At the 2008 Air Venture air show in Oshkosh, WI the Martin Aircraft Company of New Zealand demonstrated what they call "The World's First Practical Jetpack". The pack (shown below left, photo courtesy Martin Aircraft Company) weighs 250 lbs and consists of two 1.7-foot diameter fans powered by a 200 hp engine. Ten years earlier at the 1998 Air Venture show, the GEN Corporation of Japan debuted an ultralight personal aircraft that is now sold as the GEN H-4, distributed in the United States by Ace Craft (shown below right, photo courtesy GEN Corporation). This helicopter-like device weighs 155 lbs and consists of a 157-inch diameter rotor assembly powered by four 10 hp engines (for a total of 40 hp available). In this problem we will investigate the reason that the Martin Jetpack requires substantially more horsepower than the GEN H-4.

a.) The thrust provided by fans is related to how much air mass they can move and how fast they can get the air moving. As a crude approximation, assume that the fans of these two aircraft move a cylindrical column of air that has a cross-sectional area equal to the area of the circle swept out by the fan (πr^2 if r is the radius of the fan/rotor blades). Suppose the air (which has density ρ) is initially at rest, and that the fans give the air that passes through them a uniform speed v. Which of the formulas below correctly expresses the rate at which (air) mass passes through a fan (how many kg of air pass through a fan in one second)? Circle the correct answer.

ρv $\rho \pi r^2 v$ $\rho \pi r^2 / v$ $\rho v / (\pi r^2)$ $\rho / (\pi r^2 v)$

b.) Write a symbolic formula for the magnitude of the momentum given to the air per unit time by a fan and also for the kinetic energy given to the air per unit time.

c.) Suppose that the GEN H-4 was hovering above the ground (not accelerating) so that the thrust is balancing the weight. The total weight of the craft plus pilot is W. Give a symbolic expression for the minimum engine power required to achieve this that DOES NOT involve the air exit-speed v. The expression should use only the density of air, the area of the fan and the weight of the craft plus pilot. (To find the minimum power, assume the engine is producing only the energy that is given to the air as kinetic energy.)

d.) How would your expression from (c) have to be modified for the Martin Jetpack which has two fans?

e.) Suppose each craft was floating (not accelerating) with a load of 200 lbs aboard. What is the ratio of the power required to keep the Martin Jetpack afloat to the power required to keep the GEN H-4 afloat? Give a numerical answer.

f.) GEN Corporation claims that the GEN H-4 can hover with only three engines operating. Do our calculations support that claim? Explain your answer.