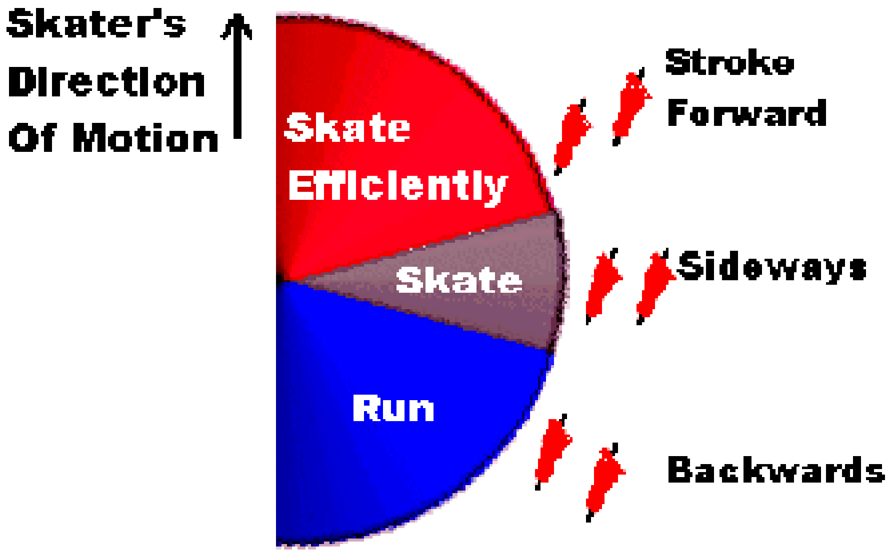
# Forward Stroking For Greater Efficiency

## c. P.J. Baum, October 1999.

## Introduction

Earlier I found that the efficiency of the sideways linear (straight-line, fixed-angle) stroke was only 50%. Here I examine the efficiency of a whole class of linear strokes of different angles finding efficiency geater than 50% for forward strokes and less than 50% for backward strokes. Still, the best stroke I have found is not a single linear stroke but involves a transition between two linear strokes -- one nearly sideways and one nearly forward.

Most skating is done in an attempt to accelerate the skater forward, but speedskating tries to accomplish this goal more powerfully and efficiently than other kinds of skating. Here I examine some of the strokes in the skater's toolbox for power and efficiency. The figure below shows how I would break stroking into three regions: backward, sideways, and forward.



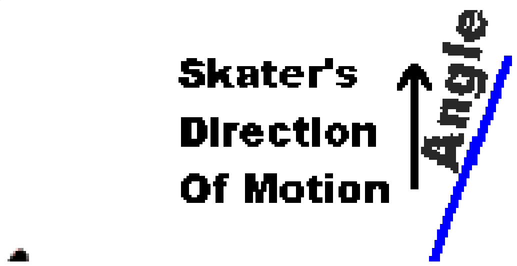

Starting from the blue sector of the figure above, the skater basicly runs on his skates for the start. This backward stroke works well when you are at very low speed but propels the body forward at the expense of leaving the skate and leg behind in the dust. Moving the skate forward for the next stroke undoes a lot of the work you just did. Because of the inefficiency of the backward stroke the skater soon enters the gray "skate" region where the stroke is pretty much sideways. The skater

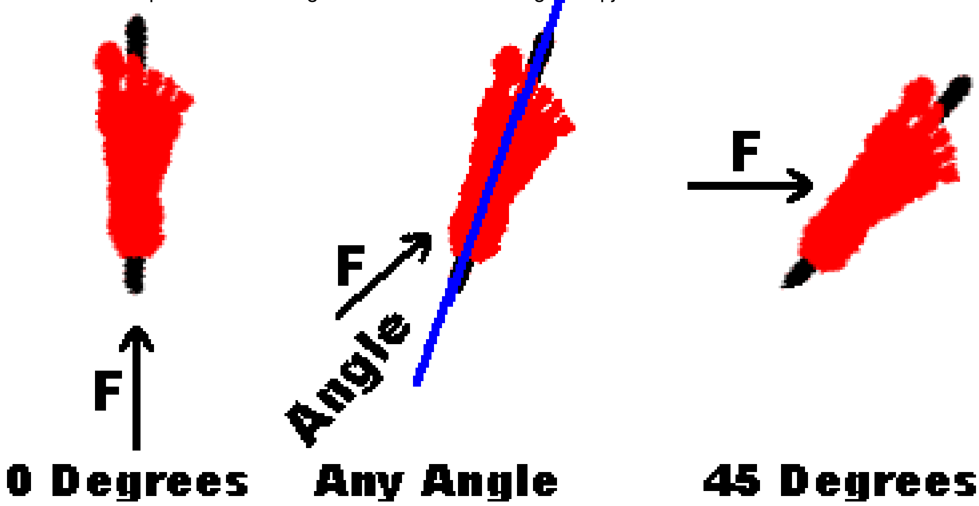
**spends a lot of time in this region where the skate now just keeps up with the skater's body. You push sideways and the skate is generous enough to convert half your work into forward motion retaining only the other half as its fee. The attempt to cajole the skate into giving up the other half of your energy is the subject of forward stroking which is the red region of the figure I labelled "skate efficiently". But before I look at the efficiency of forward stroking it should be pointed out that there are (at least) two types of forward strokes. I view them as passive and active.**

- **The passive forward stroke has as its goal the regaining of the 50% of the stroke energy which was directed sideways. This is accomplished by "turning the steering wheel" or "coasting the corner" so that the skate is turned forward at the end of the sideways stroke. Now the sideways energy is turned forward through reaction of the skate with the ground. This is really a power control stroke and not a power generation stroke like the sideways push was. It is difficult to determine the efficiency of this power control process but my observation of short track skaters suggests that the loss must be fairly small. In fact, the efficiency is complicated by the active forward stroke: a good skater actually accelerates around the corner rather than just maintaining his/her speed.**
- **So the active forward stroke has as its goal the production of another 10-30% energy while "powering the corner" at the end of the sideways stroke. This energy is in addition to the two 50%s already gained.**

## Efficiency Of Active Forward Stroking

**The figure below shows a skater's right foot and skate in relation to the force, F, the skater applies in an attempt to move forward. In the general case two angles are involved but to save space here I will discuss only a simpler case which has all the important elements but only one angle involved. For this case I have assumed that the angle between the skate and the forward direction equals the angle between the applied force and the skate. The left side of the figure shows the zero degree limit where the skate is pushed straight ahead. The right side shows the 45 degree case where you push directly sideways and move straight ahead. The arbitrary angle case is in the middle.**



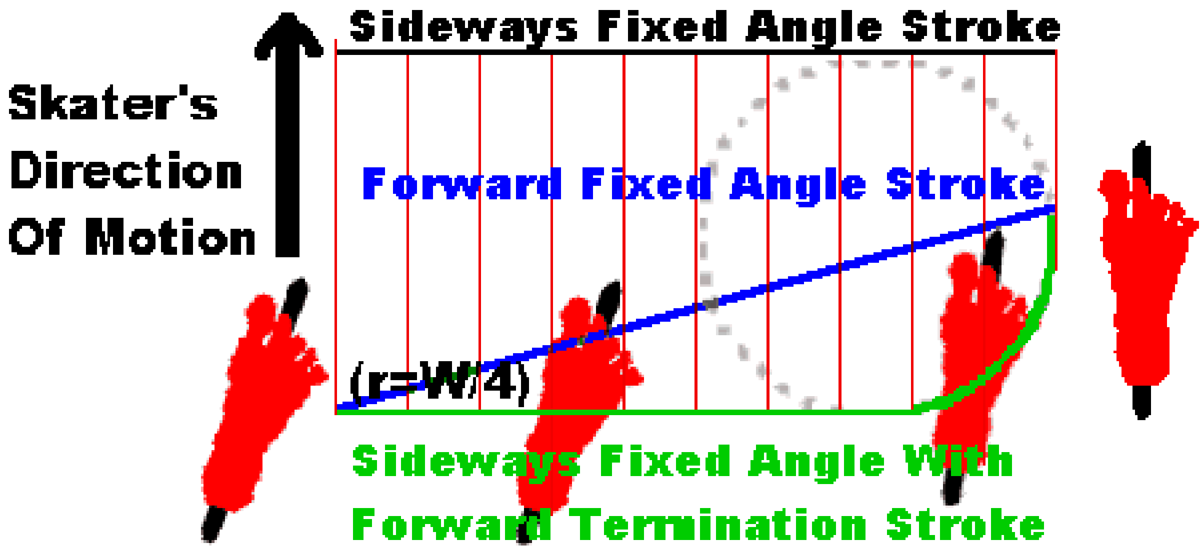



**The solution is not difficult for this model and I have plotted the results below for energy (or power) efficiency. Pushing the skate straight ahead delivers all your energy to the skate (100% efficient) as you might expect. Pushing sideways delivers the 50% efficiency I found earlier. What is novel is that you can push for an unexpectedly large range of angles around the forward direction and still maintain an efficiency in the 90% range (the angle between the applied force and the forward direction is twice the angle plotted here so this range is even greater than it appears). Also, the efficiency of backward stroking (angles greater than 45 degrees) is less than 50%.**

Efficiency vs Angle

**The advantage of the active forward stroke is that you can skate up to small angles , not too far from straight ahead, and still react against the ground for power generation but not develop a lot of sideways energy to cut your efficiency. The disadvantage is exactly the opposite of the**

**backward stroke. When stroking backwards your body gets ahead of your skates and while stroking forward you skates get ahead of your body. So start out conservatively or you may land on your backside. The forward stroke requires that your body be moved up to your skates for the next stroke. The situation is the same in the double push where the forward push is handled with body shifts, rotations, or thrusts depending on style. However, it seems a little harder to shift the body forward over the skates in the single-push (classic) style as the body is not so easily rotated in that case. Because of this limitation the amount of forward push is not too great and is best used briefly -- for example as the termination of a standard sideways push to develop additional forward thrust (see drawings here).**




**Since the efficiency of the forward stroke is greater than the sideways stroke it is tempting to try to use it exclusively. This turns out not to be advantageous because the shortest distance between two points is a straight line. That is, any linear stroke will have a short stroke path length so that although the efficiency may be high, the amount of energy generated along the short path is not maximum. The figure above shows a forward fixed-angle stroke and also a transition from a sideways to a forward stroke which ends at the same point. It seems fairly obvious that the path length of the linear stroke is shorter than the sideways-forward stroke so it will generate less energy. On the question of efficiency, the termination of the sideways stroke with the forward stroke rehabilitates the sideways stroke so that its overall efficiency will be comparable with or possibly exceed that of the single linear forward stroke.**

**Finally there are some conclusions to be drawn from the efficiency model used here. Recall these efficiencies: sideways 50%, forward 100%, midway between these ~90% (push 45 deg. off forward with skate 22.5 deg. from forward). So by pushing at 45 degrees from forward you gain 40% over sideways but at straight ahead you gain only an additional**

**10%. In other words you don't need to push anywhere near straight ahead to get a very high efficiency (90%). This allows an interesting possibility for stroke termination -- by terminating the stroke past straight ahead (around the corner and back toward the center line at a 45 degree angle) you can extend the stroke path length even further -generating even more energy- and suffer only a 10% drop in efficiency. This in fact seems to happen in the double push. I haven't worked out the overall result of this but it does have the advantage that the 10% "lost" energy due to inefficiency is used to move the skate back to the center line presumably resulting in a decreased interstroke time -- i.e. a faster stroke rate along with a possibly increased overall forward power due to the increased stroke path length.**

---

Click to go back to the *INDEX*

---