Walter Zorn's Kreuzotter Bicycle Speed and Power Calculator

Walter Zorn unfortunately passed away in 2009. During his life he was responsible for much innovation in cycling, and had a very methodical approach. Amongst the many things he created was an excellent speed and power calculator which many people have credited as being quite accurate. Unfortunately, the kreuzotter website is no longer on the web and I could only find the calculator **on the wayback machine**.

This version of the Kreuzotter calculator is as Walter Zorn's original, but modified in two ways. Firstly, the weight of the Quest velomobile has been altered to 38 kg - this being the **advertised weight** of Quests in 2010 (and born out by those I've weighed). Secondly, the Mango velomobile has been added, in three forms. My personal Mango Classic (with winter tyres), the current touring oriented Mango+ and the lightweight Mango Sport. The figures for aerodynamics of the Mango vs. Quest were taken from **this web page** and the weights for the Mangos are that of **my own Mango** and current production weights for the **Mango+ and Mango Sport**. Also, I modified the description of one of the two wheel recumbents which I previously noticed had much the same performance as **my two wheel recumbent**.

For me personally, this means I now have a calculator which seems to make sense for my own bikes. You may find that some of the example bikes are similar to your own.

There's more text **at the bottom**.

Roadster Upright ("Dutch") bike

MTB unsuspended

Tandem with racing bars **read...**

Racing Bicycles

hands on the tops (top of handlebar)

hands on the drops (bottom of handlebar)

Triathlon Bicycle

Superman Position (Racing Bicycle- 1h Record)

Recumbents

LongWheelBase under seat steering, commuting equipped

ShortWheelBase under seat steering, commuting equipped (close to PDQ)

ShortWheelBase above seat steering, racing equipped

Lowracer above seat steering *Kreuzotter race*

Lowracer with streamlining tailbox *Kreuzotter race*

Streamlined Lowracer **White Hawk** (1h World Record)

Velomobiles

Quest (closed)

David's Mango (winter tyres, slow)

Mango+

Mango Sport

Alligt Alleweder A4

Flevobike Versatile/Orca

Leitra

The comma as well as the point may be used as decimal point.

Rider's Height	172	cm
Rider's Weight	71.3	kg
Bicycle Weight	9.5	kg
Air Temperature	20	°C
Height above SeaLevel	0	m
Slope of Road	0	%

uphill positive, downhill negative values

Wind Speed	0	km/h

headwind positive, tailwind negative values

Pedaling Cadence	90	/min

"Change" the sort of **tires?** (Recumbents: calculation is based on 20inch front wheels.)

Front Wheel Tire: narrow racing tire (high pressure)

Rear Wheel Tire: narrow racing tire (high pressure)

The input field of the variable to be calculated must be empty. The result will appear in that field.
With both fields filled, the variable evaluated previously will be calculated again (facilitates quick comparisons).

Power 160 Watts Calculate (Diagram) **Speed** km/h

Notes:

Further results: **Effective Drag Area Cw*A** ft^2 **Rolling Resistance Coeff. Cr**

In case you enter (before clicking the "Calculate"-Button):

either the **TripDistance** km m or the **TripDuration** h min sek,

the amount of **Calories Burnt by the Rider** = kcal (assumed efficiency: 25 percent) will be calculated.

Besides, the program will evaluate the variable whose fields are empty (Trip Distance or Trip Duration, respectively).

For **coast-down** simulations, set the Power value to zero and the Slope to the desired negative value.
FAQ

About the Speed&Power Calculator:

The rider's frontal area is evaluated approximately from the rider's body height and weight, and a parameter which depends on the selected kind of bicycle. These assumptions yield good matches with frontal area measurements, and with measurements done with **SRM Power Measuring cranks**. Inside the fully streamlined bicycles, of course, the rider's frontal area is assumed to have no influence.

The rolling frictions of the front and rear wheel tires each are taken into account separately.

The calculation also regards the following influences:
Load distribution front/rear wheel. At wider tire tends to generate less rolling friction but more air resistance (not true with the streamliners *White Hawk* and *Quest* whose fairings enclose the wheels almost entirely). A thicker tire wall (touring tire) tends to generate higher rolling friction. Tire thread induces air vortices and thus speed-dependent additional resistance. The front wheel has more share in the air drag than the rear wheel. Smaller front wheels of recumbents generate more rolling friction but less air resistance. The air drag share of the bicycles themselves is taken into account too.

At low speeds a wider tire (less rolling friction) may be advantageous while, with higher velocity, a narrower one (less air resistance) increasingly gets the upper hand.

The applied rolling resistances refer to asphalt road pavement. On a smooth velodrome surface, rolling resistances may be essentially lower. Consider this also for the values that this calculator delivers for the Superman Position.

Most of the data and assumptions used for the calculator are based on (and match well with) frontal area measurements, and, first of all, measurements done with **SRM Power Measuring cranks**.

The most essential of the equations the Speed&Power Calculator is based on:

The following equations take into account all of the relevant resistance components: Rolling friction including the dynamic (speed-dependent) rolling friction, air drag including the influence of wind speed, mechanical losses, and uphill/downhill forces.

P	Rider's power
V	Velocity of the bicycle
W	Wind speed
T	Air temperature, in ° Kelvin (influences air density)
HNN	Height above sea level (influences air density)
rho	Air density
rho_0	Air density on sea level at 0° Celsius (32°F)

p_0	Air pressure on sea level at 0° Celsius (32°F)
m_{bike}	Mass of the bicycle (influences rolling friction, slope-dependent pull-down force, and normal force)
m_{rider}	Mass of the rider (influences rolling friction, pull-down force, and the rider's frontal area via body volume)
A	Total frontal area (bicycle + rider)
C_d	Air drag coefficient
g	Gravitational acceleration
C_r	Rolling resistance coefficient
C_{rdyn}	Coefficient for velocity-dependent dynamic rolling resistance, here approximated by 0.06 * number-of-wheels
C_m	Coefficient for power transmission losses and losses due to tire slippage (the latter can be heard while pedaling powerfully at low speeds)
grade	Inclination (grade) of road, in percent
F_{rg}	Rolling friction (normalized on inclined plane) plus pull-down force on inclined plane

Air density via barometric formula:

Air density via barometric formula

Rolling friction plus pull-down force:

Equation for rolling friction force and pull-down force

Equation for the required human power

In order to solve this Power equation for Velocity V, we write it in the implicit form

Equation for the required human power

so we can use the cardanic formulae to obtain the solutions:

If $a^2 + b^3 \geq 0$:

Velocity equation

If $a^2 + b^3 < 0$ (casus irreducibilis; in case of sufficient downhill slope or tailwind speed):

Velocity equation (casus irreducibilis)

with

Expression "a" of the velocity equation

and

Expression "b" of the velocity equation

Relation between Body Weight, Body Height and BodyMassIndex (BMI)

The comma as well as the point may be used as decimal point.
The field of the variable to be calculated must be empty. The result will appear there.

Body Weight = 71.3 kg **Body Height** = 172 cm **BMI** =

Calculate

Note: BMI = weight[kg] / (height[m] * height[m])
BMI<19 signifies underweight, BMI between 25 and 30 slight overweight...

With the values from this BMI-Calculator you can check how much a change of body weight or height (or both) would influence the bicycle speed or the required propulsion power. For example, you might want to compare riders with different heights at **identical** BMI values, meaning "adequately" changed body weights. It may become noticeable that also on a recumbent bicycle the rider's tallness has influence on the air drag. A change of the rider's weight (meaning changed body surface area and thus frontal area) has more influence on aerodynamics than a different tallness alone.

Last modified: 15.4.2010

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More text...

I find it interesting to note the interactions of the effects of weight and aerodynamics on the speed of cycling. The 38 kg Quest initially appears to beat the 27.5 kg Mango Sport due to its better aerodynamics. However, select just a 0.5% hill to climb and the Mango Sport gains an advantage over the Quest due to the difference in weight becoming a greater influence than the difference in aerodynamics.

Outside of the rather artificial environment of a velodrome, there are gradients everywhere. A 0.5% gradient is really not very much at all. It's almost too gradual to see. Even "flat" areas of the world like the Netherlands have plenty of gradients at least as steep as this. Between work and home I have a number of (very) small hills which I go up and down, and my home is about 15 m higher in altitude than my work.

Add in the effect of the lower weight every time you have to build up speed again after traffic lights or when filtering through other traffic, and a Mango is relatively spritely in real life conditions.

If you're comparing with a different bike, be realistic about weight. Some bikes are advertised with very attractive low weights, but by the time you've added mudguards, racks, lights, a toolkit, spare tubes, a pump, a little luggage etc. the weight is probably higher than you think it is. Remember that the velomobiles come with mudguards, racks, lights, and even the equivalent of a raincoat.

The figures I've added to the calculator can of course only approximate real life, as can also be said for the original figures in the calculator. Don't expect to be able to cycle in any real world situation at exactly the speed the calculator gives.

The code which generates this web page can be easily viewed. Simply save the web page, and also fetch the javascript and css files. If you believe I've made any mistakes in adding the Mango figures, **let me know**.

Saturday 17th update. I found figures for the Alleweder (from the same source as above), and also comparisons with the aerodynamics of the Versatile/Orca and Leitra (from **Adventures of Greg**) so I've added these to the calculator too. I'm a little less sure of their accuracy than of the Mango figures, but they seem about right. i.e. Alleweder which I've ridden a little is quicker than my PDQ but slower than a Mango. What I find most interesting with these extra figures is the comparison between Versatile and Leitra. The Leitra generally is shown to be a little quicker than the Versatile, and it's almost entirely a function of its lower weight. Add an incline and it does quite well, amongst the velomobiles it comes second only to the Mango Sport with a 5% hill.

Sunday 17th July 2011 update. Yesterday, a blogger accused me (not via email directly to me, but on his own blog without even telling me) of changing the results of this calculator to favour the Mango over his Quest. He based this comparison on the re-appearance of the calculator on the Kreuzotter website, saying that this "original" calculator gives different results to my modified version. He is right that the results are different, but there is a much more innocent explanation than subterfuge. The calculator **on the Kreuzotter website** has a different version of code and gets different results to that which I retrieved from the wayback machine and modified. Other people also have copies of same version as I do, including noping.net (no longer available). Their calculators give the same results for the same inputs as mine does (be careful, not all default values are the same). I am not sure as yet whether the version of the calculator on the Kreuzotter website is an updated version of what I have or an older version which has been restored. However, unfortunately it does not have the extra velomobiles defined. If you want to make a comparison between different bikes then probably either calculator will work with a reasonable degree of accuracy. Any inaccuracy in one calculator vs. another will be approximately equal for one bike vs. another in the same calculator. Making comparisons between one calculator's results for one bike and another calculator's results for another bike will not give an accurate impression. Therefore, to compare a Quest with a Mango or other velomobile, please use my version of the calculator as it is the only one which has data for these other machines. Finally, note that this is just an online calculator. It can only ever give an estimate of actual performance.