



Road Running Technical Council

Course Measurement and Certification Procedures Manual

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This manual is intended as a guide to those persons interested in measuring and certifying road running courses. The following persons have contributed directly to the preparation of this manual:

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INTRODUCTION

Certification of road race courses in the United States is done under the auspices of the [USATF Road Running Technical Council \(RRTC\)](#). Courses certified by the RRTC are also recognized as certified by the [Road Runners Club of America](#). For a mark to be eligible for record consideration by USATF, it must be achieved on a RRTC-certified course. If an entry fee is charged for a road race, runners have a right to a properly measured course. RRTC certification is an assurance to the runner that times will be based on a properly measured distance.

The rules and guidelines set forth in this booklet represent more than thirty years of experience in measuring road courses accurately. These procedures are now used by [IAAF](#) and [AIMS](#) as well as [USATF](#). Much of the pioneering work in the United States was done by Ted Corbitt, who started the certification program in 1964 after extensively researching methods of measurement. The program was initially run through the RRCA but later transferred to the AAU which was then the US governing body for track & field, long distance running and race walking--the role now played by USATF. Corbitt served as the nation's chief course certifier until 1984.

Credit is also due to Ken Young, who oversaw the establishment of [official US road running records](#), adopted in 1983. At the same time, he helped upgrade course certification with more rigorous standards to support the needs of record keeping, including a system of "Validation" measurements (see below) which put real "teeth" in the program. Young also served as Editor of the first edition of this manual, published in 1985.

The new certification procedures adopted in the early 1980s included important changes in measuring philosophy. Previously, the object was simply to produce "accurate" courses. We still try to make courses as accurate as practical; however, to meet the needs of record keeping, we've added a new emphasis: Now we try to make extra sure that courses are **not short**. Specifically, we try to make sure that the **shortest possible route (SPR)** through the available roads is **at least** the stated race distance. This is intended to guarantee that every possible path a runner can take through the course is at least the stated distance.

Although there are many ways to measure a course, experience has shown that the **calibrated bicycle method** is superior to all others because of the speed and accuracy with which it can be performed. Please note that automobile odometers, aerial survey maps, and electronic distance meters (EDM) are **not suitable for measuring road courses for certification**. An EDM may be used for measuring a "calibration course" (the course used for calibrating the bicycle), although steel tape is also entirely adequate for that purpose.

Historically, several kinds of bicycle wheel revolution counters have been used in the calibrated bicycle method. Currently, the only counter used for this purpose is the **Jones Counter**, a remarkably simple and reliable mechanical device invented by Alan Jones in 1971. The latest version is called the **Jones-Oerth Counter**, including enhancements by Paul Oerth who also markets the counter. Current ordering information can be found on the RRTC website at <http://www.rrtc.net/publications.html>.

The basic method of measurement is to compare the number of revolutions of the bicycle wheel needed to cover the course with the number of revolutions needed to cover a standard calibration course. Once you understand the method, it is simple and direct, but there are many important details which need to be done correctly in order to have an acceptable measurement.

In all probability, your course will not be checked. It is up to **you** to be sure it is right. Follow the instructions carefully and you will obtain a reliable measurement. If an open record is set on your course, it will be re-measured by a member of the RRTC (This is called a "Validation" re-measurement). For a mark to be accepted as an official record, the course length must be **at least** the stated distance. If your course is found to be short of its advertised length, the record will not be accepted and certification will be withdrawn. Follow the instructions carefully and do your best.

This booklet is organized in "stand-alone" sections. Read the statement of requirements to obtain an overall picture of the procedures. Then study the particular section(s) you need for the task you have chosen to perform next, such as laying out a calibration course. Refer to the appendices as needed for clarification of points in the main text. If you are unsure of any aspect of the process, please contact your [regional certifier](#) **before** attempting the desired task. It will save both of you a lot of time.

EQUIPMENT NEEDED

1. **Jones Course Measuring Device.** The Jones Counter is attached to the front wheel of the bicycle and displays "counts" proportional to the number of wheel revolutions. The original Jones Counters were designed so 20 counts = one revolution; the newer Jones/Oerth counters are geared a little differently, so the number of counts per revolution is $260/11 = 23.63636\dots$ Each count represents approximately 8 to 10 centimeters (3 to 4 inches) on the ground. Current ordering information for the Jones/Oerth counter can be found on the RRTC website at <http://www.rrtc.net/publications.html>.
2. **Bicycle.** A good "ten-speed" (or higher-speed) bike with high pressure tires is best but any bicycle you are comfortable riding is OK. Refer to the section on "Use of the Calibrated Bicycle" for how to attach the Jones Counter to your bicycle.
3. **Steel Tape.** A 30 meter/100 foot steel tape is best but a 15 meter/50 foot tape is OK. The steel tape is used to lay out the calibration course and to make adjustments to the course.
4. **Spring Scale.** A spring scale, capable of a 50 newton (5 kilograms-force or 11 pounds-force) pull, is needed for the steel tape to be under proper tension. The spring scale need not be a precision instrument; the inexpensive variety sold at sporting goods stores for use by fishermen is OK.
5. **Thermometer.** Use a small thermometer to take temperature readings so that steel tape measurements can be corrected for temperature.
6. **Notebook and Pencils.** A small notebook easy to use while cycling and several pencils or pens are needed to record data and to sketch the more complicated sections of the course.
7. **Pocket Calculator.** A small pocket calculator is useful in determining the counts needed for specific splits and for metric/English conversions. Use a calculator that carries at least 8 significant digits. **Note:** the built-in metric conversions in some inexpensive calculators are not sufficiently accurate; if in doubt, use the exact conversions in Appendix E.
8. **Lumber Crayon or Chalk.** Used for temporary pavement markings.
9. **Nails & Hammer.** Used for making permanent course marks.
10. **Spray Paint.** For temporary course markings and to supplement permanent course marks.
11. **Masking Tape.** Masking tape is used for temporary marks while laying out the calibration course.

12. **Bike Tools.** In the case of a flat front tire, you must recalibrate before resuming measurement.
13. **Safety Equipment.** A safety vest and helmet should be worn. Adorn your bicycle with reflective strips and reflectors front and rear as well as wheel reflectors.

STATEMENT OF REQUIREMENTS

There are seven basic steps involved in measuring a course for certification. These are:

1. **Lay out an accurate calibration course.** The calibration course must be a straight stretch of paved road, level and relatively free of traffic, and at least 300 meters in length. You may wish to check with the nearest regional certifier to determine if there is a suitable calibration course near you.
2. **Calibrate the bicycle.** Ride the bicycle over the calibration course, taking care to ride in as straight a line as possible. At least four calibration rides must be made immediately prior to measuring the race course. The "working constant" is the number of counts/km (or per mile) **times** the short course prevention factor of 1.001.
3. **Measure the course.** Ride the bicycle over the course, following the shortest possible route as it will be available to the runners on race day. At least two measurements over the course are required for certification. Use the first measurement to establish tentative start and finish marks. Use the second (and any subsequent) measurement to check the distance between those **same** marks. In particular, during the second measurement, simply record counts at the points already marked during the first measurement. **Do Not** make new marks on the road during the second measurement. If you measure on different days, calibrate both before and after measuring on each day.
4. **Recalibrate the bicycle.** Ride the bicycle over the calibration course at least four times immediately after the course measurement(s). After recalibrating, determine your **constant for the day**, which is the **larger** of the pre-measurement (working) constant, or post-measurement (finish) constant. (Note: Measurements calculated using the *average* of the working and finish constants will also be accepted; however, use of the **larger** constant is strongly preferred.)
5. **Determine the proper measured course length.** Recalculate each measured distance using the appropriate **constant for the day**. If you only measure the course twice, the proper measured length is the smaller value. E.g., you measure between the **same** start and finish points and obtain distances of 10,000 and 9,993.7 meters. The proper measured length is 9,993.7 meters. If you measure three times, the proper measured length is the **smallest** value. If you only measure twice, the two measurements may not differ by more than 0.08% or you must take a third measurement.
6. **Make the final adjustments to the course.** If the **proper measured length** differs from the **desired** (or advertised) **course length**, you will need to adjust either your start, finish, or a turn-around point. These adjustments may be made with a steel tape. Once all the measurements have been completed, the proper set of marks should be made permanent and all others should be erased.

7. **Submit applications and supporting documentation to your [regional RRTC certifier](#)** (see [Appendix F](#) for the application forms). Carefully record all data taken and prepare a **map** showing the course layout, details of the start and finish zones and turn-around points, and any areas where the certification will require erection of barriers that restrict runners to a path longer than the shortest path available using the whole roadway (but note: for simplicity and to minimize the chance of having your course found short, it always best to lay out courses **without** any "restrictions" of this sort). In drawing the map, it is also highly desirable to include a line which displays the actual path measured through the course.

LAYING OUT A CALIBRATION COURSE

Accuracy of the calibration course is vital since any error will be multiplied when it is used for measuring a race course. A calibration course must be on a **straight, paved**, level, and lightly traveled stretch of road, and must be **at least 300 meters** in length. Greater accuracy can usually be achieved by using a longer calibration course, but a short calibration course close to the race course is better than a longer one farther away.

Most calibration courses are at least 500 meters in length. This is recommended for the calibration course you lay out close to home, which you intend to use for measuring many different race courses. (Since most races are held at metric distances, you may find it convenient to lay out a 500 or 1000 meter calibration course.) The shorter calibration courses (300-400 meters) are very handy when you must travel a long distance to reach the race course site: You can quickly tape a short calibration course at the site, and then use it for measuring that particular race course.

Method of Measurement: The standard method of measuring a calibration course is to use a steel tape. Any steel tape, either surveyor's style or construction style, may be used, but to be confident of accuracy, get a tape made by one of the better-known manufacturers of surveying or construction equipment. Nylon-clad steel tapes are okay, but fiberglass tapes are definitely **not** acceptable. Electronic Distance Meters (EDM) can achieve greater accuracy than steel tapes, although that extra accuracy is **not really needed** for calibration courses used in the bicycle method.

Siting your Calibration Course: Choose a location that will be safe and convenient for calibrating a bicycle. Every time you measure a race course, you'll need to ride the calibration course at least eight times (four before and four after), and you'll want to ride it in **both directions**. Calibration courses are usually measured along the edge of a straight road, the same distance from the edge as you would ride your bike. (But on a street where vehicles may park, you may wish to measure far enough from the edge to avoid any parked vehicles.)

The marks defining the endpoints of your calibration course must be in the roadway where your bike wheel can touch them -- not off to the side somewhere. In general, endpoints should be marked by nails driven into the road. Urban areas, however, often have numerous permanent objects in the street (sewers, manholes, etc.) that may serve as one or both endpoints of a calibration course.

Your calibration course will be most resistant to getting obliterated when the road is resurfaced if **both** endpoints are permanent objects such as sewers or manholes, etc. In this case, you'll have an odd-distance calibration course such as 643.64 meters — which is perfectly acceptable. You can also make your calibration course an even distance, where both endpoints are close to permanent landmarks, and where you've precisely located both endpoints relative to such landmarks.

When laying out a short on-site calibration course that you will probably use only once, survivability of the calibration course is unimportant, and convenience is paramount. So just lay out a whole number of tape lengths; for example, 10 lengths of a 30-meter tape or 12 lengths of a 25-meter tape (laid out distance = 300 meters), or 10 lengths of a 100-foot tape (laid out distance = 1000 feet = 304.8 meters).

Certifying your Calibration Course: You are not *required* to submit a map for every calibration course you measure. However, when you lay out a calibration course that you think you'll want to use again in the future, or one that you think other measurers would like to use, you may draw up a map for it, and you will be issued a certificate that will simplify future use of the calibration course.

Whether or not you want such a certificate, you must submit an "**Application for Certification of Calibration Course**" form, along with all your measurement data (including the "**Steel Taping Data Sheet**" if course is measured by steel tape), whenever you lay out a new calibration course.

If you don't submit a map with your application for calibration course certification, then this calibration course, if approved, will be considered certified for only that one measuring occasion. If you want to re-use the calibration course on a later occasion, you must resubmit all the paperwork for the calibration course.

If you do submit a map for the calibration course, and are issued a certificate for it, then whenever you (or others) want to re-use this course, you need only submit a copy of the certificate/map.

If you draw a calibration course map, it must describe the endpoint positions as precisely as possible. Ideally the endpoints should be permanent objects in the street (such as sewers or manholes), or should be referenced to such objects so precisely that you could relocate your endpoints to an accuracy of one centimeter in case the road is resurfaced and your markings obliterated. If you can't describe the positions that precisely, then the certification will be considered to expire when the road is resurfaced.

Measuring Your Calibration Course With a Steel Tape

Equipment Needed for Taping: A steel tape, preferably at least 25 meters in length; masking tape and ball point pen for marking tape lengths on road; a thermometer for checking pavement temperature; possibly a spring balance for checking tape tension; Notebook and copies of the "**Steel Taping Data Sheet**" for recording data. You can tape a calibration course with just two people, but it might go more smoothly with a third person (for example, to watch for traffic and take notes).

Requirements: You must tape the course at least **twice**. (Normally, the second measurement will be done in the reverse direction from the first.) Use a new set of intermediate taping points (new pieces of masking tape) for the second measurement. But treat the second measurement as a check of the distance between the **same** endpoints you

measured between the first time. Thus, the second measurement should result in a **number** indicating the distance between your original endpoints (not in a new set of endpoints).

Your final result will be based on the average of both measurements, corrected for temperature (see below). If desired, you may then adjust the course to obtain a desired even distance (such as 1 km).

Basic Taping Technique:

For each tape length, the Lead and Rear tapepersons first shake out the tape until it lies straight and flat on the road. The Rear tapeperson sights ahead to keep Lead tapeperson properly aligned **or** the Lead tapeperson uses a ruler to maintain constant distance from the road edge or other desired (straight) line.

Intermediate taping points are marked with ball point pen on masking tape. *After* stretching the tape to its *approximate* position, the Lead tapeperson sticks a piece of masking tape on the road, covering the position where the mark will be made. The Lead tapeperson then starts pulling on the tape with proper force (see below). When the Rear tapeperson has his endpoint firmly positioned over the mark (with the tape under tension), he shouts "**mark.**" At this signal, the Lead tapeperson draws a fine line on the masking tape to mark the exact endpoint.

Long steel tapes are always designed so that the tape may be easily detached from the reel. You'll find that taping is easiest if you do this, and don't carry the reel along with you!

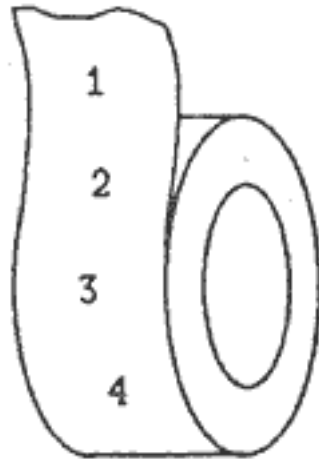
Don't panic if you see that a car is about to ride over your tape. If the Lead and Rear tapepersons hold the tape **flat** and firmly against the road, it will probably come out okay. (But a *twisted* tape will likely get broken.)

When walking from one taping position to the next, only the **Lead** tapeperson holds onto the tape, which is allowed to drag freely on the road. (If Lead and Rear tapepersons attempt to hold both ends off the ground, it may drag at a spot in the middle, resulting in one extremely worn area!)

Counting the Tape Lengths:

Miscounting the tape lengths in a calibration course is a disaster; the "10 km" race course you lay with it might really be 9 km or 11 km! Fortunately, it's easy to guard against such counting errors.

One handy trick is to **pre-number** your pieces of masking tape **before** you tear them off the roll as in the following diagram:



As pieces of masking tape are used, the Lead tapeperson adds more numbers to the roll, so it always has at least two or three numbered segments that haven't been used yet. (Be sure to write the numbers so they won't be confused with the fine lines that will denote actual tape endpoints.)

After the taping, walk or jog the course to check the tape count. It is also helpful to do a **bike check** as follows: Ride a bike equipped with Jones Counter over the whole calibration course, and also over any one tape length. The number of counts recorded on the whole course, divided by the number of counts recorded in a single tape length, should come out very close to the number of tape lengths you laid out.

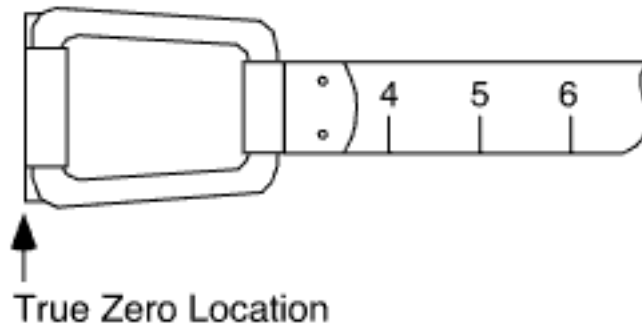
Such a bike check may not be necessary if you will be measuring with a bike that you've previously calibrated on a calibration course that you know to be accurate. Then, if you miscount tape lengths while laying out a new calibration course, you'll see that your riding constant is "way off" as soon as you start calibrating on the new course.

Know Your Tape's True Zero Point:

Many steel tapes (especially construction-style tapes) don't have their zero point on the graduated portion of the tape. Misjudging the tape's zero point is harder to catch than miscounted tape lengths, but the effect can be insidious. For example, if you misjudge the zero point by 3 cm on a 30 meter tape, your measurements can come out short by about 1 meter per kilometer, entirely canceling our "Short Course Prevention Factor." The runners won't notice anything wrong with their times, but if the course ever needs to be validated, it will be found short.

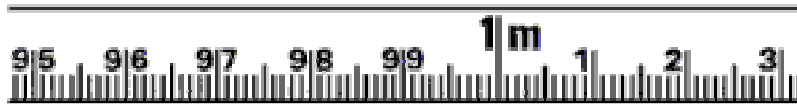
Before using any tape, examine its markings carefully. If zero is not on the graduated portion of the tape, then take a ruler (or another portion of the same tape) and measure to find out where the true zero is. On construction style tapes, it's usually at the outer edge of a "hook-ring" as in the following diagram.

Construction-Style Hook-Ring

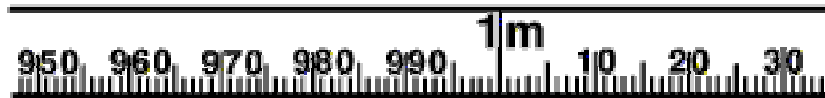


While examining your tape, make sure you also understand all its other markings. Is it a metric or Imperial tape? Metric tapes are often graduated to the millimeter, but you must check whether the numbering between meter marks denotes centimeters or millimeters. Imperial tapes may be graduated in either feet & inches or decimal divisions of a foot. The following diagram shows some common styles of tape graduations:

Metric with centimeter numbering



Metric with millimeter numbering



Imperial with feet & inch graduations



Imperial with decimal-foot graduations



Note: Drawings of tape graduations taken from [Lufkin's online catalog](#).

Correcting for Temperature:

Steel tapes are manufactured to be accurate at 20 °C (68 °F), but the tape expands when heated and contracts when cooled.

To correct your taped distance for temperature, set out a thermometer **on the pavement and shaded from the sun**. Read the thermometer before you start taping, and after you finish taping. Find the average temperature, and work out the correction to your raw taped distance by using the formula on the "Steel Taping Data Sheet," or by interpolating in the table below.

While it's a good idea to work out the temperature correction whenever you tape a calibration course, you are **required** to do so only when it's **cooler** than 20 °C (68 °F) since, in this case, the true measured distance is *shorter* than your raw laid-out distance. But note: If you are a *certifier* doing a *Validation* measurement, you should always do the temperature correction, regardless of whether it's warmer or cooler than 20 °C.

The following tables show the temperature correction for a number of temperatures cooler than 20 °C, and for several course lengths. (You may interpolate or extrapolate in the table for other temperatures and course lengths.) Remember: at temperatures *cooler* than 20 °C, the true measured length is *shorter* than your raw taped distance (so you'd need to *lengthen* your course if you want to obtain a desired exact distance). At temperatures warmer than 20 °C, the corrections are in the opposite direction.

I. Corrections in centimeters

Temp	Calibration Course Length			
	300 m	500 m	800 m	1000 m
20 °C	0.0	0.0	0.0	0.0
15 °C	1.7	2.9	4.6	5.8
10 °C	3.5	5.8	9.3	11.6
5 °C	5.2	8.7	13.9	17.4
0 °C	7.0	11.6	18.6	23.2
-5 °C	8.7	14.5	23.2	29.0

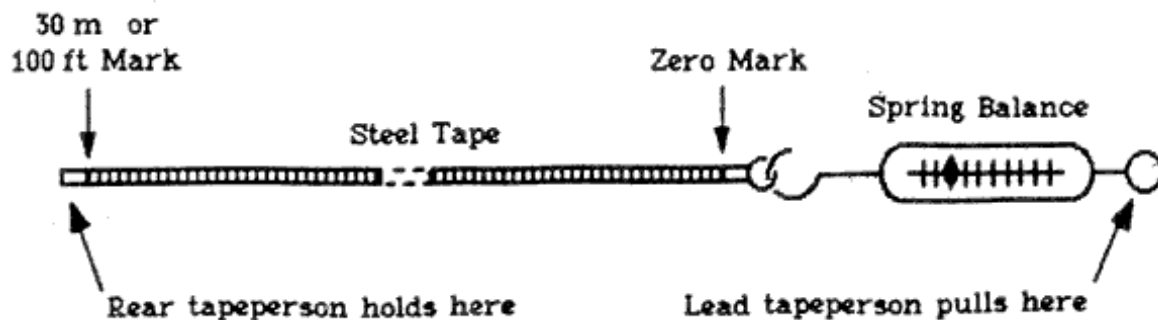
II. Corrections in inches

Temp	Calibration Course Length			
	1000'	1640.42'	2640'	3280.84'
68 °F	0.0	0.0	0.0	0.0
60 °F	0.6	1.0	1.6	2.0
50 °F	1.4	2.3	3.7	4.6
40 °F	2.2	3.6	5.7	7.1
30 °F	2.9	4.8	7.8	9.6
20 °F	3.7	6.1	9.8	12.2

How Hard to Stretch the Tape:

Just as steel tapes are manufactured to be most accurate at a particular temperature, they are also most accurate when stretched with a specified amount of force. But while you may not have much control over the temperature at which you do the measurement, you **can** adjust the force you apply to the tape to match the correct force for your tape. (Unfortunately, the proper force varies from tape to tape.)

You can find out how hard you are stretching the tape by using a **spring balance** as in the following diagram:



You needn't actually use a spring balance this way while taping your calibration course; it is enough to do a few trials beforehand to get a feel for the correct tension. With a little experience, it will be easy to judge the proper force, and you'll be able to dispense with the spring balance entirely. Note: It is acceptable to answer question 17 on the "Application for Certification of Calibration Course" by saying you estimated the tension "by feel."

Also, since the errors due to slight variations in applied force tend to be very small, the spring balance you use for checking tape tension needn't be a precision instrument. The type sold in sporting goods stores for weighing fish is quite adequate!

The correct force for stretching a particular tape is sometimes embossed on its blade near the zero end. For example, if you find the markings "20 °C, 70 N" it means that the tape was designed to be accurate at a temperature of 20 °C and tension of 70 newtons (approximately 7 kilograms-force or 16 pounds-force). If you can't find any markings of this sort, use a value from the following table. The first entry in this table (for metric tapes) seems to be emerging as an international standard, so is generally a safe choice if you're not sure which one to pick.

Standard Tension for Various Steel Tapes

Std. Metric tapes (30 m, 50 m, etc.):	50 N \approx 5.0 kgf \approx 11 lbf
Traditional U.S. 100 ft tapes:	45 N \approx 4.5 kgf \approx 10 lbf
Heavy-gauge steel U.S. 200 ft tapes:	90 N \approx 9.0 kgf \approx 20 lbf

N = newton, the modernized metric (SI) unit of force.

kgf = kilogram-force, an older (obsolete) metric unit of force.

lbf = pound-force, the unit of force in the Imperial system.

One mistake people sometimes make is to pull with less force when using a smaller portion of the tape. For example, if a 50 m tape requires tension of 50 N, they might apply a force of only 25 N when measuring a 25 m distance because only half of the tape is used. ***That is a fallacy!*** The correct tension is independent of the amount of the tape used. If a tape requires tension of 50 N you must pull with a force of 50 N, regardless of how much or how little of the tape you are using.

CALIBRATING THE BICYCLE

The pre-measurement calibration is the initial step that must be performed in the measurement of a road course. The post-measurement calibration assures against systematic sources of error such as a slow leak. At least **four** pre-measurement and **four** post-measurement calibration rides are required.

1. The bicycle tires should be inflated hard, to the pressure indicated on the side of the tire.
2. Warm the tires by riding the bicycle for several minutes immediately prior to the calibration rides. This will reduce the variability in counts for the pre-measurement calibration and insure a better measurement.
3. At one end point of the calibration course, slowly roll the front wheel forward, just through the next count. Lock the front brake and place the front wheel axle directly over the line. Record the count.
4. Ride the bicycle over the calibration course in as straight a line as possible and with the same weight and equipment on the bicycle as will be used during the actual race course measurement. A calibration ride should be one **non-stop** ride.
5. Stop the bicycle **just** before reaching the end of the calibration course and roll it slowly forward until the axle of the front wheel is directly over the line. Lock the front brake and record the count.
6. With the front wheel brake locked, turn the bicycle around and place the front wheel axle directly over the line for the next ride. Repeat steps 4 and 5.
7. Repeat the above procedure for a total of **four** rides, recording start and finish counts each time. Alternate directions on the calibration course. This will give you two rides in one direction and two rides in the opposite direction.
8. Add the results of each ride and divide by the number of rides. This gives the "average pre-measurement count."
9. Divide this count by the length of the calibration course in kilometers (or in miles) to obtain the number of counts per kilometer (or per mile).
10. Multiply this by 1.001 to obtain the **working constant**. The "short course prevention factor" of 1.001 is intended to result in a course which is **at least** the stated distance, within the limits of measurement precision. It also helps assure that (very) slight variations in the course layout on race day won't invalidate your measurement. This lengthens the course by one meter per kilometer or 5.28 feet per mile.

Now go measure the race course. When finished, return to the calibration course.

11. The post-measurement calibration must be performed as soon after the measurement as possible. Repeat steps 3 through 10. **Four** post-measurement calibration rides are required.
12. Determine the average post-measurement count by adding all the post-measurement counts and dividing by the number of rides.
13. Determine the **finish constant** by dividing the average post-measurement count by the length of the calibration course in kilometers (or in miles) and multiply this by 1.001.
14. The **constant for the day** is **either** the working constant **or** the finish constant, whichever is larger. Although measurements using the average of the working and finish constants will be accepted, it is strongly recommended to use the larger constant.

Remember: Each day's measurement **must** be preceded and followed by calibration runs. You may measure as much as you want in a day, just so calibration closely precedes and follows measuring (within a few hours). This is done to minimize error due to changes in tire pressure from thermal expansion and slow leakage. Frequent recalibration "protects" the previous measurement. A smart measurer will recalibrate frequently—you never know when a flat tire is coming!

THE SHORTEST POSSIBLE ROUTE

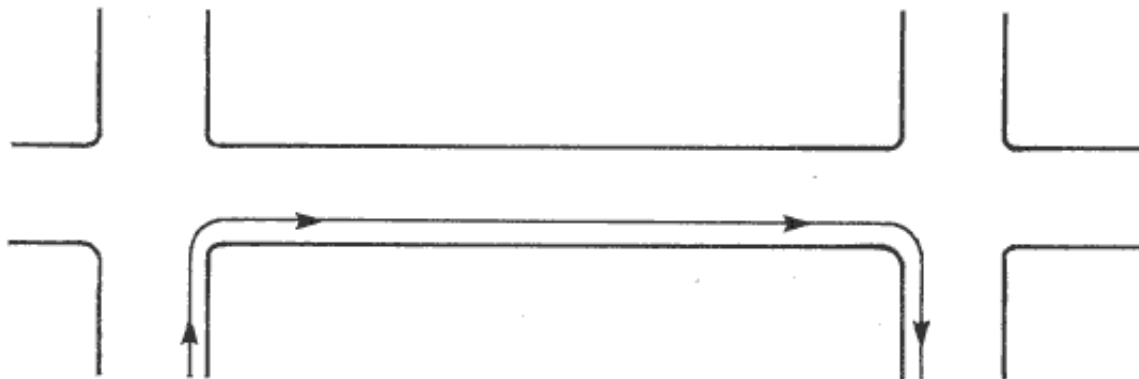
The race course is defined by the shortest possible route that a runner could take and not be disqualified. A given runner may not follow the shortest possible route, just as a runner on a track may be forced to run further to pass another runner. The actual path of any given runner is irrelevant. The shortest possible route is a reasonably well-defined and unambiguous route and insures that all runners will run **at least** the stated race distance.

You might envision the shortest possible route as a string, stretched tightly along the course so that it comes within 30 cm (one foot) of all corners, straight through S-turns, and diagonally between corners when crossing a street. You should measure the course following the same route as that hypothetical string.

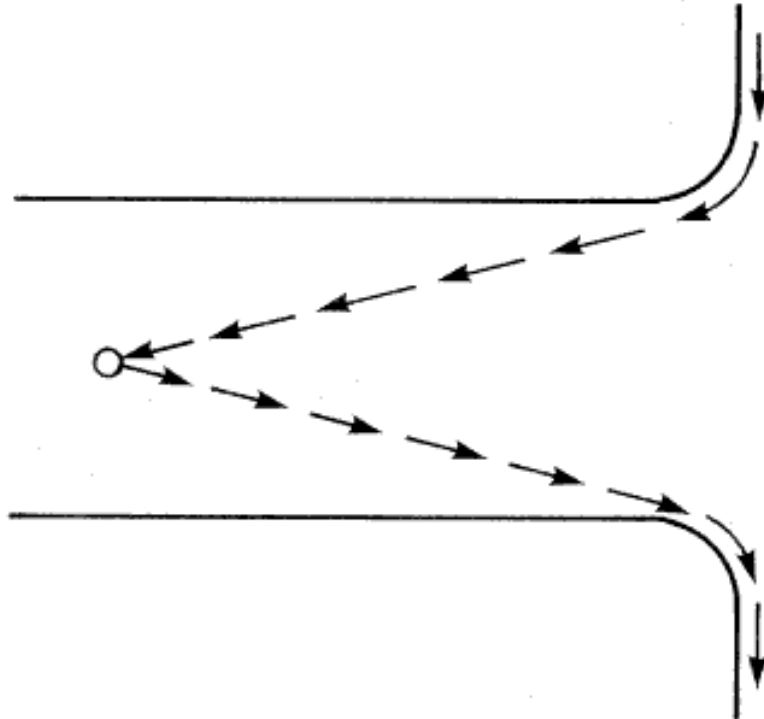
Because it is difficult to follow the shortest possible route perfectly, an extra length factor of 0.1%, called the **short course prevention factor**, is incorporated into the calibration procedure. Use of the factor assures that your course will **not** be short, even if you make small errors in following the shortest possible route.

When making a turn, measure prudently close to the curb or edge of the roadway. Thirty centimeters (one foot) from the edge of the roadway is a good guide. Often manholes, storm drains, broken pavement, and other hazards render this impractical. In such cases, attempt to measure the shortest route that a runner may be expected to take. You may wish to walk the bicycle through such sections if they are relatively short.

There are three basic situations encountered in following the shortest possible route. First, if you enter a roadway by making a right turn and also leave it by making another right turn, follow a path prudently close to the curb around both turns and in-between.



Second, if you enter a roadway by making a right turn and leave it by making a left turn, move in as straight a line as possible, diagonally from where you entered on the right to the most extreme left position allowed to the runner just before making the second turn. Again, make the second turn as prudently close to the curb as you can. In the case of heavy traffic, you may wish to employ the "offset maneuver" described in Appendix A (Supplementary Tips).

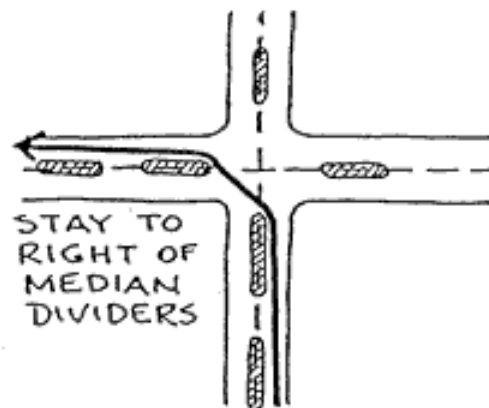
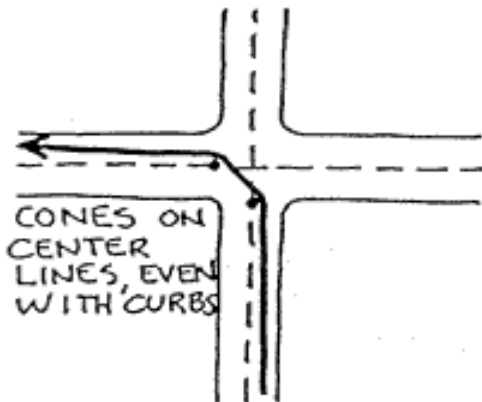
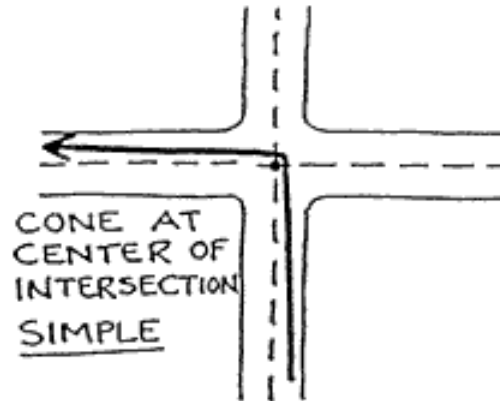
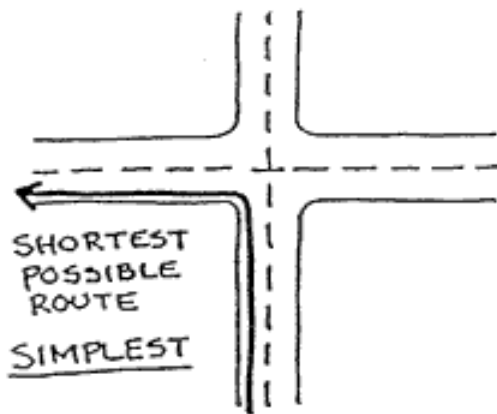
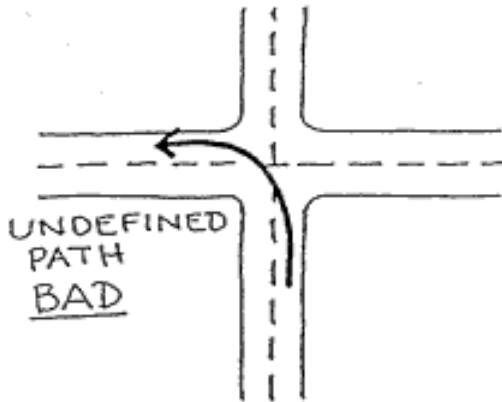


The course must be measured as it will be when the race is run. In particular, detouring around cars or other obstacles which may not be present the day of the race will make the course short (See Supplementary Tips).

If your course is laid out to restrict the runners to a route which is longer than the shortest possible route (on pavement), traffic barricades or intensive coning is required. Course monitors are nice but often are absent, mis-positioned, or simply ignored by the runners. Instruct course monitors to disqualify on the spot, any runners they observe cutting the course as defined by the barricades and cones.

The locations of barriers must be marked on the road, and their exact locations put on the map. You should be prepared to document every such marker that you put in place. If this seems like too much trouble, you should assume that runners will short-cut all they can and **measure that way**, even if the runners are instructed to run a longer route.

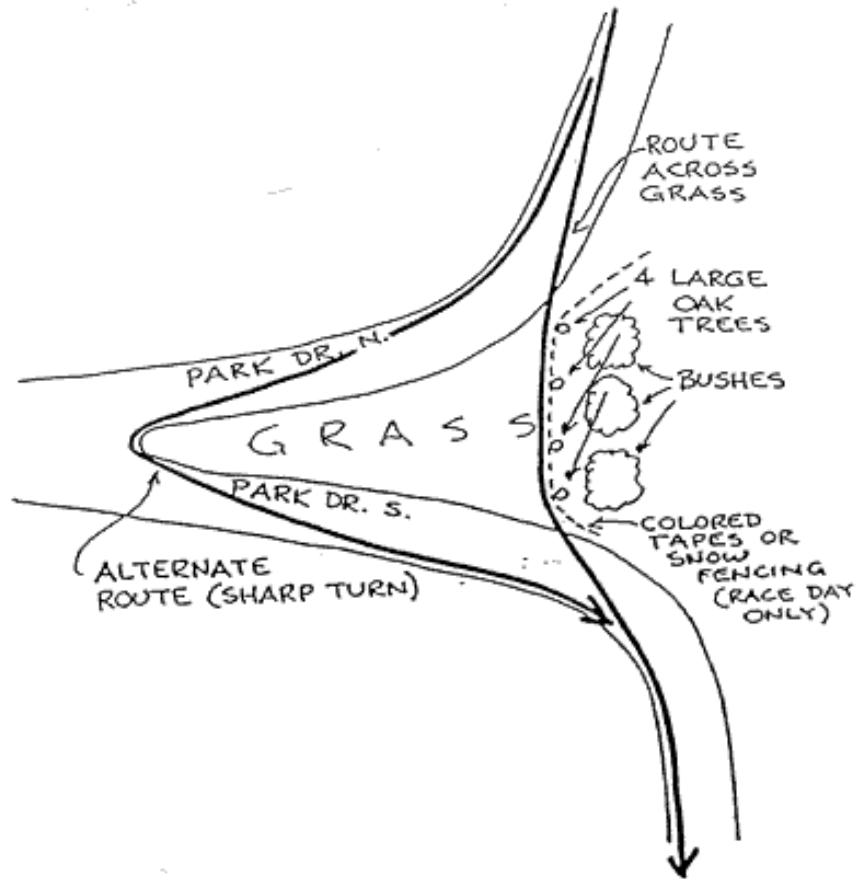
TURNING A CORNER



If you restrict the runners to one side of the road, be sure you specify how the corners are to be turned. It makes a difference. There should be no doubt of the exact measured path.

If you cannot enforce the restrictions, it's best to measure the shortest possible route and leave race-day coning as the race director wishes it.

Sometimes the paved route is likely to be ignored by the runners. Plan for this, and measure across the grass in those areas where the runners are likely to shortcut. Be sure the route you choose is bounded by something that is permanent.



Sometimes the sides of the road are poorly defined. For example, the Fiesta Island 10 km has a paved road with firm dirt shoulders that some runners prefer to run on.



Selecting the exact running/measuring route is a matter of judgment. It is probably best to remain on the pavement but as close to the dirt edge as possible **unless** the dirt route is obviously shorter. In that case, you should measure the shortest route on the dirt.

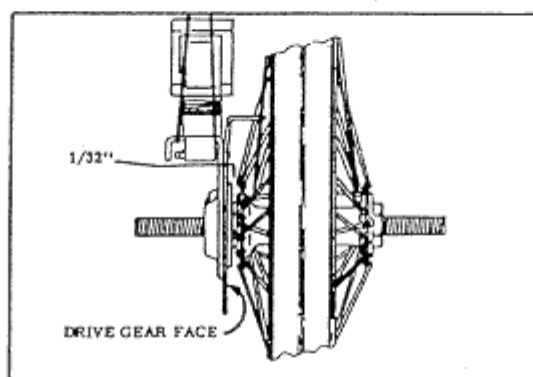
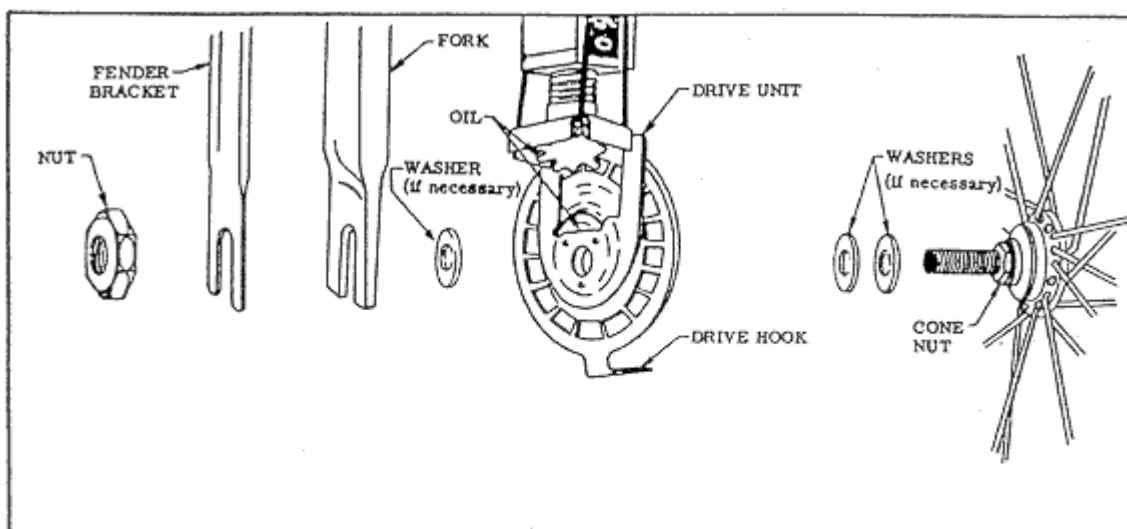
In summary, study is required to determine the shortest route that can actually be run, whether it be in the street, on the sidewalk, or on the grass or dirt.

USE OF THE CALIBRATED BICYCLE

Mounting the Jones Counter on Your Bicycle

The Jones Counter is mounted on the left side of your front wheel where it can be seen while riding. The counter goes between the hub and the fork. Remove the wheel from the bicycle and then remove any nuts and washers (or the quick release mechanism, if any) from the axle.

If you have a quick release hub, you may have trouble getting the counter on the axle while still leaving enough threads for the fork to rest on. Removing a spacing washer from the axle may help or you may loosen the bearing-keeping nuts and shift the axle to the left.



If, after you place the wheel with the counter back on the bicycle, you find that the whole counter moves with the wheel rather than staying fixed while it registers counts, the counter is binding against the wheel. The solution is to place a washer between the hub and the counter.

Riding Technique

Ride in a relaxed manner, in as straight a line as possible. The basic idea behind the method is that a small amount of "wobble" while riding the course is accounted for when calibrating the bicycle. Ride the calibration course the same way you will ride the race course.

Avoid braking with the front wheel. When you brake, apply the rear wheel brake.

Failure to ride a straight line, particularly when diagonally crossing a street, may yield a short course. Rather than watching the ground near the front wheel, aim for a distance point. Locate a point in a direct line to where you need to ride. Then ride toward that point, keeping an eye on that point.

When you encounter potholes or bad bumps, do not swerve to avoid them. Minor ones can be negotiated by slowing down and getting up off the bicycle seat. For a bad bump or hole, stop and carefully walk the bike through it. When you have to get off the bicycle and walk it, e.g., when attempting to reach an exact count or when going through a pothole, you will add roughly 1% to that portion of the course unless you push down on the handlebars to keep some weight pressing down on the front wheel.

Tires should not be checked for pressure at **any** time between calibration and recalibration. This causes a small air loss which may significantly alter your riding constant.

Avoid extreme weather conditions. Do not measure on very windy days.

Reading the Counter

Freeze the front wheel before reading the counter. This may be done by hand or by using the front wheel brake.

When reading the counter after backing up, be sure to move the bicycle forward again before taking a reading to avoid a "backlash" effect.

If you go past a count at a kilometer/mile marker, it is best to make a mark where you happen to stop, record the count there, and later adjust the split point by measuring backwards with a tape. Although it is possible to wheel the bicycle backwards, this should be avoided.

Etiquette

When measuring, you may encounter runners, other cyclists, or just people enjoying the out-of-doors. Slow down. Politely explain that you are measuring a race course and have to go in a straight line. They will usually yield to you. Except in extreme cases, avoid moving out of someone's way. If necessary, stop and wait for that person to go around you. Please

be courteous at all times. You can minimize such problems by measuring when traffic of all sorts is at a minimum.

If you do a lot of measuring, you may wish to carry fore and aft signs reading "**Official Measuring**" in yellow lettering on a dark background.

COURSE MAPS

The course map is the most important documentation of your course. Its purpose is to provide, ideally on a single sheet of paper, all the information a race director needs to run the race using the course **as certified**. This documentation is of great value in case a record is set on the course and a "validation" measurement is needed.

Without good documentation for the course, mistakes could easily be made in laying out the course on race day. By the time of **next** year's race, there may be a new race director who knows nothing about the original course measurement. In addition, all the marks you've painted on the road may have faded into oblivion by the following year!

The map should fit on a single sheet of US Letter size (8.5x11 inch) or A4 paper along with any blow-up or detail maps. The map need not be drawn to scale nor does it have to include every single cross-street or landmark. In fact, the best maps enlarge sections where more detail is needed to show how the course is to be run, and shrink sections where less detail is needed. **Do not** use colors, as the map will be photocopied (black & white) onto the notice of certification. The map **must** indicate the direction of true north.

A copy machine may be used to reduce or enlarge available maps to serve as a basic layout for your course map. Note that some colors may copy darker than others using various brands of copy machines. If you mark over the base map in a color which will copy darker and use a lighter setting on the machine, you can generate a working map which emphasizes the main features of your course. By using the enlarging feature available on some copiers, you can expand sections you wish to detail.

The map should include a line representing the **actual measured path** through the course. Use this line to show how you angled between corners and how you took each turn, including turn-arounds. In order to show the measured path, "widen" the streets or roads relative to their length. You may need to further distort the scale to display all relevant detail. (But note: If you did an "offset maneuver" to deal with traffic as explained in Appendix A, do **not** draw it on the map, as this could be very confusing to race directors; instead draw the desired diagonal path that the offset maneuver was intended to approximate.)

The line representing the measured path indicates the very **shortest** route that runners may be permitted to take during the race. If the race director chooses to restrict the runners' path in such a way that they have to run **farther**, that is OK. But the runners may not be permitted to run any shorter than the measured path or the certification will be invalid.

If your measured path was not always the shortest possible route that a runner could run using **any** part of the street or road, then traffic barricades or cones must be set up to insure that the runners cover at least the distance you measured. Your course map must indicate **exactly** where such barriers are to be placed and also show where monitors are to be stationed. If this seems like too much trouble, just measure the shortest route assuming no barricades and you'll be safe.

Your map **must** include descriptions of the **exact** locations of the **start, finish,** and any **turn-around** points. This is done by giving precise tape-measured distances from nearby permanent landmarks. In writing such descriptions, **do not assume** that your painted marks on the road will still be visible. Instead, think of your descriptions as instructions for re-locating the marks without having to remeasure the entire course in the event of repaving the road. In complicated cases, it may be necessary to include detailed blow-up maps of some or all of these points.

In addition to your start, finish, and turn-around points, you should provide documentation for your intermediate splits so they can be relocated when necessary. To avoid clutter on your main map, prepare a separate list of split descriptions.

Clearly label all streets and roads used for the course. Indicate kilometer/mile marks with circled numbers. Use arrows to indicate the direction of the race.

Several examples of course maps have been included in Appendix C for your reference.

LIST OF POINTS AS MEASURED

- START - ON HIGH ST, EVEN WITH N SIDE OF COURTHOUSE BLDG, JONESVILLE, OH
- TURNAROUND - ON JONES ST, EVEN WITH "T₁" TELEPHONE POLE #AK3014 (APPROX 280 FT N OF WINDING WAY)
- FINISH - ON MAIN ST, EVEN WITH CENTER OF 10 K SIDEWALK LEADING TO STATUE OF AMOS POTTER (E. OF COURTHOUSE)

SPLITS

- 1 MILE - 17 FT E OF MAILBOX, 237 OAK ST
- 2 MILE - 35 FT S OF STOP SIGN ON FARWELL AT WINDING WAY
- 3 MILE - 12 FT W OF TP #AK 3068, ON WINDING WAY APPROX 100 FT W OF JONES ST.
- 5 K - 182 FT S OF TP #AK 3015
NOTE - 5K IS REACHED AFTER MAKING TURN.
- 4 MILE - EVEN WITH DRIVEWAY TO UNITED INDUSTRIES, 1714 JONES ST (N. EDGE OF DRIVEWAY)
- 5 MILE - ON ST. HWY 77, 42 FT E OF STORM DRAIN IN FRONT OF BAKER'S DOZEN SPECIALTY SHOP (4900 E. ST. HWY 77)
- 6 MILE - ON LOW ST, 6 FT N OF FIRE HYDRANT BY 212 LOW ST.

THESE POINTS ARE IMPORTANT! REPAVING AND WEATHER MAY WIPE OUT YOUR MARKS. WITH THIS INFO THEY CAN BE FOUND AGAIN!

ADJUSTED POINTS - FINAL LOCATIONS.

- TURNAROUND - ON JONES ST, 169 FT S OF "T₂" TELEPHONE POLE #AK 3014
- NO OTHER POINTS WERE ADJUSTED.

IMPORTANT!

A LIST LIKE THIS MUST ACCOMPANY YOUR MEASUREMENT DATA.

APPENDIX A

Supplementary Tips

Dealing with Obstacles

When measuring the course, you may encounter an obstacle such as a parked car which will not be present on race day. One way to deal with this problem is as follows:

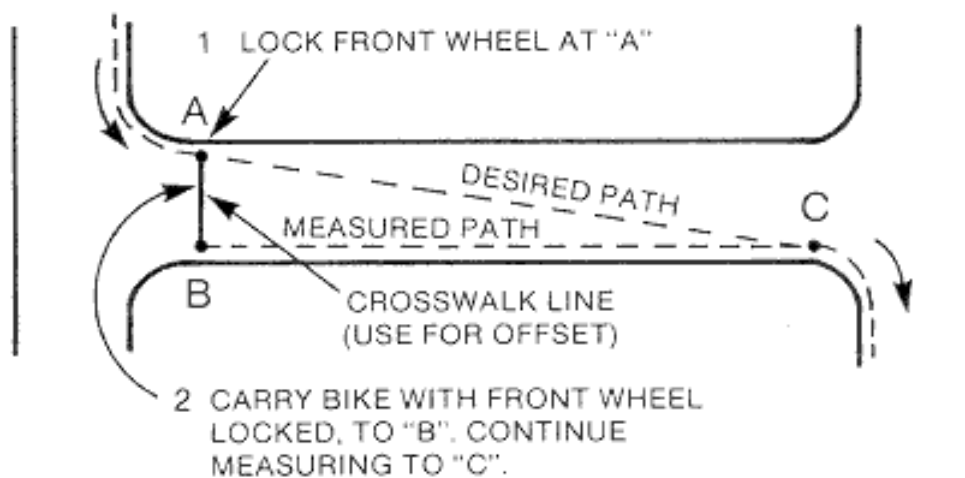
- a. stop your bicycle just before the obstacle
- b. freeze your front wheel with your hand or the brake
- c. very carefully move the bicycle perpendicular to the route being measured until you are clear of the obstacle
- d. release the wheel and proceed until past the obstacle
- e. reverse the process with the wheel frozen to return to the shortest possible route

Use this procedure sparingly and report each instance in your application for certification. If you have to do this more than a few times on the course, try again on another day when most of the obstacles are gone.

Dealing with Traffic (the "Offset Maneuver")

It may not be possible to measure some sections of a road course with reasonable safety at any time. The preferred method is to arrange an "escort" which may be an official police escort or simply a large truck equipped with arrows and blinkers used for traffic control.

If the critical section requires a long diagonal run across traffic, you may wish to consider an "offset maneuver." This is performed as follows:



Measure along the (straight) road edge to where a crosswalk or expansion crack lies. Using this as a guide, physically carry the bicycle across the street with the front wheel frozen.

Continue the measurement along the opposite side of the roadway. This errs on the side of making the course very slightly longer but it may save your life. When crossing the roadway, **be sure** you cross **perpendicular** to the direction of the roadway.

Two-Cyclist Riding Technique

It is often faster and more enjoyable, and possibly also more reliable, to measure with a second cyclist instead of just doing two rides of the course by yourself. Either way, we use the **one set of marks** technique. This means that tentative start, finish, and split marks are only painted on the road during the **first** measurement. In a two-cyclist measurement, only the **lead** rider paints marks on the road. No new marks are ever painted during the second measurement. Therefore, the second cyclist simply stops at the points already marked by the first cyclist, and records counter readings at exactly those marks. To minimize confusion during this process and subsequent data analysis, the second cyclist should **not precalculate** any counter readings from his/her working constant before riding.

The two cyclists should strive to make their measurements as **independent** as possible; i.e., each rider should exercise his/her own judgement as to where the shortest possible route lies. The measurements will not be truly independent if the second cyclist follows directly in the tracks of the first cyclist. Ideally, the second cyclist should follow two or three blocks behind the first cyclist; however, this may not be practical in certain situations; e.g., if you have a police escort.

Safety

A course measurer should always wear an orange, reflective, safety vest. A helmet is also an essential piece of safety gear. These will tend to make you look more "official," like a member of a highway crew **and** it will make you much more visible. Since the route that must be measured is often not the logical route for a cyclist, motorists will not be able to easily predict your direction and avoid you.

Even if you cannot arrange an official police escort, a friend following you in a truck with emergency lights flashing can provide considerable protection when measuring in traffic.

When steel-taping or making permanent marks, you may wish to use safety flags or stop signs to add to the protection of the measuring team.

Minimizing Stops to Check the Counter

Electronic devices are available which attach to the front wheel and provide digital readouts you can attach to the handlebars. Although not sufficiently accurate for certification purposes, such devices can alert you to the upcoming location of intermediate split points and measurement end points on your first measurement. Such devices are available in many bicycle stores.

You may also find it convenient to mark (with felt tip pen) all your intermediate stop counts on a sheet of folded 8.5x11 paper and fasten this to the front brake cables with clothes pins for easy reference.

Solid Tires and Avoidance of Flats

A flat (front) tire is a disaster! If you get a flat, **all** measurements made since the last calibration are invalid. You must fix the flat and start over with a new calibration.

Solid tires are one way of avoiding flats. Solid tires require a period of "breaking in" which you should reach after roughly 50 kilometers of riding. Solid tires have two major advantages. First, you eliminate flat tires and the wasted measurements that accompany a flat tire. This allows you to ride the shortest possible route with more confidence since glass fragments are no longer a problem.

Second, the day-to-day and within-day variations in the calibration constant are smaller. Solid tires do not eliminate the need to calibrate before and after measuring but they do reduce differences between the working and finish constants.

Locating Intermediate Split Points

Many races have signs indicating kilometer or mile points and may have times read to the runners at several points. A "locator" guide describing how to find a painted split point quickly when driving along in a car is often useful. Very little time is available to place signs and drop off timers on race day and such a guide helps assure the runners will get splits at the proper points. Few things are more frustrating to a serious runner than to realize mid-way through the race that the splits are all wrong!

Measuring at Night

For urban race courses on busy streets, the only time that the traffic density is light enough to permit a proper course measurement may be late at night. If you measure at night, you **must** calibrate and recalibrate during the same night under the same conditions as the race course measurement. **Do not** calibrate before sunset, measure at night, and then recalibrate after dawn.

You will need a good light system for your bicycle and a flashlight to read the Jones Counter. Many Ni-Cad battery powered light units are available and work very well. You may also attach a flashing strobe light to your bike or person. These units are cheap and light, and provide a greatly increased degree of safety. Use plenty of reflective material such as a vest and reflectors for your bicycle. Wear a helmet. Do not measure alone at night. Have a car behind you with high beams on.

Do not measure at night unless you know exactly where the shortest possible route lies. Visibility may not be good enough to sight distant corners.

Walking the Bicycle

Walking the bicycle removes weight and reduces the counts required to cover a given distance. If this is done while measuring the race course, it will tend to produce a race course that is slightly oversized (which is acceptable). The portions of the course that a bicycle is walked over will be roughly 1% longer than if the bicycle were ridden.

You may find it necessary to walk the bicycle for short distances near intermediate marks, through large potholes or other paving disasters, and occasionally up hills too steep to ride. You might consider measuring down such hills by making temporary marks at the top and bottom and measuring between them in the reverse direction.

You should **never** walk the bicycle over any portion of the *calibration course* since this will tend to produce short courses.

Measuring on Dirt, Grass, and Sand

Avoid laying out a course over non-paved surfaces. If you must, minimize the distance to be measured over such surfaces. Hard-packed dirt is OK but avoid sand, soft dirt, and deep grass.

The greatest accuracy is obtained by steel-taping all non-paved sections. However, measuring the entire course by a bicycle calibrated on a standard, paved calibration course is acceptable and, in fact, is the **recommended** procedure since it reduces the chance of error.

The calculations (for start, finish, splits, etc.) can get quite complicated if you piece together a course measured partly by bicycle and partly by steel tape. If you do this, make permanent marks at those points where you change between bicycle and tape measurements.

When you ride the bicycle over non-paved sections, you will tend to get fewer counts than you would riding over the same distance on a paved surface. This will tend to make your course slightly longer. Measuring on firm dirt should not lengthen that part of the course by more than 0.1%; measuring on grass may lengthen that portion by 1% or more; measuring in loose sand may lengthen by more than 3%.

Measuring dirt roads usually presents little problem **if** the road is well graded. If the non-paved road is not graded (usually two ruts) and is winding, it may be virtually impossible to ride the shortest possible route since the proper route would cross the ruts and intermediate ridge at angles which do not permit safe riding. If such sections are encountered and cannot be avoided, they must be steel-taped.

Minimizing Temperature Effects

In many locales, the daily temperature range may be 20 °C (36 °F) or more. Such temperature extremes usually create a greater difference between the working and finish (calibration) constants. You may reduce this difference by measuring on days when the temperature variation is small, such as on cloudy days or near dawn when the temperature changes slowly.

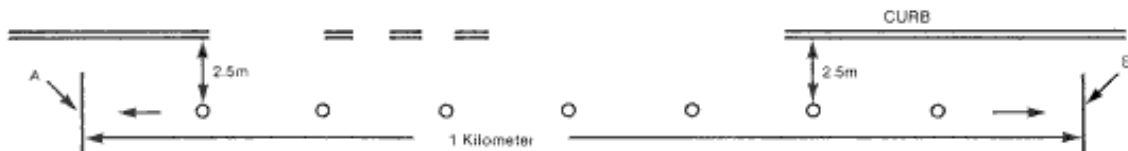
Another way to reduce this effect is more frequent re-calibration runs. If you measure over a period of five or more hours, you may wish to do a set of calibration rides mid-way through your measuring. This is feasible only if the calibration course is not too far from the race course. It does have the additional advantage that it "protects" at least some of your measurements against flats.

Calibration Course

Since you may be calibrating before dawn or after dusk, you may wish to make the paint marks on your calibration course with fluorescent paint for better visibility.

As a warning when approaching the end of the calibration course, an arrow 10 meters or so before the marked endpoints may be helpful. Another useful feature is to paint dots every 30 m or 100 ft to be used as reference points while calibrating.

If parked cars are a problem, you could establish the calibration course 2.5 meters from the curb.



As a safety measure, you may wish to lay out **two** calibration courses, one on each side of the street so that you are always able to ride legally with traffic. Note that **each** course must be measured and certified separately.

APPENDIX B

Course Layout

If you are measuring an existing race course, consult with the race director to make sure you are measuring the correct course. Find a runner who has run the race to help determine how runners actually run the course.

If you are laying out a new course, find out what restrictions the race director and local authorities may have on where the race may be run. The finish area is especially critical since you will need a traffic-free area with enough room to set up finish chutes, medical and aid stations, results processing areas, and often awards ceremonies. Many courses are laid out from finish to start.

The starting area must be wide enough to accommodate the maximum expected field. Trying to start more than 1000 runners on a two lane road without shoulders creates substantial congestion and delays the back-of-the-pack runners. **Never** lay out a course with a sharp turn within the first hundred meters; the more starting straightaway you have, the better (and safer) the course. Likewise, leave at least a 100 meter straightaway leading into the finish so runners can have a decent finishing sprint.

Avoid crossing traffic where possible. In races, police prefer that runners run with the traffic. This makes it easier, and safer, for the police escort. If you can lay out a course that consists of mostly right turns, you avoid crossing traffic and your measurement job is easier since you will have less traffic to contend with.

When laying out a course for a large race (more than 1000 runners), avoid multiple loop courses and out-and-back courses. Do not lay out a course with three or more loops for large races since monitoring against cheating is nearly impossible. Likewise, a straight out-and-back course requires some type of recording at the turn-around point. This is difficult for large races and should be avoided.

Small races and ultra-marathons are conveniently held on small loop courses, from one to ten kilometers (one-half to six miles) per loop. Certify the loop itself as a **closed loop** course. Once the closed loop is certified, **all** integral multiples of the loop are automatically certified. Thus, you may be able to certify a 100 km course with 10 km of measurement (twice over a 5 km loop).

If the closed loop course can be made an exact standard distance such as 5 km or 5 miles, races of several different lengths may be held. Intermediate splits which are an integral number of loops are also certified and considered valid for record purposes. To set up a closed loop course which is an exact standard distance, refer to the discussion below on laying out a course with fixed start and finish points.

It is important to lay out a reasonably accurate course before doing the actual measurement. One way to do this is to use large-scale maps with a scale of 1 to 5000 (1 cm = 50 meters)

or 1 to 6000 (one inch = 500 feet). Such maps may often be obtained at a city or county office. You can buy (about \$12) a small tool called a map measurer which can be pushed along on the map to measure distance.

A rough measurement with your (uncalibrated) bicycle is a good idea since it will give you a rough idea of start and finish points and will familiarize you with riding the shortest possible route. If your chosen course is way off, this is the time to make alterations.

Once you have arrived at a tentative course, consult with the race director and local authorities to determine how much of the roadway will be available to the runners. If the runners are to be restricted to following a longer route while a shorter one is available, it is necessary to include temporary barriers to keep them along the correct path. Instructions such as "stay on the right side" are universally ignored, unless enforcement exists. Note that it is easier to let them run wherever they want on the road and measure the shortest path they can take.

If you measure a restricted route, **it must be coned and monitored** or the certification will be invalid. The restricted route must be marked in such a manner that cones and/or barricades may be properly placed on race day. The positions of barricades and cones must be clearly specified on the course map. Usually, painted lane markings are used as the basis for a restricted route.

If you need to adjust the course, small adjustments can be made by moving the start, finish or turn-around points. If the needed adjustment is large, you may need to reroute the course and make additional bicycle measurements. Making changes in the middle of a course is usually awkward.

If both the start and finish must be at fixed points, you should have a turn-around point somewhere on the course. The position of the turn-around may be varied to get exactly the desired length. Remember when you move a turn-around, the runners will run twice the distance you move the turn.

Mark all important points on the final course carefully and permanently. Determine their locations relative to fixed landmarks so they can be found again in case of repaving or other changes in the road surface. Make sure provisional marks are not confused with final marks. Provisional marks may be obliterated by spraying over them with black spray paint (on asphalt) or simply "block" them out in the original color.

The entire race course should be inspected just before the race by someone who knows the course as it was measured. Be sure the start, finish, and turn-around points are correctly located. Check the positions of course monitors and marshalls as well as the positions of cones and barricades. If there is a lead car, someone who knows the route should be in the lead vehicle. This person should also have a map of the course. In any complicated undertaking involving lots of people, there are bound to be errors. Anticipate them. Check and double check.

APPENDIX C

Example of Course Measurement

Setting Up the Calibration Course

It is 7:15 AM on 7 October 1982 in Elysium, OH. You arrive at your pre-selected site for the calibration course on Fargo Road with your two trusty helpers, Ralph Doe and Susan Marker. This section of Fargo Road is straight and level, recently paved, with no cross-traffic and little traffic of any kind. You have checked your equipment list and everything is accounted for.

You have decided to set up a one kilometer (1000 meter) calibration course since the race course will be 10 kilometers. You couldn't find a metric tape in your local hardware store so you are using a 100 foot tape instead. Since a kilometer is 3280.84 feet, you will be laying out 32 and a fraction lengths of the 100 foot tape.

[Note: You probably **can** find a metric tape by checking stores that sell to the surveying profession, or companies that sell equipment for track meets, or educational supply houses, or by visiting any hardware store outside the United States.]

Locate the start. There is a storm drain just south of the intersection of Fargo Road with Turtle Road. This will make a nice permanent reference. You drive a PK nail into the pavement, 18 inches west of the east edge of Fargo Road and exactly 2.0 feet south of the south edge of the storm drain located in front of 2317 Fargo Road. This will be the permanent northern endpoint of your calibration course (point A).

You lay the thermometer on the pavement, standing so that you shade the thermometer. After three minutes, the temperature seems to have stopped changing. It reads 53 °F. Susan records the start time and temperature.

Ralph holds the 100 ft mark of the tape over the PK nail at point A. You grab the "Zero" end and extend the tape (southward) while walking it out to its full extension of 100 feet. You are using the Zero end because that is the end with a ring to which you can attach a spring balance. You and Ralph jiggle the tape as needed until it lies straight and flat, and you check that your end is still 18 inches from the curb. Then you start pulling on the spring balance until it reaches 50 newtons (5 kilograms-force, or 11 pounds-force), moving the tape slowly forward.

In the meantime, Susan tears off a piece of masking tape (which she has already pre-numbered with numeral "1") from her roll, and sticks it on the roadway at your end of the tape. When you have the tape steadily under tension and Ralph signals that his end is over the mark, Susan puts a thin black mark on the masking tape alongside the Zero mark of the measuring tape.

You continue in this manner until you have marked 32 one hundred foot sections. At this point, you mark an 80 foot section. The procedure is exactly as before except that Ralph uses the 80 foot mark instead of the 100 foot mark on the tape. You still pull the spring balance with **50** newtons (not 40). The marked point (which we'll call "B") is now 3280 feet south of point A. It isn't necessary to get exactly 3280.84 feet at this step since a final adjustment will be made later. Susan enters 32 tape lengths \times 100 feet each, with a "partial" tape length of 80 feet.

You now start measuring back (northward) from point B, in 100 foot lengths, using new pieces of masking tape which will each be intermediate to the previous marks. You use a **red** pen this time, to clearly distinguish these marks from the old ones. Note that you had to turn the tape around at point B since only the Zero end has a ring where you can attach the spring balance.

As before, you lay out 32 full 100 foot tape lengths. However, you measure the last interval to the PK nail at point A. This is found to be 79 feet 8 $\frac{3}{4}$ inches. Thus, according to your second measurement, the distance between the permanently marked point A and your temporary point B is 3 $\frac{1}{4}$ inches short of 3280 feet. The second measurement is 3279 feet 8 $\frac{3}{4}$ inches or 3279.73 feet in decimal form.

You repeat the temperature reading as before and find it to be 59 °F. Susan records this datum.

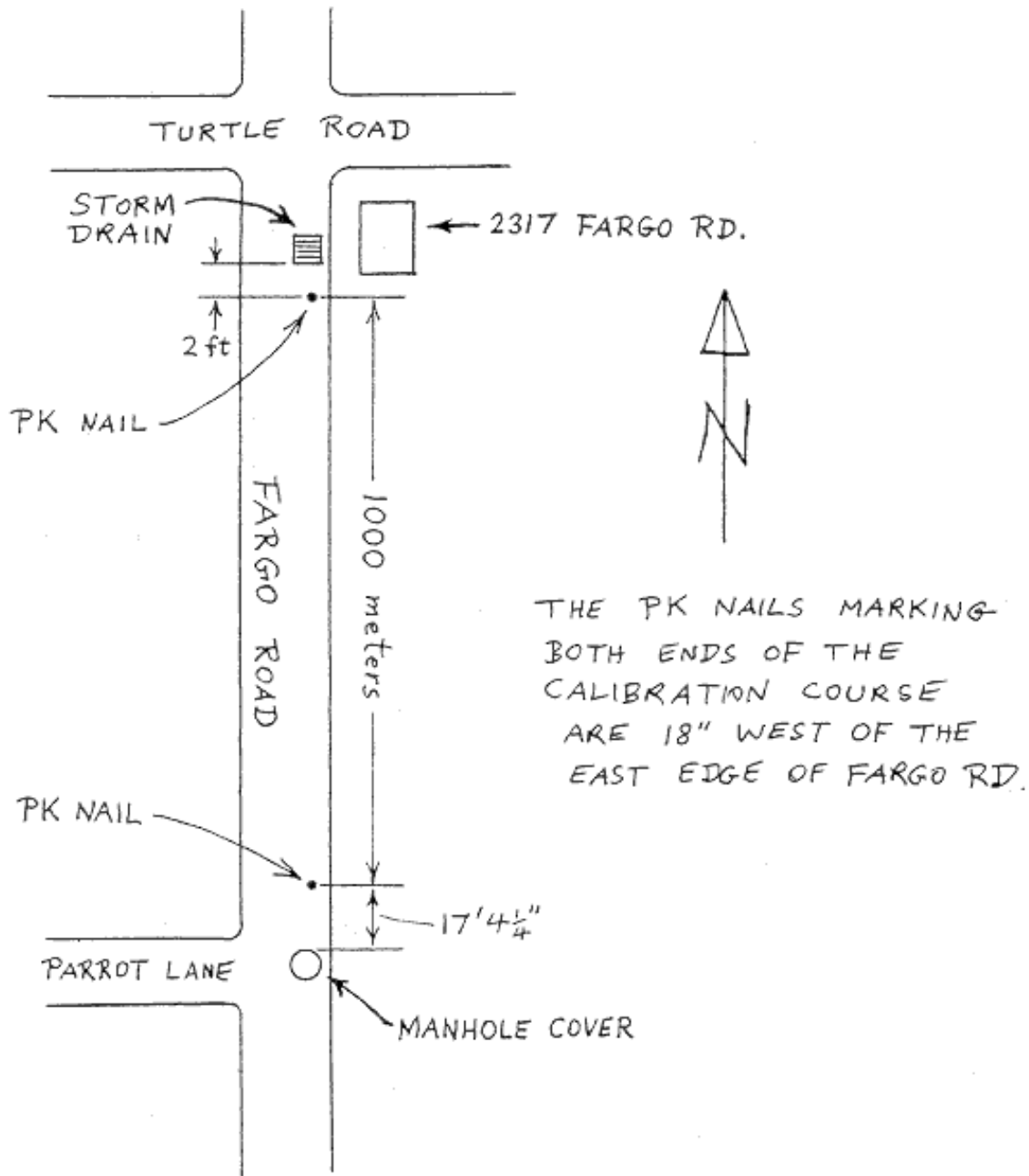
You now calculate the temperature-corrected average measured distance between points A and B, as instructed in the Steel Taping Data Sheet. The corrected measurement is 3279.61 feet. Since your desired calibration course length is one kilometer or 3280.84 feet, you must now lengthen the tentative course by 1.23 feet or 1 ft 2 $\frac{3}{4}$ inches. You do this by moving point B to a point 1 ft 2 $\frac{3}{4}$ inches further south. Using the tape measure once more, you find that the corrected point B is 17 ft 4 $\frac{1}{4}$ inches north of the north edge of the manhole in the center of the intersection of Fargo Road and Parrot Lane.

You are now almost finished. But, before permanently marking point B, you check to make sure you haven't missed a whole tape length somehow. You take your bicycle off of the rack and ride it around for a few minutes to warm up the tires. You place the bicycle's front axle over the north endpoint and record a count of 12546. You then ride southward one 100 foot tape length (being careful to use a 100 ft interval rather than the 80 ft interval!), and stop with the front axle over the mark. You record a count of 12833. The difference, corresponding to one tape length, is 287 counts.

You now return to the northern endpoint (point A) and, pointing the bike southward again, note a counter reading of 13217 with the front axle over the mark. You ride the bicycle over the full calibration course, stopping with the front axle over the corrected southern endpoint. You record a count of 22622. The difference is 9405 counts. Dividing the full course count of 9405 by the 100 ft count of 287 yields a course length of 32.77 tape lengths which, for such a rough check, is in excellent agreement with the intended course length of 32.8084 tape lengths.

Finally, you put a PK nail at the corrected endpoint (point B) of your one kilometer course. You thank Ralph and Susan and head home to fill out the forms necessary to obtain certification of your new calibration course.

FARGO ROAD KILOMETER
(1000 METER CALIBRATION COURSE)
ELYSIUM, OHIO



STEEL TAPING DATA SHEET
(for measuring a calibration course)

Name of Calibration Course FARGO ROAD KILOMETER

City and State ELYSIUM, OHIO Date 7 OCT. 1982

Start Time 7:15 AM Finish Time 9:00 AM

Pavement Temperature: Start 53 F Finish 59 F Average 56 F
(if you do not use a bimetallic thermometer, the thermometer must be shaded)

Measurements and Calculations:

1. First Measurement. This establishes tentative start and finish marks which should not be changed until the final adjustment on line 6 below.

$$\frac{32}{\text{\# tape lengths}} \times \frac{100 \text{ FT}}{\text{distance per tape length}} + \frac{80 \text{ FT}}{\text{partial tape length}} = \frac{3280.00 \text{ FT}}{\text{measured distance}}$$

2. Second measurement. This checks the distance between the same tentative start and finish points marked in the first measurement, but use new intermediate taping points.

$$\frac{32}{\text{\# tape lengths}} \times \frac{100 \text{ FT}}{\text{distance per tape length}} + \frac{79' 8\frac{3}{4}''}{\text{partial tape length}} = \frac{3279.73 \text{ FT}}{\text{measured distance}}$$

3. Average Raw (uncorrected) Measurement of Course 3279.865 FT

4. Temperature Correction. Use the average pavement temperature during measurement, in whichever formula is appropriate (for Celsius or Fahrenheit temperature). Work out answer to at least seven digits beyond the decimal point.

$$\begin{aligned} \text{Correction factor} &= 1.0000000 + (.0000116 \times [\text{Temp } (^{\circ}\text{C}) - 20]) \\ \text{Correction factor} &= 1.0000000 + (.00000645 \times [\text{Temp } (^{\circ}\text{F}) - 68]) \\ \text{Correction factor} &= 1.0000000 + (.00000645 \times [56 - 68]) \\ &= 1.0000000 + (-.0000774) = .9999226 \end{aligned}$$

NOTE: For temperatures below 20° C (68° F), factor is less than one
For temperatures above 20° C (68° F), factor is greater than one

5. Multiply the temperature correction factor by the average raw measurement of the course (line 3).

$$\frac{0.9999226}{\text{correction factor}} \times \frac{3279.865 \text{ FT}}{\text{avg. raw measurement}} = \frac{3279.61 \text{ FT}}{\text{corrected measurement}}$$

6. If you wish, you may now adjust the course to obtain an even distance (such as one kilometer). This is not necessary as you may choose instead to use an odd-distance course whose end-points are pre-existing permanent objects in the road to guard against hazards such as repaving. If you adjusted the course, explain what you did. ADDED 1.23 FT
1.23 FT = 1' 2³/₄''

$$\text{Final Adjusted Length of Calibration Course } \frac{3280.84 - 3279.61 = 1.23 \text{ FT}}{\text{FINAL LENGTH} = 1 \text{ KM}}$$

CONVERSION FACTORS: 1 foot = 0.3048 meters
1 kilometer = 1000 meters = 3280.84 feet

APPLICATION FOR CERTIFICATION OF CALIBRATION COURSE

1. Name of Calibration Course FARGO ROAD KILOMETER
 2. Length of Calibration Course 1000.00 METERS
 3. City and State ELYSIUM, OHIO
 4. Date(s) Measured 7 OCT 1982
 5. Method Used to Measure Calibration Course STEEL TAPE
 6. How many times did you measure the calibration course? 2
 7. Measuring Team Leader: JOHN DOE, 614-123-4567
 (name) (telephone #)
123 ACCURATE RD - PERFECTION OH
 (address) 43807

Credentials or Experience: HAS HELPED MEASURE OTHER CALIBRATION COURSES

8. List Names and Duties of Team Members:
JOHN DOE - LEAD TAPEMAN RALPH DOE - REAR TAPEMAN
SUSAN MARKER - MARKED TAPE LENGTHS AND KEPT NOTES
 9. Submit a map of this calibration course, showing the name of the road (and relevant cross streets), and the exact locations of start and finish points, including taped distances from nearby permanent landmarks. ENCLOSED
 10. Is this calibration course: STRAIGHT? YES PAVED? YES

11. How are the start and finish points marked? NAILS & PAINT
 12. Are the start and finish points located in the road where a bicycle wheel can touch them or elsewhere? IN THE ROAD
 13. Approximate altitude of calibration course 700 FT
Mark end points in a permanent way (concrete or PK nails). Paint will fade. The calibration course, once certified, can be used to measure many courses. TAKE CARE OF IT!
 14. If the calibration course was measured by **Electronic Distance Meter (EDM)**, describe on a separate sheet the exact procedures used; also include a copy of the original field notes from the measurement. N/A
 15. If the calibration course was measured by **steel tape**, fill out a copy of the calibration course data sheet for steel taping and complete the following:

16. How much tension was applied to the tape while measuring? 10 LB
 17. How was this tension maintained? SPRING SCALE
 18. Was the tape free of any kinks, crimps or splices? YES

19. Bicycle Check. This is a check against miscounting the number of tape lengths. (If you used a gross measurement check other than a bicycle, please explain.)

- | | | | |
|---------------------------------------|----------------------|--------------|---|
| A. Counts for full calibration course | <u>26222 - 13217</u> | <u>9405</u> | } CLOSE ENOUGH TO SHOW NUMBER OF TAPE LENGTHS IS CORRECT. |
| B. Counts for one tape length | <u>12833 - 12546</u> | <u>287</u> | |
| C. Divide A by B | | <u>32.77</u> | |
| D. Number of full tape lengths | | <u>32.8</u> | |

APPENDIX C

Example of Course Measurement

Calibrating the Bicycle

You take your trusty bicycle with tires fully inflated and your pack of equipment out to the calibration course you previously submitted for certification. It is 7:15 AM. You determine the temperature as before (53 °F) and ride the bicycle around for roughly five minutes to warm the tires up. You record the time and temperature.

You position the front axle of the bicycle over the start point on the calibration course. You record the start count as 116091. You ride the calibration course, carrying your equipment. You carefully stop the bicycle with the front axle positioned directly over the end point. You record the finish count as 125499.

You then repeat this procedure three more times, recording the start and finish counts. Each time you reverse direction, you freeze the front wheel with the handbrake before turning the bike around. In this way, your finish count for one ride is your start count for the next ride. This isn't necessary but makes it slightly easier to calculate your average count.

You now sit down and fill in the first part of the **Bicycle Calibration Data Sheet**. The average pre-measurement count works out to be 9407.25 counts. If you had been using an odd-distance calibration course, you'd have to convert this to one kilometer (or one mile), but in your case, your calibration course is already one kilometer. You multiply your average pre-measurement count by 1.001 to obtain your **working constant** of 9416.6572 counts per kilometer. You raise this to 9417 and will use this value for preliminary course markings. Also, since you will be marking some mile splits, you multiply the 9416.6572 figure by the conversion factor of 1.609344 (see Appendix E) to obtain a mile constant of 15154.64 which is raised to 15155 counts per mile.

You now measure the course (see next section).

After you have completed your two measurements of the race course, you return to the calibration course. It is now 10:30 AM. You check the temperature and record 63 °F.

You calibrate the bicycle just as you did for the pre-measurement calibration with four rides. This time the average count is 9399.75. You multiply this by 1.001 to obtain your **finish constant** of 9409.1497 which is raised to 9410 counts per kilometer.

Since the **finish constant** is smaller than the **working constant**, the **constant for the day** is taken to be the **working constant** or 9417 counts per kilometer. If you start your measurements in the early morning, you will generally find your working constant to be larger than your finish constant. This means that the preliminary course marks will not need to be adjusted for the change in the bicycle calibration.

BICYCLE CALIBRATION DATA SHEET

Date of Measurement 16 OCT 1982

Name of Measurer JOHN DOE

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

Ride	Start Count	Finish Count	Difference	
1	116091	125499	9408	Pre-measurement Average Count <u>9407.25</u> Time of Day <u>7:15 AM</u> Temperature <u>53 F</u>
2	125499	134905	9406	
3	134905	144314.5	9409.5	
4	144314.5	153720	9405.5	

Length of Calibration Course 1 KILOMETER

WORKING CONSTANT = Number of counts in one kilometer or one mile, calculated from Pre-measurement average count, and multiplied by 1.001 "safety factor".

$$\text{Working Constant} = 9407.25 \times 1.001 = 9416.66 \text{ COUNTS/KM}$$

(USED 9417 FOR LAYOUT)

$$\text{ALSO } 9416.66 \times 1.609344 = 15154.64 \text{ COUNTS/MI}$$

(USED 15155 FOR MILE SPLITS)

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 4 times, recording data as follows:

Ride	Start Count	Finish Count	Difference	
1	342567	351965.5	9398.5	Post-measure Average Count <u>9399.75</u> Time of Day <u>10:30 AM</u> Temperature <u>63 F</u>
2	351965.5	361366	9400.5	
3	361366	370765	9399	
4	370765	380166	9401	

FINISH CONSTANT = Number of counts in one kilometer or one mile, calculated from Postmeasure average count, and multiplied by 1.001 "safety factor"

$$\text{Finish Constant} = 9399.75 \times 1.001 = 9409.15$$

9410

Constant for the Day = Either the Working Constant or the Finish Constant, whichever is the larger.

CONSTANT FOR THE DAY = 9417 COUNTS/KM

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 24 hour period. This is done to minimize error due to changes in tire pressure from thermal expansion and slow leakage. Frequent recalibration "protects" the previous measurement. A smart measurer will recalibrate frequently—you never know when a flat tire is coming!

CONVERSION FACTOR: 1 mile = 1.609344 kilometers

APPENDIX C

Example of Course Measurement

Measuring the Race Course

The race course has already been defined in terms of the route and desired start and finish points. The course is to be a 10 kilometer course. The start may be adjusted but the finish line is fixed.

You have completed your pre-measurement calibration rides and have determined your working constant to be 9417 counts per kilometer (15155 counts per mile). You have decided to lay out mile splits and splits for one and five kilometers (Splits at every multiple of 5 km are recommended for all metric races and the half and full marathons).

You mark the finish line in the pavement on Turtle Road and note its location as 37 feet west of the "No Parking" sign by the Weed Shoe Store. You place the front axle of the bicycle over the Finish line and rotate the wheel *forward* until you reach an even thousands of counts (154000 counts). This simplifies the arithmetic but is not required. In your notebook, you record the initial count and calculate the count for each intended split, working backwards from the finish to the starting line.

These counter readings are calculated as follows. First you work out the metric splits:

Finish									
5 km	154000	+	5 x 9417 cnt/km	=	201085	counts			
1 km	154000	+	9 x 9417 cnt/km	=	238753	counts			
Start	154000	+	10 x 9417 cnt/km	=	248170	counts			

Knowing what the count will be at the starting line, you then work backwards to figure out what the count will be at each mile split:

Start									
1 mile	248170	-	15155 cnt/mi	=	233015	counts			
2 miles	233015	-	15155 cnt/mi	=	217860	counts			
3 miles	217860	-	15155 cnt/mi	=	202705	counts			
4 miles	202705	-	15155 cnt/mi	=	187550	counts			
5 miles	187550	-	15155 cnt/mi	=	172395	counts			
6 miles	172395	-	15155 cnt/mi	=	157240	counts			

After computing all these counts, you arrange them in a single list, in the same order as you will come to them in the measurement, from Finish to Start.

[Note: If these calculations for inserting mile splits into a metric course seem complicated, perhaps you can avoid them by laying out the course entirely with kilometer splits. An increasing number of races are moving to an all-metric format; e.g., see Tulsa Run example in the next section on examples of course maps.]

You check the temperature and record the time and temperature. You mount the bicycle and ride, checking the count periodically. You make a sharp right-hand turn onto Fargo Road, staying close to the right-hand curb as you round the corner. Since the next turn will be a left, you sight a straight diagonal that will take you to the curb at the northeast corner of the intersection of Fargo and James Roads. Following this shortest course, you ride until you reach a count of 157240. You dismount and paint a short line and a small "6" on the pavement at the position of the front axle, indicating the tentative six mile mark. You record the mark as located opposite the center of the driveway at 2180 Fargo Road.

You continue the diagonal path to the James Road intersection. At this point, you know that the next turn will also be a left turn. You find the corner to be gravelly and runners could cut here. You note that a cone and monitor must be placed at this corner to keep the runners on the pavement. You measure following a path close to the curb on the north side of James Road. As you reach your count of 172395, you dismount and mark the tentative five mile point.

Your next turn is left onto a winding bike path. You carefully follow the shortest route, crossing from one side of the path to the other as needed to follow the shortest route. You note and mark the four mile, 5 kilometer, and three mile marks.

Your next turn is a left onto River Street. As soon as you can see a straight path for the southwest corner of River Street and the bike path, you head for it. The next turn will be a right, heading north onto Joy Street. You sight the diagonal and ride the shortest route to the northeast corner of Joy and River Streets. You note and mark the two mile mark.

Your tentative turn-around point on Joy Street is adjacent to a high-voltage tower. You head for the middle of the street adjacent to the tower. When you are opposite the tower, you stop and "freeze" the front wheel. You mark the turn-around with a line and a "T." You record the count. You then carefully reverse the direction of the bicycle while holding the front wheel frozen. You now sight for the northwest corner of Joy Street and Turtle Road where you will make a right turn, noting and marking the tentative one mile and one kilometer marks enroute.

You round the last corner and stay to the north side of Turtle Road. When the counter reaches 248170, you have reached your tentative starting line. You mark as before and paint a small "S" on the pavement next to the line. You then locate and record that the tentative starting line is 1.0 feet west of the telephone pole #3014-6C in front of Mergor Hardware Store at 2717 Turtle Road.

Now you are ready for the return measurement. This time, you've decided to ride from Start to Finish so you can make independent judgments of the shortest possible route. You hold the front axle of the bicycle over the tentative starting line that you marked in the first measurement, and rotate the wheel *forward* until the counter reads an even number of 100s (248200). You mount and ride the course in the direction the race will be run. This time, you do not need to make any calculations before riding, and you **do not** make any new marks on the road. You simply stop at each of the marks you painted on the road during

your first measurement (start, splits, turn-around, finish). At each such mark, you record exactly what your counter reads when the front axle is directly over the previously painted mark. You continue in this manner all the way to the (previously fixed) finish line.

Your count at the previously painted finish line is 342326. You calculate the start-to-finish counts for measurement #1 as 94170 and for measurement #2 as 94126. You divide each start-to-finish count by the working constant to obtain the preliminary course length for each measurement. You record these as 10,000 meters and 9,995.33 meters. Their difference is 4.67 meters. You then divide this difference by course length #1 (10,000 m) and note that the two measurements differ by 0.0467% which is within the 0.08% maximum allowable tolerance.

You now return to the calibration course and recalibrate the bicycle.

After recalibrating, you find that your post-measurement "finish" constant is smaller than your pre-measurement "working" constant, which means that your "constant for the day" (defined as the larger of the working constant or finish constant) is identical to the working constant. This allows you to avoid recalculating your measurements using the constant for the day. You need only adjust the race course for the difference between the lesser of the two measurement rides and the desired race distance.

The lesser of the two measured distances was 9,995.33 meters, based on ride #2. (Very likely, you did a better job of riding the shortest possible route during your second ride over the course; it is often easier to concentrate on riding the shortest route during the 2nd ride because you don't have to worry about making new marks on the road this time.) This is the "official" measured length of the tentative course. To bring the course up to the full desired distance of ten kilometers, it must be lengthened by 4.67 meters.

At this point you must convert back to the English system since you are (unfortunately) using a non-metric tape. You check Appendix E and note the conversion between meters and feet is 0.3048 meters equals one foot. Dividing the 4.67 meters by 0.3048 meters per foot gives you 15.32 feet or 15 feet 4 inches which is the distance that you must lengthen your course by to bring it up to the full 10 kilometers.

Rather than adjust the starting line, you opt to adjust the turn-around point. Using your steel tape, you measure 7'8" north from your tentative turn-around point and make a permanent mark, using concrete nails pounded into the pavement. You also mark the turn-around with spray paint and a "T" for turn-around.

Since the difference between the marked intermediate split points and the split points that would result from using the lesser measurement value would not be greater than 5 meters (the overall adjustment was 4.67 meters), you opt to leave the intermediate split point marks where they are and mark them with concrete nails and spray paint.

You return to the start/finish area and make permanent marks for the start and finish lines.

You now return home and have lunch before sitting down to fill in the blanks in the forms for certification. You are satisfied with the morning's work.

COURSE MEASUREMENT DATA SHEET

Name of Course or Race Name ELYSIUM 10K
 Name of Measurer #1 JOHN DOE Working Constant #1 9417 $\frac{CTS}{KM} = 15155 \frac{CTS}{MI}$
 Date 16 Oct 1982 Start: Time 7:45 AM Temperature 53 F
 Finish: Time 9:00 AM Temperature 57 F
 Name of Measurer #2 JOHN DOE Working Constant #2 9417
 Date 16 Oct 1982 Start: Time 9:10 AM Temperature 57 F
 Finish: Time 10:15 AM Temperature 62 F

Measurement Data. Use the first measurement ride to lay out the start/finish points and all intermediate split points. Use the second ride to check the location of those same points. Do not use two sets of marks!

Measured Point	Counts for Measurer #1			Counts for Measurer #2	
	Recorded	Elapsed		Recorded	Elapsed
FINISH	154000	3240	FIN	342326	3237
6 MI	157240	15155	6	339089	15145
5 MI	172395	15155	5	323944	15139
4 MI	187550	13535	4	308805	13528
5 KM	201085	1620	5 KM	295277	1620
3 MI	202705	15155	3	293657	15151
2 MI	217860	15155	2	278506	15149
1 MI	233015	15155	1	263357	15157
START	248170		START	248200	

Preliminary Course Length	start-to-finish counts	divide by	working constant	=	measured length
Measurer #1	94170	/	9417	=	10.000 KM
Measurer #2	94126	/	9417	=	9.99533 KM

Difference between lengths #1 and #2 0.00467 KM divide by 10.000 KM = .000467 Measurement comparison (less than 0.0008?) YES () (yes or no)

IMPORTANT. Before you leave the course, compare the two measurements. They should agree to within 0.08%. If the two preliminary measurements do not agree to within 0.08%, something is wrong. Fix it! Then go to the calibration course and recalibrate.

If either of the **Constants for the Day** (for measurements #1 and #2) are not the same as the **Working Constant**, recalculate the length of the course here.

Final Course Length	start-to-finish counts	divide by	constant for day	=	length of course
Measurer #1		/		=	
Measurer #2		/		=	

NOT NEEDED SINCE WORKING CONSTANT = CONSTANT FOR DAY

The length of the race course as measured by the calibrated bicycle is the lesser of the two lengths calculated above.

Measured course length 9995.33 METERS Desired course length 10,000 METERS

Use a steel tape to add or subtract distance as required to bring the **minimum** length to the same value as the desired course length. 4.67 METERS / .3048 m/FT = 15.32 FT

How much did you add or subtract, and where (start, finish, turn-around point)?

ADDED 4.67 m (15.32 FT) BY MOVING TURNAROUND 7'8" TO NORTH

Note: You need not adjust intermediate split points unless certification is desired for those points as well. Did you adjust the intermediate points and, if so, how?

NO

APPLICATION FOR CERTIFICATION OF A ROAD COURSE
The Calibrated Bicycle Method

- Name this Course will be Known By ELYSIUM 10K
- Advertised Race Distance 10 KILOMETERS Race Date 23 Nov 82
- Location of Start ELYSIUM, OH Finish (if different) SAME
city, state city, state
- Person in Charge of Measurement:
JOHN DOE, 123 ACCURATE RD, PERFECTION (614-123-4567)
(name) (address) OH 43807 (telephone)
- Race Director (if course is measured for a specific race):
M. OFFOT, 82 JALOUSIE LN, ALTIBOR, OH (614-555-6602)
(name) (address) 44167 (telephone)
- Is this an application for **recertification** of a previously certified course? If so give the reason(s) for recertification. NO

CALIBRATION OF BICYCLE

- Did you calibrate the bicycle on a calibration course previously certified by the Road Running Technical Committee? NO (YES or NO)
If YES, enclose a copy of the letter or certificate, and map, verifying RRTC certification of the calibration course.
If NO, you must enclose an Application for Certification of Calibration Course. ENCLOSED
- Is your **bicycle calibration data sheet** attached? YES (YES or NO)
- Did you include the factor of 1.001 in your calibration constant? YES (YES or NO)

SUMMARY OF MEASUREMENTS

- Date(s) of measurements 16 OCT 1982
- How many measurements of the course were made? 2
- Name(s) of measurer(s) JOHN DOE
- Exact length of course 10.000 KM
- Difference between longest and shortest measurements 4.67 METERS
- Which measurement was used to establish the final race course and WHY?
2ND RIDE - YIELDED SHORTER MEASURED VALUE
- Is your **course measurement data sheet** attached? YES (YES or NO)

COURSE LAYOUT AND MARKING

- Is your **course map** attached? YES (YES or NO)

NOTE: The course map need not be to scale but must indicate direction of north. It must be in one color and fit on 8.5x11 paper. Descriptions of the **exact** positions on the **start**, **finish**, and all **turn-arounds** relative to permanent landmarks must be included on the map. Details of any restricted portions where cones and monitors are required must be detailed. Include a line representing the actual measured path.

- List all intermediate **splits** (attach list describing the position of each relative to permanent landmarks). EVERY MILE PLUS 5 KM
- How far from the curb (edge of pavement) did you measure on curves? 30 CM (1 FOOT)
- If your course contains pairs of opposite turns (right-to-left or left-to-right) did you follow the shortest diagonal path? YES (YES or NO)
If NO, attach a detail of the measured path.

APPLICATION FOR CERTIFICATION OF A ROAD COURSE
The Calibrated Bicycle Method (continued)

21. Does your course contain any turn-around (double-back) points? YES (YES or NO) If YES, attach a detail of the measured path. SEE MAP.
22. Does your course include any winding or "S" curved sections? YES (YES or NO) If YES, show, by attached example, how you chose the route you measured. SEE MAP
23. Are the runners to be restricted to a route longer than the shortest possible route for any portion of the race course? NO (YES or NO) If YES, attach a description of how you plan to insure that the runners follow the measured course.
24. Type of course (check one):
 one loop _____ time(s) same out/back _____ time(s)
 figure-8 _____ time(s) several out/back sections
 partial loop keyhole (out/loop/back)
 complex of different loops point-to-point
25. Straight-Line Distance (as the crow flies) between Start and Finish 69 FT (21 METERS)
26. Altitude of Race Course (above mean sea level):
start 778 FT finish 778 highest 787 lowest 738
27. Total Climb (summation of all up-hill altitude changes) _____ (optional)

28. Type of surface (give percentages):

- | | |
|---|---|
| <u>45</u> curbed streets | <input type="checkbox"/> graded dirt road |
| <u>25</u> uncurbed streets/roads | <input type="checkbox"/> ungraded dirt road |
| <input type="checkbox"/> concrete sidewalk | <input type="checkbox"/> gravel road |
| <input type="checkbox"/> concrete/brick streets/roads | <input type="checkbox"/> undefined paved surface |
| <u>30</u> paved bike path | <input type="checkbox"/> undefined dirt surface |
| <input type="checkbox"/> unpaved bike path | <input type="checkbox"/> undefined grass surface |
| <input type="checkbox"/> trail (single file) | <input type="checkbox"/> track (curbed or uncurbed) |

If your course includes any unpaved sections, please attach a detail of the method(s) used to measure such sections.

29. Is a description of the exact starting and finishing points (and any turn-around points, if any) attached? This description should include diagrams, including street names and taped distances from the start/finish points to near-by prominent landmarks, so that a stranger could find them. SEE MAP YES (YES or NO)

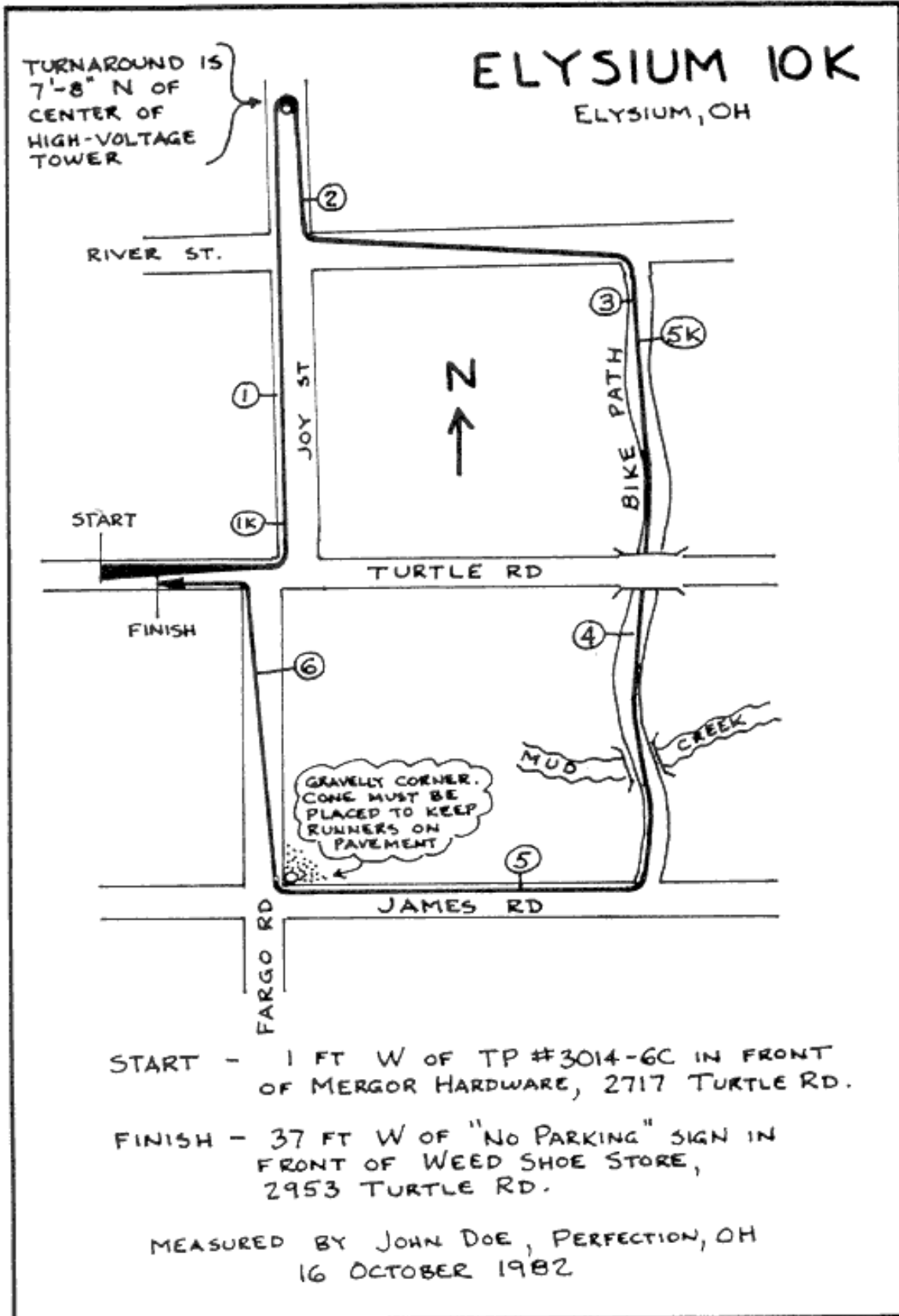
30. How did you mark the start and finish points (and turn-around points)?

PAINT, NAILS & WASHERS

31. Did the same person ride the bicycle on both the calibration course and the race course for any given measurement? YES (YES or NO)

32. Were both the calibration and the race courses DRY during the calibration and measurement rides? YES (YES or NO)

33. Did you perform both the pre-measurement and post-measurement calibrations and the measurement of the race course on the same day? YES (YES or NO)



ELYSIUM 10K

LIST OF MEASURED POINTS

START:	1' W OF T.P. #3014-6C IN FRONT OF MERGOR HARDWARE STORE, 2717 TURTLE RD., ELYSIUM, OH.
1km:	43 ft. N OF LIGHT POLE AT NW CORNER TUR- TLE & JOY.
1 mile:	8 ft. N OF "JOY CAFE" SIGN ON JOY ST.
Turn-around*	7'8" N OF CENTER OF HIGH-VOLTAGE TOWER
2 mile:	4 ft. N OF "BURIED CABLE" SIGN ON JOY ST.
3 mile:	17 ft. S OF DRINKING FOUNTAIN ON BIKE PATH
5 km:	23 ft. S OF S. EDGE OF PUBLIC RESTROOMS ON BIKE PATH.
4 mile:	68 ft. N OF "NO DOGS ALLOWED" SIGN ON BIKE PATH.
5 mile:	3 ft. W OF T.P. #3004-8B ON JAMES RD.
6 mile:	CENTER OF DRIVEWAY, 2180 FARGO RD.
FINISH:	37 ft. W OF "NO PARKING" SIGN IN FRONT OF WEED SHOE STORE, 2953 TURTLE RD., ELYSIUM, OH.

*Turn-around description includes final course adjustment.

APPENDIX C

Example of Course Measurement

Course Maps

One of the most valuable results of your paperwork will be your course map. Not only should it demonstrate to the certifier the manner in which you measured your course, but it should document **exactly** how the course is laid out and where the crucial start, finish, and turn-around points are located.

The following examples of course maps demonstrate there are many ways to draw maps. However, they **all** clearly show how the course is to be run and where crucial points are located. Note in particular that each map shows how the shortest possible route was followed. This assures the regional certifier that the measurer was aware of and followed the shortest possible route in the measuring.

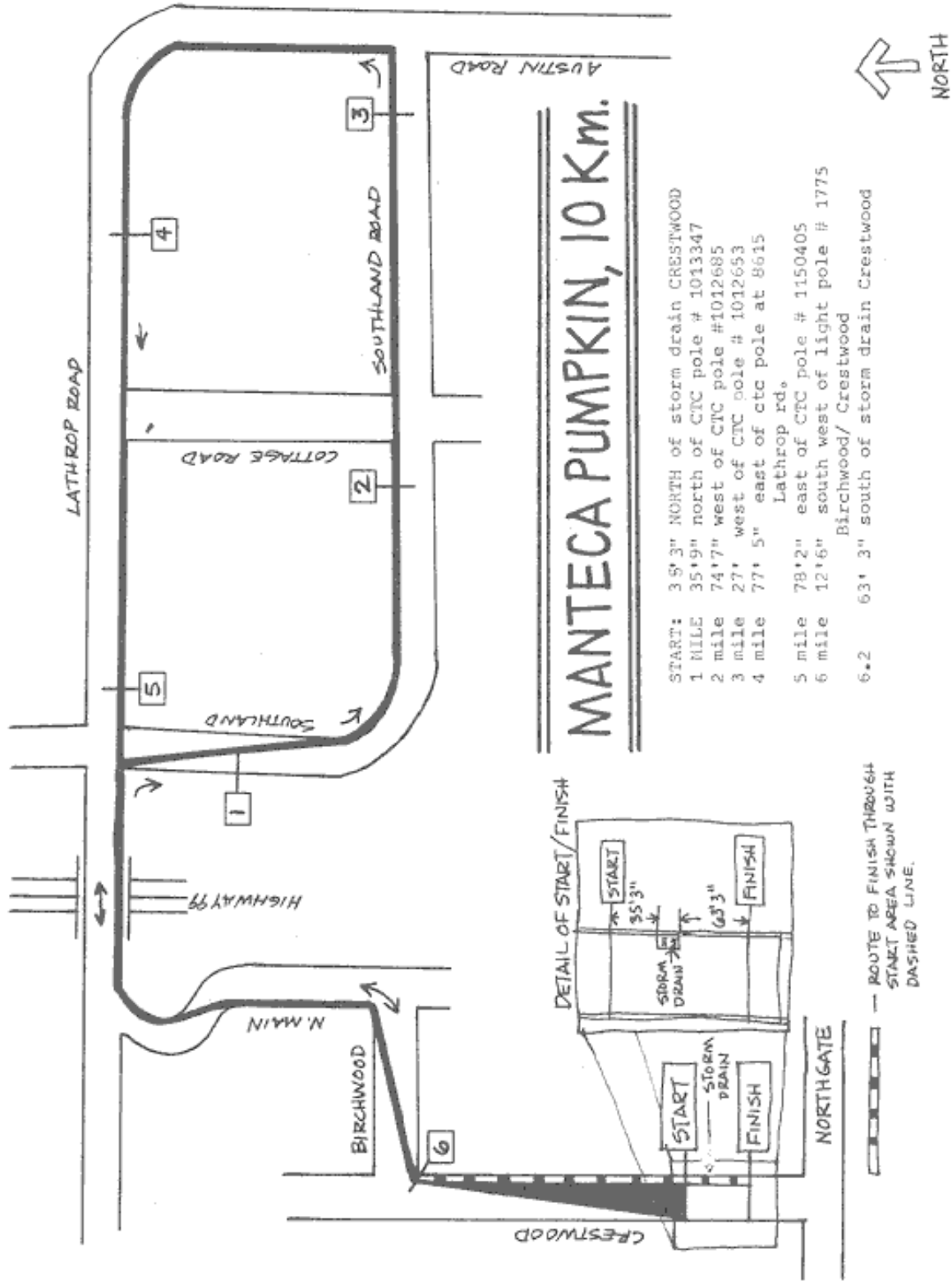
The Manteca Pumpkin 10 km shows a fairly simple keyhole course with only one **S-curve** (encountered twice) and two **diagonals** across traffic. Note the blow-up of the start/finish area. Note also that the runners are kept to the **inside** of the loop and are allowed full use of the roadway on all portions of this course. The lack of a 5 km split is a deficiency.

The Reflecting Pool 5 km is a complex course with many turns, some across grass. Note that each and every turn is defined by an object:

The Bay Bridge 10 km shows use of cones to restrict runners to one side of the road. Note that all splits appear on the map. This is desirable if there is room:

The Kaw City 8 km in Kaw City, OK illustrates proper measurement of a **turn-around** point. The course is classified as an out-and-back since only 20% of the course is a loop and the start and finish are 109 meters apart. Note the detailed description of the location of the turn-around point and metric splits.

The Tulsa Run 15 km in Tulsa, OK is an example of a metric race conducted in a totally metric format. When the Tulsa Run adopted this all-metric format, they also adjusted (and re-certified) their mostly out-and-back course to place the turn-around at exactly half-way, so the kilometer splits going out and coming back would occur at the same points. The split points aren't shown directly on the map, but are described in a separate list, which the certifier then xeroxed to the back of the certificate. This map also includes a verbal description of the course route, which is sometimes very helpful.



MANTECA PUMPKIN, 10 KM.

- START: 3' 5" 3" NORTH of storm drain CRESTWOOD
 1 MILE 35' 9" north of CTC pole # 1013347
 2 mile 74' 7" west of CTC pole #1012685
 3 mile 27' west of CTC pole # 1012653
 4 mile 77' 5" east of CTC pole at 8615
 Lathrop rd.
 5 mile 78' 2" east of CTC pole # 1150405
 6 mile 12' 6" south west of light pole # 1775
 Birchwood/ Crestwood
 6.2 63' 3" south of storm drain Crestwood



— ROUTE TO FINISH THROUGH
 START AREA SHOWN WITH
 DASHED LINE.



MAP NOT TO SCALE

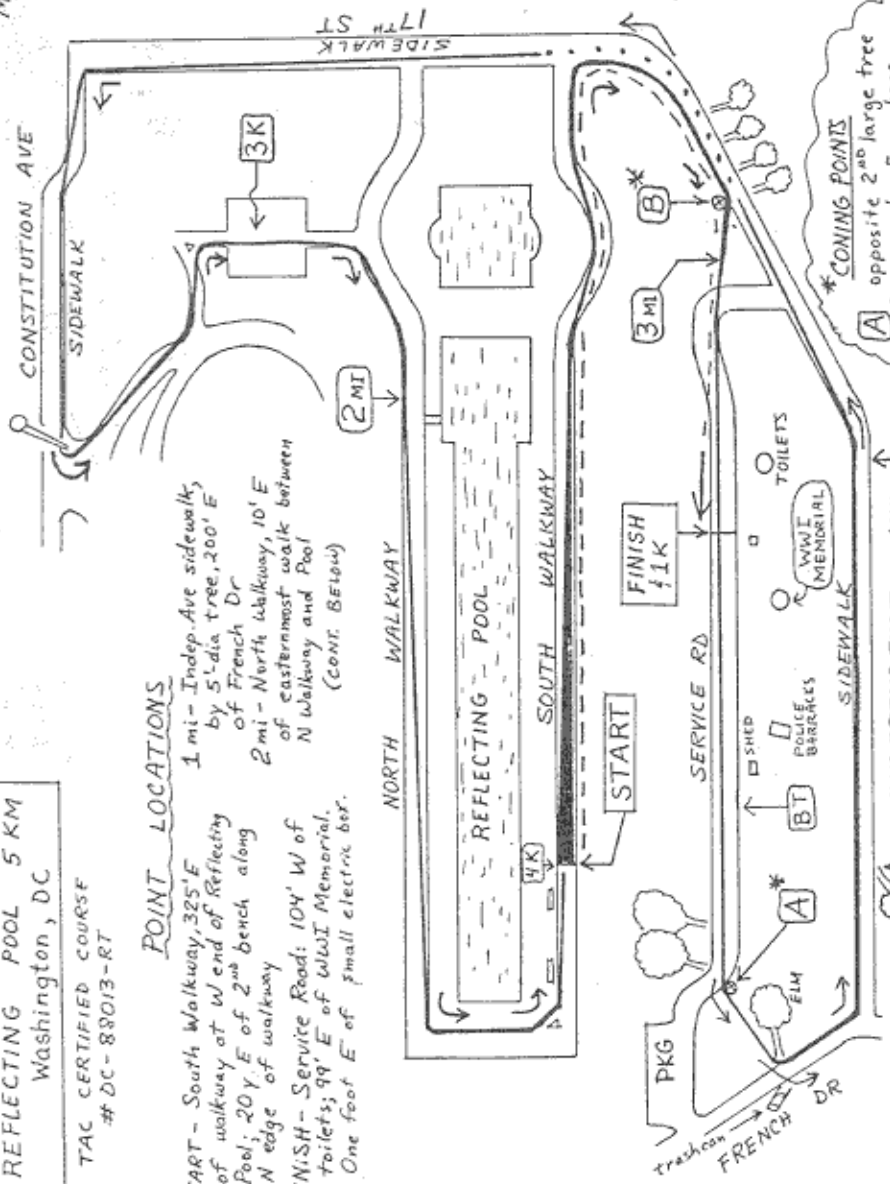
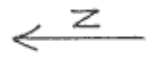
REFLECTING POOL 5 KM
Washington, DC

TAC CERTIFIED COURSE
DC - 88013-RT

POINT LOCATIONS

START - South Walkway, 325' E of walkway at W end of Reflecting Pool; 20 Y. E of 2nd bench along N edge of walkway
FINISH - Service Road; 104' W of toilets; 99' E of WWI Memorial. One foot E of small electric box.
1 MI - Indep. Ave sidewalk, by 5'-dia tree, 200' E of French Dr
2 MI - North Walkway, 10' E of easternmost walk between N Walkway and Pool (CONT. BELOW)

KEY
— 1ST TIME
••• 2ND TIME
--- 4K TO FINISH



1-Mile Event:
START as for 5K.
Turn around at point BT, return to finish. BT is on service road, 160 y W of Police Barracks, 150' W of shed

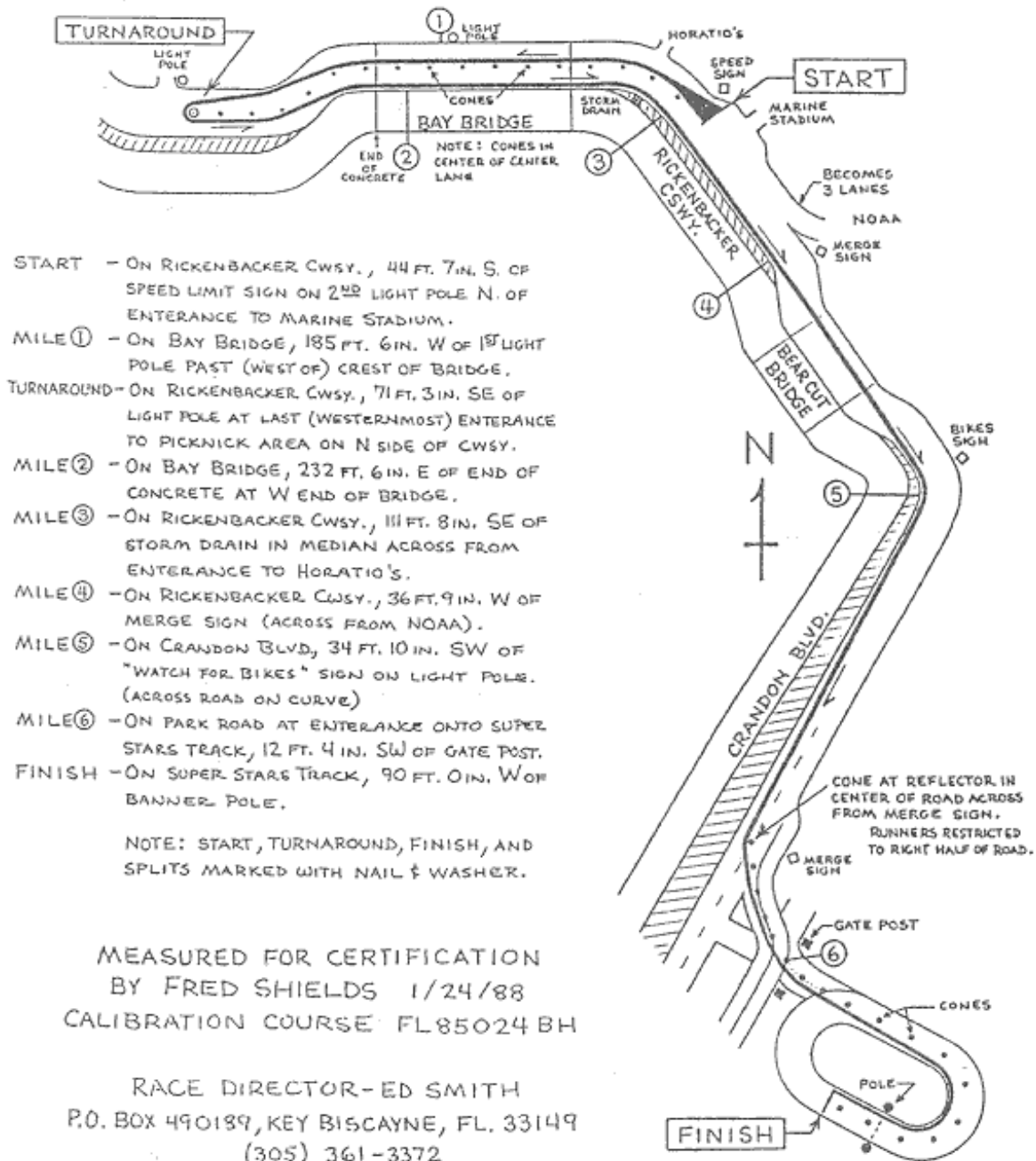
Measured:
9/6, 9/11 - 1986
4/1 - 1988
by R Thurston

ELEVATIONS
Start: 15'
Finish: 15'
Highest: 21'
Lowest: 10'

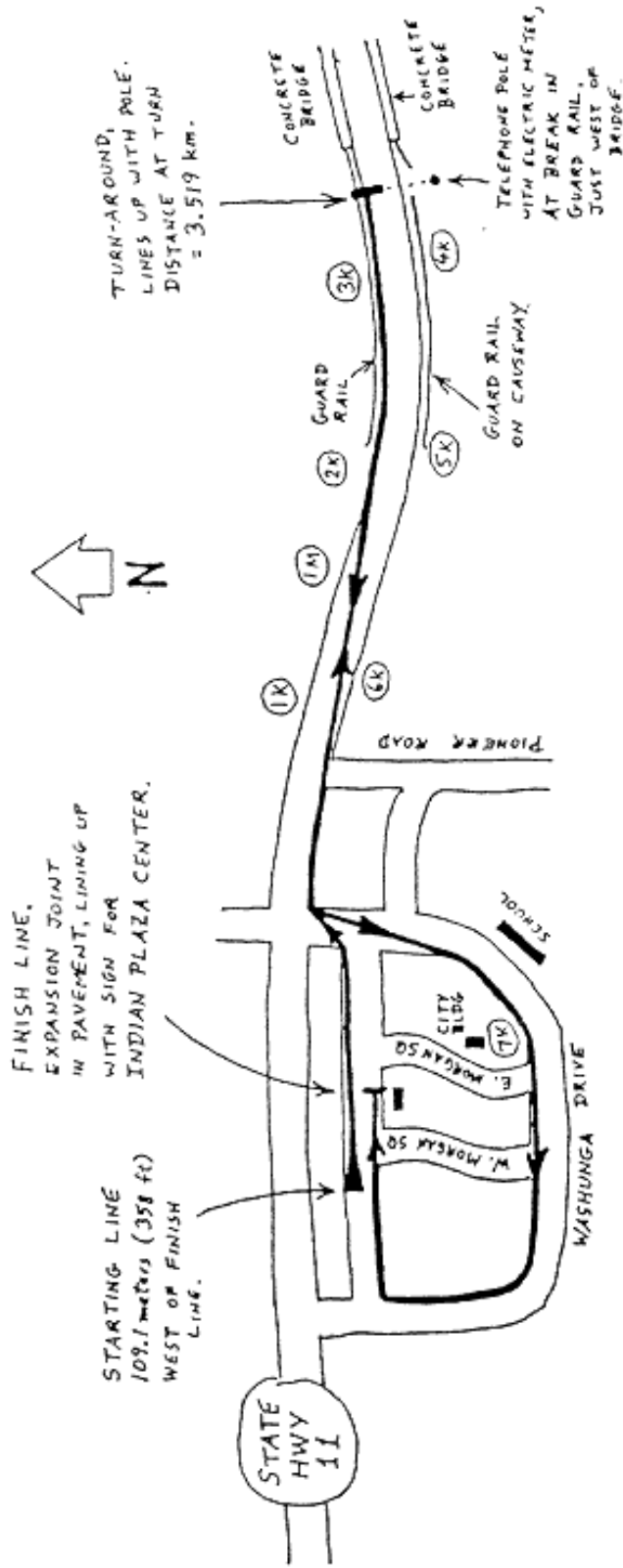
* CONING POINTS
A opposite 2nd large tree from east; from here, go around 30" Elm along French Drive
B opposite 4th large sycamore along SE side of sidewalk; round none then to Service Rd

3 MI - on grass crossover to Service Road; marked on pavement, 50 FT forward of 3-mi point
2K - Ind. Ave. sidewalk, 186' E of ctr, WWI Memorial
3K - Plaza, E end of Const. Gardens, 42' S of row of trees along N edge
4K - Same as start
1K - same as finish = 5K

OFFICIAL ROUTE OF
BAY BRIDGE RACE
 MIAMI, FLORIDA



- START - ON RICKENBACKER CWSY., 44 FT. 7 IN. S. OF SPEED LIMIT SIGN ON 2ND LIGHT POLE N. OF ENTRANCE TO MARINE STADIUM.
- MILE ① - ON BAY BRIDGE, 185 FT. 6 IN. W OF 1ST LIGHT POLE PAST (WEST OF) CREST OF BRIDGE.
- TURNAROUND - ON RICKENBACKER CWSY., 71 FT. 3 IN. SE OF LIGHT POLE AT LAST (WESTERNMOST) ENTRANCE TO PICKNICK AREA ON N SIDE OF CWSY.
- MILE ② - ON BAY BRIDGE, 232 FT. 6 IN. E OF END OF CONCRETE AT W END OF BRIDGE.
- MILE ③ - ON RICKENBACKER CWSY., 111 FT. 8 IN. SE OF STORM DRAIN IN MEDIAN ACROSS FROM ENTRANCE TO HORATIO'S.
- MILE ④ - ON RICKENBACKER CWSY., 36 FT. 9 IN. W OF MERGE SIGN (ACROSS FROM NOAA).
- MILE ⑤ - ON CRANDON BLVD, 34 FT. 10 IN. SW OF "WATCH FOR BIKES" SIGN ON LIGHT POLE. (ACROSS ROAD ON CURVE)
- MILE ⑥ - ON PARK ROAD AT ENTRANCE ONTO SUPER STARS TRACK, 12 FT. 4 IN. SW OF GATE POST.
- FINISH - ON SUPER STARS TRACK, 90 FT. 0 IN. W OF BANNER POLE.



INTERMEDIATE SPLITS

- 1 km: 15 meters West of the "Pioneer Park Recreation Area" sign on the East side of Pioneer Road.
- 1 mile: 28 meters East of center of Mahanna's Drive.
- 2 km: 30 meters East of curve sign, with green sign on back, showing the numbers 36, 28, 12, 80 (arranged vertically).
- 3 km: Alongside "Watch for Ice on Bridge" sign.
- 4 km: 32 meters East of sign used as reference for 3 km mark.
- 5 km: 62 meters East of sign used as reference for 2 km mark.
- 6 km: 15 meters East of sign used as reference for 1 km mark.
- 7 km: 17 meters West of West driveway of City Building.

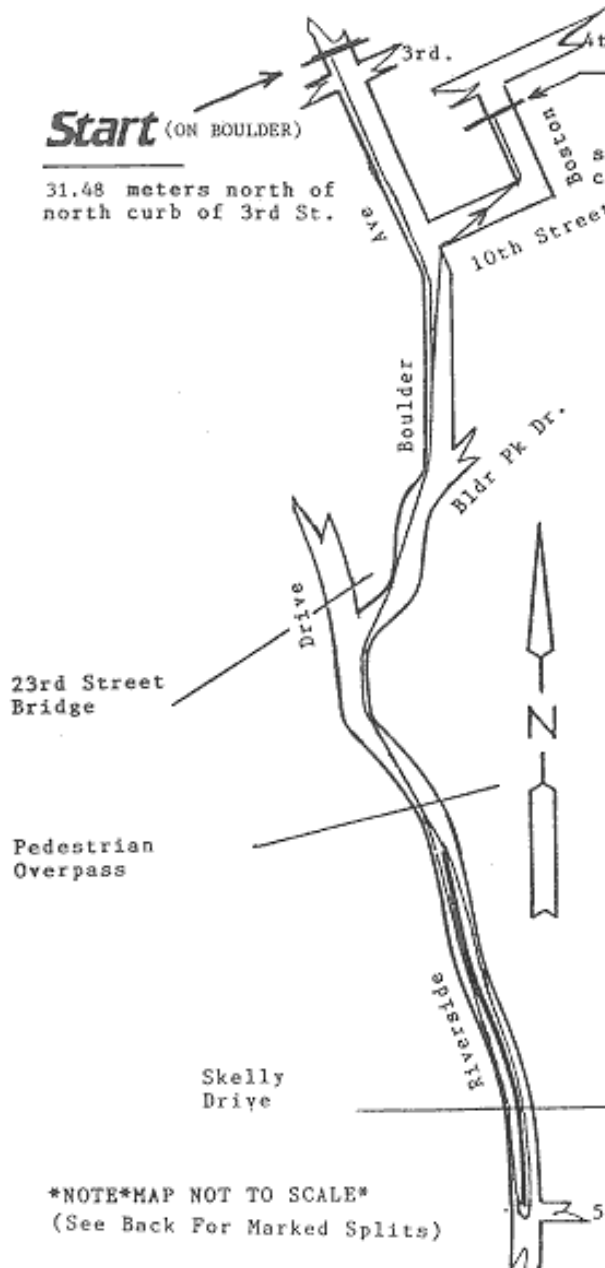
Note: Reference distances for intermediate splits are approximate -- estimated by pacing.

The Starting Line, in addition to being 109.1 meters West of the Finish Line, is also 16.15 meters West of the West end of curbing on the West side of W. Morgan Square.

The turn-around is marked by a PK nail on North side of road.

KAW CITY 8 km
KAW CITY, OKLAHOMA

COURSE MEASURED ASSUMING RUNNERS
ARE FREE TO USE ANY PART OF
THE ROADWAY, INCLUDING THE (PAVED)
SHOULDER ON HIGHWAY 11.



Start (ON BOULDER)
 31.48 meters north of
 north curb of 3rd St.

Finish (ON BOSTON)
 31.18 meters
 south of south
 curb of 4th St, (0.3 meters south of 1st
 building on west side)

Tulsa Run 15 km
Tulsa, OK
OK-94041-BB

THE RACE starts on Boulder Avenue,
 31.48 meters north of the north curb
 of 3rd Street.--- Follow Boulder south
 to Boulder Park Drive. Follow Boulder
 Park Drive across 21st Street to River-
 side Drive. Continue south on River-
 side Drive (keeping right of median
 from 32nd Street to the turning point),
 to 53rd Street. Turn around the median
 counter-clockwise and follow the same
 route back to 10th Street. Turn right
 on 10th Street to Boston Avenue. Turn
 left on Boston and finish 31.18 meters
 south of south curb of 4th Street.

***Runners must keep right of median
 at all times from a point near 32nd
 Street to 53rd Street***

ELEVATIONS:

Start	-	221	meters
Finish	-	226	meters
High	-	226	meters
Low	-	191	meters

*NOTE*MAP NOT TO SCALE*
 (See Back For Marked Splits)

Turn Break in median at 53rd
 Street just south of
 Skelly Drive.
 = 7.5 km split!

#455 08 94 Glen & Coneil

Tulsa Run Splits

1/14 km - 2 meters south of north curb of 12th Street.

2/13 km - 1 meter south of 2nd seam south of 18th, &/or Council Oak Trail.

3/12 km - 14 meters south of south curb of 26th Place.(measure along west side of Riverside)

4/11 km - 14 meters south of sewer grate at 1st street light south of 31st, or 19 meters south of cross-walk.

5/10 km - 7 meters south of north end of median at 37th Street.

6/9 km - 3 meters south of 1st street light in median north of 43rd Place.

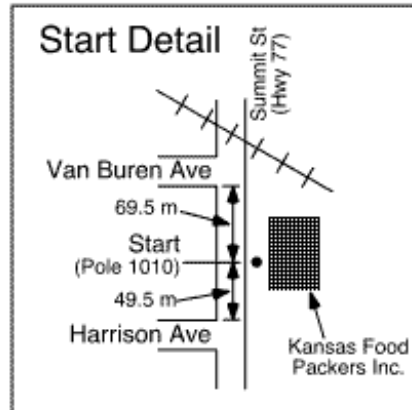
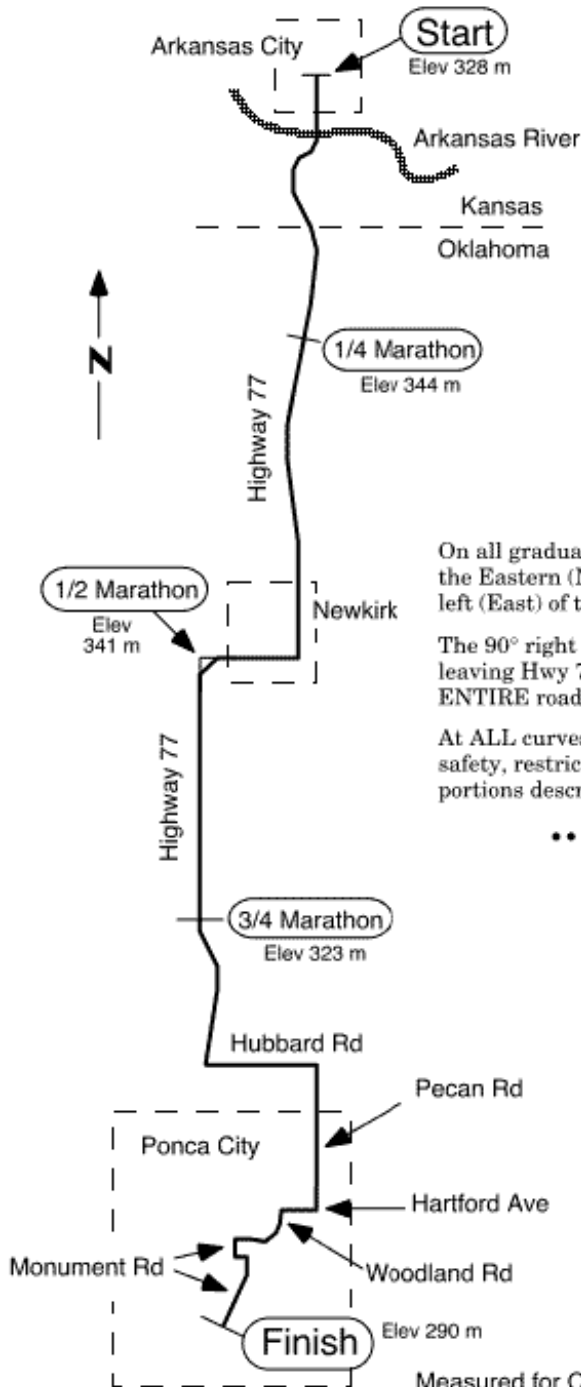
7/8 km - 8 meters north of 1st sewer grate north of 50th Street.

The Cherokee Strip Marathon, a point-to-point course from Arkansas City, KS to Ponca City, OK, illustrates a **single-line map**. (This also happens to be a *computer-drawn* map, which is becoming more common as suitable graphics software has become widely available.) Sometimes, especially for long courses such as marathons, it isn't practical to draw a line depicting the measured path through the entire course. In such cases, it is acceptable to draw the road as a single line, as long as the actual measured/certified path is clearly described. For this particular course, the measured/certified path was chosen as a well-defined path that can be easily described, although it's probably not safe for runners to run this path (unless the course could be closed to traffic, which isn't likely in a small rural race). Therefore, the map also advises that, in the interest of safety, the race director may restrict runners to any desired sub-region of the allowed road portions — which would force running **longer** than the measured distance. It is always acceptable for race directors to impose additional restrictions of this sort. We just need to make sure that runners never run *shorter* than the measured distance.

Still more complicated course maps could be shown but they would be comprised of the same kinds of features, just more of them. Remember the best course is the simplest course, i.e., the one that requires the least monitoring and is easy for the runners to follow. The more complicated the course, the more monitors you need and the course map will take longer to draw (and you also run a greater risk of something going wrong on race day). The more turns you have, the slower the course will be for the runners. Start with something simple.

Cherokee Strip Celebration Marathon & Relay

(OK-93028-BB)



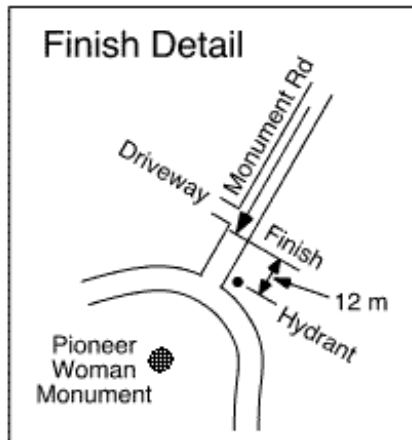
Restrictions:

On all gradual curves on Highway 77, runners must remain within the Eastern (Northbound) shoulder or lanes; i.e., they must keep left (East) of the median or center-line.

The 90° right turn in Newkirk, and all turns in Ponca City after leaving Hwy 77, were measured as if runners are free to use the ENTIRE roadway.

At ALL curves and turns, race director may, in the interest of safety, restrict runners to any desired sub-region of the road portions described above.

•• See Splits on Back of Certificate ••



Measured for Certification by Bob Baumel 31 May & 13 June 1993

APPENDIX D

Filling Out the Forms

This section is intended to clarify certain portions of the "Application for Certification of a Road Course."

Type of Course

Courses rarely fit the simple categories exactly. Attempt to determine the **basic** structure of the course with the following points in mind.

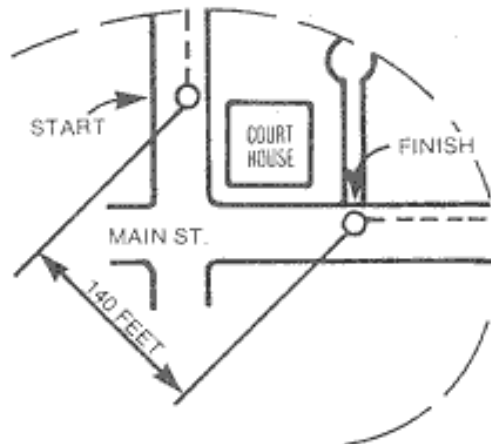
A **loop** course follows a path that eventually closes on itself with the runner headed in the **same** direction as he/she was at the start of the loop. This circular motion can be repeated indefinitely without the need for the runner to reverse his/her direction of running.

An **out-and-back** course follows a path **out** to a turn-around point where the runner is required to reverse direction and come **back** on the same roadway. When the out-and-back section is completed, the runner is headed in the **opposite** direction to that followed at the start of the out-and-back section.

A **point-to-point** course is defined as any course whose straight-line distance between the start point and the finish point is greater than 30% of the overall race distance **or** any course whose net decline averages more than 1.0 meter per kilometer (i.e., where the finish elevation lies below the start elevation by more than 1/1000 of the race distance).

Straight-Line Distance Between Start and Finish

The **straight-line distance between start and finish** is usually taken from a map drawn to scale. This is the distance "as the crow flies." Locate the start and finish points. Place a ruler edge so that it touches both the start and finish points. Read off the distance on the ruler. Convert this to kilometers (or miles) using the map scale.



The rules on eligibility for USATF records make a distinction between courses with start-to-finish separation less than or greater than 30% of the race distance (such as 1.5 km for a 5 km race). If it appears that your course is close to this threshold, try to determine its separation more accurately. Your course can be certified either way; however, if separation exceeds 30%, official records can be accepted only when there isn't a significant tailwind during the race.

Altitude of the Race Course

The **altitude of the race course** may be obtained from section (quadrangle) maps available from the U.S. Geological Survey. If your library does not possess a set, check the major blueprint stores in your area. These often carry a full set of maps for your state. Hiking stores often carry a selection of USGS maps. Prices may run between about \$4.00 and \$8.00 each.

Note: USGS maps may also be ordered online or by telephone. See information on the RRTC Publications page at <http://www.rrtc.net/publications.html>.

The USGS maps show locations of prominent natural and man-made features. The locations of cities, towns, and major roads are of primary interest. The background of the map consists of contour lines, indicating elevation above mean sea level. Depending on the roughness of the terrain, the contour interval may range from 10 feet up to 80 feet.

If possible, copy the pertinent sections of the USGS map so that you can mark the race course on it. Locate the start and finish points and estimate the elevation if either is between contour lines. Unless you are trying to determine elevation at a "saddle point," a linear interpolation between given contours is usually quite good. This will give you the elevation or altitude of the start and finish points.

Next, trace over the race course to find the highest and lowest points. These two elevations complete the altitude section. A good magnifying glass is very helpful in reading elevations.

Note: We are most interested in the **difference** in elevation between the Start and Finish; therefore, it is more important to determine this difference accurately than to get all of the individual elevations above sea level just right. Eligibility for records depends on whether the course has a net **drop** in elevation exceeding 1/1000 of the race distance (such as 10 meters for a 10 km race). If it appears that your course is close to this threshold, try to determine its drop more accurately. Your course can be certified either way, and will also be eligible for USATF "best" times either way; however, it must not drop more than 1 m/km in order to be eligible for official USATF "records."

Type of Surface

The various classifications are, for the most part, self-explanatory. The "undefined" surfaces are those which do not offer a preferred direction of travel, such as a large parking

lot or an open field. Defining a course in such areas presents certain problems. Often these areas are traversed between prominent landmarks which provide guidance for measuring the course as well as laying it out on race day. If the route is straight, only the entry and exit points need to be defined. If the route is curved or uses several landmarks, such as light poles in a parking lot, the route must be coned and monitored.

APPENDIX E

Metric-English Conversions

It should be kept in mind that the metric system is the fundamental measurement system of the United States. Ever since 1893, all customary "English" units in the US have been defined in terms of metric units. The easiest such definition to remember is that of the inch:

$$\text{one inch} = \mathbf{2.54} \text{ centimeters } \textit{exactly}^*$$

*Throughout this appendix, all conversion values in **boldface** are *exact*.

From the above, one can derive the equivalents of other units of length, e.g.:

one foot	= 12 × 2.54 cm	= 30.48 cm	= 0.3048 meters
one yard	= 3 × 30.48 cm	= 91.44 cm	= 0.9144 meters
one mile	= 5280 × 0.3048 m	= 1609.344 m	= 1.609344 km

Doing Conversions in the Working Constant

If both mile and kilometer distances must be marked when laying out a race course, the conversion is most easily done in the **working constant**:

- a. Determine the working constant in counts/km or counts/mile.
- b. **Multiply** constant in counts/km by **1.609344** to obtain the constant in counts/mile, or:
- c. **Divide** the constant in counts/mile by **1.609344** to obtain the constant in counts/km.

Conversion Table for Standard Distances

The following table shows how kilometer and mile distances are related but is not intended for routine measuring. It is much easier to do the conversion **once** in your measuring constant, as described above, than to do repeated conversions for each split. The table does show, for example, that 10 km is not exactly 6.2 miles. Courses measured to exactly 6.2 miles **will not** be certified as 10 kilometers!

1 km = 0.62137119 miles	1 mile = 1.609344 km
5 km = 3.1068560 miles	5 miles = 8.04672 km
8 km = 4.9709695 miles	10 miles = 16.09344 km
10 km = 6.2137119 miles	20 miles = 32.18688 km
12 km = 7.4564543 miles	30 miles = 48.28032 km
15 km = 9.3205679 miles	40 miles = 64.37376 km
20 km = 12.427424 miles	50 miles = 80.4672 km
25 km = 15.534280 miles	100 miles = 160.9344 km
30 km = 18.641136 miles	
50 km = 31.068560 miles	
60 km = 37.282272 miles	

100 km = 62.137119 miles
150 km = 93.205679 miles
200 km = 124.27424 miles

half marathon = **21.0975** km = 13.10938 miles
marathon** = **42.195** km = 26.21876 miles

The marathon is **defined as **42.195 km** *exactly*.

Conversions for Steel Taping

1 foot = **0.3048** meters
1 kilometer = 3280.84 feet
degrees Celsius (°C) = [degrees Fahrenheit (°F) – 32] ÷ **1.8**
1 pound-force = 4.448 newtons

APPENDIX F

Application Forms

The application forms needed for USATF/RRTC course certification are all provided in an Adobe PDF (Portable Document Format) file named "appforms.pdf" which you can download from this page. The forms contained in this file are as follows:

- Steel Taping Data Sheet
- Application for Certification of Calibration Course
- Bicycle Calibration Data Sheet
- Course Measurement Data Sheet
- Application for Certification of a Road Course
- Application for Renewal of Certified Course (after 10-year expiration)

[Download **appforms.pdf** file](#)

Note: You'll probably have to include a **processing fee** when sending the filled-out application forms to your regional certifier. The exact amounts of these fees vary from state to state. Therefore, check with your certifier **before** sending in the application forms.

[View current list of RRTC certifiers](#)