BCER Engineering, Inc.

Scholarship Contest
Mechanical Engineering

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Proposal by
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Executive Summary:

The scope of the problem consists of creating a human powered fan to be connected to a piece of plastic piping with the ability to raise a ball to a maximum height. The fan can only be made of wood, rope, cardboard, duct tape, and glue.

In an effort to meet these challenges I have created a design that should be quite effective. The basis of the design centers on the unique fan blade design. As the blade diameter increases, so does the blade area, while maintaining a shallow blade pitch. A ring concentric to the hub of the fan supports the blade tips. This allows for a lighter blade design without worry of destruction. As can be noticed from the attached figures, this design is implementing two fans stacked in series to provide more pressure. The device will be powered by a bicycle via chain to sprocket to worm gear to pulley to v-belt to the pulley built into the fan. The fan will be comprised primarily of wood. Different kinds of wood have been selected for different parts of the fan based on function.

This is a very promising design and should prove to perform well.

Analysis:

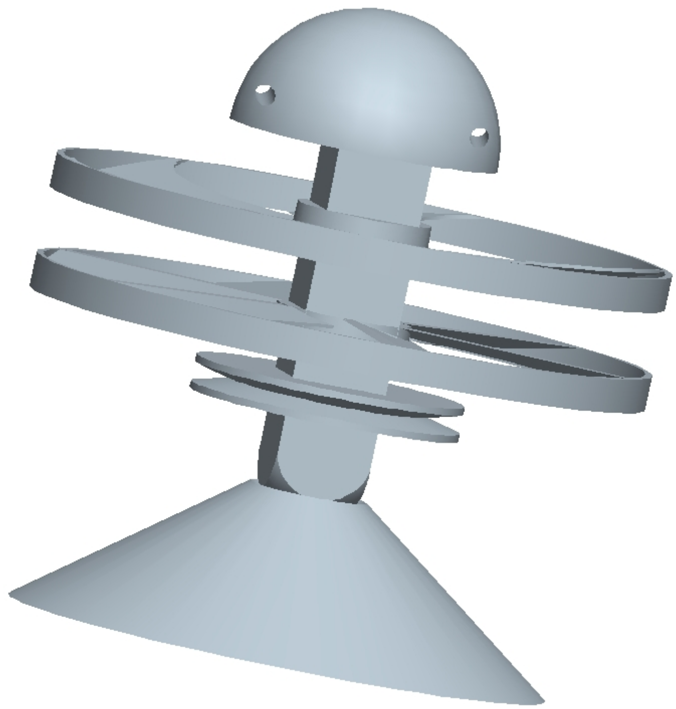
The unique design properties of this fan will allow it to accomplish the goals intended. The shallow blade pitch will allow for a high cfm flow rate, which is very important for the ping-pong ball test. The air from the fan will attempt to escape around the ping-pong ball because of its small relative size to the tube. The design implements a stacked dual fan system. This will increase the pressure but will not increase the cfm. Pressure can be considered for the larger balls, especially the tennis ball, because their size will allow them to seal fairly well with the tube. This fact allows pressure to be used instead of wasted. The increased pressure bellow the ball will cause it to rise.

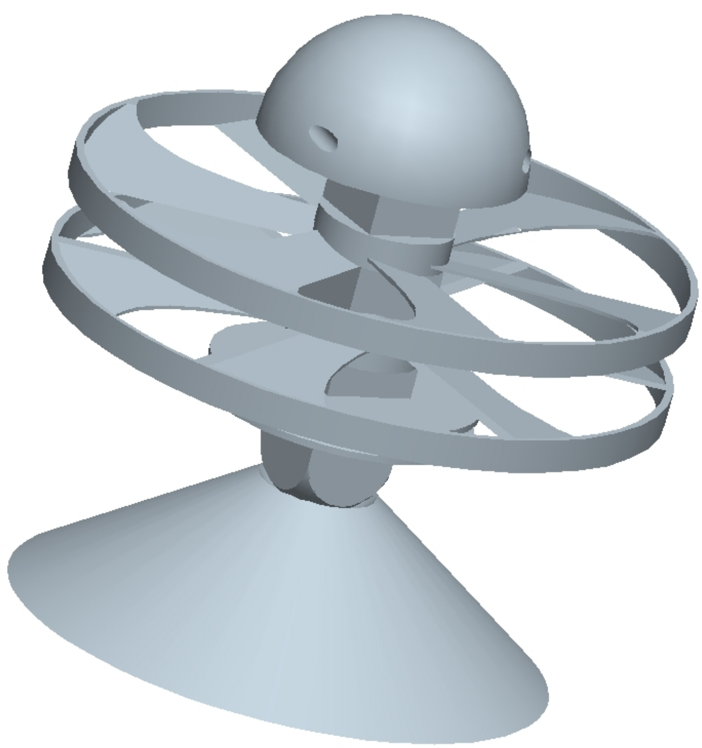
Balsa wood will be used for the blades to provide a smaller moment of inertia for the system. The blades will most likely be braced by smaller rectangular pieces of wood. The outer ring of the blades, the fan hub and the pulley will most likely be made out of oak because of the availability and price of oak. The joining "drive shafts," base and top will be made out of lignum vitae. Lignum vitae, also known as ironwood, is a very dense and strong wood. This makes it very desirable for the joining drive shafts. It also contains a naturally oily resin. The density and oily resins make it a great candidate for bearings.

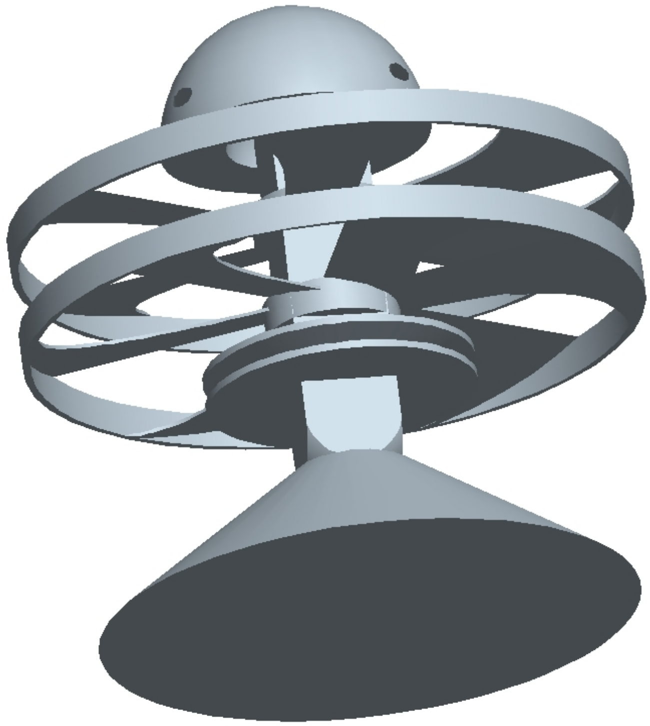
A worm gear will be used for the drive train connected to the bicycle because of its large gear ratio. This will be used to increase the speed of the fan. With increased speed, the fan will provide increased cfm.

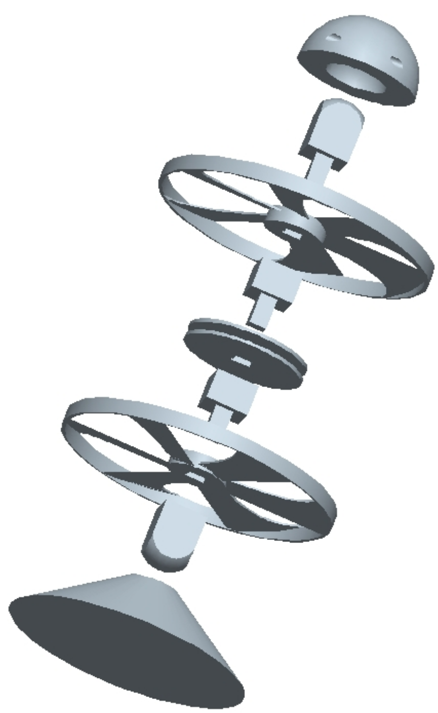
The fan will be contained in a box made of wood for support and seal to the tube. Slots will be cut into the bottom of the box below the lower fan for the air intake. The box will be cylindrical in shape to match that of the blade assembly. The box will be connected to the tube with cardboard and duct tape, forming an inherent expander, allowing for even more cfm flow (at the expense of pressure). The top piece (bearing cap) of the fan assembly will have holes drilled in it for a rope go through and attach to the box, holding the cap down and thus everything in place.

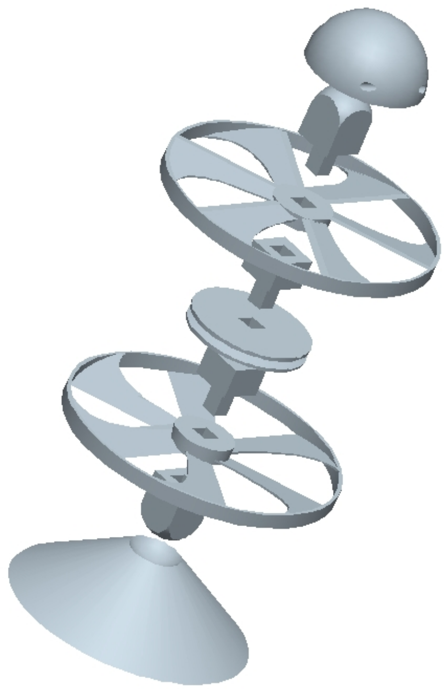
Appendix A Pictures











Appendix B Calculations

For an airfoil:

L = lift c_l = lift coefficient ρ = air density V = air velocity A = wing are

$L = c_l * 1/2 * \rho * V^2 * A$

So, applied to fan design, the more lift provided, for all other factors as constant, air velocity is increased directly.

Fan total efficiency = Total Pressure Rise * Volumetric Flow-rate / Shaft Power

So, pressure and cfm (volumetric flow-rate) both contribute to the fans efficiency, but they are inversely proportional to each other.

Velocity can also be related to the static pressure by $V = \sqrt{\frac{2(P_o - P)}{\rho}}$

Calculating the maximum shear forces for a square versus a circular driveshaft with equivalent cross-sectional areas:

$A_{sq} = x^2 \qquad A_{cir} = \pi \cdot r^2 \qquad A_{sq} = A_{cir} \qquad x^2 = \pi \cdot r^2$

$$T_{max_{sq}} = \frac{1}{.208 \cdot x^2} = \frac{1}{\left(.208 \cdot \pi \cdot r^2\right)} = \frac{1.4074}{r^2}$$

$$T_{max_{cir}} = \frac{1}{\frac{\pi}{2} \cdot r^3} = \frac{.6366}{r^3}$$

Therefore, a rectangular driveshaft will be able to withstand more shear force before breaking than will a cylindrical one.