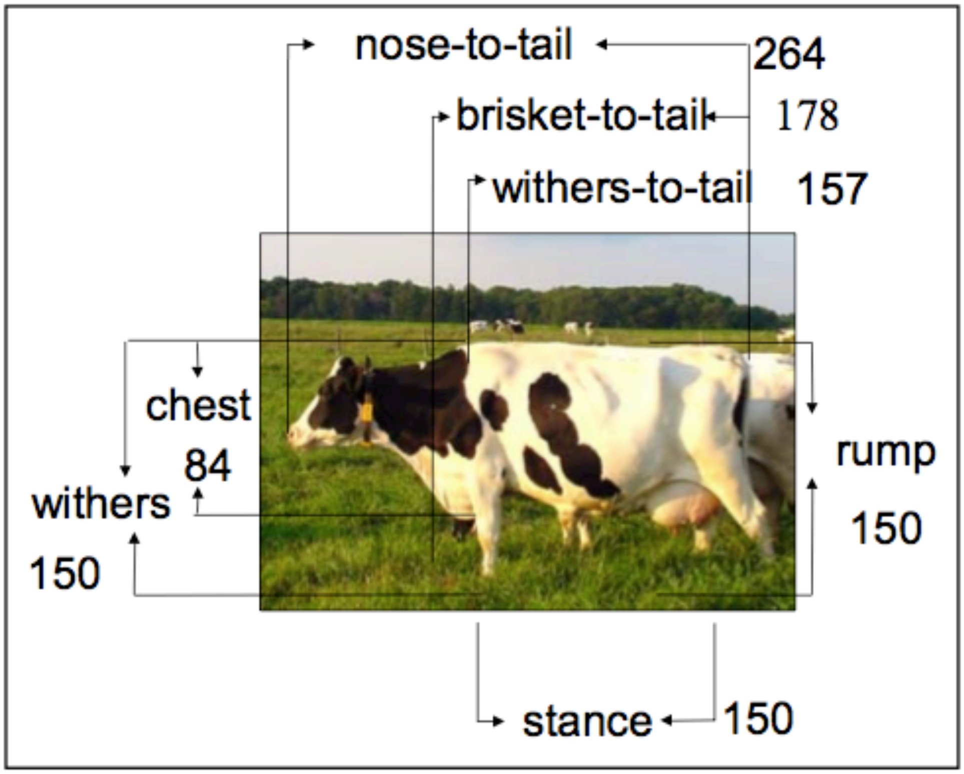
Terminal Velocity of a Falling Cow



Dimensions (cm) for a mature Holstein cow.

Figure 1 http://www.wcds.afns.ualberta.ca/Proceedings/2003/PDFs/Manuscripts/Chapter%2007%20Anderson.pdf

The rump width and mass of a mature Holstein is given by Anderson as 68 cm and 600 kg, respectively. The volume of a cow, neglecting head and legs could be measured as the box composed by the dimensions of brisket to tail length (178 cm), rump width (68 cm), and chest height (84 cm) or, approximately 1.02 cubic meters.

The downward force acting on a falling cow is the product of the mass of the cow and the gravitational constant. The force resisting the downward force is the force of drag as determined by the fluid properties of the air and the relative size, speed, and configuration of the falling cow.

$$F_D = \tfrac{1}{2} \rho u^2 C_D A,$$

where

F_D is the force of drag, which is by definition the force component in the direction of the flow velocity,[1]
ρ is the mass density of the fluid, [2]
u is the velocity of the object relative to the fluid,
A is the reference area, and
C_D is the drag coefficient — a dimensionless constant, e.g. 0.25 to 0.45 for a car.

Figure 2 http://en.wikipedia.org/wiki/Drag_equation

And the measured drag coefficients relating to the shape of the falling object are, as shown:

Using the a gravitational constant of 9.81 m/s^2 and a density of air (at 20^oC and 1 atmosphere) of 1.204 kg/m^3 the following were calculated:

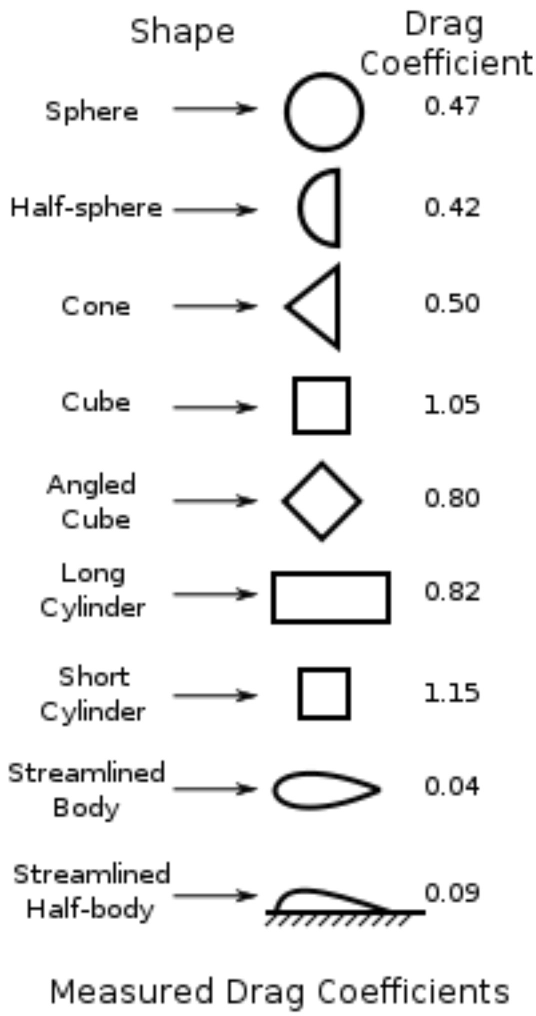


Figure 3 http://en.wikipedia.org/wiki/Drag_coefficient

Assuming a spherical volume of a cow this gives a radius of a sphere of 0.63 meters and a cross sectional area of 4.9 square meters – the terminal velocity is calculated at approximately 65.3 meters per second or about 146 miles per hour.

Assuming a cylindrical volume of a cow with a cylindrical length of 178 cm and a radius of 0.2132 m and assuming the cow falls against gravity as a long cylinder (side first or back/belly first) – the terminal velocity is calculated at approximately 125.3 meters per second or about 280 miles per hour!

6-OCT-2009 | Terminal velocity (cow)

$F_D = F_g$ @ terminal velocity

$\frac{1}{2} \rho v_T^2 C_d A = mg$

$$v_T^2 = \frac{mg}{.5 \rho C_d A}$$

$$v_T = \left[\frac{mg}{.5 \rho C_d A}\right]^{1/2}$$

$$\forall_{cow} = \overset{L}{(1.78\,m)}\overset{w}{(.68\,m)}\overset{h}{(.84\,m)} = \underline{1.02\,m^3}$$

$m_{cow} = \underline{600\ kg}$

$\forall_{sphere} = \frac{4}{3}\pi r^3 \quad r = \left(\frac{3}{4}\frac{\forall}{\pi}\right)^{1/3} = \underline{.63\,m}$

$A_{circle} = 4\pi r^2 = 4\pi(.63\,m)^2 = \underline{4.87\,m^2}$

$\forall_{cylinder} = L(4\pi r^2) \quad r = \left(\frac{\forall}{4\pi L}\right)^{1/2} = \underline{.213\,m}$

$A_{long\ cylinder} = 2rL = \underline{.759\,m^2}$

$A_{short\ cylinder} = 4\pi r^2 = \underline{.571\,m^2}$

$C_{d1} = .47$

$A_1 = 4.87\,m^2$

$C_{d2} = .82$

$A_2 = .759\,m^2$

$C_{d,3} = 1.15$

$A_3 = .571\,m^2$

$v_{T,\ sphere} = 65.3\ m/s = 146\ mph$

$v_{T,\ long\ cylinder} = 125.3\ m/s = 280\ mph$

$v_{T,\ short\ cylinder} = 120.0\ m/s = 273\ mph$

Terminal Velocity of a Falling Cow

Assuming a cylindrical volume of a cow of the same dimensions, but falling head or butt first as a short cylinder (showing a cross sectional surface area of about 0.57 square meters) – the terminal velocity is calculated at approximately 122.0 meters per second or about 273 miles per hour.