FLUIDS

Unit 18 Dr. John P. Cise, Professor of Physics, Austin Com. College, 1212 Rio Grande St., Austin Tx 78701 jpcise@austincc.edu & New York Times , July 1, 2016 by Nicholas St. Fleur

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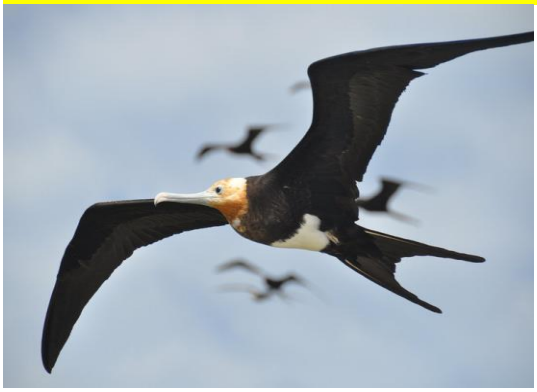
A Roller Coaster in the Sky for Frigatebirds



NASA: Aerodynamic lift requirements: An aircraft's (**a bird possibly**) lift capabilities can be measured from the following formula:

$$L = (1/2)\, d\, v^2\, s\, CL$$

- **L** = **Lift, which must equal the airplane's weight in pounds**
- **d** = density of the air. This will change due to altitude. These values can be found in a I.C.A.O. Standard Atmosphere Table.
- **v** = velocity of an aircraft expressed in feet per second
- **s = the wing area of an aircraft in square feet**
- **CL** = Coefficient of lift , which is determined by the type of airfoil and angle of attack.

A frigatebird can stay aloft for two months by riding on air currents. CreditHenri Weimerskirch

Frigatebirds are high-flying thrill-seekers that can stay in the air for two months without needing to come down. They can also travel more than 250 miles a day, reach altitudes as high as two-and-a-half miles and glide 40 miles without ever flapping their wings. To them, the ocean air is an amusement park with one rule: You must be this light to enjoy this ride. **Frigatebirds weigh between two and four pounds and have wings spanning more than seven feet, giving them the highest ratio of wing size to mass of any bird.** They typically live on coastlines and islands in the Pacific and Indian Oceans. **Canada geese, for comparison, have wingspans of about six feet but weigh almost 15 pounds.** With their light frames and relatively large wings, the frigatebirds enter their theme park by swooping beneath a fluffy cumulus cloud about 100 feet above the water's surface. There, rising currents of warm air pull the birds thousands of feet high in a corkscrew motion. The thermals are so strong that the birds don't need to flap their wings. They can just throw them up and enjoy the ride. "The heat pulls them up from the air, and they use this force to climb," said Henri Weimerskirch, an ornithologist from the National Center for Scientific Research, in Paris, and an author of the paper in Science. "What we showed is how they use this convection to fly." For most frigatebirds the ride ends once they soar to the base of the cloud, which is around 2,000 feet high. That's when they will finally flap their wings to fight against the turbulence and exit. From there they will fly downward with the winds for about 11 miles without flapping until they find another rising air current. Ride, glide and repeat. The reason the birds need to be efficient fliers is because, unlike most seabirds, the frigatebird does not have waterproof feathers, so it only gets close to the ocean surface to hunt. "They rely entirely on prey at sea but they cannot sit on the water, they have to catch prey in flight," said Dr. Weimerskirch. "This is why they have this very extraordinary behavior."

INTRODUCTION: **Take frigatebird weight to be 3 lb. Lift = weight (m g). S = area of wings = l w = length x width Thus , from above equation for lift we have: $L = m\,g = \tfrac{1}{2}\, d\, v^2\, l\, w\, (CL)$. Note: CL(coefficient of lift)& d are constant.**

$$\text{Ratio of wing size to mass(weight)} = l\, w / m\, g = 2 / d\, v^2\, (CL)$$

QUESTIONS: **(a) Find ratio of wing size to weight for Frigatbird? (b) Find ratio of wing size to weight for Canada geese?, (c) How much larger is this ratio for the frigatbird compared to the Canada geese? , (d) Comment on the frigatbird's speed (v) required to have adequate lift for flight?**

ANSWERS: **(a) 7 w/ 3 = 2.33 w, (b) 6 w/ 15 = 0.4 w, (c) frigatbird's ratio is 5.8 times larger than Canada geese. (d) $2.33\, w = 2/ d\, v^2\, CL = [\, 2/d\, CL]\, (\, 1 / v^2\,)$, thus the frigatebird's speed can be quite a bit less than Canada geese for adequate flight lift. This can be seen in equation (d) as ratio (wing size to mass) gets larger the speed v ca become smaller for adequate lift.**