**Problem Statement:**
Compare the amount of power required to pedal a racing bicycle a 9 m/s with a 4.5 m/s tailwind and a 4.5 m/s headwind

**Known Constants:**

$A_p := 0.36m^2$ average projected area of cyclist and bicyle normal to direction of travel

$C_D := 0.88$ tabluated drag coeffecient for a "racing" cycist

$\rho_{air} := 1.227 \frac{kg}{m^3}$ density of air

$V_c := 9 \frac{m}{s}$ $V_c = 32.4\,kph$ velocity of the cylist relative to the ground

$u_w := 4.5 \frac{m}{s}$ $u_w = 16.2\,kph$ velocity of the air relative to the ground

**Equations:**

$Power(F_{drag}, V_c) := F_{drag} \cdot V_c$ where $F_{drag}$ is the drag force on the cyclist and $V_c$ is the velocity of the cyclist relative to the air

$F_{drag}(u_{rel}) := \frac{1}{2} \cdot C_D \cdot A_p \cdot \rho_{air} \cdot u_{rel}^2$ where $u_{rel}$ is the relative velocity of the air

**Solutions**

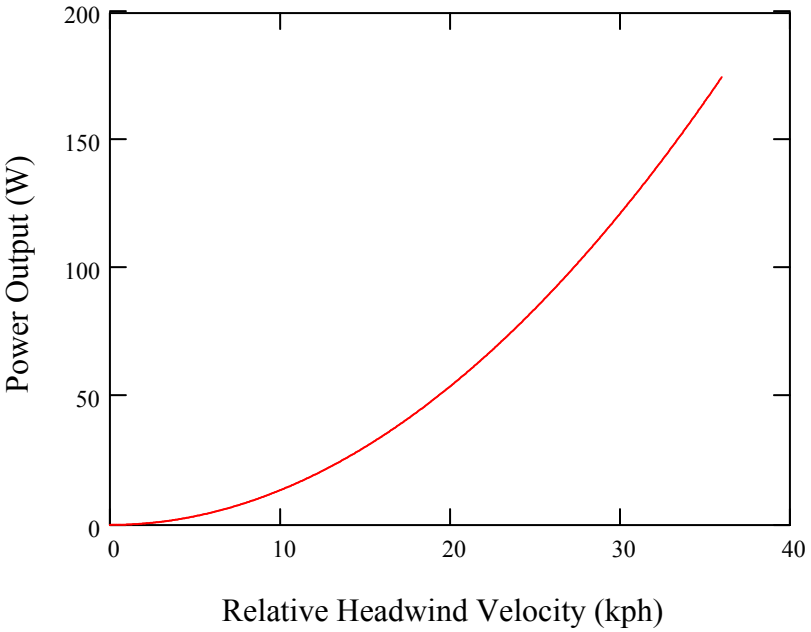
$u_{rel} := \begin{pmatrix} V_c - u_w \\ V_c + u_w \end{pmatrix}$ $u_{rel} = \begin{pmatrix} 16.2 \\ 48.6 \end{pmatrix} kph$ tail and head winds defined and evaluated

$F := F_{drag}(u_{rel})$ $F = \begin{pmatrix} 3.936 \\ 35.422 \end{pmatrix} N$ drag forces defined and evalutated

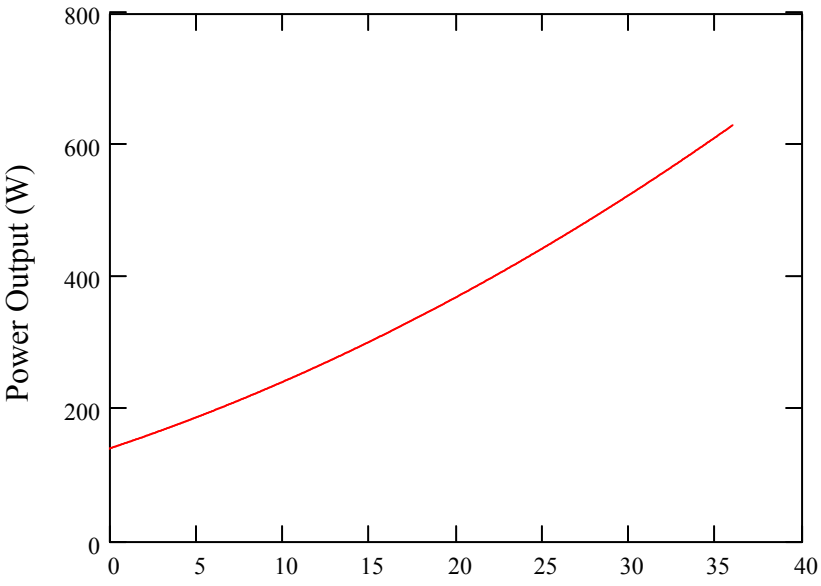
$P := Power(F, V_c)$ Power outputs defined

$P = \begin{pmatrix} 35.422 \\ 318.794 \end{pmatrix} W$ Power outputs evalatuated and then compared

$P_2 - P_1 = 283.372\,W$ $\frac{P_2}{P_1} = 9$




Power @ 9 m/s vs. Relative Headwind Vel




Power @ 9 m/s vs. Absolute Headwind Vel

- In the first graph, a "relative headwind velocity" of 0 kph means a tailwind equally fast as the rider. Thus, no drag occurs and therefore no additional power is required from the rider.
- In the second graph, an "absolute headwind velocity" of 0 kph indicates that air is not moving relative to the ground. As a result, the rider moving through the stagnant air creates her or his own drag creating the need for addition power output.
- In all calculations, inefficiencies of the bicycle drivetrain are totally neglected.