TURN TO P 14 FIRST

MN #2

3354 Kirkham Road
Columbus, OH 43221
December 25, 1982 (MC!)

To: Ted Corbitt, Allan Steinfeld, A. J. VanderWaal, Len Evens, Bill Hauda, Bob Baumel, Bob Letson, George Delaney, Carl Jeansonne, Carl Wisser, Kevin Cahill, Alan Jones, Tom Knight, A. C. Linnerud, Ben Buckner, Ken Young • Tom Benjamin

Dear All,

When I sent out my broadcast letter of December 6 I wasn't quite sure what would come of it, and now I'm not too sure what to do with the info I've received. One solution would be to simply reproduce the letters I get and send everybody a copy, but I don't like that. Instead, I'll try to outline briefly some of the more important ideas that I've received and comment on them. Considering that there are a fair number of recipients of this letter, I'm starting to think of it as a sort of "Measurement Newsletter".

In order to keep the size of it manageable, if anybody has anything to say to the bunch at large, try to boil it down to a page or a paragraph and I'll include it verbatim. Otherwise you will have to put up with what I do to your thoughts as I try to condense them.

This newsletter is entirely unofficial. In it we may criticize, suggest improvements, promote theories, and exchange ideas and data. As far as I am concerned, I will change none of my methods from the official standards until it becomes an official change. To me, this means that I must either hear it from Ted Corbitt or see it in NRDC News. So, if somehow our exchanges of ideas should result in some new breakthrough in measurement, don't act until an official decision is made. Otherwise we'll have chaos.

We have no shortage of measurement theories. Everybody seems to have an opinion on the goodness and badness of certain measurement methods. What we <u>are</u> short of is data. Some of us have conducted our own private experiments while trying to get smart about some aspect of measurement. Often these experiments were conducted hastily or informally. There's no need to be perfect when it's your own enlightenment you seek. Your own mind fills in the gaps. I'd like to hear from you about any actual experiments you've done, or data you know about, that might yield information regarding the <u>accuracy</u> of the calibrated bicycle method. We all know that the method is reasonably precise - the good agreement we get between rides when calibrating and measuring indicates pretty good precision - but there is little information concerning how good the end result is.

A system of measurement must have as its foundation a clearly understood method, and some definitions. Here is a definition I'd like to propose for your commentary:

Course Length - The length of a course is that established by a rider who, using the calibrated bicycle method, rides both calibration course and shortest possible route with no deviation from the proper route lines.

If we accept the above as a definition we eliminate the need to consider what course length might be if a surveyor came in and accurately measured the course. We cannot use conventional surveying methods as a standard in our work because they are too time-consuming to apply to race measurement.

Given the perfect nature of course length, and the probability that most measurers will deviate more on measurement than they do on calibration, it is highly likely that no real person will measure a long course, without using the 0.1 percent additional. It is quite possible that some courses will still be short even with the 0.1 added - we have no way of knowing for sure. Personally I believe that 0.1 should be enough but I have no proof. That's why I'm hoping for some data from you.

There has been some complaint about the idea of deliberately measuring courses long. Whether we like it or not, we must either try to measure long or short. Is short better? All measurement techniques have inherent error. We have settled on the idea that a remeasurement by a top-gun measurer should not find the course "short". If 0.1 was added originally, this means that the course, as originally measured, may be short by 0.1 percent. As far as the mathematics go, we could just as well try to hit the true value dead on, and then accept any course that is no more than 0.1 short.

If we did that there would be very few courses that were really the right course length, because all measurers, even the best, are imperfect. I prefer thinking that all courses are a trifle long rather than a trifle short. That's why I was glad to see the decision that came out of the last TAC meeting that requires use of the measurement that results in the longest course, and the adding of 0.1 percent.

Given the imperfect nature of us as measurers, we can be almost certain that any course that is laid out is short before the 0.1 is added. We believe that the 0.1 will make it long.

An experiment to try

Go to your favorite calibration course and find the halfway point (use counts-they're accurate enough). Lay out a point across the street from the halfway point, and measure how far away from the calibration line it lies. Pretend that you are trying to measure as a "course" the dogleg distance from the cal course endpoint, across the street to the midpoint, and back across the street to the other end of the cal course. I think that you will find that you tend

to measure the dogleg distance a bit longer than it really is. When I tried it, in a preliminary trial, I found that I tended to measure the distance about 0.1 percent longer than it really was. I'm going to go out and try to do a better job at it and I'll let you know how it comes out. It's sometimes frustrating to have to ruin a run just to keep from being smashed by a car, but if I wait for the right time I think I'll be able to get some good dope.

The reason to do the above experiment is not to get any particular number, but to see whether we really do tend to measure short courses. I believe that we do, I think that the idea that measurement is usually done with more deviation than calibration holds water, but believing don't make it so. Try a few dogleg calibration runs - Deeds, not words.

By the way, if you don't have a cal course handy by your house do not despair. Use the bike to lay out any long straight stretch and just assume that the straight-line distance is correct. It won't affect the validity of the calculation, if you do a good job of taping the offset.

I think I'm getting a bit long-winded. At this point I'm going to reply to the individual letters I received. Then I'm going to wait another week or two for some of the later replies, comment on them, and send this out. Here goes:

Bob Baumel - Yours was the first letter I received, and it was a dandy. It was fun to find another who has done some playing with the records and come up with a mathematical expression to see how they run. As for converting all my own PR's and races to the metric system, I haven't done it because, with few exceptions, the races I run are measured in miles, or, in the case of marathons, oddball metric distances. I have become somewhat burnt-out on the subject of mathematical analysis of running performance, because I've been hammering away at it since 1975 and the new has worn off. I still will turn out the odd article, but the fire of enthusiasm isn't there like it used to be. To avoid boring the others with my thoughts on that subject, I'll enclose a separate note to you about this.

[I am chagrined about my previous recommendation that the "dogleg" should be a proper calibration course to ride. Although I believe that it would give slightly better accuracy, the idea of trying to weave back and forth across the road is ridiculous with traffic as it is. I agree with you on this. I retract my previous ill-considered opinion.]

You're also right when you say that I'm concerned about people failing to ride the SPR. Bob Letson made a believer out of me on this. The errors that can occur on corners are large if the rider is careless. I was glad to see the old standard of "within a meter" be changed to "one foot" A lot of error can occur "within a meter" depending on where within that meter the bike is ridden.

With only a foot to work with, however, the error is much more limited.

I've also been happy to see the idea of the SPR replace that of "measure where the runners will run". Although the latter makes more sense, no two measurers will agree on just where the runners will run, whereas the SPR is tightly defined. If we are to have standards they must be able to be interpreted identically by all, and the SPR concept can be so interpreted.

You are right about the difficulty of actually <u>riding</u> the bike around tight turns. I don't like to scooter my bike around turns either, preferring to just smoothly ride around. Still, I <u>do</u> scooter when measuring when I have to. After all, I'm not riding a bike but operating a precisely calibrated measuring instrument. I can live with those scooter turns - they are few, fortunately.

Thanks for telling me about the 0.08 percent tolerance for differences between measurements. I had thought that it was 0.1, wrongly.

The best thing you gave me, Bob, was the way you measure courses (use the first measurement to lay out the start, finish and intermediate splits. Use the second ride to check the distances of the <u>same</u> points). I've tried it, and it works a whole lot better than laying out two complete sets of marks. All the data I need to make corrections is right there, and I no longer have to concern myself with which rider is in "front" at any given point.

I used your method, and some of the ideas from your forms, to create some new forms for Ohio. It was not tough since there were no existing forms. I'm lucky in Ohio - no previous paperwork procedure existed, so I'm free to set it up as I think best. I don't have to deal with unhappy measurers who believe that the old way is the best way. There aren't very many measurers in Ohio at present. I hope that I can make these forms so easy that most would-be measurers will be able to go out and do the job right without me having to make a personal appearance at each measurement site.

Other measurers may have been using your method for decades, but I only knew the method of laying out two sets of marks. Although your method produces no greater accuracy, it does eliminate ambiguity. I can't see why everybody would have to measure exactly the same way, just so it's done right, but I'm adopting your method.

I don't believe that any substantial increase in accuracy would result if we had a more finely-divided bike wheel. The Jones Counter gives us a "least count" of about 4 inches. If we were able to read down to say, 1/10 inch we would be able to get more decimal places, but we can already calibrate to about 1/4000 - far better than we can measure. IF SHORTER CAL COURSES GET APPROVED, WE SHOULD READ TO 1/2 COUNT. A 2 INCH LEAST COUNT IN A 1000 FOOT MEASUREMENT SHOULD BE SMALL ENOUGH. STILL, LIKE YOU, I'D <u>LIKE</u> A LEAST COUNT OF, SAY, .05 FOOT, OR 1/2 INCH.

It would truly be a pain if the components used to make the Jones counter became unavailable. There is so little demand for the gadget that mounts to the axle that if it should stop being manufactured we would have to find a substitute. As long as bicycle speedometers are made, however, there will probably always be something like it around. As for the counter itself, there's little danger of it becoming extinct - there's great industrial demand for those for the foreseeable future. I've been toying with the idea of putting a flexible cable between the gear wheel and the counter so I can mount the counter on my handlebars. So far, through laziness, I haven't done it.

As for irate Oklahoma measurers giving you grief about recent changes in measurement methods, perhaps an explanation of what happens when a record is set on a course is in order. A course remeasurement that finds the course short would be humiliating for the guy who did the original measurer.

A course measurement is, in a sense, a <u>contest</u>. The original measurer is pitted against some super-accurate perfect rider who may come to town to shoot down the course. Are we as good as the phantom rider? Maybe not, but when that extra 0.1 percent is thrown in, we'd have to be pretty bad to be shot down.

Those who object to long courses must realize that we must choose between short or long. Our method is not accurate enough to hit it right on the money. All we have done is to place the extra tolerance on the long side rather than on the short side. When you buy potatoes at the supermarket, or gas at the pump, or goods by the yard, the concept of "not less than..." applies. State departments of weights and measures see that the customer gets at <u>least</u> what he pays for. Whether the customer likes the quality is another question. I've run some terrible courses that were certified. We guarantee only a correct length, not a racer's high.

[Your subsequent letter in which you enclosed that copy of the Wallingford article about measurement of the '76 Montreal Olympic Marathon was a goodie. I'm sending a copy of the article to everybody.]

The calibration and riding seems to have been done with great precision. I'm not impressed with the 8 count difference, because at one point they were 3 meters different. If they wound up only 8 counts off, it's because they made ~~a~~ another 3 meter error in the opposite direction (actually either 2.2 or 3.8). That's still pretty good measuring.

I don't see where Wallingford can substantiate the idea that the 30 meter discrepancy between the bike measurement and the survey is attributable to pavement undulations. If the marathon course undulated like the calibration course, I would see the difference as amounting only to that which resulted from the difference between taped cal course vs

Distomat measured course, which amounts to only 3.7 meters in the 42.2Km as I figure it. The rest I would attribute to failure to follow the SPR. The remaining difference of 26 meters is, interestingly, about half of what would be added to the course by an additional 0.1 percent. In other words, the course was short by 26 meters, and 0.1 percent would make it long by 16 meters.

These observations are irrelevant if we use my proposed definition of course length, but it is still interesting to see the comparison between the calibrated bike method and an accurate survey. Does anybody else know about a similar comparison between methods?

Bob Letson - You have been a tremendous source of information and guidance in the time that we've been corresponding. I can't adequately express my gratitude for your help, so you'll have to accept this "thanks" using the most favorable interpretation you're capable of making.

We don't always agree on things, but the differences are usually philosophical rather than matters of fact. For instance, as a measurer I'm not concerned where the runners will run so much as where they can run. Many times I've sacrificed a shorter route in exchange for more comfortable footing (I like to run right in the middle of the road, because the surface is flattest. Sometimes I cut corners, but only when I get pretty close to the turn. I never run the shortest possible route. I like the SPR concept for measuring because it's unambiguous.

A runner who takes a turn on the sidewalk should be disqualified. That's clearly not on the route. I don't like the idea of measuring the route that might be taken by the faster runners because it's subject to individual judgement and therefore impossible to verify.

What all this business of long vs short boils down to is this: We are presently saying that a course must be between 1 and 1.001 times its nominal distance. We could just as well say that it should be .9995to 1.0005, or .999 to 1. All have the same tolerance. All we have varied is the median measured point, which presently is 1.0005 times course length.

I'm content with our measurement process as it now exists. While "trial by ordeal" may seem cruel to some, the presence of the out-of-town phantom coming to measure your course will put the fear of God into measurers, making them be careful. I'm very picky about SPR when I ride, because I worry about that guy. He may be better than me at measuring, but with that 0.1 percent in my pocket I've got the equalizer.

You seem to have some sympathy for the runner who turns in a great performance on a short course. I also have sympathy for him, but I'm unwilling to bend the rules. A runner who does a great job, only to find that the course was short has been robbed. He should be mightily pissed, but not at us. His anger should be directed at the person who made the sloppy measurement. If we set up the system to measure exact distance, and allowed a negative tolerance, the situation wouldn't change. There would still be short courses. I've agreed to be the out-of-town badass in one case where a record was set. Next spring when the weather gets better I've got to remeasure a course. I hope it's right, because I think it would be mighty uncomfortable telling those people their course is short. If it has to be short, I hope it's good and short, so I won't have to split hairs. I'll be riding that SPR like a bandit, all the time wishing I could let myself weave just a bit more. I'll take my best shot, they will watch me like a hawk, and we'll see what happens.

[If we are wishy-washy in enforcing our standards, this will be perceived by the runners and the public, and our system of measurements and records will become ill-respected.] !

Thanks for the forms you sent. I notice that you use the measure-twice-identically method, in which you establish two sets of markings and keep track of which is the lead bike. Try out a measurement a la Baumel - you may find that you like it. I know I do. Your comments welcome.

12/26/82

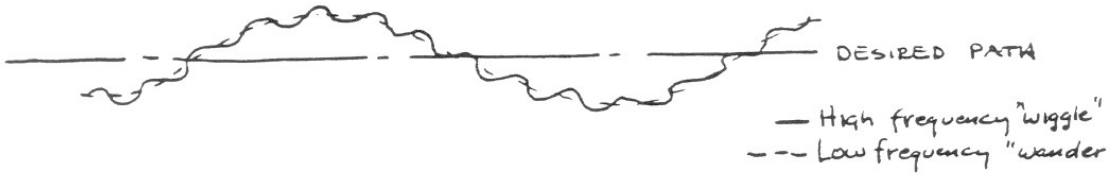
Bill Hauda - Your 5077.24 foot cal course sounds like a dandy. My own personal course I laid out with a Distomat Infra-red device about 4 blocks from my house. It's 2988.79 feet long, and I took elevations at each grade change in the road to correct for large undulations. Actually the undulation correction didn't amount to more than about .02 feet, because there were only three slight deviations from ~~straight~~ LEVE, and they were all widely separated from one another. The course is totally flat except for those four grade changes, the largest of which is five feet off the straight line. Just for my own information I intend to tape it, just to see what the difference is. I expect the taped distance to give a greater length for the course than the EDM measurement, but not much. We will see. I'd be delighted to find a discrepancy as trivial as the one they got in Montreal.

I don't quite understand how you figure that you are already measuring long courses. Certainly the bike rolls a distance that is somewhat farther than the line-of-sight distance, but that is true of any calibration course, even a taped one. The rider will wiggle when he measures too, and in addition will deviate more from the SPR than he does from the line-of-sight when calibrating. Try the "dogleg" experiment and see what you get.

12/27/82

Ben Buckner - Ben, it is now my fourth rainy day off from work at home, and I'm going bananas. Another four days off next weekend. I like to work as little as the next man, but I find myself wishing that those who order my universe would throw some of this time off at me during prime-time. I really don't appreciate all this leisure at this time of the year. With all of your students on vacation now I expect that you have the same job of finding something in these dreary days to fill your time. It's obvious what I'm doing - I'm running my mouth through my fingertips.

Your observations concerning my hallway measuring experiment are probably valid. I think that my people probably did a bit worse with a measuring wheel than they might have with a bike. I see the deviation from the straight line as having two components. The first is the inevitable wiggle or weave that occurs when we try to follow a line. This is a high-frequency low-amplitude wave. It is superimposed on a high-amplitude low-frequency wave, the "long-radius arc" effect that you wrote about. I think that we're doing fine in covering the first kind of wiggle - we probably don't wiggle too much different during calibration than we do when measuring. It's our inability to hew to the line that makes us come out short. The diagram below is what I mean:



Since runners don't necessarily follow the SPR it may well be that in measuring short one really measures properly. However, since the route that runners will run is not a clearly defined one, I think that the SPR is the way to go.

I also agree with your observation that a measurement that achieves good agreement between two riders on two bikes is better than when one rider does both measurements. I don't think it would make life easier for us if this were to be a requirement though. Two measurements by the same good measurer are probably better than one by a good measurer and another by a beginner.

[Running tracks are measured by steel-taping. I understand that they may <u>not</u> be short. OK. Does anybody know how <u>long</u> they may be? If measured to our present road racing standard a 400 meter oval could be .4 meters long. Does anybody out there have any dope on this?]

Ben, I received from Ted Corbitt a method which you wrote about measuring an oval by measuring its length and width and using plane geometry to arrive at the curb length of the oval, and also the path distance 30 cm from the curb. Bob Letson also worked up the same thing. Does the IAAF or whoever makes tracks official permit this type of measurement? Does anybody know about this? I don't.

Ted Corbitt - Thanks for the copy of your letter to Bob Baumel which included some of the history of the measurement process in America. It would be nice to have the Canadians join our fold with a common system of race measurement. And maybe we will see all the world someday getting together on the same method.

-SEE BOB LETSON'S EXPERIMENT THAT HE SENT YOU!

"Start-up wobble" happens to everybody. It's one of those things we have to live with, I think, as long as we're stopping at each point we measure. Maybe we should have some kind of videotape rig mounted on the bike when calibrating and measuring. Then we could get a flying start, ride the course non-stop, and look at the videotape to see what the count was at each point. When I get a system perfected that sells for less than $20 I'll let you know. Since the calibration run involves one start-up wobble each half-mile, and since many courses have a corner or something that may force a wobble each mile or so (including when we stop to mark the pavement or read the counter each mile) maybe the wobble is already compensated for. In any case, it's one of those things that may not even be a problem.

The subject of measurement has been brought to the ordinary runners' attention with the publicity about the NYC remeasurement and subsequent course lengthening. So far I've seen nothing that would lead me to believe that the course did not meet the measurement standard in effect at the time of the race.

Unfortunately the ordinary human does not understand that a course can be short without being "short". The lengthening of the course reflects only a tightening of the standard, but the media people have seized on it as a good story, and their allegations make good, exciting reading. Was the "fix" in for Salazar's WR? Tune in next month.

The increasing attention paid by TV and the press to the big road races makes it imperative that we do a good job of measurement. We all read about Clayton's short-course WR until we were sick of it. Even today nobody really knows for sure whether that course was really short. Most think it was, but all anybody really knows is that it wasn't measured with an accurate method. I was overjoyed when Salazar broke Clayton's record and removed all doubt. I hope that the NYC course doesn't lead to Salazar's record being tarnished as Clayton's was.

The media can help us promote the sport, but if we screw up we can be sure that they'll be right there to let those folks out in TV land know about it.

A CALIBRATION EXPERIMENT

On July 27, 1982 I wanted to start the layout of a calibration course near my house. I selected Redding Road because it was flat and straight. Because at that time I had no idea of the value of my bike constant, I determined an approximate constant by measuring the bike wheel. I went to Redding Road and rode the bike until I was confident that I'd gone further than ½ mile. Then I went to another local calibration course, located atop Hoover Dam, and made three rides. Then I returned to Redding Road and measured some more. Here's the data:

Redding Road - first series:	9354.5 9354.5	average - 9354.5
Hoover Dam - second series:	7230 7230 7227.5	average - 7229.167
Redding Road - third series:	9359 9355.5	average - 9357.25

Length of courses: (feet)
Hoover Dam - 2415.85 (measured by infra-red distancer)
Redding Road - 2988.79 (measured by IR) plus 138.61 (steel tape) for total of 3127.40

In the calibration rides, the higher counts occurred when I had to gradually swerve off the straightest line to avoid a pedestrian (on Hoover Dam) or a newly-parked car (on Redding Road).

* * * * * *

If I had been measuring the Hoover course, using the average of the before/after Redding values, a difference of 1/3720 would have resulted.

If, believing that the lowest count for a course is probably the most accurate, I used the average of the Redding <u>minimum</u> values, along with the minimum of the Hoover counts, the difference would have been 1/7500. See calculations below.

LENGTH OF HOOVER COURSE BASED ON AVERAGE VALUES:

$$L = \frac{3127.4}{\frac{1}{2}(9354.5 + 9357.25)} \times 7229.167 = 2416.50 \text{ FT}$$

$$\text{ERROR} = \frac{2416.50 - 2415.85}{2415.85} = .000269 = 1/3717$$

LENGTH OF HOOVER COURSE BASED ON MINIMUM VALUES:

$$L = \frac{3127.4}{\frac{1}{2}(9354.5 + 9355.5)} \times 7227.5 = 2416.17 \text{ FT}$$

$$\text{ERROR} = \frac{2416.17 - 2415.85}{2415.85} = .000133 = 1/7550$$

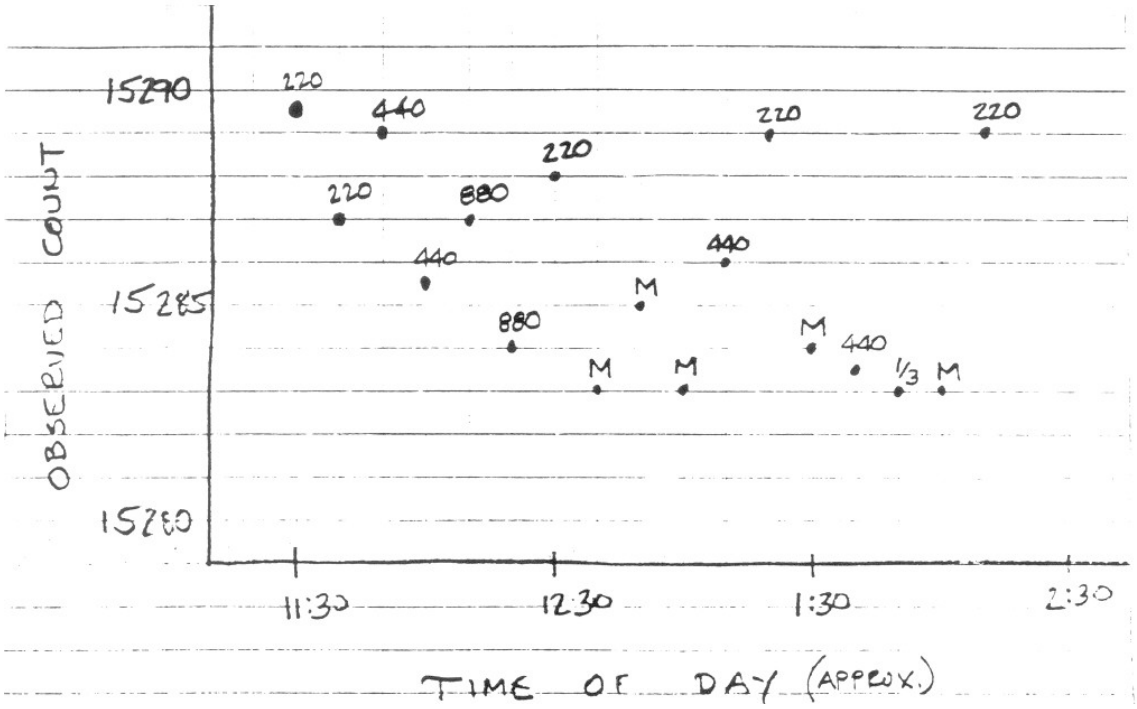
At the time I did the measuring I had no idea that the data might have any concrete value, and perhaps it doesn't. However, since then I have acquired a better sense of how things go when measuring, and the data obtained seems reasonably close to what might be seen in some real situations.

Although this one experiment alone cannot support a very heavy theory, it does confirm the idea that the best measurement is that which makes the measured distance appear shortest.

It is inconceivable to me that similar comparisons have not been done before, given the number of years that people have been fooling with calibrated bicycles. Has anybody else got some dope on this?

BOB LETSON DOES! 1/6/83

Bob, I just got your letter concerning your cal course experiment, and it provides some thought-provoking dope. Like a true measurement champion, you dared to show your <u>real</u> data sheet, and I had some fun with it. For openers. I plotted your observed counts vs the time of day at which they were gotten. See below:



I did the plot because I suspected that there might be a tire-heat effect. I think I see one, but it is minor compared to the effect that you noticed - that the shorter the calibration course, the larger the constant.

With regard to my own experiment, if we look at your data and look for the best measurement at each distance (the one that produced the least count), your constants would fall as follows:

Length	Minimum count	Constant	2nd lowest count	Constant
220 yd	1910	15280	1910.5	15284
440 yd	3821	15284	3821.5	15286
880 yd	7642	15284	7643	15286
mile	15281	15281	15283	15283

I'm impressed with the agreement, not dismayed by the disagreement.

I like the idea of short cal courses because they can be laid out right on the course to be run. With the present ½ mile length requirement, it is easier to use your own handy cal course than to lay one out on site, because it takes a while to do it. However, if we could use, say, 1000 feet as a minimum distance that wouldn't be such a big job to do.

I believe that accuracy just has to be better with a 1000 foot course laid out right on site than with a ½ or 1 mile course laid out miles away. The travel time plays hell with those tire temperatures. Sure, we're legal, but deep down you can tell when that sun has given you a bum calibration.

As long as we have the ½ mile requirement we are going to favor the use of remote calibration courses. Reduction of the distance to 1000 feet would make an on-site cal course much more feasible.

Your experiment clearly shows the effect of those stops and starts. I would personally hesitate to try to ask my measurers to mathematically allow for the short cal course by adding 1½ counts per stop (or subtract?), but would instead have them go ahead in the usual way. The effect is, as you said, to subtly lengthen the course a small amount, but that amount is too small to bother with.

For calibration, I'll throw this out for argument: Use a 1000 foot calibration course. Four ride minimum, both before and after measurement. Use the second lowest count as the one for calculation. This reduces the chance of getting caught by a freak count, and keeps the calculation from being affected by those high-count rides that come, as we all know, when we have to swerve around an unexpected obstacle.

Opinions of all solicited.

I don't think that the sequence of rides need be unbroken, so long as the slack is carefully taken out of the counter at the start of each ride.

I don't think we want to jump too soon to grasp this seemingly golden method. I like it, but I'd like to see it thoughtfully discussed a bit first. I believe that Bob's suggestion is a good one. It gives us the opportunity to calibrate right on site, where it ought to be done. Certainly, I also believe that the longer the cal course, the greater the accuracy. However, if we have to use ½ mile, we'll tend to keep using those remote, already-measured cal courses, because it's just too much trouble to lay out a whole half mile.

Let's hear some arguments!

Remember, here's the scheme:

1) 1000 foot calibration course minimum
2) 4 rides required, both before and after measurement
3) Use the second lowest count to determine the constant
4) Use present course measurement procedure
    a) 2 measurements
    b) Use the measurement that makes the course come out the longest

* * * * * * * * *

January 8, 1983

If you've waded through this you deserve a medal. I hope it hasn't seemed too much the ravings of a deranged mind. I want to get smart about measurement with calibrated bikes. We course measurers are collectively the world's experts on this subject. It's not taught or used in traditional surveying, so surveyors don't know any more than we do, and in most cases far less. We are currently the only ones who possess real, practical knowledge about the subject. That's why I'm bugging everybody to open up their storehouses of experience.

Any suggestions about this newsletter that do not refer to me rolling it into a small tube will be welcome. Pass on your experience. Knowledge is power!

Pete

P. S. I'm attaching the instructions for course measurement that I send to prospective measurers. I want them to be clear to inexperienced people, yet accurate so far as method is concerned. Any suggestions for improvement will be welcome.

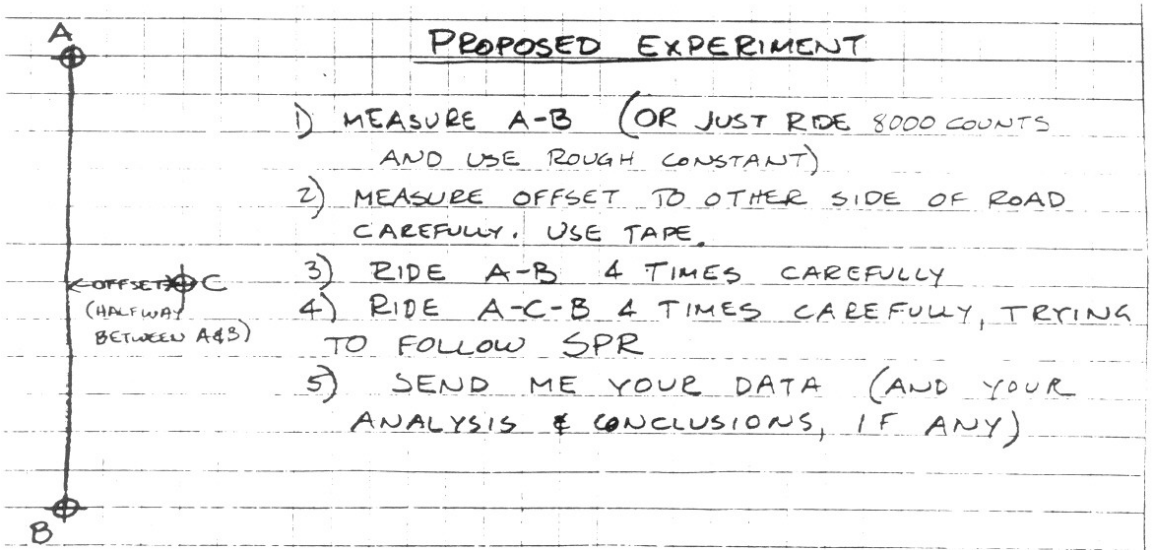
"If you can measure what you are speaking about, and express it in numbers, then you know something about it: but if you cannot measure it, if you cannot express it in numbers, then your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely advanced to the stage of science."

- Lord Kelvin

The ramblings I've sent you represent my thoughts on the subject of course measurement, as well as some thoughts of some of you who have replied to my first broadside.

I have put brackets around the paragraphs I think are most important, just in case you don't want to try to wade through the whole thing. Some important things are:

1) A proposed definition for "course length"
2) A plea for solid information on the subject
3) A proposed experiment to see whether you tend to measure "short" and by how much (see below)
4) A nifty article about measuring the 1976 Olympic marathon course (other side of this page)
5) Results of two measurement experiments



TECHNICAL SUPPLEMENT

The costs of producing this supplement are covered by a grant from Sport Canada to the Canadian Track & Field Association. Editorial responsibility for the supplement remains with the CTFA.

Measurement of the Olympic marathon course, Montreal 1976

by R.R. Wallingford

Ron Wallingford was the Race Director of the Montreal Olympic marathon and is now Technical Coordinator of the Canadian Track & Field Association. The "bicycle method" of course measurement described in the article is the official CTFA method for measuring road courses. Further information on road course certification can be obtained from the CTFA National Office, 355 River Road, Vanier, Ont. K1L 8C1.

Due to the very late completion of the ramps leading down to the stadium (June 26th, 1976), the final measurements of the Montreal Olympic marathon course were only taken after this date. However, the course had been measured by a professional survey crew in March 1976, using blue prints for calculating the connecting ramp distances with the main road course measurements. Since the telephone company needed to know the location of the 5 km points in order to plan installation of telephones used to relay en route information back to the stadium, a survey crew was hired by COJO (the Olympic organizing committee) to do this job.

The survey crew followed the basic international (IAAF) rules of staying one metre from the curb in the running direction and taking the shortest distance between two points on curved roads. A steel tape was used for all curved areas and a distomat measuring instrument was used to record the straight lines. The distomat measures the time taken for a beam of light to be reflected from the measuring point to its source and thus measures "air" distance and not the undulations of the pavement. In several instances, snow had to be shovelled out of the way to accomplish this feat. It took the survey crew three weeks to complete the task.

The crew inserted nails in the asphalt as bench marks along the course in several places and appropriately identified these points for us in drawings for future reference. Unfortunately, one-third of these nails were occluded by the fresh paving of a third of the course in preparation for the race, before we could use them. The few points we did locate served as a double check for us when carrying out the actual measures.

The writer as Marathon Race Director, along with Norm Patenaude, an experienced marathon runner, and Canadian distance runner Peter Quance formed the nucleus of a team which set up the official measurement.

Cursory exploratory measurements took place using the calibrated bicycle method, verifying the basic surveyed course except for the stadium ramp. These preliminary experiences convinced us of the importance of having an experienced rider (Norm Patenaude) and a first rate bike after our initial bad experiences. We found that we had to do all our measurements at night and under police protection. The reasons were that the air in the tires expanded if we started in the morning and proceeded during the heat of the day, thus causing the bicycle to lose its original calibration. In addition, the traffic was too formidable to attempt to go against it during the day, especially while charting the shortest distance across curved roads.

Our first task was to get the surveyors to measure the standard kilometre on a flat straight section of the course. This was measured with a distomat and then three times by steel tape under the supervision of a land surveyor. The steel tape measures were 5-13/16" (14.6 cm), 2⅛" (5.4 cm), and 2½" (6.35 cm) short of the distomat measures in a kilometre. The distomat evidently loses this much in the undulations of the pavement and so is not too reliable for standardizing a kilometre or measuring a course.

Using the mean of the steel tape measures, we proceeded to calibrate the bicycle late in the evening and continued through to daylight the next morning. A Jones Counter, which records 20 counts per revolution of the bicycle wheel, was employed. Norm Patenaude rode over the kilometre course three times to calibrate, recording 9359, 9358 and 9357 counts. We then pegged 9358 counts as being the equivalent of 1 kilometre. We started in the stadium at the point the surveyors calculated to be the start and proceeded with the measurement. Each kilometre was duly marked on the pavement with a spray can, and notes taken as to its location. After measuring the course, we rode over the kilometre distance twice more to check the calibration of our bicycle. Our recalibration on the kilometre course was dead on, being 9358.5 and 9357.5 counts.

Our first result had a discrepancy of 81.8m with the surveyors result. The surveying crew on rechecking their figures found a discrepancy of approximately 50m due to a blue print change from the original design, leaving their measure and ours about 30m different. I would suspect a distomat distance to be approximately 30m too long if used exclusively due to the lack of "credit" for undulations of the pavement.

Using our earlier measure as a basis for starting, we carried out the second official verification measure. Calibration of the bicycle before course measurement gave readings of 9334, 9334.5 and 9335 counts. We considered 9335 to be the official kilometre count. Our verification measure waas never more than 3 metres different from our first one at any of the 5 km points and in fact ended up with an incredible 8 count difference in 393.890 total counts for the course. The 8 counts verified the earlier measure by within 0.86m. Our recalibration was again dead on, being 9335, 9334 and 9335 for three rides taken over the earlier calibrated kilometre.

We were in touch with Ted Corbitt of New York who graciously advised us as we proceeded with our measurements, and thus ensured more reliability. We feel that since the bicycle did not lose its calibration and that all the intermediate check points were consistent, we had an extremely accurate course.

Other sidelights on the race organization

Because of the numerous intersections (more than 400 on the course), we insisted on the painting of a 4" (10 cm) blue line. This was very difficult as the blue was distinct for only so long when painted on busy city streets. With several patch-up jobs and good cooperation from the five municipalities through which the race passed, the lines were ready by race day.

Although the course had several turns it was as flat as was practical for a race being held in a congested city. The relatively cool day with comforting rain allowed the quality field to perform up to expectations. The electrical vehicles used by TV personnel also allowed closer proximity to athletes without affecting the runners. We had a TV dress rehearsal one week before with several athletes who had a tour of the course. This helped us get a preliminary feel for the actual event. As a result, TV coverage of the actual race was excellent.

Our major problem was relaying times from the early kilometre points. Even our well-trained specialized time place recorders had trouble at the 5 km point where the first 34 runners went by in three seconds. Unfortunately the runners rounded a bend just before this point which added to the difficulty. Other minor problems were also encountered. Due to internal problems in COJO, black on red numbers were substituted for the black on light blue originally ordered. These were not as distinct on an overcast day as they should have been. Also, the overhead helicopters involved with the live TV coverage unfortunately drowned out the voices of the officials at the checkpoints who were reading athletes' numbers into tape recorders for use in monitoring places.

One electric vehicle had a person to identify numbers on the run and call them to a recorder. This would have proven satisfactory if the electric vehicle doing this task had not mechanical trouble.

By having triple checks in most instances the few unexpected problems did not appreciably affect the total result. The lay-out for refreshments seemed quite good although not having the expected heat we could not test the system accordingly. Essentially, every athlete had a potential drink opposite his number at each refreshment station, with ten numbers per table.

As a final point, I would suggest that the bell be rung (at least for the leaders) when they have one lap to go in the stadium. I believe this would tend to dramatize the last lap, and reinforce earlier instructions on distance remaining in the stadium.

Some Hints on Course Measurement

Plan Ahead - Course measurement is the last of many steps in establishing a course. Be sure to discuss the route with local and state authorities to be sure you're legal. Get the race director involved, so that you are sure you're measuring the course you're supposed to be measuring. If the race is an established one, try to get a runner who has run the course to help. Runners know where runners will run - and they'll take every allowable shortcut!

Find out just how much of the road will be available to the runners. If runners are expected to take a somewhat longer route while a shorter one is available, it may be necessary to include temporary barriers to keep them along the right path. Instructions like "stay on the right side" are universally ignored, unless enforcement exists. It's easier to let them run wherever they want on the road, and measure the shortest path they can take.

It's not always easy to measure, especially in traffic. If you can, try to do your measuring at a time when traffic is light. Early morning is good. If you can't get free of traffic, some arrangement with the police may be made - they might even provide an escort, if you're measuring a race of large local importance.

On corners, be sure to try to measure one foot from the edge of the pavement or from a curb. Every foot you swing wide shortens the course so if you have a lot of turns, you could wind up with a short course if you're not careful.

On s-bends, measure the straightest line that a runner could run. If you have any tricky turns, such as where the runners turn onto grass, you may have to establish a known, marked spot where a traffic cone or a person should be on race day to mark the turn exactly.

Use maps, automobiles, and your calibrated bike to do enough rough measurements so that you have a pretty good idea where the start and finish will be. It's no fun to do your final, official measurement only to find out that the course doesn't come out right. Know which end of the course is most important. If the location of the finish is most important, start your measurement there and measure toward the start. If the start is more important, begin your measurement there.

Tools for measurement

Jones counter

Bicycle with high-pressure tires

steel tape (100 foot is best, but 50 is OK)

notebook and pencils

calculator

10 lb spring scale

thermometer

hammer

bike tools (if you get a flat, recalibrate before resuming measurement)

Crayon/chalk for temporary pavement marking

Concrete or PK nails for permanent markings

Spray paint

Masking tape for temporary calibration course layout marking

lunch

Establishing a Calibration Course

The calibration course should be laid out with extreme care. If it is done sloppily, any measurements using it as a base are worthless.

The course must be straight and at least ½ mile long. To lay out a course, do the following:

1) stick a piece of tape on the pavement and mark a start point with ball-point or felt-tip pen.

2) measure the temperature at ground level by laying the thermometer on the pavement. If it's sunny, shade the thermometer.

3) stretch the tape out for its full length and stick another piece of tape to the pavement.

4) Have the rear tape holder get a good grip and hold the rear mark exactly on the start point while you pull the tape tight with a 10 pound pull. Use a spring scale to pull the tape.

5) Mark the tape when you have the 10 pound tension applied. You now have two marks that are 100 feet apart. If you're not sure where the zero mark is on your tape, use the 1 foot mark as a zero, and you'll then be marking 99 foot intervals. The exact length of the calibration course is not important, just so it's long enough.

6) Repeat the process until you have measured at least ½ mile (I use 27 lengths of a 100 foot tape)

7) Starting from the end you've just reached, repeat the process in the opposite direction, using a different color pen to make the marks Do not re-use your first set of marks, but make new marks on the second measurement.

8) Measure all the way back to your starting point. You will find that your two measurements are not exactly the same. If you have been careful they should agree within two to four inches.

9) Measure pavement temperature again.

10) Drive a nail at each end of the distance you measured. Your course is now laid out. Its exact length will be the average measured distance, corrected for temperature. Follow the example to see how this is done.

11) Ride the bike along the entire length of the calibration course, and record total counts. Do the same for any 100 foot interval. If you measured 27 tape lengths, the count of the total course should be about 27 times the count for 100 feet. It is not uncommon for people to measure a course with great precision, agreeing in both directions within an inch or two - but omitting to count an entire 100 foot length in their calculation. The bike ride checks for this - the two runs should agree within 1 percent of each other if the course is right.

INSTRUCTIONS FOR USE OF JONES COURSE MEASURING DEVICE

To calibrate the counter, measure a half mile or one kilometer course using a steel tape with 10 lb. (4.5 kg) tension.

Record the reading of the Course Measuring Device at the beginning and end of the course. Only read when the bike is advancing to the mark. If you overshoot by a few inches, back up behind the mark so that the counter is advancing as you come again to the mark. This will eliminate "backlash". Ride over the course at least twice. Record the results as shown in the example:

	Run 1	Run 2
STOP	86590	94449
START	78735	86592
Difference	7855	7857

Subtract and take the average. If a half-mile course, multiply by two for counts per mile. If a mile or kilometer course use the average. For this example we get (if from a half-mile course):

counts per mile = 15712 (9763 per km)

Then we use this to figure the number of counts for the desired distance. For example, for a 10 mile course it would be 157120 counts. Since the counter only records 5 digits, note that it will "turn over" about every 6.4 miles (10.2 km).

For a 20 kilometer course (12.4274. . . miles) it would be 12.427424 x 15712 = 195260 counts or 20 x 9763 = 195260 counts. (We recommend the use of a calculator to aid in these computations.) When measuring the actual course, read the counter as the bike is set at the starting point and add the desired counts to get the number to obtain at the finish. You may want to compute the count for each mile (or kilometer) mark. Then each mile can be marked for use by the runners during the race.

If you measure an existing course and want to find its length, determine the total number of counts and divide by the counts per mile. For example, using the counts per mile from above, if the total counts for the course was 166734 this would be:

166734/15712 = 10.6119 miles = 10 miles 1077 yds
or 166734/9763 = 17.0782 km = 17 km 78 Meters

. . . . . .

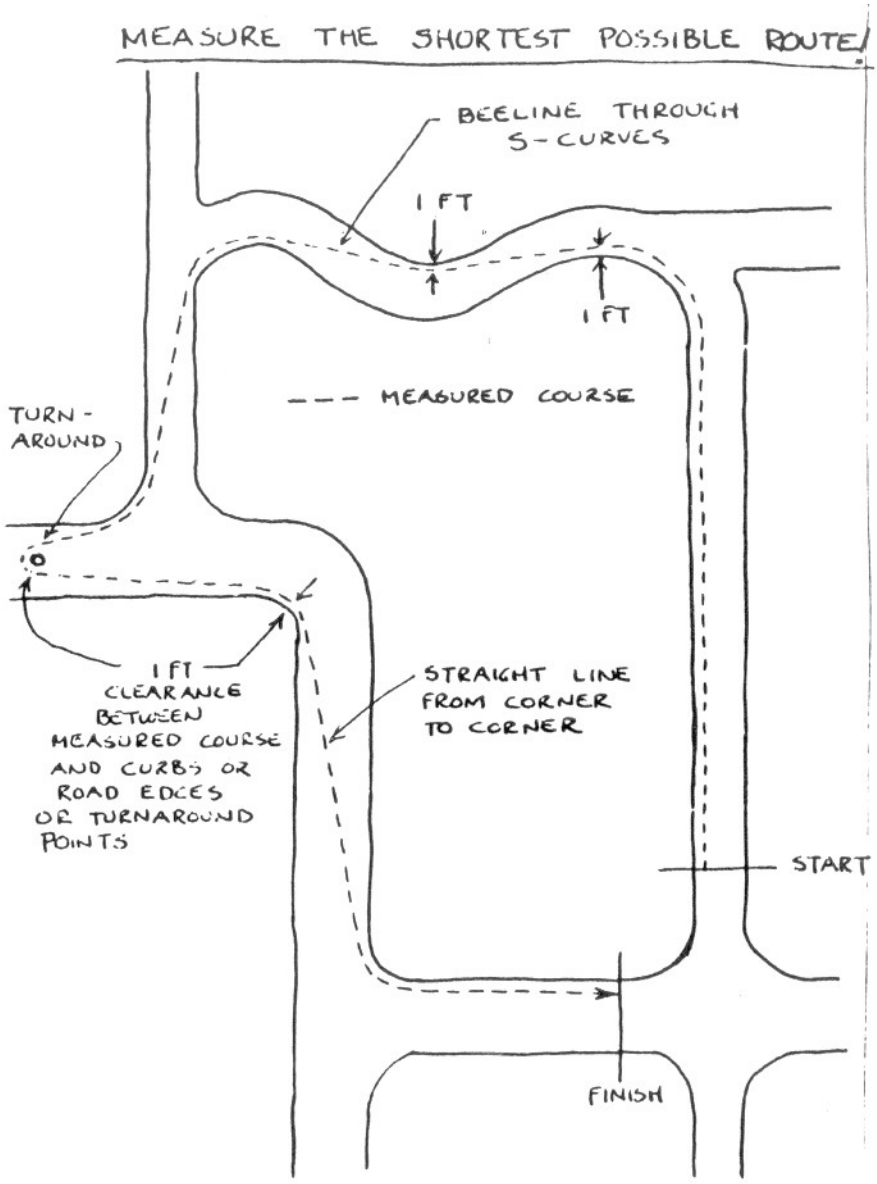
For your convenience, the following conversion factors are given:

1 mile	=	1.609344 kilometers (exact)
1 kilometer	=	0.62137119. . . miles
5 kilometers	=	3.106856. . . "
10 kilometers	=	6.213711. . . "
15 "	=	9.320568. . . "
20 "	=	12.427424. . . "
25 "	=	15.534280. . . "

Marathon = 42.195 meters
= 42.195 kilometers
= 26 miles 385 yards
= 26.21875 miles

The Jones Course Measuring Device is available from

New York Road Runners Club
Box 881 FDR Station
New York, New York 10150
Attn: Bill Noel (212) 860-4455


MEASURE THE SHORTEST POSSIBLE ROUTE!
BEELINE THROUGH S-CURVES
1 FT
1 FT
--- MEASURED COURSE
TURN-AROUND
1 FT CLEARANCE BETWEEN MEASURED COURSE AND CURBS OR ROAD EDGES OR TURNAROUND POINTS
STRAIGHT LINE FROM CORNER TO CORNER
START
FINISH

CALIBRATION COURSE DATA SHEET

Note: You may use a calibration course that has already been certified, instead of laying out a special course. If you used a certified calibration course, indicate its name and location:

If you laid out a calibration course, fill out the following:
Date 7 OCT 82 Start time 7:15 AM Finish time 9:00 AM

Pavement Temperature at Start 53 at Finish 59 Avg 56

Measured length of course: First 2700.00 FT Second 2700'-3¼" Average 2700.14'
2700.27'

Bicycle Check for gross mistake in measurement: Note: if you used another checking method, explain it.

COUNTS FOR FULL CAL COURSE = 8074
COUNTS FOR 100 FT = 300

$\frac{8074}{300} = 26.91$

WE USED 27 LENGTHS.
ROUGH CHECK OK

Temperature correction = .00000645 x (length) x (68F - Avg pavement temp)

Temperature correction = .00000645 × 2700.14 × (68-56) = .21 FT

Note: you must use a steel tape or tool of equal accuracy. Did you use a steel tape? YES If not, what did you use?_____
If the pavement temperature is less than 68F, the tape will be short. If pavement temperature is greater than 68F, the tape will be long. A steel tape is exactly 100 feet long at 68F, when supported horizontally and stretched with a ten pound pull. So, if the pavement is cool, subtract the temperature correction from the measured course length. If it's warmer, add the correction.

Calibration Course length = Average length ± Temperature Correction

Calibration Course Length = 2700.14 - .21 = 2699.93

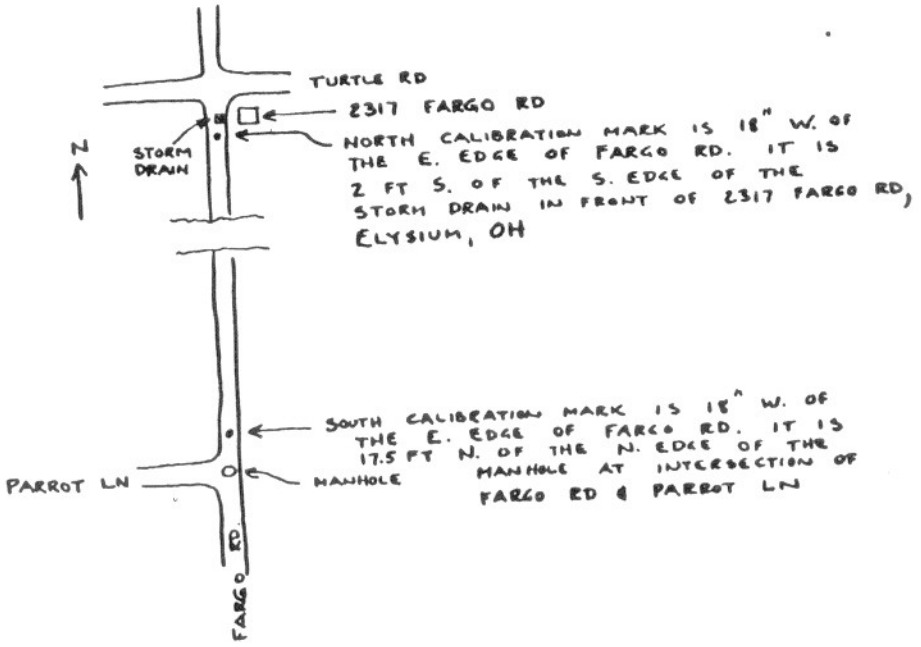
Note: Mark the end points in a permanent way (such as nails or chisel marks). Paint will fade. This calibration course, once certified, can be used to measure many courses. Take care of it!

Answer the following:

1) Name and address of leader of team that measured the calibration course:
JOHN DOE - 123 ACCURATE RD - PERFECTION, OH 43807
2) What experience has the leader had in measuring?
HAS HELPED MEASURE OTHER COURSES AND FOLLOWED INSTRUCTIONS
3) How many persons helped measure the calibration course? List their duties:
1) HEAD TAPEMAN 2) REAR TAPEMAN 3) DATA RECORDER
4) How many times did you measure the calibration course? 2
5) How did you check the tension in the tape while measuring? USED A SPRING SCALE - 10 LB TENSION
6) Are the start and finish of the calibration course located on the road where the bicycle wheel can touch them, or elsewhere?
ON THE ROAD
7) Did the tape have any kinks, crimps or splices? No

8) Electronic Measuring Device: If you used an electronic measuring device to lay out the calibration course, give: Name of device, who operated it and his qualifications/experience, results, date, location of course, and copies of field notes and calculations. Describe how start and finish points are permanently marked.

9) Submit sketch of calibration course start and finish points. Include name of road, its location, and taped distances from nearby permanent landmarks.



BICYCLE CALIBRATION DATA SHEET

Date of measurement 16 OCT 82

Name of measurer JOHN DOE

1) Ride the calibration course 4 times, recording data as follows:

Ride	Start Count	Finish Count	Difference
1	120691	128765	8074
2	128799	136871	8072
3	136903	144976	8073
4	145015	153087	8072

Pre-measurement Average Count 8072.75

Time of Day 7:15 AM

Temperature 53 F

Length of Calibration Course (feet) 2699.93

Extra length correction = 1.001

$$\text{Working Constant} = \frac{\text{Pre-measurement average count} \times 5280 \text{ feet per mile} \times 1.001}{\text{Length of calibration course in feet}}$$

$$\text{Working Constant} = \frac{8072.75 \times 5280 \times 1.001}{2699.93} = 15802.91$$

USE 15803

2) Now, measure the course, including all intermediate distances, using the working constant. Enter data on the "COURSE MEASUREMENT DATA SHEET".

3) Recalibrate the bicycle by riding the calibration course 2 times, recording data as follows:

Ride	Start Count	Finish Count	Difference
1	350300	358366	8066
2	358400	366465	8065

Post-measure Average Count 8065.5

Time of day 10:30 AM

Temperature 63 F

Avg Count for the day = ½ (pre-measure avg count + post measure avg count)

$$\text{Average Count for the day} = \frac{1}{2}\left(8072.75 + 8065.5\right) = 8069.125$$

$$\text{Constant for the Day} = \frac{\text{Avg count for the day} \times 5280 \text{ feet per mile} \times 1.001}{\text{Length of calibration course in feet}}$$

$$\text{Constant for the Day} = \frac{8069.125 \times 5280 \times 1.001}{2699.93} = 15795.8$$

Remember, each day's measurement must be preceded and followed by a calibration run. You may measure as much as you want in a day, just so calibration precedes and follows it in the same day. This is done to minimize the error due to changes in tire pressure due to thermal expansion or slow leakage.

COURSE MEASUREMENT DATA SHEET

Name of course or race ELYSIUM 10K

Name of Measurer #1 JOHN DOE

Working Constant for Measurer #1 15803

Time started 7:45 AM Time Finished 9:00 AM Date 16 OCT 82

Temperature at start 53 F at finish 57 F

Name of Measurer #2 JOHN DOE

Working Constant for Measurer #2 15803

Time started 9:10 AM Time finished 10:15 AM Date 16 OCT 82

Temperature at start 57 F at finish 62 F

Measurement data - Use the first measurement ride to lay out the points. Use the second measurement ride to check the location of those same points.

Point	Count #1	Count #2	Location of Point
FINISH	154000	350148	37 FT W of "No PARKING" SIGN BY WEED SHO
6 MI	157377	346772	CENTER OF DRIVEWAY, 2180 FARGO RD
5 MI	173180	330974	3 FT W. OF TP # 3004-BB ON JAMES RD.
4 MI	188983	315181	68 FT N OF "NO DOGS ALLOWED" SIGN ON BIKE PA
3 MI	204786	299384	17 FT S OF DRINKING FOUNTAIN ON BIKE PATH
2 MI	220589	283592	4 FT W OF "BURIED CABLE" SIGN ON RIVER ST.
1 MI	236392	267795	8 FT N OF "JOY CAFE" SIGN ON JOY ST.
START	252195	252000	TP # 3014-GC IN FRONT OF MERCER HOME.

Elapsed count #1= 98195 Elapsed count #2= 98148

After measuring, recalibrate the bikes and, using the Constant for the Day, calculate the measured length of the course:

Length by #1 = Count/Constant for the Day(#1)

Length by #1 = 98195/15795.8 = 6.21653 MI

Length by #2 = Count/Constant for the Day(#2)

Length by #2 = 98148/15795.8 = 6.21355 MI

DIFFERENCE = .00298 MI = 15.7 FT

DESIRED LENGTH = 6.21371 MI

Minimum length as measured = 6.21355 MI

Using a steel tape, add or subtract distance as required to bring the minimum length to the same value as the desired course length.

How much did you add or subtract, and where did you do it (start or finish)?

6.21355 - 6.21371 = .00016 MI = .84 FT

ADDED 1 FT TO MEASURED LENGTH AT START

Note: You need not adjust intermediate miles, unless certification for the intermediate distances is desired. Did you adjust them? How? NO