CYCLING ROUTE ENERGY DEMAND

By: PJ van Staden

2017

Cycling Route Energy Demand (CRED) is about knowing how energy is related to cycling, and to effectively analyze any route's cycling energy demand it will place on your own body's unique features, considering weather conditions as well as the condition of your own bike. CRED also enables you to prepare various strategies in advance based on different weather conditions that may occur on race day. Furthermore, CRED enables you to better prepare your buildup, nutrition and energy intake on race day. The CRED program is build upon tested scientific laws, which will answer to your experience on the road while cycling. Using the CRED program will help you to become more competitive, as well as a better cyclist. In this tutorial you will learn about the concepts of energy and force, and how it is related to cycling. In the last part of this tutorial the CRED program is explained in a step by step sequence, taking you through the program.

CRED Tutorial

van.staden.pj.x@gmail.com
Drafter by PJ van Staden

Foreword

When you first open the CRED program, you may feel intimidated as it looks complex. However, be rest assured, there is nothing complex about it and you will find it very simple to use and easy to understand once you have worked your way through this tutorial. You do not need any scientific knowledge or experience to understand CRED, because it was developed for everyone to use. There is no calculations for you to make, because CRED does it all for you. You simply tell CRED about yourself, the route you intend to ride, and how you would like to ride it, then CRED will show you what you are in for. If you don’t like what CRED shows you, you simply change how you want to ride the route until you like what CRED shows you. As simple as that.

This tutorial consists of six parts;

CRED: Part 1 (Page 3); is an introduction to CRED, about energy and force. In this part you will gain an excellent understanding of what energy is, and how it helps you to better understand cycling. You will also see how the concept of force is related to energy, as well as how your nutrition fits into the picture.

CRED: Part 2 (Page 8); tells you about riding up-hills and down-hills, and how gravity influences your energy requirements.

CRED: Part 3 (Page 16); tells you about friction, what it is, and how it works against you while cycling. You will see why friction drains your energy.

CRED: Part 4 (Page 19); tells you about drag (wind resistance) while cycling, and how it impacts on your energy. You will see how air is a medium in which we exist, just like water is a medium in which fish exist, and why it requires energy to move through this medium, as well as why more energy is required to move faster through it, and how wind direction impacts on your energy requirements.

CRED: Part 5 (Page 23); tells you about heat loss. You will see how your body loses energy due to heat loss in various ways, and how it is related to cycling.

CRED: Part 6 (Page 26); takes you through the CRED program step by step, and uses an analogy to make you clearly see and understand how the program works.

Once you have worked your way through this tutorial, you will wonder how you ever managed to plan for a race or adventure without CRED. Through the knowledge you gain in this tutorial, in conjunction with the power CRED provides you with, you will feel like a professional cyclist. And indeed, you then will be.

Now there is only one thing left to do: Enjoy the experience!

CRED: Part 1

Good cycling is all about energy management. To know energy is what separates the professional from the amateur, and this program is all about how to calculate your personal Cycling Route Energy Demand (CRED) effortlessly, whether it may be for a race, your training route, or a trial through the woods. Cyclists do not all weigh the same, neither do they all ride the same bikes, and even if they do, the same bikes may not be similar in their component dynamics. For instance, the levels of friction between all moving parts may differ due to various levels of bearing wear, or due to the condition of lubricant on moving parts. Or the rolling friction between rubber and road may differ due to dissimilar tyres fit, etc. Taking all your individual characteristics as well as that of your bike into account, the same route may very well bear diverse energy requirements for even twins riding the same bikes. Apart from the individual differences that exist between you and other cyclists, and between your bike and theirs, there is also weather conditions that affect you differently than others. Furthermore, apart from all these external factors, your body also reacts differently to cycling energy due to the environment based on your metabolic rate and age, and upon whether you are a male or a female. Taking all these factors into consideration, it can be stated that no training program will prepare any two cyclists equally well. To further complicate things, your body as well as your bike's parameters are subject to constant change over time, which alter your energy requirements even for the same route. Consequently, once you start using CRED, you may find that your energy requirements for a race will be different the next year than it was for this year, because of changes you as well as your bike underwent over the course of a year. CRED enables you to easily and quickly analyze all these parameters in no time, with no difficulty. Put in a different way, CRED enables you to analyze yourself and to plan your adventure like a scientist would, and to prepare for it accordingly, without the need of being a scientist yourself. CRED will give you the advantage of strategizing your build-up and your approach to any cycling event with efficiency, as well as to better prepare your dietary intake towards an upcoming event. You will also be able to plan your amount of energy intake on the route with precision. Knowing your CRED for a route is imperative in further developing your personal performance, especially when you are competitive and the competition is tight.

What is CRED?

Cycling Route Energy Demand (CRED) is a system I have developed for cyclists to easily calculate the energy they will need to complete a given route in a given time, taking into account their own personal variables like weight, size, age, sex, metabolic rate, and how it all is affected by the elements on the route like topography, wind, temperature, as well as the friction of their individual bikes. What's more, you do not need any expensive equipment in order to do so. CRED enables you to know in advance how much energy you will need to complete an entire route, or any section of it. It will also enable you to see how your energy demand is distributed over the course of a route, as well as the rate at which you need to burn energy in order to ride any section in any specified time. CRED thus, is a scientific analyzing tool you use to show you your energy dynamics a route is going to demand from you, which depends on your own personal credentials and the time in which you want to ride the route. Your results for every section of the route is then displayed in table, as well as graph format, making it easy for you to see at once the whole picture you are in for. Knowing your CRED, you will have no need to ever again tug into group cruising during any stage of a race, or attempt to ride your race according to someone else's strategy, because you will be able to race the route to your own energy analysis, at the end of the day giving you the best performance possible with respect to your own individual condition. Furthermore, CRED is based on sound, tested and verified laws of physics, giving you piece of mind that your analysis will answer to your experience out there on the road, which in turn will make race day that more interesting, for then your knowledge will combine with your body's abilities to deliver your own unique personal performance with distinction. As the saying goes, "knowledge is power in a competitive environment," CRED is about knowing and understanding your own personal condition, as well as that of your intended endeavour. What's more, this tutorial is written in laymen's language so you will easily grasp it.

What is energy?

Energy is a unit of measure. Just like meters and yards are measures of distance, energy is a measure of the amount of work your body can do. We describe distance in meters and yards. We say, the Cape Town Cycle Tour is 109 kilometers long, or 68 miles. That makes us understand the magnitude of the distance. To ride this distance, you have to paddle your bike. To paddle your bike is to perform work. To ride the distance, you need to perform a certain amount of work. That work is described by energy. We say, you need that amount of energy to perform that amount of work. We measure work in energy, like we measure distance in meters. Your body's energy comes from the nutrition you take. On all food stuff you buy, you will see that the amount of energy it gives you is stated on the package, usually in kilojoules (kJ), or calories. Calories is just another unit of energy, just like miles is a another unit of distance than kilometers. We will get to that later. Most of the world today use the unit of Joules for energy, which CRED is also using. However, CRED still shows you the calorie equivalent in case you are used to work with calories, or in case your nutrition is rated in calories. CRED also provides you a converter to easily convert between the two.

This already makes you understand that CRED is about the amount of work you will need to do to ride any specific route, shown to you in Joules of energy. It is thus fundamental for you to know energy in order to understand CRED. So, let's quickly recap, and then take it further: In cycling, energy is simply another word for "work." When you ride your bike you do work, you pedal. Pedal is energy (work), and as it is with everything else in life, energy (work) is measured in units as well. Just as distance is measured in units of meters (m) and kilometers (km), energy (work) is measured in units of joules (J) and kilojoules (kJ). Kilo means 1000; 1 km = 1000 m; 1 kJ = 1000 J.

To race is to cover distance, which is measured in metres (m)
To pedal is to work (to burn energy), which is measured Joules (J)

To race means to pedal. To cover distance means to work (burn energy). To cover a set amount of metres in a set amount of time, you need to burn a set amount of joules at a set rate. This set amount of joules has to come from your body, which you get from the nutrition you take. If you and I ride identical bikes, with all variables the same, over the same distance, but you pedal (work) twice as hard as I do, you will burn twice the energy I do over the same distance. Since you work twice as hard as I do over the same distance, you will complete the trip in "about" half the time I do. I am saying "about", because it depends on forces you need to overcome, like drag (wind resistance) for example. However, we will look at that later. Your performance (time) is thus a result of the total amount of energy (work) that you put into your ride.

In the CRED program you will simply enter the distance and the speed at which you intend to ride every section of a route, and based on your personal parameters you told CRED, as well as that of the environment, it will calculate your energy for you, and show you at what rate you will need to burn that energy to ride at the speed you intend, or in the time you intend to complete it. Thus, there will not be any calculations for you to do, but you need to know what energy is in order to understand what CRED is telling you. In Part 2, we will look at an example when going up a hill. The concept of energy and how it is related to your nutrition will then become very clear to you.

How is CRED energy calculated?

CRED is built upon four disciplines of physics; kinematics; thermodynamics; fluids & pressures; energy & work. It incorporates all relevant laws of physics in these fields, which are tested and confirmed facts of nature that never changes. For instance, gravity always stays the same, because earth's mass always stays the same, which determines the gravitational pull on you as you work your way up a hill. This enabled us to describe gravity mathematically, which in turn enables us to predetermine the effect of gravity on any mass at any time under any condition. All these laws are related to, and can be described in terms of energy, which makes it possible for us to correctly analyze and predict the energy requirements of any sequence of actions any object would take. While cycling, you are subject to these laws of physics; gravity pulls on you; air pushes against you; heat flows out of your body; friction between moving parts holds you back; etc. And since all these laws are mathematically grounded, we can accurately calculate its effects on you, as well as how its ratios changes with respect to your motion and personal parameters, which determines the amount of energy you will expend. And that is exactly what CRED does for you.

Furthermore, CRED does not only calculate your energy requirements for any route based on the external factors as mentioned above, but also calculates your body's internal energy loss based on your metabolic rate, age, size, sex, and heat. CRED thus gives you a complete energy analysis of the total energy you require, not only to just ride the route, but also to keep all your organs working and your blood flowing while you ride. And since no two persons are the same in all these criteria, CRED is your answer to knowing your own self as a cyclist. If you plan to ride a route with a friend, and plan to ride it together the whole way, CRED will show you how your energy requirements will differ from that of your friend's.

Later, you will also find answers to many other questions you may still be unsure about. For instance, how do your crank length and gear selection influence your energy burned on the ride? How do the terms power, force and torque relate to it all? How do your crank, gears and wheel sizes fit into the whole picture? Although it may sound like a lot now, you will see how simple CRED makes it for you. Even when weather conditions are not as planned for on the morning of the race, you simply change those variables in the program to give you your new strategy within a few seconds. You can thus conclude that you will also be able to determine various strategies in advance, based on different conditions that may exist on race day.

What is the difference between joules and calories?

We already touched on Calories earlier, that it is just another unit of measure for energy. Just as you get “meters” and “yards” for distance, you get “calories” and “joules” for energy. Some nutrition is rated in calories (cal), whilst CRED is determined in Joules (J), which means that you will sometimes need to convert from calories to Joules. Provision is made for this in the program so you will not struggle with it.

1 cal = 4.186 J

Your CRED energy is the same thing as your nutritional energy. For instance, if CRED finds that you require 401 856 J of energy to climb a specific mountain, it means that your body needs 401 856 J of energy to climb that mountain. In calories it will thus be,

Cal = (401 856 J) / (4.186 J/c) = 96 000 cal.
This is equal to the energy of one cup (3 tablespoons (24g)) of Milo, for example.

An introduction to forces

Energy and force directly relate to one another. Thus, to make you a better cyclist right away, your perception of cycling first need to change. If you see a wild lion for a pussycat pet, you may end up dead. If you see a wild lion for a wild lion, you will take the necessary precautions to stay safe. Perception makes a huge difference to a situation’s outcome. With cycling it is no different.

To pedal (work) is not to get into motion, and neither to ride, but to overcome forces that prevent you from getting into motion. For instance, gravity is a force that pulls you backward on an uphill. You therefore need to work (pedal) to overcome gravity in order to move up the slope. Friction is a force that attempts to decelerate (brake) you all of the time. Wind resistance (drag) is a force that pushes you backward harder the faster you go. Inertia is a force of your mass resisting motion when you accelerate. Thermodynamics is a thermal force that drains energy out of your body on a cold morning. Once you overcome these forces with the energy stored within you, and you keep overcoming them, you spontaneously stay in motion. And the more you overcome them, the faster your motion is. Furthermore, you overcome them by applying force to your pedals that is greater than their combined restraint on you. If it were not for these restraining forces, you would cruise the world by stepping down on the pedal only once. Unfortunately, we need these forces to live and to make things possible, therefore that you need to sweat to cycle and battle to move –burn energy. The more you know about these forces the more you are able to strengthen yourself against them and improve your performance against them.

Force is an ingredient of energy

As the saying goes, to fight fire with fire, you also need to fight forces with force, which is to apply force to your pedals. As your pedals start moving when you apply force to it, you are applying force over a distance. The distance here is the circumference (circle) or part thereof through which your pedals move while you apply force to it. This combined effect of force applied over a distance (force times distance), is energy (work), measured in joules (J). Thus, force and distance are both ingredients of energy.

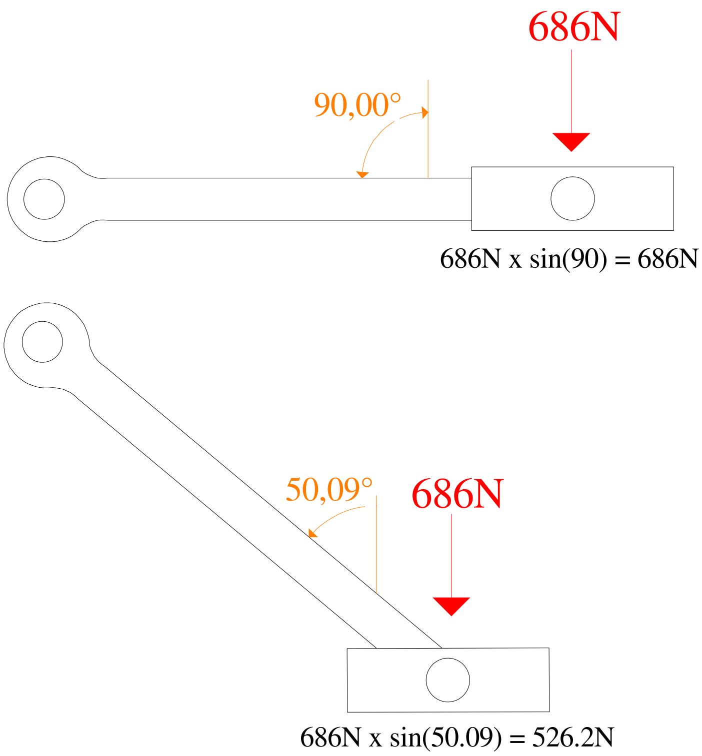
To use an example, not that you will need to do any math in CRED, but to help you understand force, let us assume you weigh 70 kg and you stand up on your pedal with your whole weight. And let us assume your pedal moves through 10 cm (0.1 m) until it reaches the bottom of its rotation where it doesn't turn any further. Put differently, your weight is a force working on the pedal over a distance of 10 cm. We first need to convert your mass (m) to force, which is measured in Newton (N). You don't have to mind the math here, just look at the answers. We find the force of your mass by multiplying gravitational acceleration, which always stays the same on earth's surface at g = 9.8 m/s^2, by your mass;

Force = mg = (70kg) (9.8m/s^2) = 686 N

Now we can calculate the work that has been done, which is the energy used;

Work = Force x Distance = (686N) (0.1m) = 68.6 J

Thus, your body has worked 68.8 Joules of energy on your pedal. However, this does not necessarily mean that you have added 68.8 J of energy into your ride, because you perhaps did not apply the force perpendicular at 90 degrees with your crank throughout the whole 10cm. Look at the two sketches below of a pedal and crank.



In both sketches your weight's force (red arrow) is applied directly downward, but as the pedal rotates down the angle of your force to the crank gets smaller. The force you apply to the pedal stays the same, but because the angle changes, it causes less force applied to your ride as the pedal moves downward. In the bottom position you are still applying 686N to the pedal, but only 526.2N of it is going into your ride. This means that less energy will go into your ride than what you apply to your pedals. For this reason, CRED makes provision for pedal efficiency, which is always less than

100%. So, once again, CRED will show you your total energy needs for a route, including this loss in pedal efficiency.

Every degree you deviate from 90˚ with your crank causes the force you apply to your ride to be less than what you exert onto the pedal, which means you expel more energy onto your pedals than what goes into your ride. However, it would be an enormous task to analyze every step precisely, therefore CRED makes provision for “pedal efficiency” in the program, which is something you will need to improve on as much as you can –how to apply force to your pedals with an angle as close to 90˚ as possible throughout its rotational path. It means you have to exercise your pedal technique, to make as much energy you apply to your pedals go into your ride.

While on the topic of cranks, does crank length alter your energy needs over a distance you ride? The answer is, No! Although a longer crank causes your pedals to rotate through a longer circumference (distance), you apply less force to a longer crank to do the same work. Thus, the ratio between force and distance stays the same between a longer and a shorter crank, which means you will expel the same amount of energy. Put in a different way, you will pedal easier with a longer crank, but your feet will work through a longer distance, bringing the amount of energy you expel to the same value. Thus, crank length is purely a personal choice that best suits your taste, with the aim to get your pedal efficiency as close to 100% as possible, so that you waste as little energy as possible on the pedals.

This is what energy (work) is all about as far as pedalling is concerned, to apply a force through a distance. Now that you know what energy (work) is, in part 2 we will look at gravity and see how CRED calculates hills’ and mountains’ energy.

In conclusion of this first part, train your mind to see cycling for what it is. Cycling is to overcome forces that restrain your motion. Also, see pedalling as a force applied through a distance, which is energy (work), and then focus on your technique to apply most of the force you exert onto your pedals as close to 90˚ with your crank throughout its rotation. Cycling experts can help you set your ideal seat height to help improve your pedal technique in this regard.

CRED: Part 2

In this part, you will learn how energy relates to slopes, and how it gets determined. In the previous part, you were given a background on what cycling entails and how it is related to forces, which you need to overcome for you to get into motion. Slopes have all to do with the force of gravity pulling down on you, which you are up against on an uphill. It will thus be a good idea to first give you an understanding of what exactly gravity is.

Gravity is a force that physically pulls mass (your body and bike) towards the centre of the earth. This force is the same strength everywhere around the planet, with infinitesimally small variations close to earth's surface, which can be neglected for cycling. In your mind's eye, you can see it as a rubber band tied to you and your bike, which is anchored to the centre of the earth. Therefore, gravity works against you on an uphill and together with you on a downhill. The strength of gravity is called "earth's free fall acceleration (g)" and its value is 9.83 meters per second, per second, written as $g = 9.83\ m/s^2$. It simply means that a falling object would accelerate with 9.83 metres per second, every second as long as it falls. However, as a cyclist, free fall would only apply to you should you ride off a cliff, or a bridge. With cycling, we are only concerned with gravity's pull on you as you go up or down a slope. The 9.83 value still holds true in conjunction with the angle of the slope, which is applied in CRED's calculations. This pull force gravity imposes on you is calculated by multiplying your mass (including that of your bike) by gravity's acceleration, just as we did in the example where you stood up on your pedal earlier. For instance, if you and your bike together weigh say 90kg, gravity's pull on you will be $(90\ kg)(9.8\ m/s^2) = 882$ Newton (N). Newton is the unit in which force is measured. This means that a force of at least 883N will be required to lift you straight up off the ground. However, slopes are not straight up and vary in their degree of angle, sometimes even a couple of times up the same hill. Thus, gravity's backward or forward pull on your ride in this instance will always vary somewhere between zero Newton (0N) on a flat road, and 882N on a 90˚ rock face, which would make it a daunting task to analyze a slope using the force way of calculation, because we would have to calculate for every single time a slope's angle changes.

Fortunately, there is a much easier way for us to calculate the energy gravity will demand from you, which is directly related to energy. It is a very accurate way of calculating, no matter how many times the slope angle changes up or down a hill, or a mountain. All you need to know is the vertical height of the hill or the mountain, which is the straight up distance between the altitude where the climb starts to the altitude at the top of the climb. In **figure 1** on the next page**,** you see the same mountain with two different routes going up from the foot of the mountain to its zenith. Both routes have the same vertical height of 455m, but route A runs straight up the mountain on one side of it, which gives it a shorter slope length (1.2km) but a steeper angle (22.3˚), whereas route B runs around the mountain giving it a less steeper angle (8.7˚), but a much longer slope length (3km). In the same gear you will thus have to pedal harder (with more force) on route A because of its greater steepness, but pedal much further on route B because of its greater length. The question now is, which route would demand less energy from you?

As far as gravity's pull on you is concerned, the same vertical height between different route lengths will demand the exact same amount of energy in order to reach the top. When the friction of your moving parts, and that between your tyres and the road come into play, road B will demand more energy, because it has a longer distance over which the friction is working. We will look at friction in part 3.

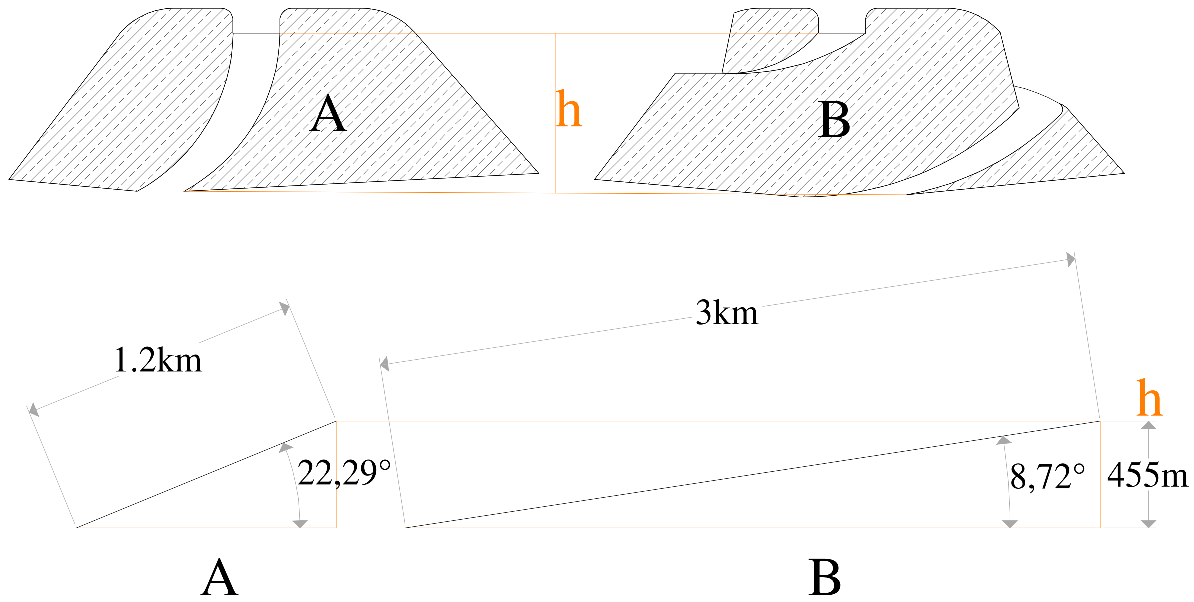


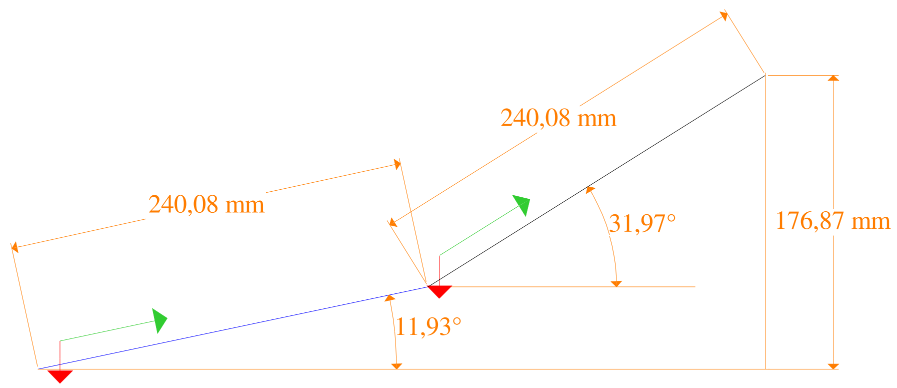
figure 1

With gravity, it will demand the same energy in both scenarios, because the vertical height (455m) is the same in both cases, and the energy is determined by multiplying your mass with earth's free fall acceleration (g), multiplied with the vertical height (h) of the mountain or hill. If you have already purchased your Activation Code for the CRED program, you make every uphill and downhill in the route a separate section, and you enter the vertical height of each uphill (slope) of the route in the "Uphill H" cells, and alike, every downhill's in the "Downhill H" cells, with the length of the slope in the "Distance" cells. CRED then instantly calculates your energy requirement for each uphill and downhill separately, as well as showing you the total energy needed for the whole route, calculated on your individual credentials you have entered in the spaces provided for it. But we will get to all that in part 6.

No matter how many times the angle of the slope changes as you go up the mountain, to reach the top you need the amount of energy as is calculated by CRED based on its vertical height. Now, let's assume you are going to climb a mountain or hill for which you have entered its vertical height, and you intend to climb it in 10 minutes (10 x 60seconds = 600 seconds), your body will need to burn energy at a rate as shown in the "Burn Rate" column next to the slope's entry as seen in the table of CRED, or as seen in the corresponding graph of CRED. If you know your body's energy burn rate at which you can perform without causing muscle fatigue too quickly, you can now see whether you are attempting to take the mountain too hard, or too easy. We will look at determining your ideal burn rate later. If you attempt to take it too hard, your muscles may run out of energy before you reach the top, because you burn energy faster than your body can generate it.

The rate at which energy is burned is called power (P), measured in units of joules per second (J/s) or Watt (W). Joules per second (J/s) and Watt (W) are the exact same thing. If you want to climb the hill faster, you will still expend the same amount of energy (Joules), but your body will have to burn it at a faster rate (Joules per second, or Watt), causing quicker muscle fatigue. Put in another way, you will expend the same amount of energy when going faster up a hill, but at a higher power (rate) over a shorter interval of time.

However, you may stop me now and say that there is a problem here, because you already know that energy is force times distance, and the distance (slope length) stays the same here, but in order to go faster up the slope, you have to pedal harder, which means more force over the same distance, which means more energy? So, how can I say that you will still expend the same amount of energy when going faster up the hill? Remember, we are here only dealing with the energy gravity demands from you, and gravity's force (pull) stays the same on you no matter at what speed you go up. The extra energy you expend by pedalling harder, CRED accounts for separately, because we are only looking at gravity's effect on your energy here. But, "wait a second" you may say, the steeper the hill gets, the harder I can feel gravity pulling on me, so gravity doesn't pull with the same force? Remember, you feel gravity pulling harder on you, because as the angle of the slope gets steeper more of your weight (mass) gets under the influence of gravity with respect to the road. Despite this experience, gravity's strength remains at 9.83 m/s². In the energy calculation CRED uses, it accounts for varying slope angles as if it would calculate the constant strength of gravity against the slope angle no matter how many times it changes up the hill. If you feel a bit confused now, to make you clearly grasp this, let me compare two examples; the force way compared to the energy way. Let's look at the sketch below. We have a hill consisting of two parts; a blue section at 11.93 degrees, and a steeper black section at 31.97 degrees. You represent the green arrows, going up the hill.



On the black section, you will feel gravity (red arrows) pull harder on you, not because gravity changes, but only because your angle is more in line with gravity. Let us assume this sketch is drawn to a scale of 1:1000, so we take the millimetres as meters. Let us assume you weigh 80 kg including your bike, we calculate gravity's force with which it pulls you backwards on each section as follows; *(You don't have to mind the math, because you won't need to do it, but it is used here to make you understand. Just look at the answers.)*

Blue section: **$F = mg\sin(11.93) = (80\text{ kg})(-9.83\text{ m/s}^2)(\sin(11.93)) = -162.56\text{ N}$**
Black section: $F = mg\sin(31.97) = (80\text{ kg})(-9.83\text{ m/s}^2)(\sin(31.97)) = -416.38\text{ N}$
The minus sign here just represents "backwards" to your motion.

You can see that gravity remains the same at $g = -9.83\text{ m/s}^2$ in both sections' calculations, but due to your angle gravity pulls backward harder on you on the black section, which is what you told me, which is true. Therefore, you have to pedal harder on the black section to ride with the same speed, which is what you told me, which is true. Now that we have calculated gravity's force on both sections, we calculate the energy of this hill using the force-times-distance method; we can see that both sections have the same distance (240.08 m), and we learned that energy is force times distance, and since gravity's backward pull is a greater force on the black section, we expect more energy to be expended on it;

Energy blue section **$E = Fd = (-162.56\text{ N})(240.08\text{ m}) = -39\,027\text{ J}$**
Energy black section $E = Fd = (-416.38\text{ N})(240.08\text{ m}) = -99\,965\text{ J}$
Total hill energy **$E = (-39\,027\text{ J}) + (-99\,965\text{ J}) = -138\,992\text{ J}$**
(The minus sign only represents "energy deducted from you" due to gravity)

Now we calculate both sections' energy at once using the energy method, where we only need the vertical height (176.87 m) of the hill;

Total hill energy **$E = mgh = (80\text{ kg})(-9.83\text{ m/s}^2)(176.87\text{ m}) = -139\,091\text{ J}$**
(The small variation of 99 J here with the -138 992 J of the force calculation is only because of the rounding off of the force values in the force calculations)

Since the angle of a hill's slope can change many times as you go up, you can see what a daunting task it would have been to calculate the energy using the force-times-distance method on slopes. You would also have had to know the exact shape of every slope, which would be hard to come by, or to figure out. By using the energy method, it doesn't matter how the shape of the slope looks like, as long as we have its vertical height, we can calculate the energy it will cause gravity to demand from you on an uphill with accuracy, as well as the energy gravity adds to your ride on a downhill.

Thus, to clear up the previous confusion; as far as gravity's pull on you is concerned, it doesn't matter how hard you pedal up the slope, gravity will demand the same amount of energy from you. However, when you pedal harder up a slope, you do burn more energy, but CRED calculates that over the distance of the slope, apart from what gravity demands from you. Therefore, in the CRED program you will enter a hill or mountain's vertical height (which is easily obtainable from topographic maps), as well as the length (distance) of the slope.

If you still feel a bit confused, don't become discouraged, because you won't need to understand any math in working with CRED. Some technically minded people, like sport scientists for example, would like to know how CRED calculates energy, and therefore that I needed to describe it here.

Burn rate

Let us continue, and look at your burn rate of energy. To ensure your best performance, you need to find your ideal burn rate (power) in order to plan your best performance over the course of a route. From a physics point of view, if you would want to determine your body's rate of energy production using a mountain (uphill) to do it with for example, where CRED shows it will demand 401 310 J for you to climb the mountain; if you cannot reach the top without stopping, you burned muscle energy faster than your body could produce energy to your muscles, therefore that you came to a halt before you reached the top. If you reach the top without stopping, let's assume you did it in 10 minutes, you take your time and use the following equation to determine your average rate of energy (Power) burned;

P = (mountain energy) / (your time in seconds) = your average energy burn rate up the mountain.
= (401 310 J)/(10 min x 60 seconds) = 668.85 J/s, or Watt.

I am saying "average rate," because you perhaps didn't go up with the same speed all of the way, and didn't necessarily burn energy at a constant rate throughout the whole climb, but may have slowed down as you got closer to the top due to the angle that increased. Your average burn rate is determined by dividing your total time (in seconds) to reach the top of the slope into the energy demand of the slope, which is a good platform to work from. In part 6, you will do a simple test to determine your ideal burn rate. If you use CRED to calculate a slope's energy demand close to where you live, based on your own mass, and you use this technique to monitor your performance, if you are able to go up the hill faster over time, it means your body's rate of energy production (Power) is increasing. Once you have established a safe burn rate that doesn't depletes muscle energy faster than your body produces it, CRED will enable you to quickly analyze and plan a whole route, showing you your maximum speed at which you can ride each section without burning yourself out too quickly, subject to all conditions (wind, heat, up slopes, down slopes, your mass, friction, your age, sex, size, etc.). And there won't be any math for you to do. All you need to know is your safe energy burn rate.

To prevent any misunderstanding about slopes, let us analyze a route as seen in **figure 2** on the next page. This is a side view of the route's change in altitude, having two mountain climbs in it. The route is not necessarily a straight road, but may run up the mountains with many bends, or around it as was seen in route B in figure 1. The altitude (vertical change in height) is what is important, as is seen here in figure 2. From point A to B the road is flat, which means that gravity has no influence on your ride over this section (except for friction, which we will deal with in the next part). From point B to C, energy to overcome gravity must be taken into account. From point C to D, we have a downhill where gravity will add energy to your ride, which is calculated with the same method as for the uphill side. CRED handles the downhill energy as a deduction from the friction and drag (wind resistance) encountered during a downhill, because gravity then works against those forces for you.

CRED automatically calculates what your average speed and time will be on a downhill without pedalling, based on the friction, wind, and your personal characteristics you have entered.

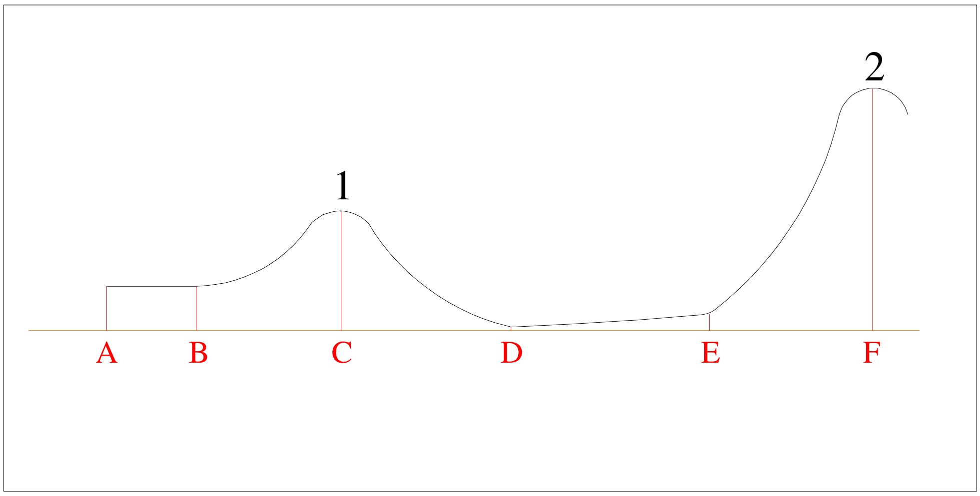


figure 2

When you enter a higher speed for a downhill than the speed CRED calculates you will reach when just cruising down freely under the force of gravity without pedalling, CRED calculates the energy you have added to your ride from the difference in time and speed. Braking and slowing down while on a downhill does not affect the energy expended, because CRED needs only take into account the final time and average speed in which the downhill was completed in order to calculate the energy expended. All this means is: No matter how much you pedal or cruise down a downhill, CRED still accurately calculates the energy you expend on the downhill from the time you say you will complete the downhill, of which this “time” CRED calculates from the speed you say you will ride it. If you prefer working in time instead of speed, CRED allows you to do that, as you will see in part 6.

From point D to F we have a special scenario; the climb up mountain 2 does not start at point E, but instead at point D, and must “h” (vertical height) be calculated as the height from D to F. Climbs are always calculated from the point where the road has an incline upwards to the point where it levels out again**.** However, in CRED’s table, you will make D to E one uphill section with its vertical height, and E to F another uphill section with its vertical height, because your intended speed will be quite different for each of these two sections. Consequently, CRED will handle it as two separate uphill slopes in the route. We will deal with that again in part 6.

Lifting your legs against gravity as you pedal will not form part of CRED’s energy analysis, because the upcoming leg’s weight is neutralized by the down going leg’s weight on the other pedal, thus cancels out gravity’s effect on your legs, unless you have one leg much heavier than the other. Up to here, you now know how CRED calculates slope (hill) energy.

However, you may still wonder; does gear selection and crank length influence the amount of energy used to go up a hill? The answer is, absolutely not! We looked at crank length earlier already. However, when a longer crank causes more body flex though, which causes you to do work in the mid to upper body, you lose energy in that extra work you do, but it makes no difference in the energy you use to pedal with. Your pedal energy (work) is determined by the force you place on the pedals multiplied by the circumference (rotational/cadence distance) your crank length provides. A longer crank will pedal easier (less force needs be applied), but through a longer circumference (distance), which keeps the amount of energy (work) you expend the same. On the other hand, with the same crank length, two different gears will have the same pedal circumference (distance), but more revolutions (higher cadence) will be pedalled in the lighter gear to travel the same road distance, again keeping the energy ratio the same. With larger or smaller diameter wheels it is the same as with your crank length; you will apply more force to the road with smaller wheels, but will need more revolutions to cover the same distance, again expending the same amount of energy in both instances. Gear selection, wheel size, and crank length are purely a personal preference to your own physical build, strength, weight, capabilities, technique, and for your own comfort, but does not influence the amount of energy you put into your ride.

If altitude details are not provided by race organizers, or available for a route you want to ride, you will have to find a topographic map of the area to get altitudes from, so you can get the vertical heights of the slopes of up and down hills/mountains.

In conclusion, gravity is a force you need to overcome when going uphill, and the energy you need to do so with dependents on your total individual weight; mass of you, your bike, gear, wear, and any other objects you ride along with. On a downhill gravity adds energy to your ride. Moreover, only the vertical height is required to calculate the gravitational energy an upward slope demands from you, which is the height you enter into CRED's table in the "Uphill H" cells for every uphill the route has, and into the "Downhill H" cells for every downhill. Crank length, gear selection, and wheel size do not alter the energy expended on a route. A slope begins where the road makes a first incline upwards, or downwards, and ends when it levels out again. Slopes can be divided into different sections, with each section's vertical height entered with its own entry, as seen in figure 3 below.

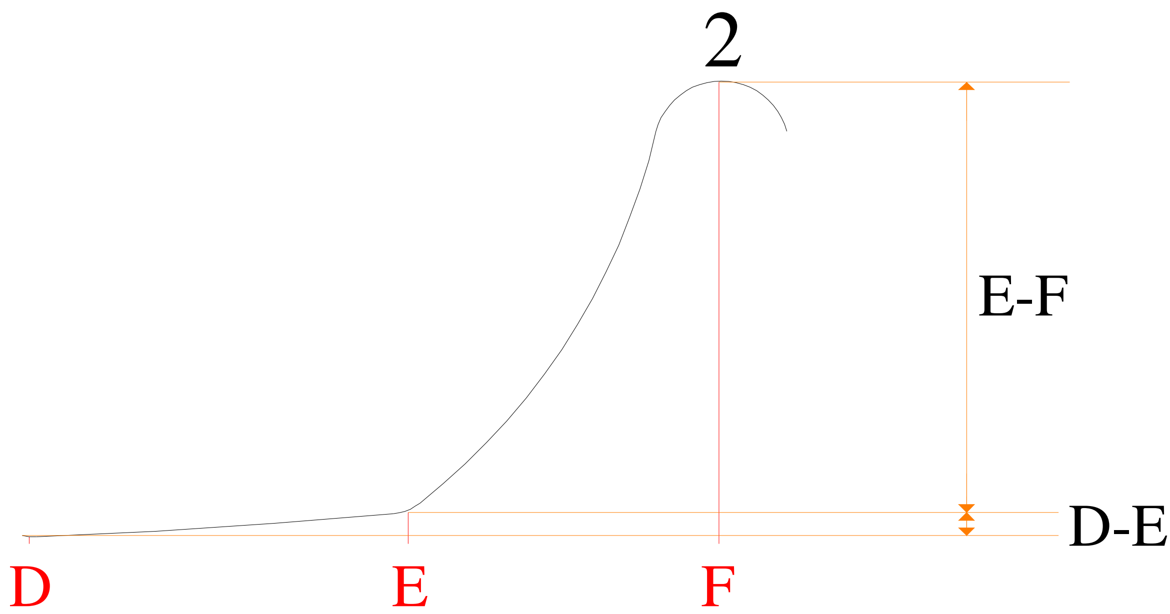


Figure 3

CRED: Part 3

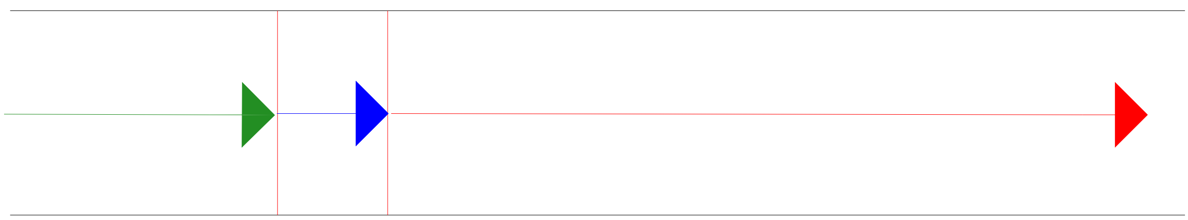
In the previous part you learned how CRED calculates the energy demand hills and mountains (slopes) require from you, and in the part before that you were introduced to the forces you need to overcome in order to cycle, of which we will be looking at friction in this part. As you have learned already, friction is a force that wants to decelerate (brake) you all of the time while you cycle. The more friction there is the more energy you need to expend in order to ride. If you do not overcome the force of friction, you cannot get into motion, so let us first have a look at what friction actually is.

In cycling, you deal with two types of friction; component friction and rolling friction. The former consists of friction generated in all the bearings of your bike, and between the chain and sprockets. Rolling friction is created between your tyres and the road while you ride. When any two moving materials come in contact with one another, friction is created, which is a phenomenon that takes place at molecular level. No matter how smooth any object's surface looks, if you take a very strong microscope that could see down to atomic level, you would see a very rough surface. It is the same as when you look at earth from outer space and you see this blue and white ball with a very smooth surface, but as you come closer, you find a very rough terrain consisting of many mountains and valleys. If two earths would rotate in contact with each other, or slide against one another, you can imagine what friction all those mountains would create as they bump into one another. Apart from physical contact, there also exist micro gravity between materials that contributes to the force of friction. To reduce friction between objects we use lubrications such as grease and oil, which forms a thin diaphragm between the objects to minimize the contact between the millions of mountains at molecular level. In science, we describe friction between materials by attributing a dimensionless number to it, which is used in calculations to see how it will affect the motion between the materials, and to calculate the energy needed to bring it into motion. We call these numbers the "friction coefficient" between materials. The static friction coefficient between two pieces of dry steel for instance, is $\mu = 0.8$, and $\mu = 0.1$ when lubricated. The Greek letter Mu (μ) is used as the symbol for friction. You can thus see that the friction in a dry bearing will be about 8 times more than in a lubricated bearing, meaning that it needs 8 times more energy to bring it into motion, of which this energy comes from your body while cycling. This is one reason why your car becomes heavier on fuel when you do not service (new oil and grease) it often, because it has to burn more petrol (energy) to overcome the higher friction between all the moving parts..

The rolling friction between your tyres (rubber) and the road (tarmac) is normally $\mu = 0.02$, which is a friction you rather do not want to lubricate, because you need it to stick through the bends. When you brake and lock your wheels, the kinetic friction between rubber and tarmac is high at $\mu = 0.8$. From this, you can see that it would be a daunting task to determine the friction of every single part of your bike, because the quality of lubrication in two different bearings may even differ. Fortunately, there is an easier way we can use to determine all these frictions' combined effect at once. We can easily determine the friction coefficient for your bike as a whole by doing a simple experiment, combining all of the friction into one final number. What's more, CRED will calculate it for you. All you need doing is to enter the values you get from the simple experiment you do into CRED.

To do the experiment, you need to find a level piece of road. It is important that the road is not inclined (have a slope), because we do not want gravity to play a secondary role in the experiment. Once you found a piece of road that is flat (horizontal), draw a line across the road, which is clearly visible. Then ride your bike at any given speed and stop pedalling all together once you cross the line with your front wheel. Let your bike roll freely until it comes to a halt. Measure the distance from the line to your front wheel at the point where the bike came to a halt. Then enter your speed (in km/h) you travelled when you crossed the line into CRED's "Rolling Friction Test" (green block) section, in the "ʆr test V" cell (rolling friction test velocity), and the distance you rolled (red arrow in the sketch below) in the "ʆr roll dist" cell (rolling friction roll distance). You do not have to ride fast, because we do not want wind resistance (drag) playing a huge factor here. A speed of even 10 - 15 km/h is sufficient, and preferably, the experiment should be done in wind still conditions. However, CRED does account for wind resistance (drag) in wind still conditions from the speed you enter when doing the test, and deducts drag from the equation when determining your friction coefficient. After entering your test speed and rolling distance, CRED will then calculate what your kinetic energy (K) was when you crossed the line from your speed and mass, and use it to calculate the total friction coefficient (ʆr coef) of your bike from your kinetic energy and the distance you rolled.

To find your speed when you cross the line, you may fit a speedometer to your bike, or use a speed detection device set up at the line. Alternatively, you may have someone take a stopwatch to measure your time as follows: Draw a second line 4m to 5m before the line where you stop pedalling (where the green arrow points in the sketch below). Measure the time it takes you to cross from the first line to the second line (blue arrow), and enter that time in the friction test time (ʆr test t) cell in the purple block. Enter the distance between the two lines (blue arrow) in the friction line distance (ʆr line S) cell. CRED will then calculate the speed you travelled when you crossed the lines, which you then enter in the "ʆr test V" cell in the green block. Thus, you need no expensive equipment to do the test.



This friction coefficient combines all the friction of all moving parts, as well as the rolling friction between your rubber and the road in one value. The better your moving parts are lubricated, the further you will roll, meaning the smaller your friction coefficient will be. In the previous part, we saw how gravity demands the same amount of energy up a mountain irrespective of the length of the road going up to the top. Friction however, is directly related to the distance you travel, because it is a constant force working against you as you move along. We know from Part 1 that work (energy) is force times distance. Therefore, in the example of part 2 where route B up the mountain was further, it will require more energy from you to overcome friction as you work your way to the top. CRED calculates your energy you need to overcome friction with for every section of the route based on your unique friction coefficient.

With mountain biking the picture changes quite a bit, because your friction coefficient will differ as the terrain changes between hard road, lose sand, grass, mud, rocky surfaces, etc. Therefore, provision was made in CRED to test your bike's friction coefficient for up to 12 different types of terrain, in the "OFF ROAD ROLLING FRICTION TEST" section. When preparing for a race, you will then enter your friction coefficient for each section of the route depending on the type of terrain the section consists of. Furthermore, you divide the route into sections yourself. CRED makes provision for you to divide every route or race up into 50 sections, and each section up into 10 sub sections. For each section, you enter its own unique parameters, which allow CRED to calculate your energy requirements accurately. CRED then ties it all nicely together in table- as well as graph format, showing you the full picture of your energy requirements for each section, as well as the rate at which you need to burn the energy for each section in order to ride it in the time and speed as you specified. You can then play with, and alter any section until you are happy with the picture you have in front of you. Once you are happy, you print a report, which shows you only what you need to know when going out on the road; each section's speed at which you should ride it, and what your stopwatch time will be at the end of every section as you proceed through the route.

That is how far CRED simplifies it all for you, taking a multitude of variables that specifically apply to your own individual condition, do all the number crunching for you, and gives you just that which you need to know; how you should ride your route from start to finish in order to deliver your own personal best performance according to your own condition, and that of your bike's.

In conclusion, friction is a force amongst others you need to overcome in order to get into- and stay in motion. The energy to overcome friction comes from your body, and the more the friction, the more energy it consumes, which is wasted energy you could have added to increase your performance. It is thus important to ensure that all moving parts are well lubricated, and in good working condition. Your tyre pressure should also be checked often to ensure it doesn't drain unnecessary amounts of energy –lower pressure tyres have higher friction coefficients on tarmac, but may be better in lose sand for mountain biking. You can now go and establish your bike's friction coefficient with CRED, without the need of having expensive equipment to do it with. In the next part we will look at drag force (wind resistance), which plays a larger role than you may think.

At this point, I would like to restate; you do not need to know all the technical issues as I explain it in the tutorial. It is just to give you a better idea of what every force entails. In the end, when you come to part 6, you will see that you only need to tell CRED about yourself, how your route looks like, and how you intend to ride it. CRED then shows you what you are in for, which you then play with until you find your perfect strategy that will prevent you from burning yourself out too early. That's it! But it's nicer to know more about what you are dealing with when working with CRED.

CRED: Part 4

In the last two parts, we looked at how CRED calculates the energy you need to overcome the force of gravity on slopes, as well as to overcome the force of friction. In this part, we are going to look at how the energy you need to overcome the force of wind resistance (drag) is calculated by CRED.

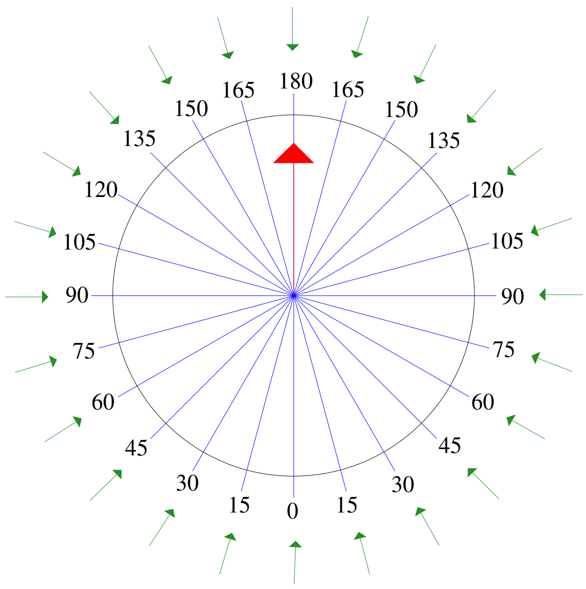
In the first part of this series you learned how cycling is all about overcoming forces in order to get into motion, and drag force is one of those forces that contributes to your energy expenditure, more than you may think. The greater part of the money you pay for fuel in your car goes to overcoming drag. Let us thus first have a look at what exactly drag entails.

All forms of life on earth exist and live in some sort of medium. Fish for instance, live in a liquid medium of water. We live in a medium of gas (air). Moreover, all medium consist of physical matter (atoms and molecules), which has mass. The air in a room of 6m x 6m and 3m high for instance, weigh 132 kg at sea level, which is heavier than two bags of cement. In order to move through this medium you need to shift (move) that mass around. To do so, you need to exert a force onto it, which requires you to burn energy. In addition, the faster you move through a medium, the faster you shift its mass around, which means that you exert a greater force onto it, consequently having to burn more energy. You have probably heard the saying; for every action there is a reaction, which means that the force you exert onto the medium, the medium also exerts back onto you. In terms of air resistance (drag), we deal with this force as a pressure being exerted onto you, of which the pressure is higher on your front profile than on your back profile as you move forward. This difference in pressure between your front and back, which is a pressure force opposite to your direction of motion, requires energy from you to oppose, of which this energy comes from your body while you pedal. To calculate this force a couple of variables come into play; your profile (surface area) as seen from the front; the density of the air; the speed and direction of the air (wind); and your speed as you move relative to the air. To complicate it even further, wind close to earth's surface is very turbulent, meaning that the pressure it exerts onto you may continuously vary up and down in intensity. The air pressure at sea level is on average also higher than inland. It will thus be a daunting task to attempt and precisely calculate the total force drag will exert onto you over the course of a route. However, its effect on your energy requirements to overcome it is excessive, and therefore cannot be ignored.

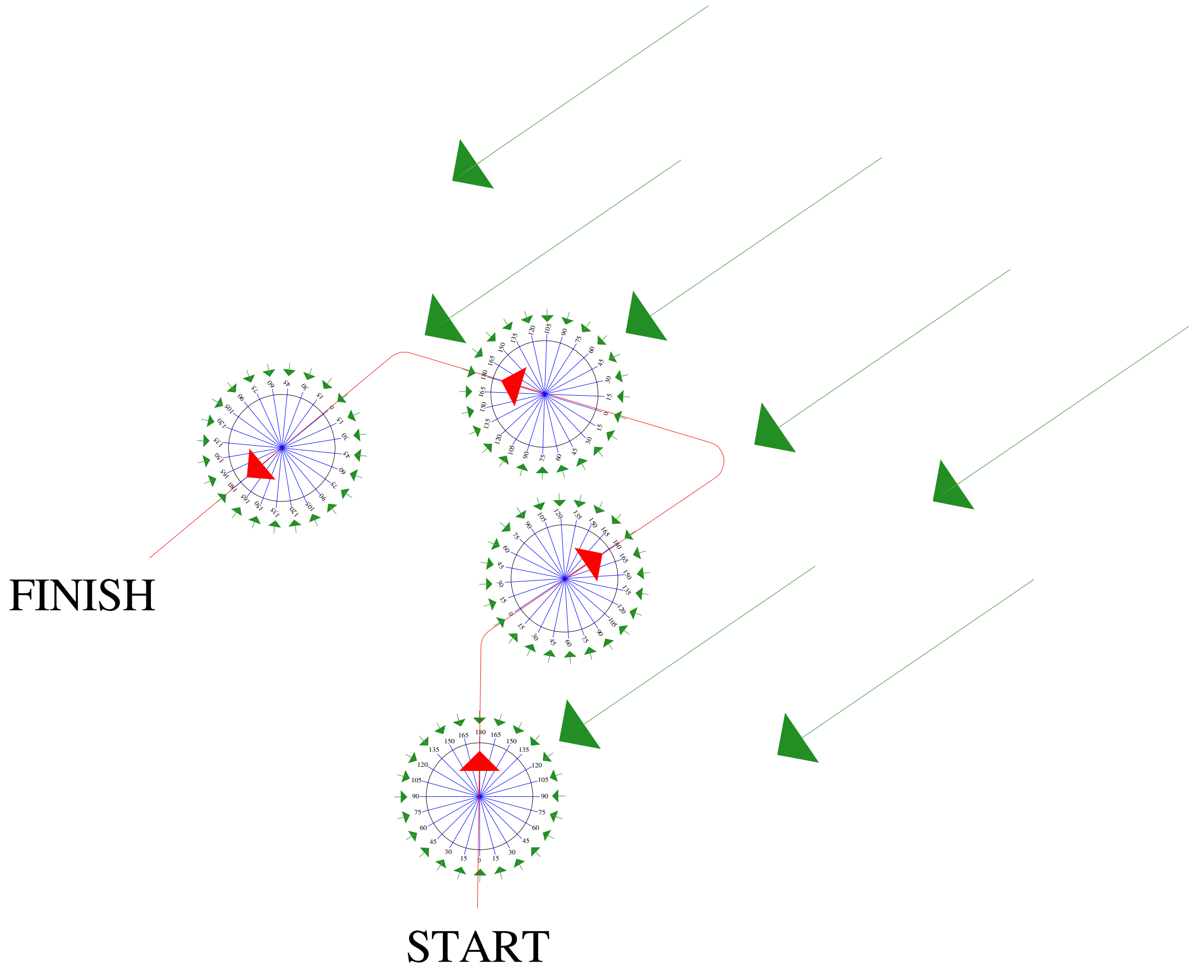
Fortunately, science has created a good model that can be used, which is sufficient to closely approximate the energy you will need to overcome drag despite all the aforementioned variables. CRED utilizes the formula $\frac{1}{4} AV^2$, where A is your profile (surface area including that of your bike's) taken in square meters as seen from the front, and V is your velocity in meters per second. The "¼" in the equation is not a pure number, but has density units "kg/m^3", which relates to the density of air and is a reasonable yet simple model of drag at speeds for cycling, whether you ride inland or at sea level. In the CRED program you enter your profile (surface area) value, the velocity (speed and angle) of the wind for each section of the route, and the speed at which you intend to ride each section, then CRED calculates a very close approximation of the energy consumption drag will impose upon you. The wind's speed and angle can be taken as predetermined by the weather bureau for the area the night before the race. However, you can have CRED to calculate you a couple of scenarios at different wind speeds that may occur on race day, so you will have a couple of strategies available on the morning of the race depending on what the conditions may be. With a map of the route, and knowing the wind's direction, which is accurately determined by weather bureaus based on high and low pressure regions building up in the atmosphere, you will be able to easily divide your route into sections every time it changes direction. You then enter the criteria for each section separately into CRED, whereupon CRED then calculates you a very close approximation of the energy drag is going to add to (wind from behind), or subtract (wind from ahead) from your energy, based on the wind's speed and angle relative to your speed.

To determine your profile (surface area), you can have a picture taken of you sitting on your bike in your typical riding position. When the picture is then inserted into a drafting application with its scale set to match your physical height when you sit on your bike, your profile can easily be determined. Alternatively, CRED contains a model that approximates your profile area from your weight.

CRED also contains a wind protractor you use to easily determine the wind's angle on any section of the route, as seen in the figure below.



For every section of the route, you place the protractor circle so that the red arrow points in your direction of travel, then enter the angle the wind will blow as indicated by the green arrows. You will notice that the CRED protractor looks a bit different from a normal protractor, and that its calibration is the same on the left than on the right sides of its circle. This is because CRED only needs to know the angle of the wind relative to your motion in order to determine the energy drag will demand from you, for it does not matter whether the wind blows from the left or from the right at a specific angle, the energy factor in both instances will be the same. If the wind comes from straight ahead, it is at 180 degrees to your direction of travel, and at zero degrees if blowing from directly behind you. Every time the route has a bend where it changes direction, you will make the part of the route following the bend a new section in CRED's table, because the wind blows in one direction, but its angle on you will change after the bend. With a map of the route and knowing the wind direction, it will be easy to determine the angle the wind will blow on you on every section of the route. Let's look at the sketch below;



Here we have a map of a route that was divided into 4 sections from start to finish. We got the wind direction (big green arrows) and its speed from the weather bureau the night before, and plotted it out on our map. We take the CRED protractor and place it on each section with the red arrow pointing in the direction we will ride. In section one, we see the wind is blowing at an angle of about 125 degrees (you do not need be exact here –a 5 to 10 degrees tolerance will not make the world's difference). In section two, after going round the first bend, we see the wind is now blowing at 180 degrees. In section three at 55 degrees, and in section four at about 5 degrees. On this route, drag will demand the most energy from you on section 2, and the least energy on section 4. On sections 1 and 2 the wind is blowing into you face, and on sections 3 and 4 on your back. This is all you will need to do for CRED to calculate the energy drag is going to demand from you. You just enter the wind speed and angle for each section into the table of CRED. You can have a printing company make you the protractor on a transparent plastic sheet, so you can easily place it on your route's map and determine the wind angle for each section.

Furthermore, race organizers may want to supply this information on a website created for the race, where they can monitor and analyze wind dynamics on the route more accurately, and place the results on the website. At some stages of a route, where it runs past cliffs for example, the wind may blow differently than the general direction in the area. Nevertheless, using CRED will still take you miles closer to predict your energy requirements, than if you do not use it.

In conclusion, wind resistance (drag) is a force exerted on you while cycling, for which you need to expend a lot of energy to overcome over the course of the route. CRED calculates you a good approximation taking into account the wind's speed and angle relative to your velocity (speed and direction of travelling), and factors in a good approximation to your total energy requirement for the route due to drag. In the next part, we will look at heat loss and its effects on your energy levels. In the part thereafter, we will go through every aspect of the CRED program, step by step.

CRED: Part 5

Up to here you may feel that you had a lot to learn, that CRED may still be complex for you to use, because a lot of scientific concepts have been explained, but be rest assured, once we get to the final part, you will see how easy it all comes together and how simple CRED is to use, as well as to understand.

In this part, we look at a force not well known by many a cyclist, called heat loss. If you sit still for long enough, doing nothing, you still become hungry after a couple of hours. This is because your body burns energy even if you are not physically active, because your body is a heat generating life form, and to create heat takes a lot of energy. For you to live, your body needs to keep its temperature around 37 degrees Celsius. Once your body temperature drops below 35 degrees Celsius, you start suffering from hypothermia, which can lead to death if not treated. What's more, the colder the environment around you is, the faster your body loses heat and consequently needs to generate heat faster to keep it at 37C. Let us take a quick look at the dynamics of heat to make you better understand why.

Heat is a substance that flows freely, meaning that your brain does not need to activate it to happen, like it activates your muscles through your nerve system for example. The only thing heat needs to get into motion, to flow out of your body, is a difference in temperature. It then takes action by itself. Heat always spontaneously flows from a hotter environment to a colder environment, and the greater the temperature difference is between the hot and the cold environments, the faster heat will flow towards the colder environment, and keep flowing until the temperature between the two environments is the same. Your body spontaneously regulates its temperature to stay around 37C independently of what the temperature of the air around you is. The colder the air is, the faster heat moves from your body to the air, meaning your body burns its energy at a faster rate to keep its temperature constant at 37C. That is why we put on more clothes in winter than in summer, because our clothing slows down this heat transfer rate between our bodies and the environment. A branch of science, thermodynamics, developed a few models by which heat energy transfers from your body outwards, which CRED takes into consideration.

Conduction

Every substance on earth has a heat conduction coefficient, which is a numerical value used to describe how fast heat will flow through it. A formula was developed that takes into account a substance's conduction rate, its surface area and temperature, the temperature of the environment around it, as well as the thickness of the substance, to very precisely calculate how much heat energy will conduct through the substance in a specified time. CRED uses the conduction formula to calculate the conduction rate of heat energy loss through your cycling wear (clothing), and adds this energy you will lose due to the temperature difference between your body and that of the environment around you to your total energy demand for each section of the route.

However, cycling wear comes in different types of materials; lycra; polyester; spandex; nylon; cotton; etc, which all have different heat conduction properties. CRED applies a median value that was determined between all these materials, which is a close approximation for all of them as their conduction properties do not differ by a large margin. This median heat conduction coefficient in air was estimated at 0.1, as shown in the maroon block in the "Heat coef (k)" cell. This will give you a good approximation of energy loss due to temperature differences between your body and the environment. However, if a science laboratory tests your specific type of cycling wear, and you would like to enter the exact value, you can do so in this cell. The thickness of your wear is also entered in the maroon block, as well as your total body surface area. If you do not know what your total body surface area is, CRED contains a calculator that uses your weight to calculate you a good approximation.

Radiation

Your body also loses heat energy due to infrared radiation. This is the heat a security alarm system detects when you walk into a room where an eye (passive infrared detector) is installed. Although this form of heat loss is very small (in the decimal quantities of energy), CRED accounts for it anyway.

Convection

Convection is the heat transfer from your body to the air where the air is in direct contact with your skin that is not covered by clothing. CRED calculates your heat loss by way of convection and conduction based on you telling CRED how much of your body is covered by clothing, and how much not. We will discuss this in part 6. The convection formula CRED applies also accounts for your speed relative to that of the wind as you tell CRED for each section of the route. If you have statistics on the rate at which daytime temperature rises in the area of the route for the time of year the race is held, you can enter what the ambient temperature will be for each section of the route, because CRED shows you what your time will be at the end of each section. Perhaps race organizers can also supply these statistics on a website of the race, otherwise you can get it from your local weather bureau.

Evaporation

Evaporation (sweating) is another form of body heat loss. However, CRED does not apply evaporation into its calculations, because evaporation is calculated by incorporating an activity factor (physical work intensity), which is a direct consequence of the work (energy) CRED already calculates. To include evaporation would be to double calculate the same energy. This is why CRED is such an accurate energy analysis program, because it deals with the true conditions of the route and of your body, which is based on proven physics laws, and does not base its calculations on far fetched assumptions as "intensity factors" that may differ from opinion to opinion, and is basically impossible to define.

Basal metabolic rate (BMR)

Even when you are at rest and do no physical work, your body needs to expend energy to keep your organs working and your blood flowing. Up to now CRED has calculated all the work you need to do to ride a route, or a race. However, while riding, your body still keep your organs working and your blood flowing, for which it expends additional energy. Therefore, CRED adds your Basal metabolic rate (BMR) to your route energy needed for each section of the route. Thus, CRED shows you the complete picture of what you are in terms of energy, from start to finish over the course of a route. To calculate your BMR, CRED uses your weight, height, age, and whether you are a male or female, which you tell CRED. Just by changing your age, you will see how your energy requirements will alter for the same race next year, or the year thereafter, or 5 years later, if all else remains the same. We will look at this further in part 6.

Congratulations! By reaching this point, you have gained the understanding that will make you appreciate CRED as a valuable tool in your cycling preparation. You are now ready to start using CRED and experience how closely it answers to your experience out on the road. Although CRED will come forth to you as a very simple tool to use, it incorporates four different disciplines of physics, as well as utilizing multiple mathematical techniques, all combined into specially created algorithms. CRED is unique, and the only of its kind. It doesn't generalizes cyclists, but looks at you in every aspect of your own uniqueness, and accordingly shows you who you are as an individual in terms of your own energy requirements for any race and route you plan to cycle. CRED is your personal cycling scientist that will analyze every route for you in seconds, and help you to better understand yourself as a cyclist who are up against every force out there on the road you need to conquer. Once you start using CRED, you are a professional cyclist in every sense of the word.

CRED: Part 6 *(The sketches in this part was copied from the program to this tutorial, and formatted to fit on the page, thus will the quality of the pictures seen in this part be of a lower quality than in CRED itself.)*

In this part, I explain CRED to you in a systematic format. If you have not purchased your activation code yet, follow the instructions in the Installation Manual you received with this tutorial, or email me at van.staden.pj.x@gmail.com with the words "Request Invoice" to do your payment through PayPal, after which you email me again with the words, "Request Activation Code –Payment done."

To explain CRED to you, I will use the analogy of Jim; when you first open CRED, Jim's information is entered into the program. If you have already changed it, clear all the cells and fill it out in Jim's particulars as you work your way through this part.

The CRED sheet you see in front of you is protected, which means that CRED will only allow you to enter data in cells with red borders. You are thus not able to accidentally hurt the functionality of CRED. You can copy CRED to friends, but they will have to follow the instructions in yellow above to get their own activation codes.

The scientific principles CRED are based upon was discussed in the previous five parts, and forms a complete tutorial of the CRED program. While in the program, hover your mouse over any cell or cell range to see a "comment" description of what information input is required in the particular cell or range of cells. Instructions for users who are used to the imperial system of units (miles, yards, pounds), will be shaded in grey, as is this sentence.

Brown Block

CONVERTER	Pounds	154,31	lbs
	kg=	69,99	kg

BROWN BLOCK

RIDER & BIKE MASS		
Rider weight	69,99	kg
Bike weight	10	kg
Gravity Force	786,30	N

Tot m

Enter your weight (nude body weight) as well as that of your bike (including all gear, wear and accessories) in the Brown Block. The program uses your weight in several of its calculations to determine the energy you are going to need to ride the route. The brown block also shows you the force gravity exerts on you and your bike, measured in Newton. If you are used to pounds, use the converter above the Brown Block to convert to kilograms.

Jim weighs 69.99 kg, and his bike, gear, wear, and all accessories 10 kg. Gravity will thus exert a force of 786.30 Newton on Jim and his bike.

Green Block & Purple Block

GREEN BLOCK			PURPLE BLOCK	
ROLLING FRICTION TEST			SPEED TEST	
4,544	(km/h)	ʃr coef	ʃr test t	
ʃr test V	16,36	0,0172	1,1	s
ʃr roll dist.	50	K (Joule)	ʃr line S	Speed (V)
	(m)	826,0	5	16,36
			m	km/h

Enter your friction test speed in (km/h) in the (ʃr test V) cell, and your rolling distance in (m) in the (ʃr roll dist.) cell, in the Green Block. See Part 3 of this tutorial on how to perform the friction test in the Purple Block. The green block then shows your overall rolling friction coefficient, which is used by CRED to calculate the energy you will need to overcome friction during the course of the route. It also shows what your kinetic energy (K) was when you crossed the line of the friction test.
Jim did the speed test as described in part 3, where his two lines were spaced 5m apart and his time to cross both lines was 1.1 seconds, which he then entered in the Purple Block to find his speed of 16.36 km/h, which he then entered in the Green Block, together with the distance of 50m he rolled after crossing the second line. CRED determined Jim's friction coefficient to be 0.0172.

If you are used to miles per hour (mph) and yards, use the converters at the top right corner in CRED to convert to kilometres per hour (km/h) and meters (m).

Converter: mph to km/h		Converter: yard to meter		
mph	1	yard	1	
km/h=	1,609	meter=	0,914	m

Maroon Block & Blue Block

				Developed by: PJ van Staden, 2017 Protected under international © Copyright Law as published in the CRED Tutorial.	
MAROON BLOCK					
Emisitivity	0,98				
Sex Factor	5	(Male: 5) (Female: -161)			
Body Temp	39	37,1 is the normal body temp. at rest +-1C			
BODY SURFACE AREA		% Body covered	90		
Man	1,79	% Body uncovered	10		
Woman		BLUE BLOCK			
THERMAL VARIABLES		WIND FACTORS		Profile Area	
Heat coef (k)	0,15	Gen Wind V (m/s)	2		0,58
C Thickness	0,002	Gen Wind ⦣	60		
Height (cm)	178	PEDAL EFFICIENCY			
Age (years)	28	Efficiency (%)	70	%	

Jim entered his emisitivity as 0.98. CRED uses it to calculate your energy loss due to infrared radiation. You can leave it like this as emisitivity accounts for very small amounts in the decimal values of your energy loss. Since Jim is a male, he entered 5 in the “Sex Factor” cell. If you are a female, enter -161 in this cell. CRED uses it in your Basal metabolic rate calculation.

The average human body temperature is 37 degrees Celsius (C)at rest, and around 39C with hard exercise. Jim entered 39 in the “Body Temp” cell for while he is riding in a race. If you are a competitive cyclist and you find that your body operates at a higher temperature while cycling, then enter that temperature in the “Body Temp” cell. CRED uses it to determine your energy loss due to temperature differences between your body and its environment as was explained in Part 5.

Enter your Body surface area in the “Man” or “Woman” cells. If you do not know what it is, use the GEN SURFACE APPROXIMATION CALCULATOR’s maroon value as seen below, which is estimated from your weight. Jim doesn’t know his body surface area, so he entered the value as CRED calculated, seen below. You can enter either a “Man” or “Woman” value, but not both at the same time. If you do, CRED calculates using the “Man” value. CRED uses this parameter in various calculations including drag and heat loss.

GEN SURFACE APPROXIMATION		
Body surface area	1,79	maroon block
Estimated front profile	0,58	blue block

Enter the percentage of your body that is covered by your cycling wear in the “% Body covered” cell, and the percentage of uncovered body (naked skin) in the “% Body uncovered” cell. Jim entered 90 and 10 respectively. CRED uses this in heat loss calculations.

The heat coefficient (k) value is determined at an average of 0.1, which you can leave like this, or replace it if your own cycling wear’s heat coefficient has been determined, as was explained in Part

5. Jim had his cycle wear tested at a university and entered 0.15. CRED uses this parameter in the heat conduction calculation.

Enter the thickness of your cycling wear in the "C Thickness" cell in meters. A value of 2 mm (0.002 m) is used as preset value. Jim left his at 2 mm (0.002 m).

Enter your height in centimetres (cm) in the "Height (cm)" cell and your age in years in the "Age (years)" cell. Jim entered his height as 178 cm, and his age, 28. If you know your height in meters or feet, use the Body Height Converter in CRED to find your height in centimetres (cm), as seen below.

BODY HEIGHT CONVERTER

Meter	1,78
Feet	
cm=	178,0

I included the Blue Block here again, for your convenience;

BLUE BLOCK

WIND FACTORS		Profile Area
Gen Wind V (m/s)	2	0,58
Gen Wind ∢	60	
PEDAL EFFICIENCY		
Efficiency (%)	70	%

In the Blue Block, you enter the general wind velocity in the "Gen Wind V" cell in meters per second (m/s), which you get from the "Wind Speed Converter" in CRED as seen below, after entering the wind speed as estimated by the weather bureau in km/h or knots. If your weather bureau uses miles per hour, use the mph to km/h converter in the top right corner of CRED to find the km/h value.

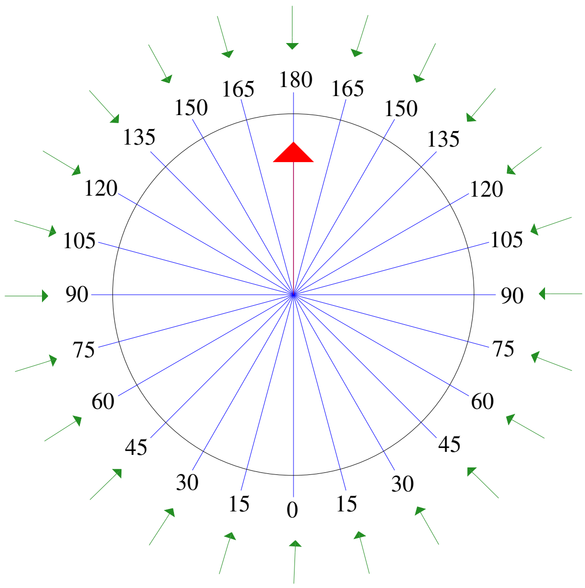
WIND SPEED CONVERTER

Knots			Km/h
km/h	7,2	3,89	Knots
m/s	**2,00**		

Jim's weather bureau gave a wind velocity of 7.2 km/h for the area in which his route is situated, which he entered into the converter, and found the 2 m/s value he had to enter in the Blue Block.

Enter the general wind angle as given by the weather bureau with relation to the general direction of the route, which you determine by using a map of the route and placing the CRED wind protractor on it as was explained in Part 3. However, you can change the wind speed and angle for each section in the CRED table. Only if you do not enter a wind speed and angle for any specific section, CRED will use these values in the Blue Block. Put in another way, if you enter a wind speed and angle for a section in CRED's table, CRED uses those values and ignores the wind speed and angle values you have entered here in the Blue Block. Jim determined that the wind's direction as shown by his weather bureau is at about 60 degrees to the general direction his route is taking.

You can have yourself a CRED protractor made as seen below, as was described in part 4. You can have it calibrated showing more degrees if you like. The one here is calibrated in steps of 15 degrees, which is adequate for the purpose of CRED to calculate a good approximate of the energy drag will demand from you.



Enter your front profile area in the "Profile Area" cell. If you do not know it, use the value CRED estimated from your weight in the "Gen Surface Approximation" calculator, as seen on page 28 (blue block). Jim doesn't know his front profile (surface area), so he used the value CRED calculated from his weight, which is 0.58 square meters (m^2). CRED uses this parameter in your drag calculations.

Enter your pedal efficiency in the blue block as well. It is taken at a preset value of 70%, which you can leave like this if yours was not determined professionally. The program uses your pedal efficiency to add the energy loss you incur by not applying force to the pedals at a constant 90 degrees angle with the crank, as was explained in part 1 (page 7). Jim left his pedal efficiency at 70%.

You have now given CRED all the information it needs to know about you, and can now start to tell CRED about your route, which you do in the CRED table. The CRED table as you see it on the next page was a bit formatted from how it looks like in the real program, to enable you to see all the columns in this document (the program's columns are wider).

CRED Table

	23000				m/s	sec	km/h	min	m/s		Celsius			
Sec	**Distance**	**ʃr coef**	**Up hill H**	**Down hill H**	**CRED Avg V**	**CRED Avg t**	**Intended V**	**Intended t**	**Wind V (m/s)**	**Wind Angle**	**Temp C**	**Energy (J)**	**Energy (cal)**	**Burn Rate J/s**
1	2000				1,0	2000	30	4,00	2	60	18	112347,32	26839	468
2	2000		30		1,0	2000	30	4,00	2	60	18,1	142840,42	34123	595
3	2000			30	12,1	165	30	4,00	2	60	18,2	81336,23	19431	339
4	2000				1,0	2000	30	4,00	2	60	18	116050,56	27723	484
5	2000				1,0	2000	30	4,00	2	0	18	107194,98	25608	447
6	2000				1,0	2000	30	4,00	2	180	18	131212,05	31345	547
7	2000				1,0	2000	30	4,00	2	60	23,8	102333,11	24447	426
8	2000				1,0	2000	30	4,00	3	60	18	111549,95	26648	465
9	2000				1,0	2000	30	4,00	1	60	18	113253,99	27055	472
10	2000				1,0	2000	40	3,00	2	60	18	119637,77	28580	665
11	2000	0,0312			1,0	2000	30	4,00	2	60	18	140970,63	33677	587
12	1000				1,0	1000	30	2,00	2	60	18	57442,33	13722	479
13														

In the CRED table above, you see Jim divided his route into 12 sections (far left column). However, instead of entering a real route's sections, I have used section one in all the rest of the sections, every time changing only one parameter to show you how it influences your energy demand. For instance, section one shows a flat 2000 meters (2 km) piece of road, and section two is that same piece of route, but as if it is an uphill of 30m high, and section 3 as if it is a downhill, etc. First I will give a short description of every column, then we will look at the 12 sections entered.

Distance Column

For every section of the route, whether a flat, uphill or downhill, a distance **must** always be entered in meters. Right at the top of the Distance column, the total distance of all the sections combined are shown.

ʃr coef Column (green)

You do not need to complete the friction coefficient column if your whole route will be of the same terrain for which you have done the test in the Green Block earlier. CRED uses the friction coefficient in the Green Block when you do not enter a value in these cells for the sections. However, if you are a mountain bike cyclist, your route may bear different terrains for which the friction coefficient differ, and for which you have done a separate friction test for each type of terrain in the "OFF ROAD ROLLING FRICTION TEST" block, as seen on the next page. The off-road tests are performed the same as was described with the Green Block, where you enter your test speed for each test and your rolling distance, and CRED shows you the friction coefficient. These tests also deduct drag's influence from the test when done in wind still conditions.

OFF ROAD ROLLING FRICTION TEST

	km/h	m			
Test	**ʃr test V**	**ʃr roll dist.**	**m/s**	**K (joule)**	**ʃr coef**
1	16,36	30	4,544	826,0	0,0312
2	16,36	24	4,544	826,0	0,0400
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

If any section has a different friction coefficient than the one determined in the Green Block, then enter that section's own friction coefficient in its corresponding cell in the table. CRED will then use that friction coefficient for that section, and not the one in the Green Block.

Uphill H & Downhill H Columns

When the section is an uphill, enter the vertical height (change in altitude) of the slope in this cell for the section, in meters. Do the same if the section is a downhill by entering the vertical height of the decent in the Downhill H cell.

CRED avg V, CRED avg t Columns (Grey)

These columns are locked and you cannot enter anything in it. CRED uses base values as if you would have ridden the section at a pace of one meter per second, which it uses to calculate base energy values for each section. You can thus ignore these two columns, they only serve as part of CRED's calculation engine. The text is also made the same colour as the cells, so they will always appear empty to you in the real program.

Intended V Column

Enter your speed at which you intend to ride the sections in these cells, in km/h. If you prefer working with the time in which you would like to complete a section, instead of the speed in which you want to ride it, then enter the time together with the section's distance in the "INTENDED VELOCITY CALCULATOR" as seen on the next page, to get the velocity in km/h for the section, which you then enter in these cells in the table.

INTENDED VELOCITY CALCULATOR

Time (min)	3	min
Distance	2000	m
Intended V	**11,11**	m/s
Intended V	**40,00**	**km/h**

In this example you entered a distance of 2000 m, which you wanted to do in 3 min, then the calculator shows you the speed you must ride in meters per second (m/s) as well as in kilometres per hour (km/h). You enter the “km/h” value in the table in the “Intended V” cell.

Intended t Column

This column shows the time in minutes in which you will complete the section after entering your intended speed in the Intended V cell.

Wind V (m/s) Column

Enter the wind speed in meters per second (m/s) in these cells for each section. Use the “WIND SPEED CONVERTER” as described earlier in part 4, to convert knots or km/h to meters per second. If you leave these cells open for any section, CRED will use the wind speed and angle as entered in the Blue Block for that section.

Wind Angle Column

Enter the wind’s angle to the section taken from the CRED protractor in these cells for every section, as was described in part 4. If you have not entered a value in the “Wind V” cell to its left, CRED will ignore this angle and use the one as entered in the Blue Block. Thus, to make this angle effective you must enter the wind speed in the cell to its left as well.

Temp C Column

Enter the ambient (air) temperature for each section in these cells, in degrees Celsius. You may want to get the average rate of rise temperatures from your weather bureau for the area at the time of year you are going to ride the route, then you can verify it against your times for each section and enter the corresponding temperature of day for each section. Use the calculator CRED provides to convert from Fahrenheit to Celsius if you are used to working in Fahrenheit.

Energy (J) & Energy (cal) Columns

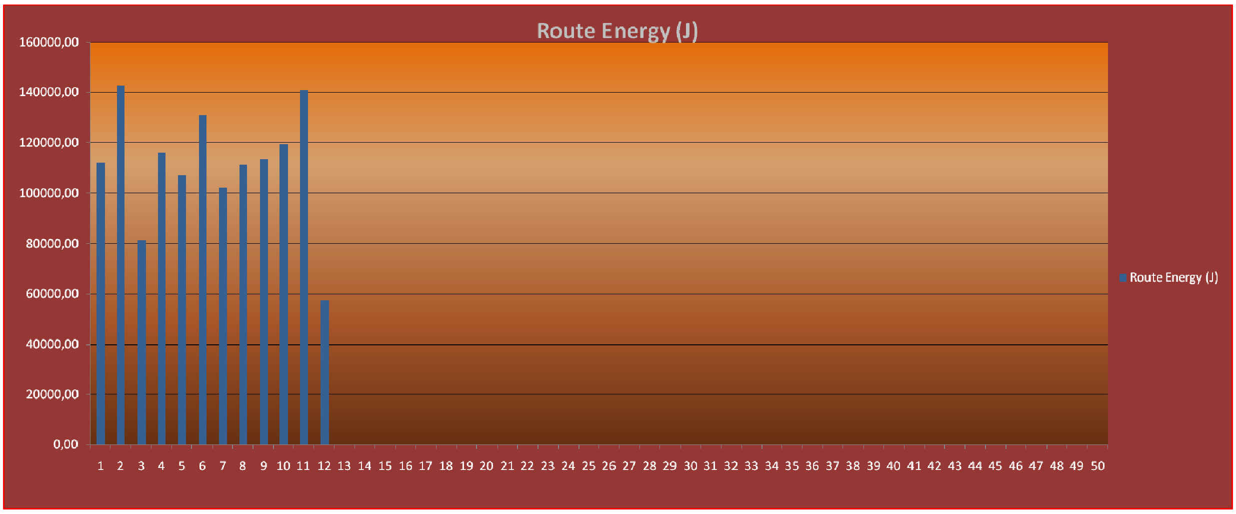
These columns show the energy demand for each section in joules (brown) and calories (yellow). The Joule column is used by CRED to plot the energy graph.

Burn Rate (J/s) Column

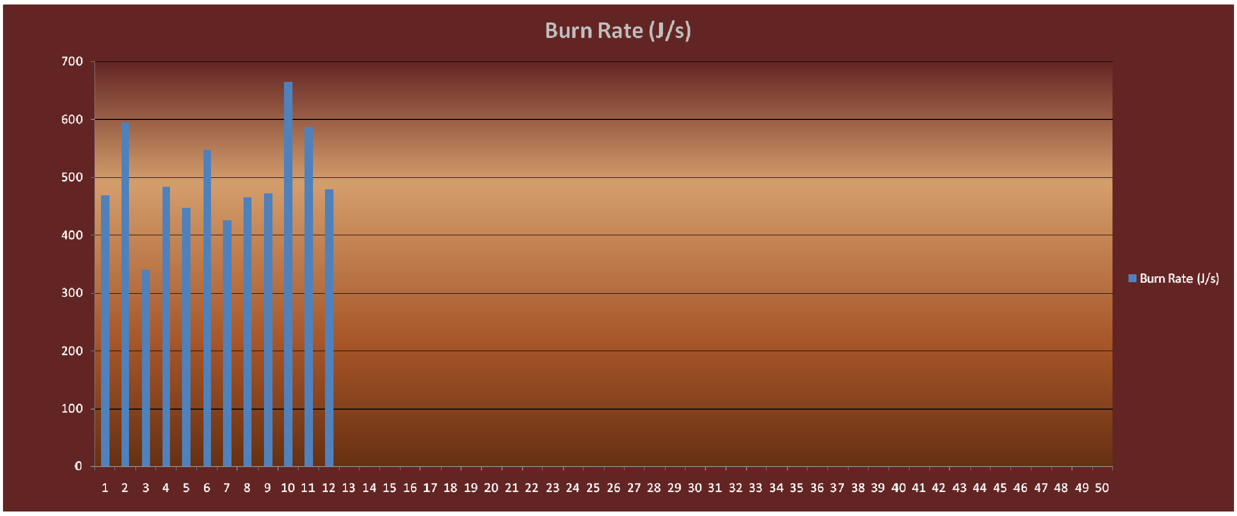
This column shows the rate at which you need to burn the energy in order to complete the section in the time as indicated in the “Intended t” cells, and is plotted in the Burn Rate graph.

Graphs

The graphs have the energy amounts plotted on the vertical (Y) axis, and the sections of the route plotted along the horizontal (X) axis.



Here we can see the energy demand of Jim's 12 sections he entered.



Here we can see what Jim's burn rate for each section is.

Analyzing Jim's 12 sections

Section 1:

1	2000						30	4,00	2	60	18	112347,32	26839	468

A 2000m flat, which Jim intends to ride at 30 km/h, with wind speed at 2 m/s at 60 degrees, and temperature 18C. CRED shows Jim it will take him 4 min to complete the section, that he needs 112 347 J of energy to complete it, and that he has to burn it at 468 J/s to do it in the time of 4 minutes.

Section 2:

2	2000		30				30	4,00	2	60	18,1	142840,42	34123	595

Section two is the same as section one, but just made an uphill. The vertical height of the uphill is 30 m, which you can see entered in the fourth cell from the left. The rest stays the same, except for the temperature that is now 0.1C higher. You can see how much more energy the uphill demands due to gravity, and if he intends to ride at the same speed of 30 km/h up this slope, he will have to burn energy at a much higher rate.

Section 3:

3	2000			30			30	4,00	2	60	18,2	81336,23	19431	339

Again the same as section one, but a downhill this time with the vertical height of the slope at 30 m. With all the rest the same, except for the temperature another 0.1C warmer, you can see how much energy gravity saves Jim on the downhill, as well as how much lower his burn rate will be when ridden at the same speed.

Section 4:

4	2000						30	4,00	2	60	18	116050,56	27723	484

With section four you see something strange; it is filled out exactly the same as section one, but CRED shows a higher energy demand and burn rate as in section one. This is because CRED also gives you the opportunity to break every section up into 10 further parts, for which there is a window each in CRED for all 50 sections you may want to divide a route into. Underneath is section 4's window;

SECTION AVERAGE SPEED CALCULATOR 4

	Distance m	Speed km/h	
1	500	30	km/h
2	500	20	km/h
3	500	40	km/h
4	500	40	km/h
5			km/h
6			km/h
7			km/h
8			km/h
9			km/h
10			km/h
m	2000	**30,00**	**km/h**
yard	2187	18,64	mph

Cancel E	
1	
Section time	
Time: hr;min;sec	
0	hrs
4	min
0	sec
Time: sec	
240	s

Energy (J) added due to acceleration: 3703,2

You can see that Jim divided section four into 4 legs of 500 m each, entering the speed he intends to ride each one of these legs. His average speed over the whole section is 30 km/h, shown in red, which is the speed he has to enter in the "Intended V" cell in the table for section 4. The acceleration from leg 2 (20 km/h) to leg 3 (40 km/h) will demand extra energy from Jim to overcome the inertia of his mass (including that of his bike), which is shown in the bottom right corner. This energy CRED automatically adds to section 4's total energy, therefore that section 4 shows more energy than

section 1 in the table. If you do not complete a section's window, CRED only uses the information in the table as if the whole section is ridden at one speed, which you enter in the "Intended V" cell in the table. If you complete a section's window, and the acceleration is due to it being a downhill, thus not because you pedal harder, then you delete the "1" in the "Cancel E" cell in the window, which will cancel the energy for that window so CRED does not add extra energy to the section because of the acceleration.
Using the windows, you can plan when you want to surge during a race in any section, and for how far, and how fast.

Section 5:

5	2000						30	4,00	2	0	18	107194,98	25608	447

Here we have the same story as in section 1, but only the wind angle is now from right behind at zero degrees. You can see that the angle of the wind causes Jim to expend less energy for this section even though the wind is the same strength, but is blowing from right behind now.

Section 6:

6	2000						30	4,00	2	180	18	131212,05	31345	547

Again the same as section 1, but with the wind from right ahead now, at 180 degrees. Between section 1, section 5 and section 6, you can see how wind direction influences your energy requirements over the same distance.

Section 7:

7	2000						30	4,00	2	60	23,8	102333,11	24447	426

Again the same as section 1, but the daytime temperature is much higher now, at 23.8C. You see that you need less energy here than in section 1, because your body loses energy at a slower rate due to a smaller difference in temperature between your body and the air.

Section 8 & 9:

8	2000						30	4,00	3	60	18	111549,95	26648	465
9	2000						30	4,00	1	60	18	113253,99	27055	472

Again the same as section 1, but here we made the wind's speed higher in section 8, whilst lower in section 9. Since the wind is blowing more from the back than from the front when at 60 degrees, section 8 requires less energy than section 9 as the wind is blowing harder from behind in section 8.

Section 10, 11 & 12:

10	2000						40	3,00	2	60	18	119637,77	28580	665
11	2000	0,0312					30	4,00	2	60	18	140970,63	33677	587
12	1000						30	2,00	2	60	18	57442,33	13722	479

Again the same as section 1, but in section 10 we made the Intended Speed 40 km/h, in section 11 we entered a different friction coefficient for the section, and in section 12 we made the distance half the length at 1000m. You can see how each of these affect the energy demand in comparison with section 1.

Let's assume Jim knows his safe energy burn rate so as not to drain energy out of his muscles faster than his body can generate it, and we assume it is 600 J/s, Jim can see on the Burn Rate graph that the speed he entered for section 10 (40 km/h) is too high, because it pushes his burn rate over the 600 J/s line to 665 J/s. Now Jim can gradually make his speed less until his burn rate falls under 600 J/s. Similarly, Jim can also increase the speed of all sections far below 600 J/s. When done, CRED shows his total time for the route at the bottom of the table. All Jim now needs, is a report he can take with him to the route or race, showing him at what speed to ride each section.

Report

At the bottom of the screen Jim clicks on the "Report" tab, and see the sheet as in the picture below. For each section the average speed is shown in red at the top left corner of the section. If the window of the section wasn't completed, the report will only show the average speed and the time for the section in blue at the bottom, with the stopwatch time at the end of the section since the start of the race shown in the yellow blocks, in hours, minutes, and seconds. If a section's window was completed, like Jim did with section 4, it will show in the report as seen below. The rest of the sections not completed in CRED's table, like sections 13 to 50 in Jim's case, the report will only show #### signs in the yellow blocks. Jim can print this report and take it with him on the route, and now ride his race to the best of his own unique body's energy dynamics.

1		2		3		4		5		6		7		8		9		10		11		12		13	
30	D	30	D	30	D	30	D	30	D	30	D	30	D	30	D	30	D	40	D	30	D	30	D	0	D
						30	500																		
						20	500																		
						40	500																		
						40	500																		
4,00		4,00		4,00		4,00		4,00		4,00		4,00		4,00		4,00		3,00		4,00		2,00			
	0		0		0		0		0		0		0		0		0		0		0		0		######
	4		8		12		16		20		24		28		32		36		39		43		45		######
	0		0		0		0		0		0		0		0		0		0		0		0		######

Since Jim could also see his total energy requirement for the complete route at the bottom of the table (1336.17 kJ), he can plan what nutrition to take, and how much of it.

To print the report

1. To print the report, hold your mouse's left button in, and drag your mouse over all the sections you want to print.
2. Right click, and select copy. *(The data is now on your clipboard)*
3. Close CRED, and it will ask you to save. Save the analysis if you want, with a descriptive name.
4. Open a new Excel workbook, right click on any cell and click paste.

5. The data will now show on the sheet, and you can format it any way you like by inserting borders, colour the cells, and set the column widths, etc.

Quick test to determine your safe energy burn rate

Now that you know how CRED works, you can determine your ideal burn rate you would like to ride at. Go and ride any piece of road (preferably a flat road where you can keep a constant speed) at a speed which you feel you can handle without burning yourself out too quickly. Enter your time and the distance of the piece of road you rode in the "INTENDED VELOCITY CALCULATOR" to find your speed at which you rode it. Then enter the distance, your speed, the wind, and temperature, all of it as it were when you rode it, as a section in CRED's table. To make it easy, do this in wind still conditions so you can enter the wind speed and angle as zero. The burn rate CRED then shows you, is your ideal burn rate. As you then enter sections of any route into CRED, you can play with your "Intended V" speed to get your burn rate for each section as close to your ideal burn rate as possible. You will then know at what speed to ride each section irrespective of all its variables that differ, as well as see in what time you will finish each section, as well as the time of the complete route.

Once you start playing with CRED and build your cycling experience, you will do minor adjustments until you find your optimum performance level (burn rate) to plan against for each and every route you plan to cycle. You will also better plan your nutritional intake, and can now experiment with it on the same route even when weather conditions will not be the same with every trial, because you will know in advance how to ride every trial in the specific conditions at the time. Thus, even if trial run 2 was slower than trial run 1, because of stronger wind for example, you will still know whether run 2 was a better performance, because you knew in advance in what time trial run 2 had to be done to compare with trial run 1, irrespective of weather conditions. You will feel how CRED becomes your mate in teaching you more about yourself and your abilities.

On the next page, find a few tips on how to use CRED.

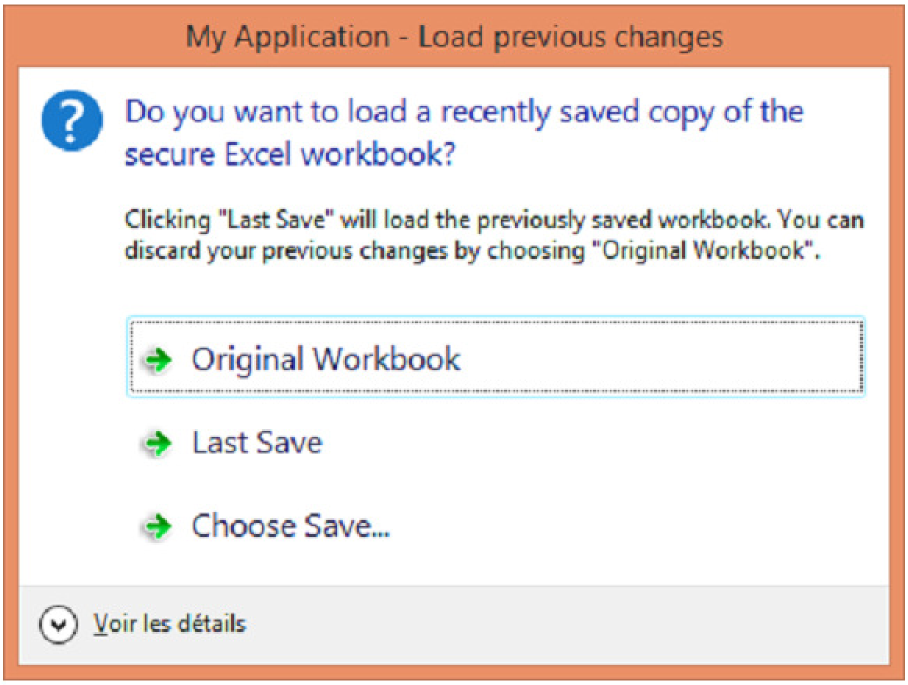
CRED Tips

Save your blueprints;

Once you have completed all the fields of CRED and you are happy with the results, you can click the close button, upon which CRED will ask you whether you want to save a copy (blueprint) of it. CRED will open the save dialog box wherein you can specify the location where to save the blueprint, and give it a descriptive name. However, CRED will only allow you to open saved blueprints on your computer when you open CRED itself. Attempting to open a blueprint on its own, or on another computer, will not work; you have to open CRED first, then it will ask you whether you want to open the Original Workbook (as was explained in this tutorial with all Jim's data as you see in this tutorial inserted into the cells), or whether you want to open the Last Saved blueprint, or a previous "Choose Save" blueprint (see the picture below).

If you are a cycling coach, this option allows you to save blueprints of all your cyclists. If more than one member in a family are cyclists, then you can save a blueprint for each member. This also enables you to save a blueprint for every race in which you usually take part, so you can just open it and revise it the next year around.

After saving a blueprint, the next time you open CRED it will give you the window as seen below;



You can load the original workbook, the last saved blueprint, or a previously saved one by clicking "Choose Save..." After opening a blueprint, you can change it and save it again. Saved blueprints will have a ".XLSC" extension. Save all your blueprints in one folder so you have them all nicely together. Remember, your blueprints will only open on your computer, and not on someone else's, even if that computer have CRED installed as well.

Note: In CRED the “Save As” function is disabled. CRED will open the save dialog box every time you close it, where you can then save your altered blueprint on the same name, or as a new blueprint under a different name.

CRED doesn’t allow you to create new sheets (tabs) in the workbook. If you want to work further on your energy analysis, you need to copy and paste the data from CRED into a new workbook, and work further on it from there.

You may copy CRED to other computers, and to friends, but to activate it, you will need to buy an activation code for each computer. See the Installation and Ordering Manual for the process of obtaining activation codes.