotate along the axis most affected by the firing of the gun (**Figure 5.1**).

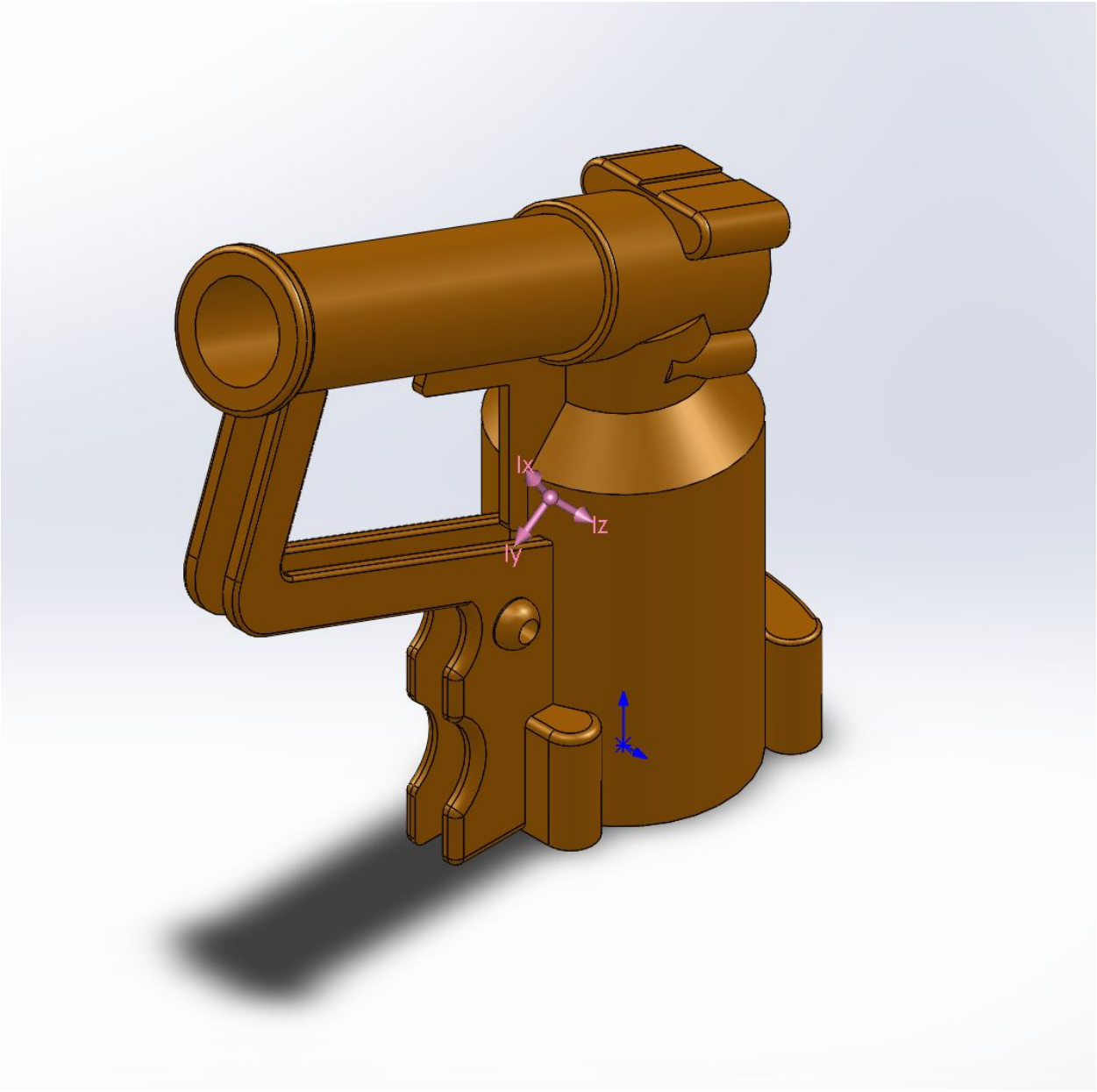

Figure 5.1 Plastic case with the center of mass, origin, and the axes of inertia.

Mass Properties Report

Mass properties of PLASTIC_CASE_fixed_barrel (1)							
Configuration: Default							
Coordinate system: -- default --							
Density = 0.04 pounds per cubic inch							
Mass = 0.05 pounds							
Volume = 1.34 cubic inches							
Surface area = 37.68 square inches							
Center of mass: (inches)							
	X = 0.00						
	Y = 1.55						
	Z = 0.45						
Principal axes of inertia and principal moments of inertia: (pounds * square inches)							
Taken at the center of mass.							
	Ix = (0.00,	Px = 0.03					
	Iy = (0.00,	Py = 0.08					
	Iz = (1.00,	Pz = 0.09					
Moments of inertia: (pounds * square inches)							
Taken at the center of mass and aligned with the output coordinate system.							
	Lxx = 0.09	Lxy = 0.00	Lxz = 0.00				
	Lyx = 0.00	Lyy = 0.04	Lyz = 0.02				
	Lzx = 0.00	Lzy = 0.02	Lzz = 0.06				
Moments of inertia: (pounds * square inches)							
Taken at the output coordinate system.							
	Ixx = 0.22	Ixy = 0.00	Ixz = 0.00				
	Iyx = 0.00	Iyy = 0.05	Iyz = 0.06				
	Izx = 0.00	Izy = 0.06	Izz = 0.18				

Figure 5.2 The Mass Analysis with the Mass Properties Discussed Highlighted